National Committee
for Sub-National Democratic Development

CLIMATE RISK AND VULNERABILITY ASSESSMENTS FOR SUBNATIONAL ADAPTATION IN CAMBODIA NATIONAL REPORT 2025

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Acronyms

ACCAF	Assessing Climate Change Adaptation Framework
ADB	Asian Development Bank
AR4	IPCC Fourth Assessment Report
AR5	IPCC Fifth Assessment Report
AR6	IPCC Sixth Assessment Report
CCCSP	Cambodia Climate Change Strategic Plan
CRA	Climate Risk Assessment
CRED	Centre for Research on the Epidemiology of Disasters
CRVA	Climate Risk and Vulnerability Assessment
CSESI	Climate Smart Education Systems Initiative
EM-DAT	Emergency Events Database
FAO	Food and Agriculture Organization of the United Nations
GBV	Gender-Based Violence
GCF	Green Climate Fund
GDP	Gross Domestic Product
GIS	Geographic Information System
HNAP	Health National Adaptation Plan
IDPoor	Identification of Poor Households
IMR	Infant Mortality Rate
IPCC	Intergovernmental Panel on Climate Change
LGA	Local government area (equivalent to District administration level)
LGCC	Local Governments and Climate Change
LISA	Local Information System for Adaptation
LoCAL	Local Climate Adaptive Living Facility
LTS4CN	Long-Term Strategy for Carbon Neutrality
NAP	National Adaptation Plan
NCDD	National Committee for Sub-National Democratic Development
NCDDS	National Committee for Sub-National Democratic Development Secretariat
NCDM	National Committee for Disaster Management
NDC	Nationally Determined Contributions
NDVI	Normalized Difference Vegetation Index
NGO	Non-Governmental Organization
NSPPF	National Social Protection Policy Framework

PBCRG	Performance-Based Climate Resilience Grants
SEZ	Special Economic Zone
SPEI	Standardised Precipitation-Evapotranspiration Index
SSP2-45	Shared Socioeconomic Pathway 2, Climate Scenario RCP 4.5
SSP5-85	Shared Socioeconomic Pathway 5, Climate Scenario RCP 8.5
UNCDF	United Nations Capital Development Fund
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
USD	United States Dollar
WASH	Water, Sanitation, and Hygiene
WSDI	Warm Spell Duration Index
3PC	Partnership Program for the Protection of Children

1 EXECUTIVE SUMMARY

Cambodia faces growing challenges from climate change, with rising temperatures, shifting rainfall patterns, and an increasing frequency of extreme events threatening its economy, ecosystems, and people. This Climate Risk and Vulnerability Assessment (CRVA) was undertaken to provide a comprehensive, evidence-based foundation for guiding national and subnational adaptation planning.

The assessment applies the analytical framework of the IPCC Fifth Assessment Report (AR5), tailored to Cambodia's context. It combines climate model downscaling, spatial risk mapping, and sector-specific analysis with a strong participatory process involving national ministries, subnational authorities, development partners, and civil society. Through this mix of quantitative modeling, geospatial analysis, and stakeholder consultations, the methodology evaluates climate hazards, exposure, and vulnerability across the country.

This approach ensures a robust yet flexible evidence base for identifying priority risks and informing adaptation measures. It also acknowledges key limitations—such as data resolution, reliance on indicator proxies, and the need for complementary local-level assessments—to guide the appropriate interpretation and use of results.

In addition to this national report, the CRVA report includes three provincial summaries for Battambang, Preah Vihear, and Pursat, offering targeted insights to support subnational planning and integration of climate resilience into local development processes.

1.1 KEY FINDINGS

- Cambodia is already warming and will warm further. Nights are warming faster than days. Projected warming is substantial by mid-century under the scenarios used in the report.
- Annual rainfall totals show little change overall, but rainfall patterns are becoming more variable and extremes are intensifying. Drought and flood risk are both rising in different places.
- Five sectoral sub-risks summarise the threat to development: food systems, water, forestry, coastal environments, and human health. Each sub-risk combines multiple hazards, overlapping exposures and entrenched socioeconomic vulnerabilities.
- Adapting successfully will require a risk-led portfolio of priority measures. Building on the CRVA evidence, a transparent multi-criteria framework identifies a set of 25 priority adaptation measures across sector packages – including climate-resilient livelihoods, community-based disaster risk reduction, water security, ecosystems and forestry, resilient infrastructure and urban systems, tourism and coastal economies, and climate-sensitive health and social protection – and targets them to Cambodia's main climate-risk hotspots. This provides a practical, investment-ready basis for guiding LGCC-III, LoCAL and other national and subnational adaptation programmes.

1.2 NATIONAL CLIMATE CONTEXT AND HAZARD OVERVIEW

The CRVA shows clear warming from 1980 to 2020. Minimum temperatures average about 22.8 °C and rose by roughly 0.22 °C per decade. Mean temperature averaged about 27.2 °C and rose by about 0.19 °C per decade. The maximum temperature averaged about 31.7 °C and rose by about

0.16 °C per decade. Warm nights have increased markedly, and the diurnal temperature range has declined.

Heat extremes have already increased substantially. At present, Cambodia experiences about 52 days per year above 35 °C, and this number has risen rapidly in recent decades. The Warm Spell Duration Index and the frequency of tropical nights also show significant increases. These trends point to growing heat stress for people, crops and livestock.

Observed rainfall totals at the national scale have remained near 1,850 mm per year on average. That total shows no statistically significant trend across 1980–2020. At the same time, heavy short-duration rainfall events have increased slightly, and water stress indicators have worsened. The country now experiences roughly 139 wet days a year and about 16 days per year with rainfall over 20 mm.

The downscaled model ensemble used in the CRVA projects continued warming for 2020–2050. Mean annual temperature over 2020–2050 is projected to be around 28.56 °C with a trend of about 0.27 °C per decade. Warm nights will become more frequent. Days above 35 °C are projected to increase to roughly 67 days per year by mid-century in the 2020–2050 window.

Rainfall is projected to rise modestly in the ensemble mean, around 1% per decade in the 2020–2050 period. However, the rainfall signal varies seasonally and regionally. Projections show increases in short-term extremes: 5-day maximum rainfall and monthly peaks increase significantly in many areas. Days over 20 mm are expected to become slightly more frequent. This combination raises the chance of both flash flooding and riverine flooding during intense wet spells while also leaving parts of the year or parts of the country exposed to dry spells.

Sea and ocean risks are clear. Sea surface temperature is projected to rise, and sea level rise, storm surge and coastal flood risk increase, especially along the southern coast. Ocean acidification indicators show a deterioration likely to affect marine ecosystems.

1.3 DRIVERS OF EXPOSURE AND VULNERABILITY

Roughly 80% of the population lives in rural areas, concentrated on river floodplains, around Tonle Sap, and across agricultural lowlands. This pattern places large numbers of people and their livelihoods directly in zones of flood or drought exposure. Urban exposure is increasing as the urban population and infrastructure expand. Phnom Penh and secondary cities face compounded exposure from heat, pluvial flooding and infrastructure stress. Coastal exposure concentrates in provinces with ports, tourism and fisheries economies.

Important exposed assets include rainfed cropland, livestock holdings, fisheries, forested ecosystems, coastal infrastructure, transport corridors and essential services such as health facilities, schools, and water supply systems. The CRVA maps show that many of these assets sit in areas that score above the national median for hazard indices.

Socioeconomic and institutional vulnerability is the critical multiplier of climate hazards. High poverty, heavy dependence on climate-sensitive livelihoods, limited access to health and education services and insufficient local technical and financial capacity are pervasive drivers of vulnerability. Gender gaps, child and elderly vulnerability, and disability increase sensitivity in many communities. Local governance and adaptive capacity remain weak in many districts. Where poverty, service gaps and infrastructure fragility coincide with elevated hazards, the resulting risk is high.

Key cross-cutting drivers

- Dependence on rainfed agriculture. A large share of food and income depends on seasonal rainfall timing and quantity. This amplifies sensitivity to both drought and intra-seasonal rainfall shifts.
- Limited water storage and groundwater recharge in many districts. Groundwater recharge is low in parts of the inland plains and upland areas. This reduces buffer capacity in dry spells and limits irrigation options.
- Land use change and ecosystem fragmentation. Deforestation and agricultural expansion increase sedimentation, reduce watershed function and raise wildfire risk where soils dry.
- Concentration of critical services in hazard-prone areas. Health facilities, roads and markets are often located where they are vulnerable to floods, storm surge or heat, making service disruption likely in extreme events.

1.4 SECTORAL HOTSPOT

Together, these hazards, exposures and vulnerabilities will have implications for loss or degradation of agricultural livelihoods, food and water security, forest resources, coastal systems, and human health resulting from ongoing and projected climate change and the physical impacts of more extreme weather. These overarching risks are further divided into specific sub-risks that capture the main climate threats facing each key system

SUB-RISK 1: FOOD SYSTEMS COMPROMISED BY CLIMATE CHANGE

Food systems in Cambodia are vulnerable through three linked pathways identified in the CRVA. First, water insecurity caused by changing rainfall patterns and greater drought risk undermines crop production and yields. Second, more intense rainfall events increase damage to farm assets, erode soils and destroy post-harvest stocks and infrastructure. Third, rising heat and more frequent hot days and warm nights cause crop stress, reduce germination and lower livestock productivity. The combination reduces food availability and incomes, and raises malnutrition risk among vulnerable groups.

The CRVA shows the agricultural hazard is spatially mixed. Much of the Tonle Sap floodplain and dense agricultural zones are exposed to increases in extreme rainfall days and peak monthly rainfall. Inland and upland areas in the northeast see stronger drought and aridity signals. Projected warming and increased warm days are highest in central inland districts and the northwest. All of those hazards converge on food systems in different districts.

Large areas of rainfed crops and high livestock density lead to high exposure across many districts. Poverty, low education and high dependency ratios reduce adaptive capacity and limit farmers' ability to invest in irrigation, storage and climate-resilient practices. The CRVA highlights that densely populated agricultural districts show the greatest risk because hazard and exposure align there.

Impacts and likely outcomes

- Higher frequency of crop failures and yield loss in drought-prone upland districts.
- Recurrent asset damage to smallholder infrastructure from intense rainfall and floods.
- Increased heat stress on livestock leads to lower productivity and higher mortality in heat waves.

- Rising food price volatility and higher malnutrition risk for poor households.

Actions: Prioritise investment in water storage and irrigation where recharge and capture are possible. Scale up resilient seed varieties and diversification. Strengthen post-harvest storage and cold-chain where feasible. Deploy targeted social protection and index-based insurance for high-risk districts. Focus extension services on drought and heat-adapted agronomy.

SUB-RISK 2: WATER INSECURITY AND CONTAMINATION FROM CLIMATE CHANGE

Water risks arise from two pathways. First, changing rainfall patterns and higher evaporation can reduce capture and groundwater recharge, increasing water insecurity. Second, more intense rainfall events and overland flows increase contamination risk to surface and groundwater, and in coastal zones, sea-level rise and saline intrusion compound freshwater loss. The CRVA treats both scarcity and contamination as coexisting threats.

The report maps high water-stress signals in northeastern and some central provinces. At the same time, coastal southwestern provinces face increased overland flow and flood-related contamination. Groundwater recharge is lowest in the inland and central plains. Projected increases in short-duration heavy rainfall raise contamination risk from runoff and sewer overload.

Large populations depend on shallow groundwater and surface water for drinking, irrigation and industry. Hygiene, sanitation and wastewater treatment remain inadequate in many areas. The combination of limited infrastructure and heavy overland flow increases the likelihood that extreme rainfall events will mobilise pollutants into water supplies. Poverty and weak local water governance reduce the capacity to maintain and protect supply systems.

Impacts and likely outcomes

- Reduced availability of reliable freshwater in water-stressed upland districts.
- Higher incidence of contamination events after heavy rains increases the risk of waterborne disease.
- Salinisation of coastal aquifers and irrigation zones from sea-level rise and storm surge.
- Higher costs to maintain and repair water infrastructure after extreme events.
- These effects will hit poor households and agriculturally dependent communities hardest.

Actions: Invest in safe water infrastructure and decentralised small-scale storage. Map and protect critical recharge zones. Strengthen monitoring and early warning for contamination events. Integrate coastal saline intrusion risk into water planning. Improve wastewater management upstream of drinking-water sources.

SUB-RISK 3: FORESTRY LOSSES OR COMPROMISE FROM CLIMATE CHANGE

Forests face two linked threats in the CRVA. Rising temperatures and more frequent heatwaves increase wildfire risk and cause physiological stress to trees. Reduced water availability and drought episodes further limit tree growth and regeneration. In combination with deforestation and fragmentation, these climate drivers raise the probability of large forest losses and biodiversity decline.

Current risk is concentrated in central and northern forested areas and in land use interfaces where forests meet agriculture and development. Projected changes increase risk countrywide, but central and northern provinces show the largest rises. Southwestern natural areas are at lower present risk but are not immune under future scenarios.

Forest-dependent communities, biodiversity and ecosystem services such as watershed regulation and carbon storage are exposed. Fragmentation and existing deforestation trends increase vulnerability by limiting resilience and species migration. Weak fire management and limited funding for restoration reduce adaptive capacity.

Impacts and likely outcomes

- Increased frequency and extent of wildfires in hotter, drier years.
- Reduced forest regeneration and loss of species that cannot adapt quickly.
- Greater soil erosion and reduced watershed function, which feed back into water and agriculture risks.
- Loss of forest-based livelihoods and ecosystem services.
- Forestry loss will also worsen downstream flood and sedimentation dynamics.

Actions: Prioritise community-based fire management, reforestation and landscape restoration in hotspot districts. Protect watershed integrity by controlling deforestation and incentivising conservation. Strengthen forest monitoring and restore connectivity to allow species movement.

SUB-RISK 4: COMPROMISED COASTAL ENVIRONMENT FROM CLIMATE CHANGE

The coastal sub-risk springs from sea-level rise, increased storm surge, tropical cyclone impacts and warming and acidifying seas. These forces damage coastal infrastructure, erode shorelines, intrude saline water into freshwater systems and stress marine ecosystems and fisheries. The report identifies specific coastal districts where exposure and socioeconomic vulnerability make the impacts acute.

Sea-level rise, increased storm surge and more severe coastal flooding are strongest along the southern coast. Sea surface temperature rise and indicators of ocean acidification point to stress for coral, shellfish and fisheries. Tropical cyclone occurrence, while uncertain, contributes to episodic high-impact events that amplify coastal risk.

Coastal populations, tourism hotspots, ports, and coastal agriculture sit at the front line. Many coastal districts have dense populations and infrastructure with limited coastal protection. Economic reliance on fisheries and tourism increases sensitivity. Coastal areas with low adaptive capacity are the most vulnerable.

Impacts and likely outcomes

- Erosion and permanent inundation of low-lying coastal lands.
- Saline intrusion into coastal freshwater systems is reducing water availability for people and crops.
- Damage to tourism and fisheries that undermine coastal livelihoods.
- Increased frequency of coastal infrastructure failure during storm surge events.
- These impacts are already visible in higher-risk coastal districts and will worsen with sea-level rise.

Actions: Implement integrated coastal zone management that combines hard infrastructure with nature-based solutions. Protect and restore mangroves and coastal wetlands to buffer against surges and erosion. Factor sea-level rise into land use and infrastructure planning. Strengthen early warning and evacuation systems for cyclone and storm surge events.

SUB-RISK 5: INCREASING IMPACTS ON HUMAN HEALTH FROM CLIMATE CHANGE

Human health risk grows through three linked channels. Rising heat increases direct heat stress and exacerbates chronic illness. Changing rainfall and temperature patterns alter vector ecology and waterborne disease risk. Acute disaster events cause injury, infectious disease outbreaks, and disruption of health services. The CRVA highlights how these channels overlap with social vulnerability to produce high health risk in particular districts.

Heat hazard is strongest in the northwest and central inland districts. Vector and waterborne disease suitability increases in the northeast and northwest, where climate conditions become more favourable for transmission. Flood-related and storm-related health impacts are concentrated in coastal and floodplain districts.

Distance to health services, infant mortality and baseline health indicators, plus poverty and limited electricity access, raise vulnerability. Informal settlements and the urban poor face higher exposure to heat and floods because of high density and weak infrastructure.

Impacts and likely outcomes

- Increased heat-related mortality and morbidity in cities and hot inland districts.
- Greater incidence of dengue and other vector-borne diseases occurs where rainfall patterns and temperature favour transmission.
- More frequent outbreaks of waterborne disease follow contamination from floods and runoff.
- Disruption of health services at times of disaster reduces the capacity to respond.
- The poorest and those with existing health deficits will suffer most.

Actions: Strengthen early warning for heat, flood and disease outbreaks. Invest in health system resilience, including reliable power and emergency supply chains. Integrate climate-health into public health planning and surveillance. Target heat-health measures in urban hotspots and improve water and sanitation to reduce disease risk.

1.5 GEOGRAPHICAL CLUSTER AND INVESTMENTS MENU

The CRVA identifies three main territorial clusters of high climate risk.

- Northeast highlands: Ratanakiri, Mondulkiri and Stung Treng rank high for drought stress, water insecurity and forestry risk. These areas combine pronounced aridity and water recharge limits with high social vulnerability and dependence on forest and rainfed livelihoods. Heat and drought drive much of the projected risk increase.
- Tonle Sap floodplain and major agricultural lowlands: Kampong Thom, Siem Reap and Battambang stand out as highly exposed agricultural zones that are sensitive to both flooding and periods of drought. They show high exposure of people and assets to extreme rainfall, riverine flood dynamics and growing economic impacts on food systems.
- Southern coast and key coastal districts: Preah Sihanouk and Kampong Trach, together with Koh Kong and Kampot, are identified as coastal hotspots. They combine high exposure from ports, tourism development and population density with rising sea-level and surge hazards.

Across these clusters, the CRVA emphasises that future scenarios widen the spatial footprint of risk and raise risk intensity. In most projections, the same districts that are already at risk see the greatest increases in hazard and risk scores.

The CRVA shows that modest investments targeted at hotspot districts will yield outsized benefits. Where hazard, exposure and vulnerability overlap most strongly, the need for finance and technical support is greatest. For each hotspot, dominant risks have been identified, the highest leverage measures drawn from the sector packages, and practical delivery notes that sequence quick wins and enabling steps. It also lists illustrative priority districts to indicate where implementation should start and why.

The findings highlight the urgency of targeted adaptation responses that address both sectoral and spatial priorities. Building on the CRVA evidence, a transparent risk-led multi-criteria framework identifies 25 priority adaptation measures and organises them into coherent sector packages – climate-resilient livelihoods, community-based disaster risk reduction, water security, ecosystems and forestry, resilient infrastructure and urban systems, tourism and coastal economies, and climate-sensitive health and social protection – which are then territorially anchored in Cambodia's main climate-risk landscapes.

Effective measures include promoting climate-resilient agriculture and sustainable water management, applying ecosystem-based solutions for forestry and coastal protection, strengthening health systems to address emerging risks, and improving governance and social protection mechanisms. Subnational governments play a vital role in implementation, supported by initiatives such as the LoCAL programme that integrates resilience-building into district and commune development plans and budgets through performance-based grants and capacity building. Overall, the CRVA emphasises that Cambodia's development trajectory depends on urgent and sustained investment in resilience. By providing robust data, district-level risk profiles, and sectoral analysis, this report equips government, development partners, and communities with the tools needed to identify priority interventions, mobilise resources, and protect vulnerable populations and ecosystems from the impacts of climate change.

2 INTRODUCTION

Climate change poses significant and growing challenges for Cambodia's sustainable development. Rising temperatures, shifting rainfall patterns, and an increasing frequency of extreme weather events have already begun to affect the country's key sectors and the livelihoods of millions of people. Understanding the extent of these risks and how they vary across locations and communities is essential for building resilience and achieving Cambodia's development priorities. This national report on Climate Risk and Vulnerability Assessments for Subnational Adaptation provides an evidence-based foundation for policymakers, practitioners, and development partners to identify priority areas for intervention and guide effective adaptation planning. The report integrates scientific analysis, spatial risk mapping, and participatory approaches to deliver actionable insights at both national and subnational levels.

The study is also rooted in Cambodia's experience with the Local Governments and Climate Change (LGCC) project, which has been supported by the United Nations Capital Development Fund (UNCDF) in close partnership with the National Committee for Sub-National Democratic Development Secretariat (NCDDS). The LGCC initiative has demonstrated the central role that subnational governments can play in fostering climate resilience, particularly by integrating climate change considerations into local planning and finance systems. Through the Performance-Based Climate Resilience Grant (PBCRG) mechanism, UNCDF and NCDDS have helped build the capacity of local administrations to identify climate vulnerabilities, prioritize adaptation measures, and channel resources directly to provinces, districts, and communes. This approach has provided practical lessons on how to mainstream resilience into subnational development planning while strengthening accountability and local ownership. Against this background, the current CRVA responds to the need for systematic, spatially explicit evidence that can guide both national-level strategic decisions and local-level adaptation actions. While Cambodia has already taken important steps through its Nationally Determined Contributions (NDCs) and National Adaptation Plan (NAP), effective implementation requires a clearer understanding of where climate risks are most severe, which populations and sectors are most vulnerable, and how limited resources can be prioritized. By linking scientific climate analysis with the institutional experience of UNCDF and NCDDS under the LGCC framework, this study provides a critical knowledge base to scale up and institutionalize climate-resilient planning across Cambodia.

2.1 BACKGROUND AND CONTEXT

Cambodia is among the countries in Southeast Asia most vulnerable to the adverse impacts of climate change. Its geographic location within the Mekong Basin, coupled with a predominantly agrarian economy and high dependence on natural resources, places significant portions of the population and critical infrastructure directly in harm's way from climate-related hazards. Approximately 75% of Cambodians live in rural areas[1], with heavy concentrations along the floodplains of the Mekong River and around the Tonle Sap Lake system. These communities face recurring floods, seasonal droughts, and increasingly intense extreme weather events such as storms and heat waves. Coastal areas are similarly exposed to sea-level rise, storm surges, saltwater intrusion, and coastal erosion.

Observed climate trends show that while average annual rainfall has remained relatively stable, there has been an increase in short-duration extreme rainfall events, prolonged dry periods, and overall water stress indicators. At the same time, Cambodia has experienced clear and significant warming, particularly in night-time temperatures, increased hot days, and prolonged heatwaves. Projections under mid- and high-emission scenarios (SSP2-4.5 and SSP5-8.5) indicate continued increases in temperature and rainfall variability, with more frequent and intense extreme events.

Without adequate adaptation, these changes threaten agricultural productivity, water availability, forest health, coastal ecosystems, human health, and economic stability.

The Government of Cambodia has recognized these challenges through national policies such as its Nationally Determined Contributions (NDCs) and National Adaptation Plan (NAP). However, effective adaptation planning requires detailed, location-specific risk and vulnerability information to guide subnational interventions. In this context, climate risk and vulnerability assessments (CRVA) play a critical role in providing evidence-based insights into hazard exposure, sectoral vulnerability, and spatial hotspots of risk, enabling more informed and targeted adaptation strategies at provincial and district levels.

2.2 THE GOAL OF THE ASSIGNMENT

The primary goal of this assignment is to conduct a comprehensive Climate Risk and Vulnerability Assessment to inform Cambodia's subnational adaptation planning and decision-making. The assessment aligns with the IPCC AR5 climate risk framework and builds upon ongoing initiatives such as the UNCDF LoCAL pramme, which emphasizes mainstreaming climate resilience into subnational planning and finance systems. Specifically, the CRVA aims to:

- Quantify current and future climate hazards for Cambodia under different climate scenarios and identify multi-hazard hotspots.
- Assess exposure and vulnerability of key sectors—agriculture, water resources, forestry, coastal zones, and human health—to current and projected hazards.
- Provide a quantitative basis for prioritizing adaptation actions and investments at the subnational level, including potential sites for climate-resilient interventions.
- Support Cambodia's efforts to meet its NDC commitments and strengthen resilience in line with its national development strategies.

The outcome of this assignment is a national report that synthesizes climate risk findings and provides actionable recommendations for planners, policymakers, and development partners. By offering detailed subnational-level data and analysis, the CRVA facilitates evidence-based decision-making to protect lives, livelihoods, and ecosystems from climate risks.

2.3 SCOPE AND LIMITATION

The Scope of the Cambodia CRVA is to present a national and Subnational Strategic Assessment that provides a systematic, spatially explicit overview of climate risk across Cambodia down to the district level. This is done through the three dimensions of risk being climate Hazards (climate-related events or trends such as floods, droughts, storms, heat stress, and sea level rise), Exposure (people, livelihoods, infrastructure, and ecosystems situated in hazard-prone areas), and Vulnerability (sensitivity and adaptive capacity shaped by socioeconomic conditions, governance, income, health, and services). This assessment is done against noted risks in priority sectors of i) Food systems compromised, ii) Water insecurity and contamination, iii) Forestry losses or compromise, iv) Compromised coastal environment, and v) Increasing impacts on Human Health from climate change.

The CRVA highlights relative differences between -and hotspot areas and sectors to support national-level strategic prioritisation, and tactical sectoral focus areas with the detailed local indicators acting as support for further community-level assessments. Based on the noted climate risks, the CRVA can suggest broad categories of sectoral interventions such as water management, agricultural adaptation, ecosystem-based solutions, or health system strengthening with a menu of indicative options that can be considered in subsequent sectoral or local planning exercises.

The CRVA, however, has several limitations. These include the limitation of capturing local context, the selection of the sectors, the use of indicators, the climate data itself, and the application level of the CRVA methodology.

1. The majority of the work was conducted at the desktop level with a mission providing a limited local context. The CRVA attempts to capture local context and area-specific nuances such as local adaptation mechanisms, undocumented hazards, or community priorities across the whole country. While the CRVA could not capture every local nuance, hotspot areas were identified by combining climate hazard projections with socio-economic and demographic exposure indicators at district and commune levels. This spatial overlay allows us to highlight relative high-risk areas nationally, which can then be validated and refined through local consultations and future community-level assessments.
2. The CRVA considers only five impacted sectors rather than all possible impacted sectors in a single, larger multi-sector risk assessment. The CRVA broke into different sub-assessments for each of the impacted sectors, and by the different climate impact types, such that the risk outputs would remain sectoral and hazard relevant rather than being muted by opposing risks averaging the combined risk scores.
3. The CRVA relies on proxy indicators to represent complex realities where no such data exists. Examples of this may be poverty rate or income, or education level as a proxy for adaptive capacity, rainfed crops and crop yields as a proxy for livelihood sensitivity or infant mortality as a proxy for health care capacity. Such proxies can oversimplify realities and may not fully capture multi-dimensional vulnerabilities. Results will depend on indicator selection, weighting (if any), and aggregation methods.
4. Even though the climate models were downscaled and validated against reanalysis climate data, there will always be uncertainty in the climate hazards. This was mitigated through selecting the ensemble subset models that are most representative (spatially and statistically) of the historical climate and by considering two climate scenarios for the future. These are the SSP2 most likely middle-of-the-road climate and the SSP5 worst-case scenario. Additionally, the data used as inputs for the CRVA had varying spatial resolution and timeframes. To adjust for this, the datasets were linearly resampled to ~0.01° or ~1km to ensure consistency. This scaling from varying coarse resolutions will, however, will introduce uncertainty. This results in the CRVA showing relative distribution of, not precise risk estimates for individual communes.
5. The CRVA is not designed for detailed local-level planning and is not able to specify site-specific interventions or engineering designs. It is not intended to substitute for participatory community assessments, hydrological modelling, or detailed sectoral studies, but rather should be used to identify priority areas, at-risk sectors and then as the supporting material for these local assessments that would then benefit from dedicated bottom-up data collection and stakeholder engagement to develop the community-level adaptation plans.

The CRVA should be used as follows:

- Strategic entry point: For national decision makers to identify broad climate risk hotspots and priority themes.
- Sectoral guidance: For ministries to identify which risks are most relevant to their portfolios.
- Supporting information: For development partners and project implementers to target feasibility studies and consultations.
- Capacity building: For provincial and district actors to understand relative risks, but with explicit guidance that local studies are needed before action.

3 METHODOLOGY

The methodology for the Climate Risk and Vulnerability Assessment (CRVA) in Cambodia follows the framework of the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5), adapted to the national and subnational context. It combines climate science, spatial analysis, and participatory approaches to assess risks across hazards, exposure, and vulnerability dimensions. The overall approach ensures consistency with international best practice while remaining practical and policy-relevant for Cambodia's development planning.

The CRVA framework defines risk as the interaction of three core components: hazard (climate-related physical events and trends), exposure (people, infrastructure, ecosystems, and assets located in areas affected by hazards), and vulnerability (the sensitivity and adaptive capacity of these systems). A Geographic Information System (GIS) environment was used to integrate and analyse multiple datasets, enabling the identification of relative hotspots of climate risk at provincial, district, and commune levels.

To identify local climate risks, the assessment applied downscaled climate model outputs for rainfall and temperature under both SSP2-4.5 and SSP5-8.5 scenarios, validated against reanalysis datasets. These projections were combined with hazard indices such as frequency of heavy rainfall, consecutive dry days, drought indices (SPEI), heatwaves, sea-level rise, and tropical cyclone anomalies. Hazard maps were then overlaid with exposure indicators (population distribution, poverty rates, agricultural dependence, location of critical infrastructure, and gender-differentiated vulnerabilities) and vulnerability indicators (health outcomes, education levels, forest cover, water resources, and adaptive capacity proxies) to provide a comprehensive multi-risk profile.

Sector-specific analyses were conducted for agriculture, water resources, forestry, coastal areas, and human health, reflecting priority concerns for Cambodia. Each sector was assessed against climate hazards most relevant to its functioning, with indicators selected through expert consultation and review of available national datasets. Proxy indicators were applied where direct data were unavailable, for example, using crop yields as a proxy for livelihood sensitivity or infant mortality rates as a proxy for health system capacity.

A participatory process was integral to the methodology, ensuring that technical analysis was validated and contextualized by local knowledge. Field missions and consultations with line ministries, provincial authorities, development partners, and NGOs provided feedback on the relevance of indicators, interpretation of results, and prioritization of adaptation measures. A technical review meeting further refined the methodology, while a planned dissemination and capacity-building workshop will support integration of CRVA findings into subnational planning processes.

Risk was ultimately quantified through a multi-criteria analysis that integrated hazard, exposure, and vulnerability scores into composite indices. These indices were used to rank districts and provinces by climate hazard, exposure, vulnerability, and overall risk, and to identify priority hotspots. The cumulative multi-risk index provides a strategic overview of climate risks, while sectoral breakdowns allow for more targeted recommendations.

In summary, the methodology ensures a balanced approach that combines quantitative modeling, spatial analysis, and stakeholder participation. It provides a robust yet flexible evidence base to guide Cambodia's climate change adaptation at both national and subnational levels, while also highlighting the limitations of data resolution, indicator proxies, and the need for complementary community-level assessments.

3.1 CLIMATE RISK AND VULNERABILITY ASSESSMENT FRAMEWORK

The climate risk assessment methodology is an update of the IPCC AR4 (2007) methodology and is based on the IPCC AR5 (2014) definitions. This seeks to align climate assessments and disaster risk structures and terminology in terms of "risk". It also frames the presence of elements, assets, or populations as paramount to the risk, rather than relying on these being included as an index of sensitivity. Further, it seeks to remove ambiguity around terms such as sensitivity and adaptive capacity which were often misinterpreted. The methodology applied is taken from Climate Risk Assessment for Ecosystem-based Adaptation - A Guidebook for Planners and Practitioners[2].

The CRA methodology uses **exposure, vulnerability**, and current and projected future **hazards**, to calculate **risk**. The risk of an area is expressed through the potential impacts that will occur as a result of the hazards, the exposure of people and assets, and the vulnerability that makes them susceptible to impact.

- **Hazard:** 'The potential occurrence of a natural or human-induced physical event or trend or physical impact that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources. In [the IPCC] report, the term hazard usually refers to climate-related physical events or trends or their physical impacts.' This is essentially the old "exposure" in the AR4 methodology and relates to changes in extreme precipitation, flooding, drought, heat waves, and/or trends in the baseline variables that may compromise systems in the future.
- **Exposure:** 'The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.' This is the presence of systems, people, and assets that may be at risk due to a particular hazard. In the AR4 methodology, this was incorporated into the sensitivity index but its relationship with the risk necessitates the need to be distinctively defined.
- **Vulnerability:** The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.' Different from the AR4 definition, vulnerability is now the merging of the factors that may render an area including its social and ecological systems predisposed to heightened impact or having resilience to a hazard. Vulnerability comprises both sensitivity (factors that affect the impact severity of a hazard) and adaptive capacity (factors that allow areas to prepare and recover from a hazard).

- **Impacts:** 'Impacts generally refer to effects on lives, livelihoods, health, ecosystems, economies, societies, cultures, services, and infrastructure due to the interaction of climate changes or hazardous climate events occurring within a specific period and the vulnerability of an exposed society or system.' Assets, communities and environments generally note the impacts more so than smaller average anomalies and hence the emphasis is placed on the more extreme events. The clear definition of these impacts allows for the development of impact changes and highlights potential adaptation interventions.
- **Risk:** 'The potential for consequences where something of value is at stake and where the outcome is uncertain (...). Risk results from the interaction of vulnerability, exposure, and hazard (...).' higher hazard, exposure, and/or vulnerability will lead to higher risk.

The analysis processes use the framework of the IPCC AR5 Climate risk assessment approach with calculations done in a GIS spatial analysis environment. (Figure 1). The risk relationship is based on the sum of the indicators making up the Hazard, Vulnerability and Exposure and the weighting that is applied to each. The higher the Hazard, Vulnerability and Exposure components, the higher the Climate Risk and potentially the more severe the potential impacts experienced on the ground. The impacts are the potential manifestation of the risk on the ground.

Equation 1. Climate Risk Assessment

$$Risk = Hazard * Wh + Vulnerability * Wv + Exposure * We$$

Where W is the weighting for each of the components

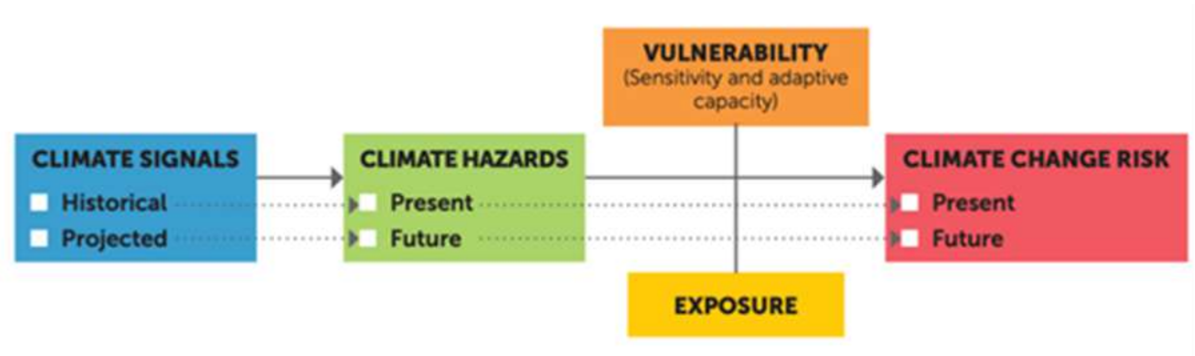


Figure 1. Basic Risk relationship incorporating Hazard, Exposure, and Vulnerability

3.1.1 IDENTIFICATION OF THE LOCAL CLIMATE RISK

Studies from World bank[3], FAO[4], UNICEF[5], UNDP[6], ADB[7], and the Ministry of Environment of Cambodia[8] show strong alignment in their identification of the primary climate risks facing Cambodia and in their recommendations for action.

These reports highlight Cambodia as highly vulnerable to climate risks due to its geography, dependence on agriculture, and widespread poverty, with floods and droughts recognised as the major source of frequent and damaging hazards and the likely increase in frequency and severity of extreme weather events due to climate change, impacting water, health, food systems, rural livelihoods, and infrastructure. There is a focus on adaptation for vulnerable groups, especially children and women are and more broadly across rural and low-income households. They, however, note a lack of resources and technical capacity as a core barrier to climate adaptation.

The local climate risk assessment buildings on these data to further assesses local risk. The study determines all aspects of a climate risk assessment and this needs to contextualise the impacts and activities on the ground, objectives of interventions and locations of the project. This is done with the process applied as follows:

- **The context of a climate risk assessment for adaptation**: The project seeks to build on the LoCAL project of Cambodia. The objective of the LoCAL-Cambodia initiative, which features under the Local Governments and Climate Change Project (LGCC), is to demonstrate the role of local governments in fostering climate change resilience and identify practical ways to mainstream climate change resilience into subnational planning and finance systems. The UNCDF LoCAL initiative for Cambodia, known as the Local Governments and Climate Change Project (LGCC), showcases the crucial role of local governments in enhancing climate change resilience. It identifies effective strategies to integrate climate change resilience into subnational planning and financial systems. The LoCAL approach involves building the capacity of local governments and operating through Performance-Based Climate Resilience Grants (PBCRG). In order to do this, there needs to be an objective assessment of climate risk to serve as the knowledge base from which to further build local climate change resilience and to find practical hazard-specific methods to mainstream this resilience into local planning and finance systems.
- **Objectives and expected outcomes**: The objectives of the sector-specific CRVA are to evaluate multiple hazard, vulnerability and exposure-appropriate indicators to validate and support the identified more at-risk areas in Cambodia. Thereafter, the hotspot analysis developed through the climate risk assessment provides a quantitative assessment of possible site selection criteria. The CRA, validation and contextual analysis are designed to allow for the further prioritisation and development of applicable and practical interventions for current and projected future climate hazards as experienced by the farmers. The outcome of these interventions is to build greater resilience to the major climatic risks for the priority sectors.
- **Scope of the assessment**: Analysis indicates that Cambodia is projected to warm by 3.1°C by the 2090s under the highest emissions scenario, with extreme heat posing severe risks to human health, livelihoods, and ecosystems. Rising temperatures, especially in urban areas, will increase heat-related illnesses and may facilitate the spread of water and vector-borne diseases. Climate change is also expected to exacerbate extreme weather events, with more severe floods and droughts potentially reducing Cambodia's GDP by 10% by 2050. River flooding could expose an additional 4 million people by the 2040s. Without significant adaptation efforts, extreme heat will reduce crop yields, particularly for subsistence farmers reliant on

rain-fed agriculture, further worsening poverty and income inequality. The scope of the assessment is to review potential agricultural, water, forestry, coastal and human health susceptibility when confronted by current and projected future climate hazards in the near future 2020-2050 under the SSP2-45 and SSP5-85 climate scenarios.

3.1.2 RISK CLASSIFICATION

The following sectors have been highlighted as the major sectors at risk from climate change in Cambodia[9]. To assess the climate risk, each of the sectors needs to be broken down into the pillars of climate hazards that will impact the sector, the people, assets and/livelihoods that are and will be exposed to these climate hazards, and the underlying factors that enhance or reduce vulnerability in terms of local sensitivity factors that may result in greater severity of the impact, as well as adaptive capacities that may enhance the ability to recover from these hazards.

The prioritization of these sectors is based on three main criteria: (i) their critical importance to Cambodia's economy, livelihoods, and ecosystems; (ii) the evidence from past studies and national strategies such as the NDCs and the National Adaptation Plan that consistently identify these sectors as highly vulnerable; and (iii) the availability of data and indicators that allow for meaningful risk assessment at national and subnational levels. Agriculture, water, forestry, coastal systems, and human health are therefore prioritized because they are both highly exposed to climate hazards and central to human well-being and economic stability.

Table 1. Priority sectors

Sector	Possible risk factors
Agriculture	Dependence on monsoon rains, increased droughts and floods, saline intrusion in freshwater sources, and shifting growing seasons.
Water Resources	Water resources, assets and infrastructure. Heavy reliance on hydrological resources.
Forestry	Deforestation, forest degradation, increased wildfire risks, shifting species distribution due to temperature changes
Coastal Zone	Rising sea levels cause erosion, saltwater intrusion affecting freshwater sources, increased storm surges and flooding.
Human Health	Increased vector-borne diseases (e.g., malaria, dengue), heat-related illnesses, food and water security risks

As informed by the high-level assessments noted above, the major risk factors affecting agricultural livelihoods are i) water scarcity resulting from changing annual rainfall volumes, prolonged dry periods and severe drought, as well as seasonal shifts impacting growing seasons, ii) physical damages to farm assets including soil, nutrients, infrastructure and livestock as a result of changes to peak and extreme rainfall event magnitude and duration, and iii) compromised health of livestock and crop yields from unseasonably high temperatures and compromised germination. The risk is therefore defined as:

Risk: The loss, compromise, and/or inability to improve agricultural livelihoods and food security, water security, forestry integrity, coastal zone function and human health for the population of Cambodia due to current and projected climate change and acute physical damages from extreme events associated with more severe climates.

This high-level risk can be further classified into sub-risks for each sector and for the prevailing major climate risks. This includes the following sub-risks:

- **Sub-risk 1:** Food systems compromise from climate changes as a result of **(a)** water insecurity from changing rainfall patterns and meteorological drought, **(b)** damages and losses to farm assets from more severe rainfall events from severe event occurrence change, and **(c)** crop wilting, poor germination, and livestock stress associated with increased hot days and warm nights in a warming climate.

- **Sub-risk 2:** Water insecurity and contamination from climate changes as a result of **(a)** changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture **(b)** increased severe events and saline intrusion resulting in contamination of water resources
- **Sub-risk 3:** Forestry losses or compromise from climate changes as a result of **(a)** increased temperatures and wildfire risk impacting tree health and **(b)** decreases water availability limiting forest growth.
- **Sub-risk 4:** Compromised coastal environment from climate changes as a result of **(a)** physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations and **(b)** changes in ocean systems such as salinity and temperatures impacting biodiversity.

Sub-risk 5: Increasing impacts on Human Health from climate changes as a result of **(a)** increasing heat stress from notable rising heat index and extreme heatwaves, **(b)** heightened incidence of vector and waterborne diseases due to changing climate suitability factors, and **(c)** acute impacts and disasters resulting from extreme weather events such as floods and severe storms.

3.1.3 RISK INDICATORS

In assessing climate risks for the sectors, a comprehensive analysis of climate hazards, vulnerability, and exposure indicators is crucial to understanding potential impacts and planning resilience measures. These assessments follow a structured framework to gauge current and future risks, ensuring alignment with international standards and sector-specific needs. The following are the proposed indicators for the hazards, vulnerabilities and exposures for each of the sub-risks[10].

Table 2. Hazard, vulnerability and exposure indicators for the different sub-risks11

<table>
<tr><th>Sub risk</th><th>Climate hazard</th><th>Vulnerability</th><th>Exposure</th></tr>
<tr><td colspan="4">Sub-risk 1: Food systems compromised by climate changes</td></tr>
<tr><td>Sub-risk 1 (a) water insecurity from changing rainfall patterns and meteorological drought.</td><td>• (-) Annual rainfall volume[12]
• (-) SPEI index[13]
• (+) Annual rainfall variability index[14]
• (+) Number of consecutive dry days[15]
• (+) Aridity index[16]</td><td rowspan="3">• Areas of rainfed crops[17]
• Drought sensitivity[18]
• Crop yield gap[19]
• Malnutrition[20]
• Erosion[21]
• Water stress[22]
• Poverty[23]
• Education ratio[24]
• Dependency ratio[25]
• General climate stress
• Proximity to flood areas[26]</td><td rowspan="3">• Population in rural and agricultural areas[27]
• Gender Gap[28]
• Livestock density[29]</td></tr>
<tr><td>Sub-risk 1 (b) damages and losses to farm assets from more severe rainfall events from severe event occurrence change.</td><td>• (+) Rainfall days above 20mm[30]
• (+) 1-day Peak volume[31]
• (+) Peak monthly rainfall[32]</td></tr>
<tr><td>Sub-risk 1 (c) crop wilting, poor germination, and livestock stress associated with increased hot days and warm nights in a warming climate.</td><td>• (+) Peak maximum temperature[33]
• (+) Number of days above 35°C[34]
• (+) Peak temperature of the warmest month[35]
• (+) Lowest minimum temperature[36]</td></tr>
</table>

Sub risk	Climate hazard	Vulnerability	Exposure
Sub-risk 2: Water insecurity and contamination from climate changes			
Sub-risk 2 (a) changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture.	• (-) Annual rainfall volume[37] • (-) SPEI index[38] • (+) Annual rainfall variability index 39 • (+) Evaporation index[40] • (-) Groundwater Levels and Recharge Rates[41]	• General climate stress[42] • Water stress[43] • Water demand[44] • Poverty[45] • Groundwater vulnerability[46] • Education ratio[47] • Proximity to flood areas[48] • Dependency ratio[49]	• Population density[50] • Gender Gap[51] • Heavy water use industry[52] • Agriculture livelihoods[53]
Sub-risk 2 (b) increased severe events and saline intrusion resulting in contamination of water resources.	• (+) Peak 1-day rainfall[54] • (+) Peak 5-day rainfall[55] • (+) Days over 20mm[56] • (-) SPEI index[57] • (+) Peak monthly temperatures[58] • (+) Overland flow[59]		
Sub-risk 3: Forestry losses or compromise from climate changes			
Sub-risk3 (a) increased temperatures and wildfire risk impacting tree health.	• (+) Days over 35°C[60] • (+) Heatwave[61] • (+) Monthly temperature peak[62] • (+) Average maximum temperature[63]	• Ecosystem fragmentation[64] • Forest losses[65] • Deforestation trends[66] • NDVI trends[67] • Accessibility[68] • Groundwater availability and recharge[69] • Water stress[70]	• Forested areas[71] • Natural areas[72] • Population near forested areas[73]
Sub-risk3 (b) decreases water availability by limiting forest growth.	• (-) Annual rainfall volume[74] • (-) SPEI index • (+) Aridity index[75]		
Sub-risk 4: Compromised coastal environment from climate changes			
Sub-risk4 (a) physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations.	• (+) Sea level rise[76] • (+) Storm surge[77] • (+) Tropical cyclone occurrence[78] • (+) Coastal flood risk[79]	• Coastal Accessibility index[80] • Coastal Tourism hotspots[81] • Coastal erosion hotspots[82] • Coastal vegetation integrity[83] • Coastal Population Education index[84] • Coastal population Poverty[85]	• Economic activity near coastal and inundated areas[86] • Coastal infrastructure[87] • Coastal population density[88]
Sub-risk 5: Increasing impacts on Human Health from climate changes			
Sub-risks (a) increase heat stress from notable rising heat index and extreme heat waves.	• (+) Days over 35°C[89] • (+) Heatwave[90] • (+) Monthly temperature peak[91]	• Infant mortality index[92] • Distance to healthcare[93] • Vaccine coverage[94] • General heath index[95] • Water Access[96] • Education ratio[97] • Electricity access[98] • Mortality risk areas[99] • Settlement support[100] • Major extreme hazard risks[101] • Malnutrition index[102] • Life expectancy[103] • Dependency ratio[104]	• Population density[106] • Gender Gap[107]
Sub-risk5 (b) heightened incidence of vector and water-borne diseases due to changing climate suitability factors.	• (+) Rainfall seasonality[108] • (+) Maximum temperature increases[109] • (+) Increased peak precipitation • (+) Annual rainfall[110] • (+) Aridity index[111]		
Sub-risk5 (c) acute impacts and	• (+) Extreme single-day rainfall[112]		

Sub risk	Climate hazard	Vulnerability	Exposure
disasters resulting from extreme weather events such as floods and severe storms.	• (+) Number of days above 20mm[113] • (+) Peak monthly precipitation[114] • (+) Overland flow areas[115] • (+) Tropical cyclone occurrence [116] • (+) Coastal flood risk[117]	• Relative Deprivation Index[105]	

3.2 PARTICIPATORY PROCESS FOR THE CRVA STUDY

The Climate Risk and Vulnerability Assessment (CRVA) for Cambodia was implemented through a highly participatory and inclusive process designed to ensure ownership, transparency, and alignment with national and subnational priorities. At the core of this process was the active engagement of key stakeholders—ranging from line ministries and subnational authorities to development partners and civil society organizations—throughout all phases of the study.

The participatory approach combined data collection, consultation, validation, and capacity-building activities to strengthen both the technical quality and institutional relevance of the CRVA. The process began with initial consultations and a field mission to Rukhak Kiri District, Battambang Province, where the team introduced the objectives and expected outcomes of the CRVA, discussed the roles of participating institutions, and collected local data and evidence on climate risks and vulnerabilities. This early engagement ensured that local perspectives were embedded in the analytical framework from the outset.

Following the field mission, a series of online consultation meetings were organized jointly with the National Committee for Sub-National Democratic Development (NCDD) and the UNCDF Representative Office in Cambodia. These sessions gathered technical experts and institutional representatives from government, development partners, and NGOs to review and validate the CRVA indicators, provide technical inputs, and ensure the consistency and quality of the analysis. Feedback and recommendations from these sessions were systematically integrated into the draft report, reinforcing its accuracy and applicability.

Subsequent validation meetings, held with development partners and the Ministry of Environment, provided an additional platform to discuss preliminary findings and confirm the robustness of the assessment. This iterative process allowed the CRVA team to refine the analysis and build consensus around its conclusions and recommendations.

The participatory process concluded with a national dissemination and capacity-building workshop, co-organized with NCDD and UNCDF. The workshop served multiple purposes: to share the final CRVA results; to guide national and subnational stakeholders on how to interpret and utilize the findings; and to strengthen capacities for integrating climate change adaptation into local and national planning and budgeting processes. It also introduced tools such as the Assessing Climate Change Adaptation Framework (ACCAF) to support future planning, monitoring, and evaluation.

The CRVA process ensured that **stakeholders were engaged from design and data collection to validation and dissemination, making it a collaborative exercise. This participatory methodology not only enhanced the legitimacy and technical soundness of the CRVA but also reinforced local ownership and capacity for informed climate decision-making in Cambodia.

4 CLIMATE CHANGES

Cambodia is already experiencing significant climate change impacts, with national data from recent decades showing steadily rising average and night-time temperatures, more frequent and severe heatwaves, increasingly erratic rainfall marked by heavier downpours and longer dry spells, and growing risks of both floods and droughts, while future projections under moderate and high-emission scenarios indicate temperature increases of up to 3–3.5°C by mid-century, further variability in seasonal rainfall, and sea-level rise of up to 70 cm by 2100, which together are expected to seriously disrupt agriculture, fisheries, and water resources, heighten the vulnerability of forests and biodiversity, accelerate coastal erosion and saltwater intrusion, and worsen human health outcomes, thereby posing profound threats to livelihoods, ecosystems, and Cambodia's overall sustainable development trajectory.

4.1 CLIMATE CHANGE CURRENT TRENDS

Cambodia's climate profile reveals a complex interplay of stable annual rainfall, seasonal redistribution, and significantly rising temperatures (based on the analysis of AR6 data). While rainfall volumes have not shifted dramatically, increases in short-duration extreme events and water stress indicators highlight emerging vulnerabilities, particularly for agriculture, water management, and disaster risk reduction. The thermal regime is unequivocally warming, especially through increased night-time temperatures, more hot days, and prolonged heat waves, all of which demand urgent adaptation planning in both urban and rural contexts.

4.1.1 RAINFALL

Cambodia's long-term rainfall patterns, assessed over the 1980–2020 period (based on observational data), show an annual precipitation average of approximately 1849.5 mm, with no statistically significant trend in long-term change—equating to a near 0% per decade variation. This annual total typically fluctuates between 1822 mm and 1914 mm, reflecting general climatic stability in terms of national totals. Comparing the more recent period (2000–2020) with the 1971–2000 baseline, there's been a modest increase of 23 mm in annual rainfall.

Seasonally, the wettest months are clearly defined, spanning June to September, with rainfall peaking in August. In contrast, the driest months fall in December through March, especially January and February. Spatially, the southwestern coastal regions and far northeastern areas receive the most rainfall, while central Cambodia remains comparatively dry.

Rainfall variability within the year shows a shifting balance. The largest average monthly decrease is seen in May (-7.9 mm), with reductions also apparent in February, June, and August. Meanwhile, September records the largest average monthly increase (15.8 mm), along with gains in March, July, and October.

From 1980 to 2020, Cambodia experienced an average of 139 wet days annually—days receiving measurable rainfall—showing a statistically insignificant increase of 0.16 days per decade, now ranging from 138 to 141 days per year. Intense rainfall days (defined as those receiving over 20 mm) occur roughly 16 times per year, mostly concentrated in September. Similarly, very heavy rainfall days (>50 mm) occur less than once per year on average, again peaking in September.

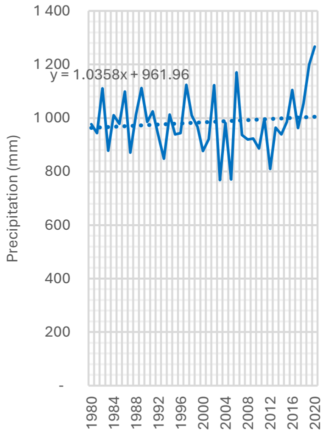
Rainfall extremes follow this pattern. The largest 1-day rainfall averages around 46.4 mm, while the maximum 5-day cumulative rainfall reaches around 113.8 mm, both most likely occurring in September. Although these events are increasing slightly (1.93% and 6.06% per decade, respectively), the trends remain statistically non-significant.

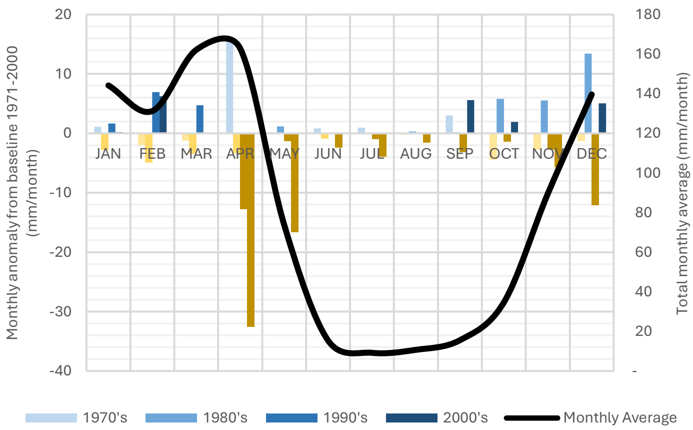
Flooding is most pronounced along central river plains, driven by upstream rainfall and regional topography. Additional flood risk exists in the northeast, where rainfall contributions are similarly high. Spatial patterns for extreme rainfall events, 1-day and 5-day accumulations, and days above 20 mm align with broader rainfall distribution—strongest in the southwest coast and inland northeast.

Despite relatively stable rainfall totals, drought signals have grown slightly. The Standardized Precipitation Evapotranspiration Index (SPEI) averaged 0.13 nationally, with a non-significant declining trend of -0.03 per decade, now ranging from -0.08 to 0.47—suggesting a modest rise in drought severity.

Cambodia also faces increasing water stress, with levels rising significantly from 0.56% to 0.92% between 1980 and 2020, marking a 0.5% per decade increase. While average rainfall intensity remains near 13.29 mm/day, this has slightly declined at a non-significant rate of -0.01 mm/day per decade, now sitting between 13.14 and 13.59 mm/day.

Rainfall-triggered landslides are most common in the southwestern highlands, where steep terrain and intense rainfall intersect. Some moderate landslide risk also exists in the northeast. Though tropical cyclones typically track to the south and east, especially around Vietnam, their storm surges only moderately affect Cambodia's coastal zones.





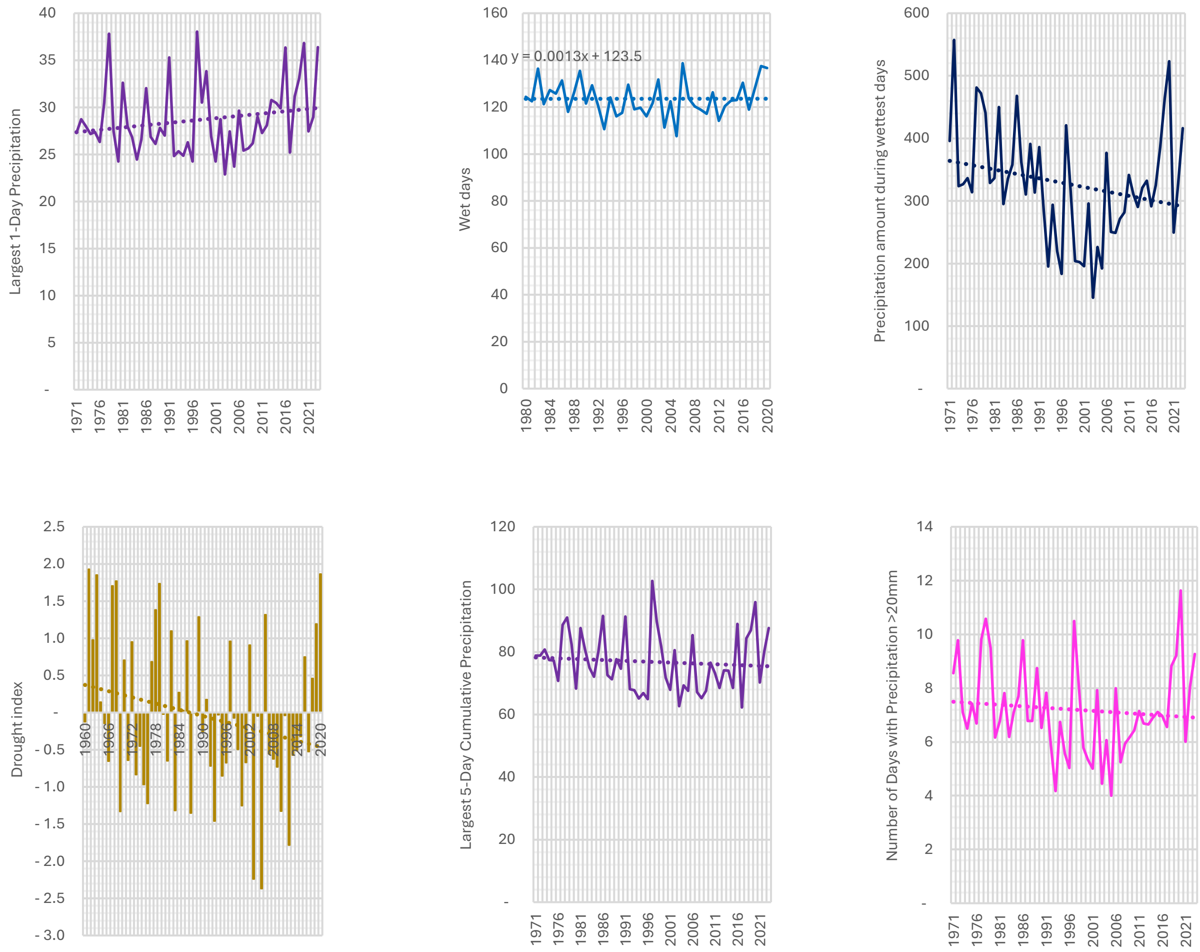


Figure 2. Observed national rainfall character changes

Table 3. Trends in national rainfall character changes

	Precipitation (mm)	Wet days	Rainfall intensity (mm/day)	SPEI - Drought index	Potential Evapotranspiration (mm/day)	Level of water stress	Largest 1-Day Precipitation	Days >20mm
Mean 1980-2020	1849.52	139.01	13.29	0.13	3.98	0.50	46.40	15.98
95% confidence interval	1822.24 1913.7 mm	138.07 - 141.23 days	13.14 13.59mm/day	-0.08 0.47	3.96 4.02mm/day	0.56 0.92 %	44.15 51.27 mm	15.58 17.06 days
Statistical Trend	Not Significant	Not Significant	Not Significant	Not Significant	Not Significant	Significant	Not Significant	Not Significant
Trend (change per decade)	0.001%	0.16 days	-0.01mm day	-0.03	0.02mm day	0.5%	1.93%	0.53%

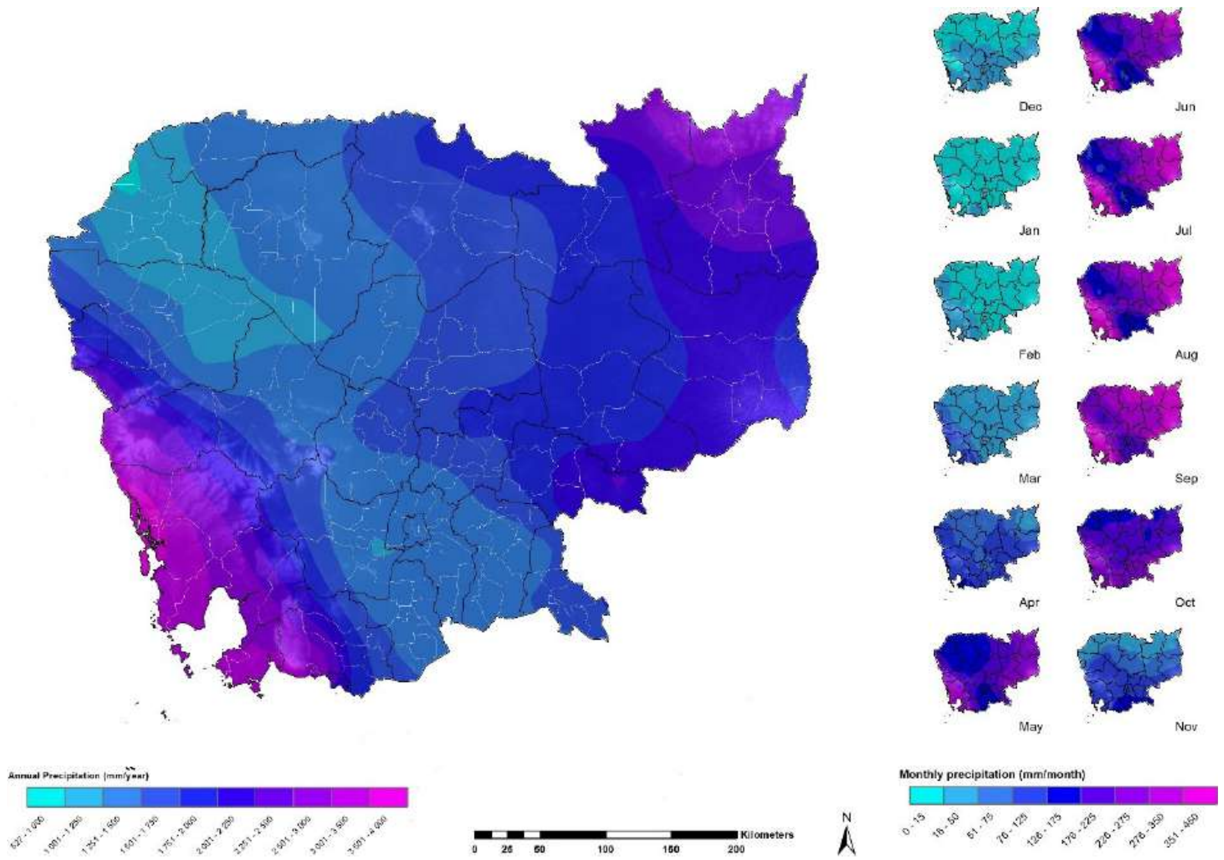


Figure 3: Current rainfall volume distribution. Annual (left) and monthly (right)

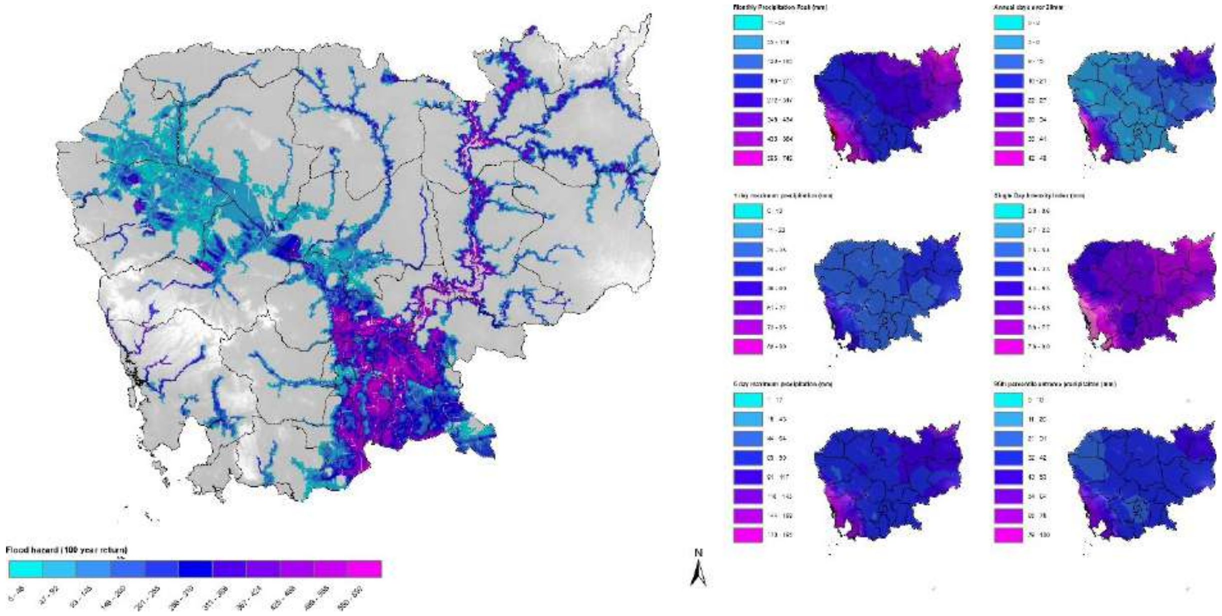


Figure 4: Current flooding and extreme rainfall characteristics. Flood areas (left), extreme rainfall characteristics (right)

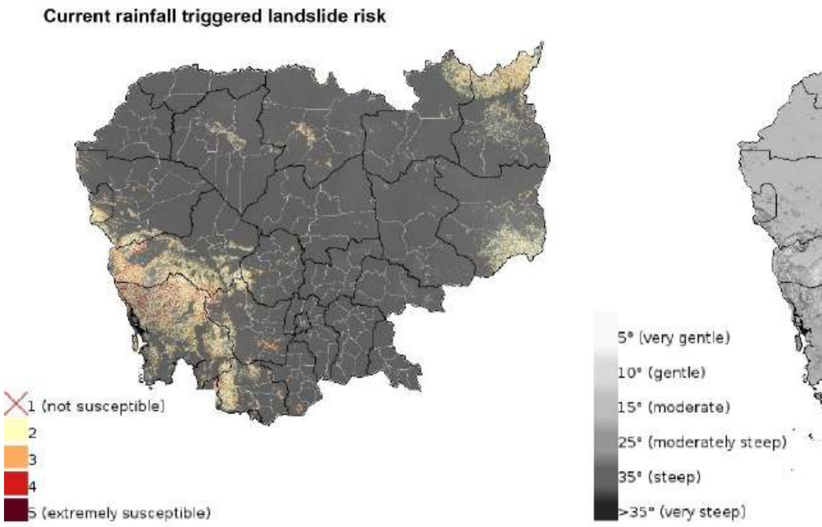


Figure 5: Current precipitation triggered landslide events

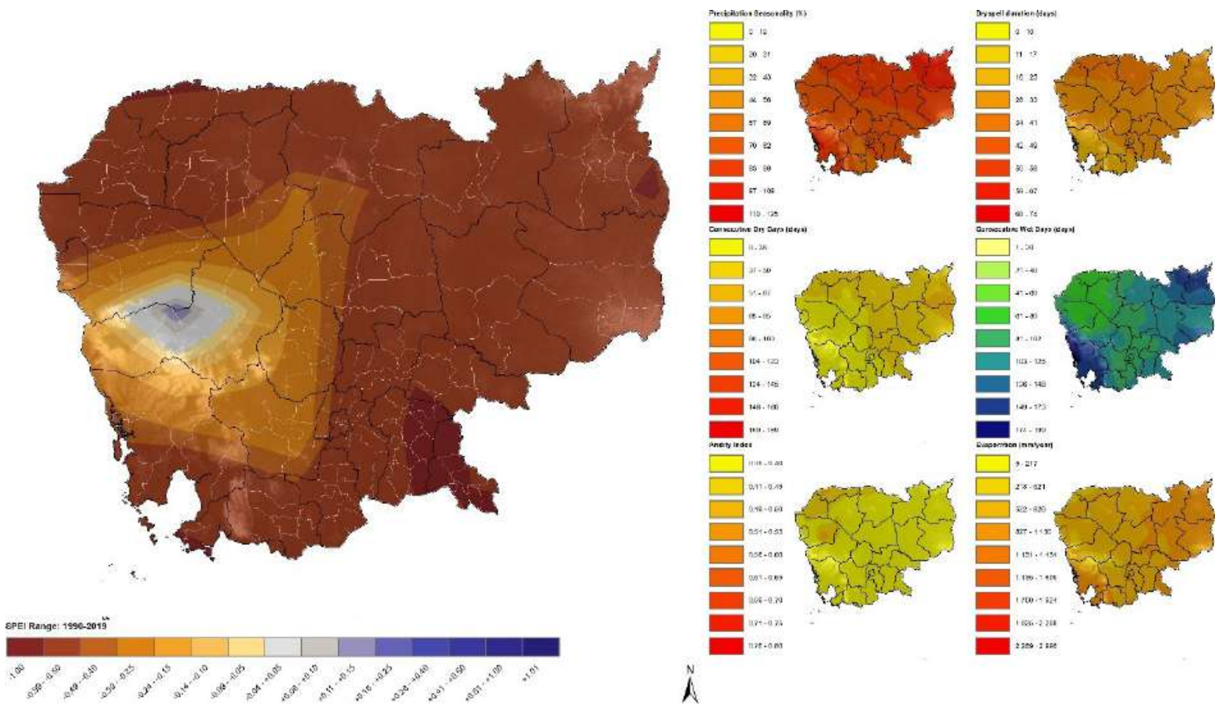


Figure 6: Current Drought and drying rainfall characteristics. Flood areas (left), extreme rainfall characteristics (right)

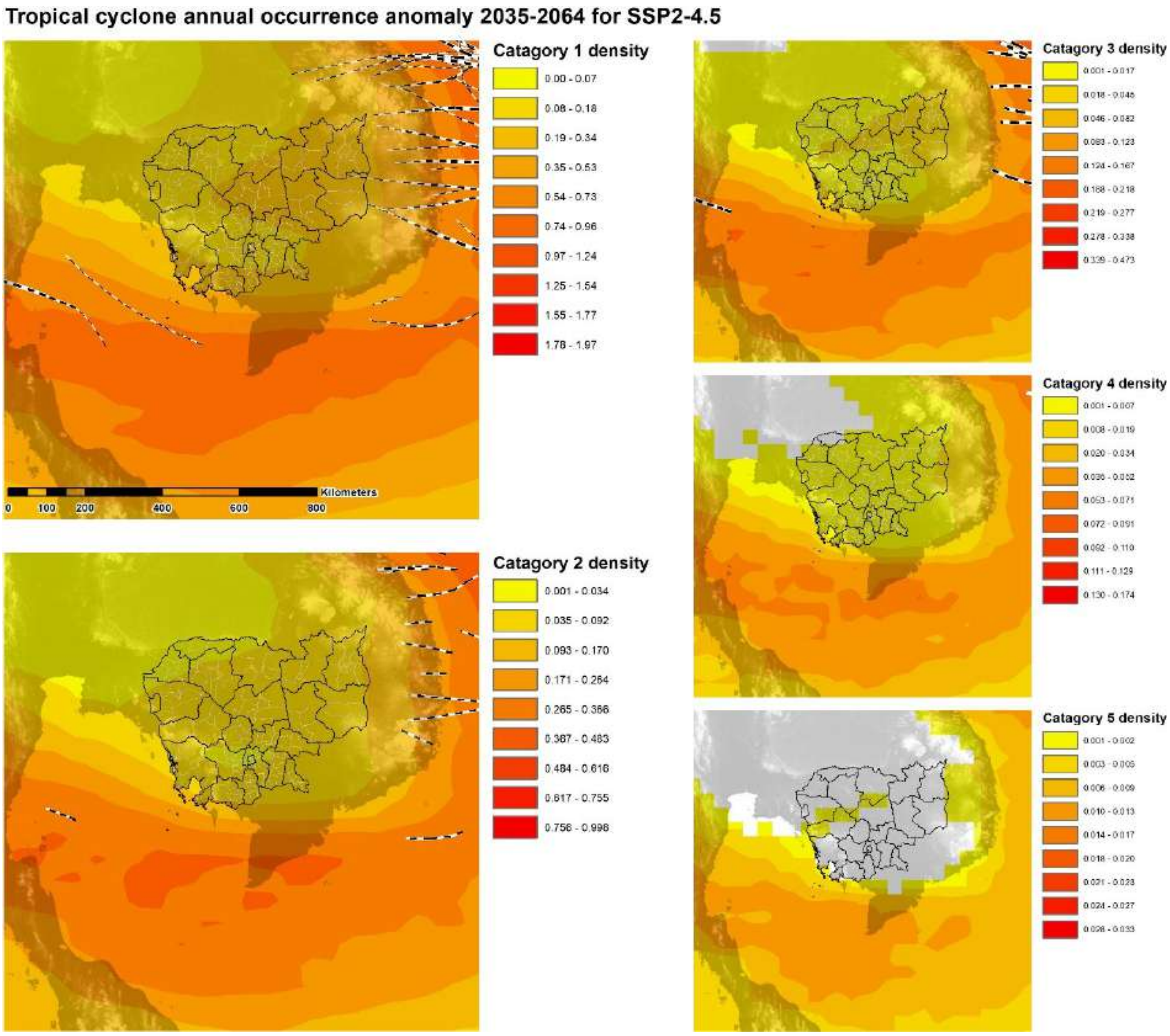


Figure 7: Current Tropical cyclone occurrence

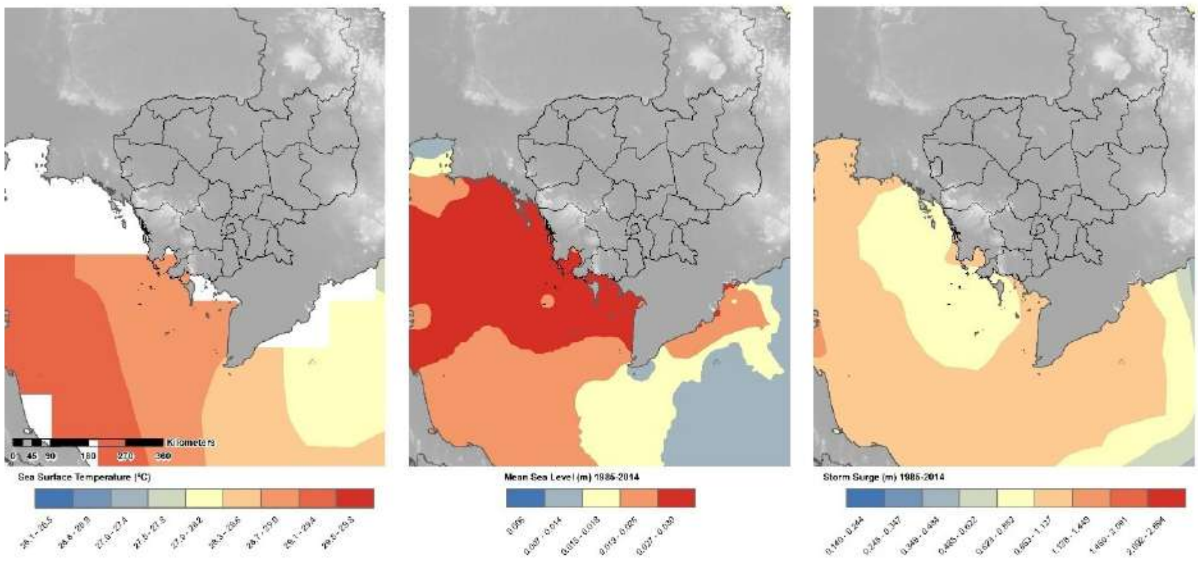


Figure 8: Current ocean-based climate characteristics

4.1.2 TEMPERATURE

Cambodia has experienced clear and significant warming across all temperature indicators from 1980 to 2020

- Minimum Temperature: ~22.8°C, increasing 0.22°C per decade
- Mean Temperature: ~27.2°C, increasing 0.19°C per decade
- Maximum Temperature: ~31.7°C, increasing 0.16°C per decade

The warming is most pronounced in nighttime temperatures, reflected in the shrinking diurnal temperature range (DTR), which has declined significantly by -0.06°C per decade, from an average of 8.92°C. This pattern suggests warmer nights are outpacing daytime warming.

Spatially, the hottest conditions are inland, particularly in the northwest and southeast, with temperature peaks between March and May.

Cambodia experiences a high frequency of hot and very hot days:

- Days >25°C (Summer Days): ~362.5 days/year, increasing by 0.58 days per decade
- Days >30°C: ~282.2 days/year, increasing 11.6 days per decade
- Days >35°C: ~52.3 days/year, increasing by 8.2 days per decade
- Days >40°C: ~0.56 days/year, increasing by 0.27 days per decade

The hottest days (>35°C and >40°C) occur most often in March and April, especially in central inland areas. The maximum daily high averages around 37.7°C, with slight but statistically non-significant increases.

The Warm Spell Duration Index (WSDI)—a measure of prolonged heat events—averages 8.73 days annually, increasing significantly at 6.18 days per decade, and currently ranges between 10.3 and 17.5 days.

Tropical nights (minimum temperatures above 20°C) are extremely common, with ~337.6 nights annually, increasing significantly to 5.45 nights per decade. These warm nights are especially frequent in May, contributing to sustained thermal discomfort and higher heat stress, particularly in urban centres and poorly ventilated areas.

The coldest minimum temperatures, while still mild at ~16.7°C, are rising significantly at 0.33°C per decade, suggesting a broad warming across all extremes.

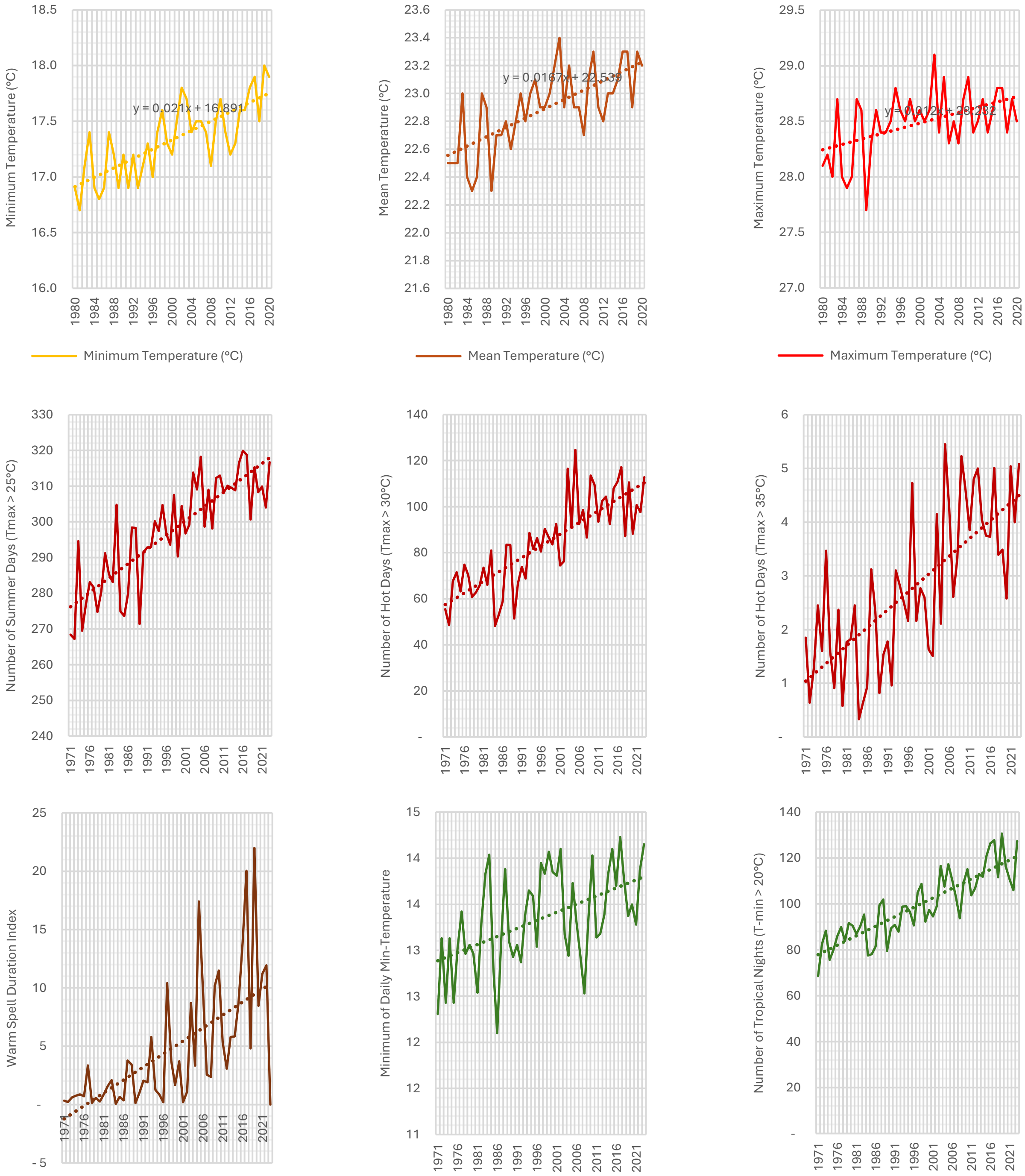


Figure 9. Observed national temperature character changes

Table 4. Trends in national temperature character changes

	Min Temperature (°C)	Mean Temperature (°C)	Max Temperature (°C)	Summer Days (Tmax > 25°C)	Hot Days (Tmax > 35°C)	Tropical Nights (T-min > 20°C)	Daily Min-Temperature	Daily Max-Temperature	Warm Spell Duration Index
Mean 1980-2020	22.80	27.23	31.72	362.48	52.26	337.56	16.74	37.73	8.73
95% confidence interval	22.86 23.1°C	27.25 27.49°C	31.7 31.96°C	362.79 363.95 days	53.93 66.23 days	340.16 346.05 days	16.84 17.62 °C	37.58 38.05 °C	10.34 17.5 days
Statistical Trend	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Not Significant	Significant
Trend (change per decade)	0.22°C	0.19°C	0.16°C	0.58°C	8.22°C	5.45°C	0.33°C	0.12°C	6.18°C

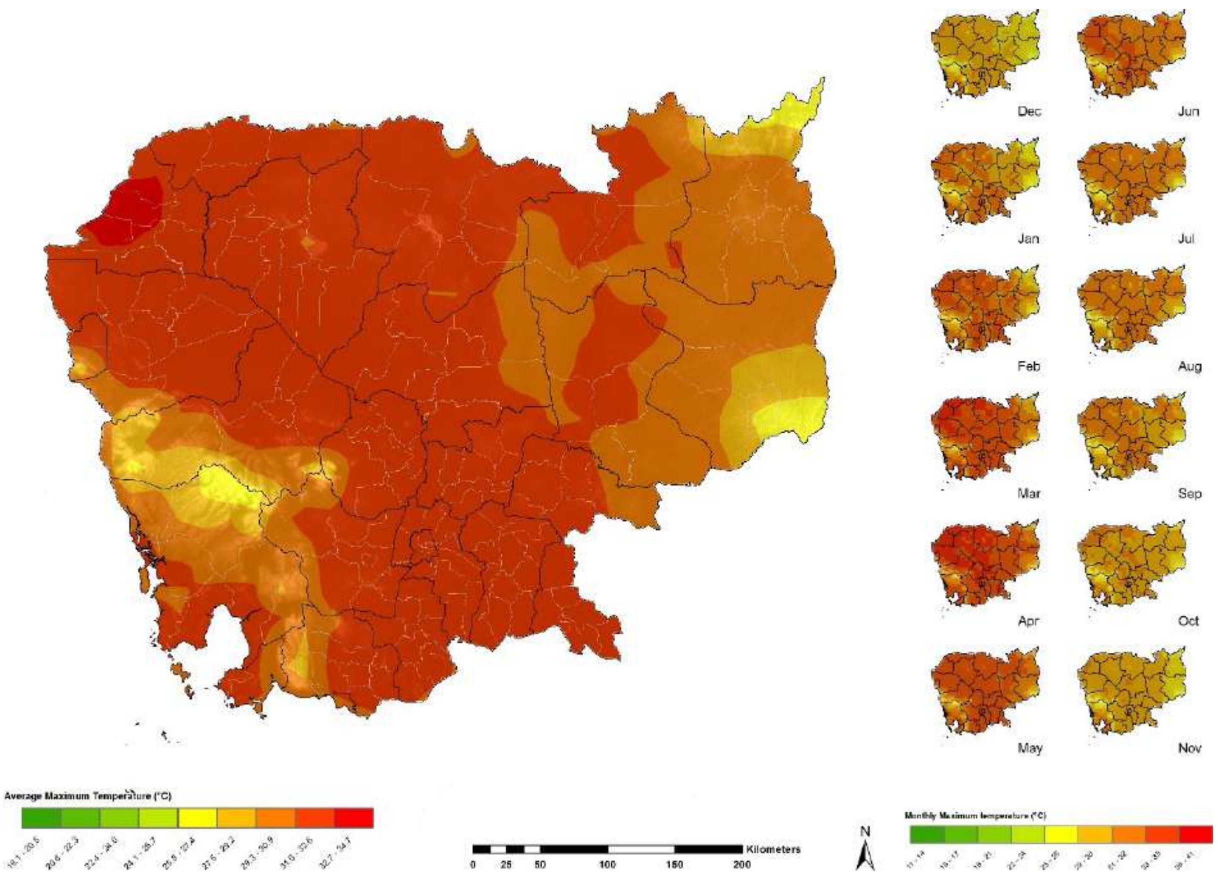


Figure 10: Current temperature distribution. Annual (left) and monthly (right)

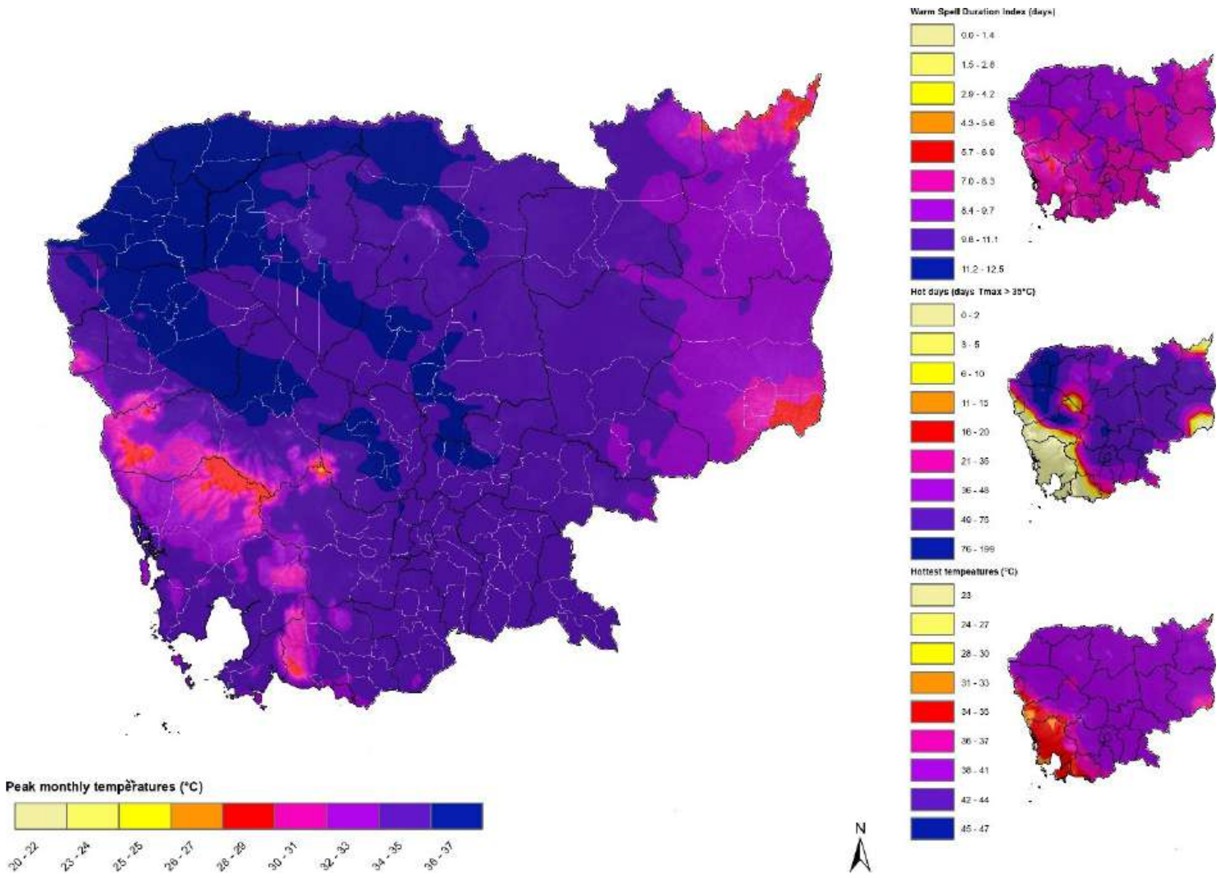


Figure 11: Current heatwave and extreme temperature characteristics. Peak monthly temperatures (left), extreme temperature characteristics (right)

4.2 PROJECTED CLIMATE

Cambodia's climate under SSP2-4.5 is characterised by warming temperatures, increasing rainfall, and greater extremes in both domains. While rising precipitation offers potential benefits for water resources, seasonal shifts, enhanced variability, and more intense rain events may challenge agriculture, infrastructure, and disaster risk management. At the same time, rising temperatures, especially extreme heat events and warm spells, will likely place growing stress on public health, agriculture, and energy systems.

Overall, these projections highlight the urgency for adaptive planning, particularly in sectors sensitive to rainfall timing and temperature extremes. Regional differentiation in climate signals, such as the warmer northeast and the more flood-prone southwest, underscores the need for locally tailored adaptation strategies.

4.2.1 RAINFALL

Cambodia's future rainfall regime under SSP2-4.5 suggests a modest but consistent upward trend in total annual precipitation. From 2020 to 2050, annual rainfall is projected to average around 1791.78 mm, reflecting a significant increasing trend of approximately 1% per decade. This represents a net rise of 26.11 mm compared to the baseline period of 1995–2014, with expected values ranging between 1776.86 mm and 1806.7 mm.

The traditional wet season—peaking in July, August, and September—is expected to continue dominating the annual cycle, while the dry season remains most pronounced in January, February, and December. However, subtle seasonal shifts are emerging. For instance, April, May, and June show the largest relative declines in rainfall, with April seeing an average decrease of 4.15 mm. In contrast, October—already part of the late monsoon—could become wetter, with an average increase of 11.36 mm.

Regionally, most of the country is projected to experience wetter conditions, especially from July to November. Notable increases are anticipated in:

- Northeastern areas during July, September, and November
- Southern provinces in August
- Across the country in October

Conversely, rainfall reductions in April, May, and June may impact early-season agricultural activities.

While the frequency of extreme daily events remains relatively stable, their intensity is projected to increase. The maximum 1-day rainfall is expected to average around 37.86 mm, with a slight, non-significant upward trend (0.56 mm/decade). More telling are the changes in shorter-duration cumulative rainfall, which could indicate greater flash flood risk:

- 5-day maximum rainfall is projected to increase significantly, averaging 110.14 mm, and growing by 2.25 mm per decade
- 1-month maximum rainfall is also expected to rise significantly to 355.59 mm, with a trend of 6.5 mm per decade

Days with rainfall above 20 mm and 50 mm are increasing too, indicating more frequent heavy downpours. Projections suggest:

- ~11 days annually >20 mm (increasing by 0.44 days/decade)
- ~0.19 days annually >50 mm (increasing by 0.016 days/decade)

These shifts point to more frequent and intense rainfall events, particularly in southern and southeastern Cambodia, which are already prone to flooding. Increased rainfall during the wettest months also enhances flood risks in the southwestern coastal zones, while some southwestern and central regions may face more volatile rainfall patterns.

The 95th percentile rainfall—a common indicator of heavy rainfall days—is projected to increase across most of Cambodia, with the northwest as a partial exception.

Despite overall wetter conditions, dry spells may become more intense in specific regions. The average number of consecutive wet days is set to decline slightly to 104.38 days, with a non-significant decreasing trend of 0.71 days per decade, particularly notable in the southern half of the country.

The consecutive dry days also show a minor decrease, down to 38.31 days, suggesting a potential shortening of dry seasons. The SPEI (Standardised Precipitation Evapotranspiration Index), a widely used drought metric, indicates a shift towards milder drought conditions, increasing significantly by 0.08 units per decade, to average around –0.04. This could reflect better soil moisture retention or reduced water stress in many areas—though northwestern Cambodia may continue to experience more intense droughts due to increased rainfall variability.

At a national scale, there is a projected increase in rainfall seasonality. This points toward greater year-on-year variability, increasing uncertainty for rain-fed agriculture and water resource planning.

Regions already susceptible to rainfall-triggered landslides—notably the southwest and northeast—are expected to remain at elevated risk, with limited spatial changes in susceptibility.

Future projections also suggest a general increase in tropical cyclone activity intersecting with Cambodia, especially for Category 1 and 2 events, though confidence in these trends remains low. Higher-category storms (Categories 3–5) exhibit no clear trend, underlining the uncertainty in future tropical cyclone dynamics under SSP2-4.5.

Cambodia's coastal zones will be impacted by ocean-related climate change drivers. Sea surface temperatures are projected to increase by up to +0.7°C, with sea levels rising by approximately +0.13 m. Storm surges may intensify, with projected increases of +0.2 to +0.5 m, compounding coastal flooding risks. At the same time, the ocean is expected to become less saline, with declining pH, calcite, and aragonite levels—indicators of increased ocean acidification, potentially harming marine ecosystems and fisheries.

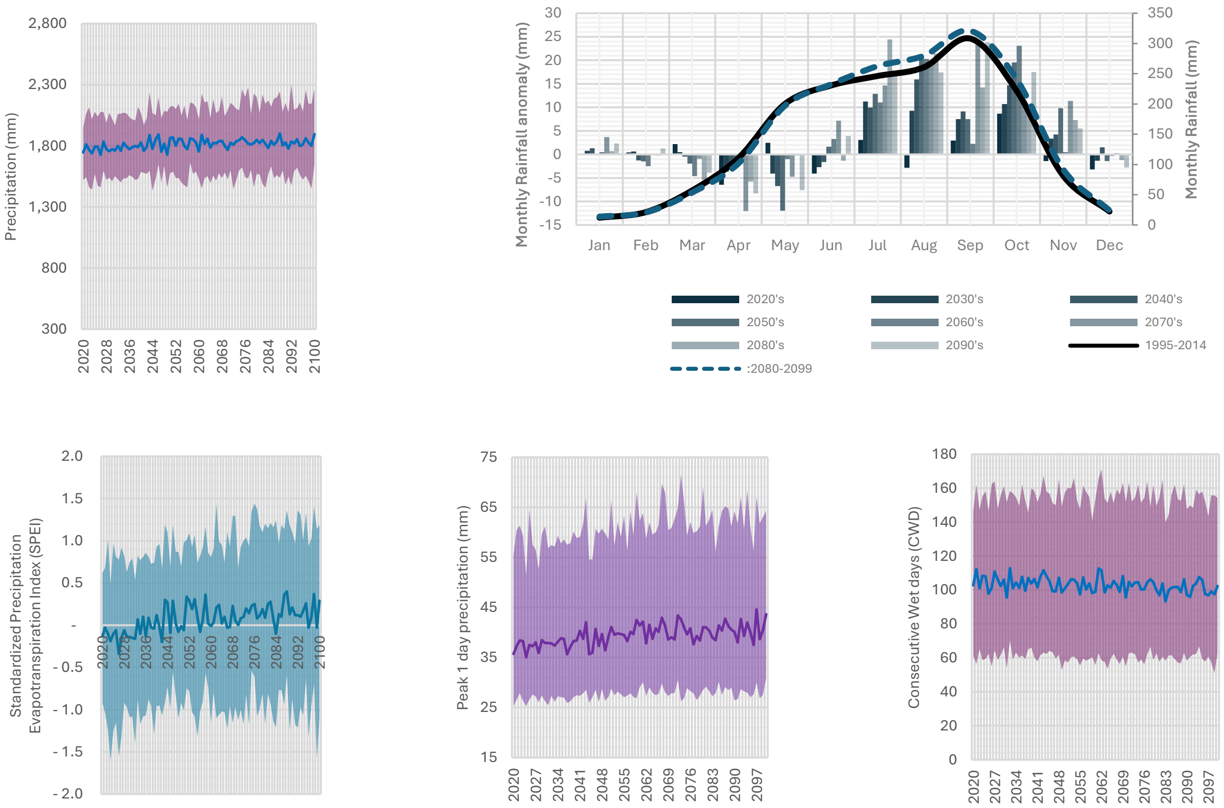


Figure 12. Projected national rainfall character changes

Table 5. Trends in future national rainfall character changes

	Precipitation	1-Day max rainfall	5-Day max rainfall	1-Month max rainfall	Days >20mm	Consecutive Wet Days	Consecutive Dry Days	Drought index
Mean 2020-2050	1791.78	37.86	110.14	355.59	10.95	104.38	38.31	-0.04
95% confidence interval	1776.86 - 1806.7mm	37.32 38.41mm	108.86 111.43mm	351.87 359.31mm	10.72 11.19 days	102.8 105.95 days	37.71 38.91 days	-0.09 0.01
Statistical Trend	Significant	Not Significant	Significant	Significant	Significant	Not Significant	Not Significant	Significant
Trend (change per decade)	1.00%	0.56mm	2.25mm	6.5mm	0.4366 days	-0.71 days	-0.11 days	0.08

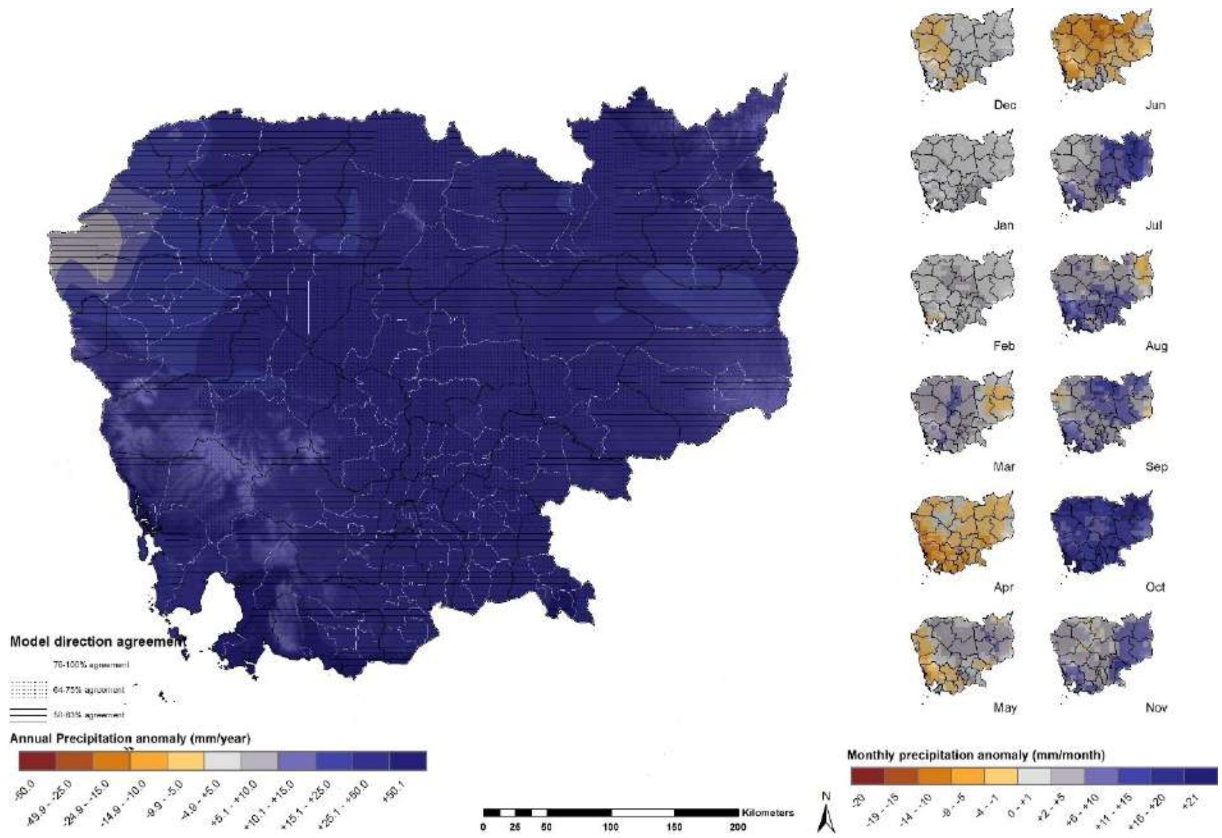


Figure 13: Projected rainfall volume distribution anomaly. Annual (left) and monthly (right)

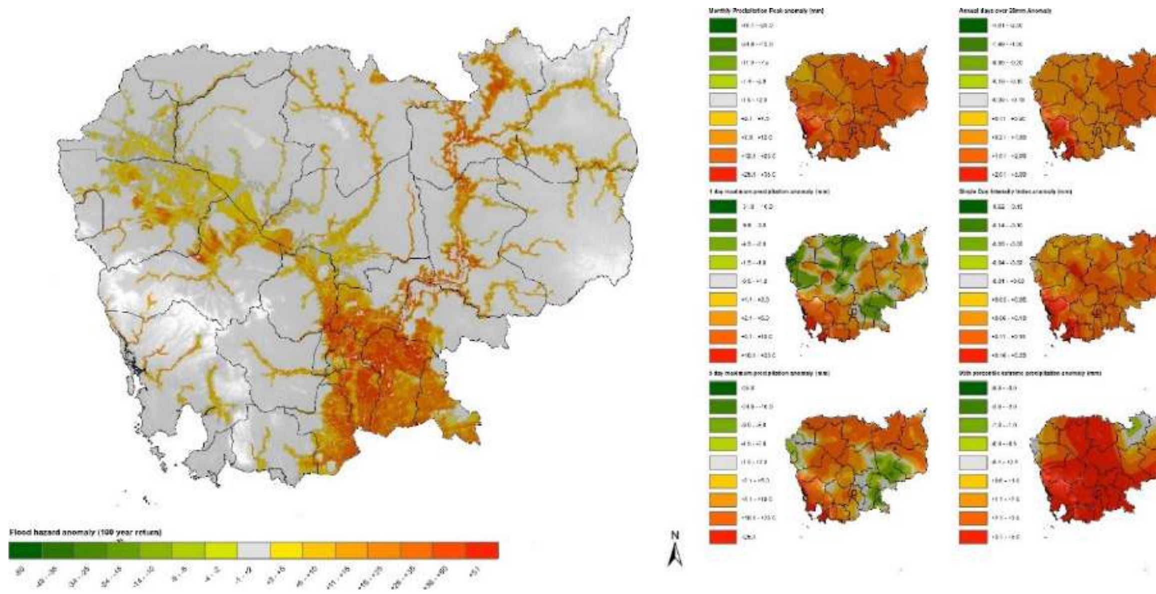


Figure 14: Projected flooding and extreme rainfall characteristics. Flood areas (left), extreme rainfall anomaly characteristics (right)

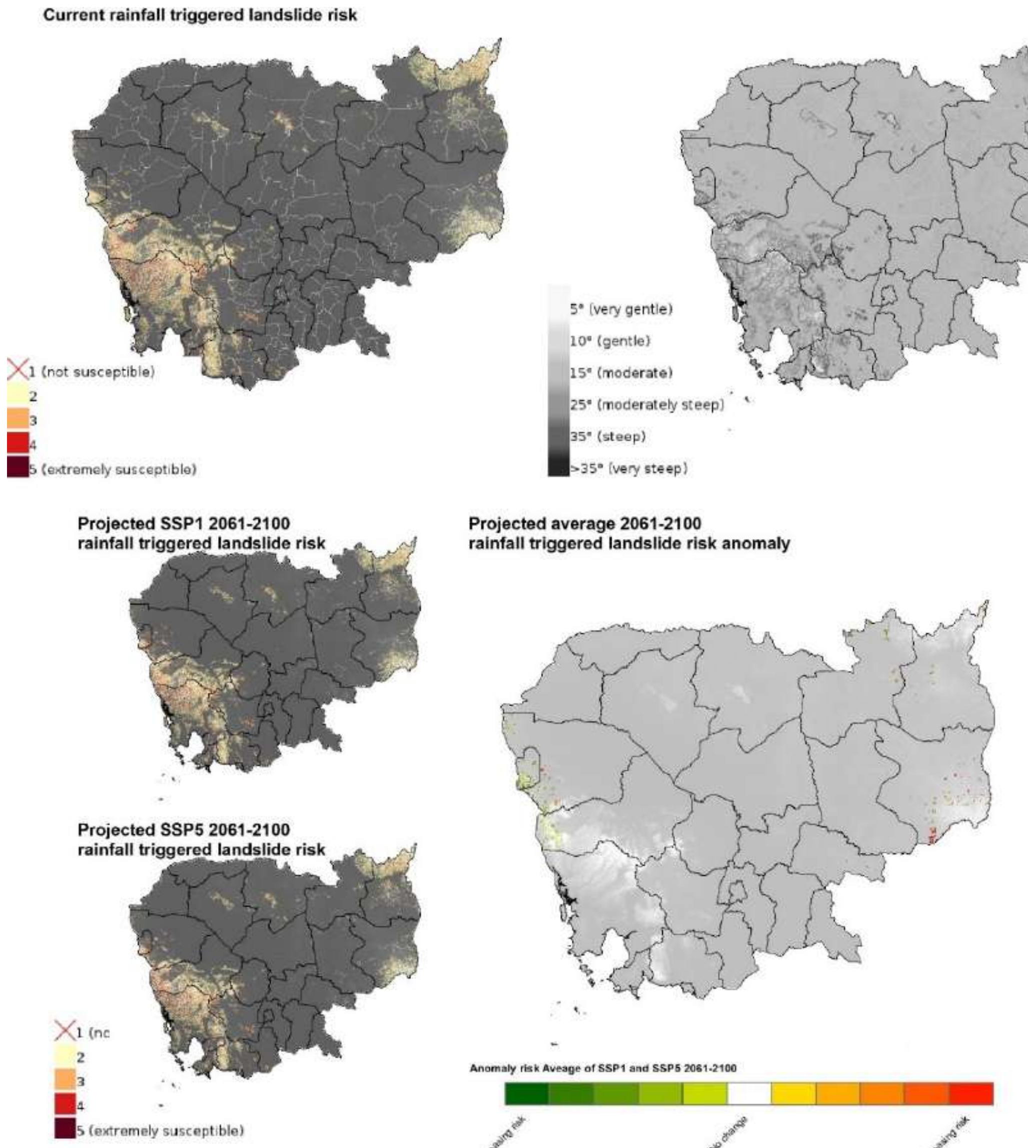


Figure 15: Projected precipitation triggered landslide events

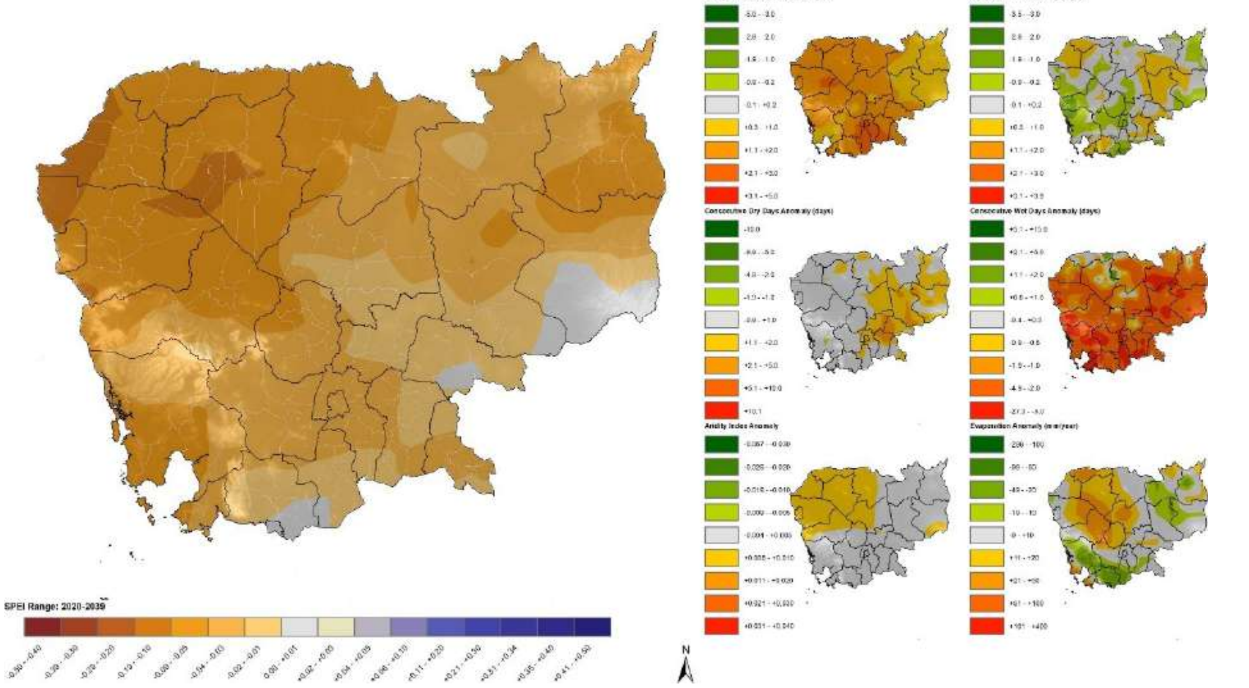


Figure 16: Projected Drought and drying rainfall characteristics. Flood areas (left), extreme rainfall characteristics (right)

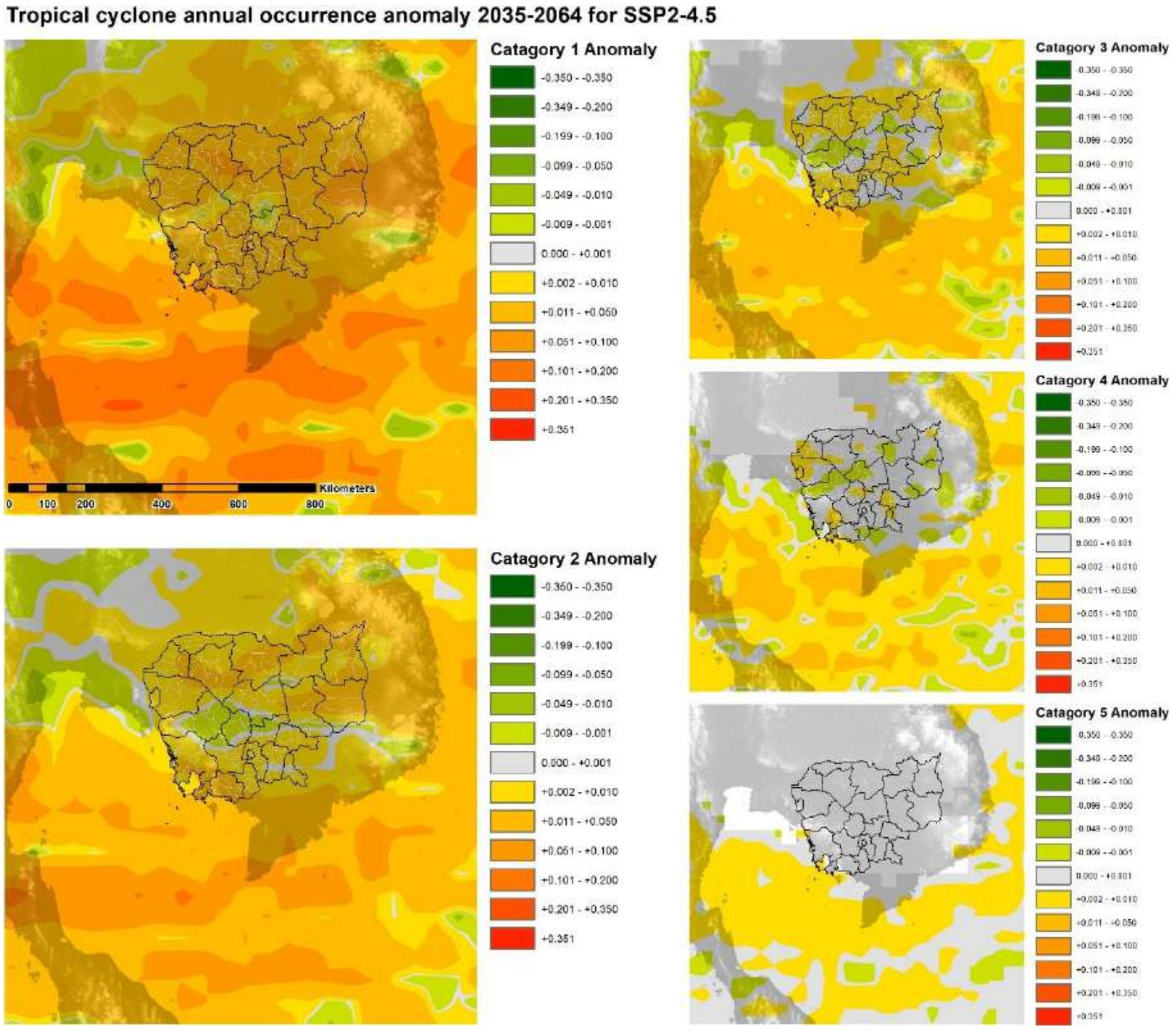


Figure 17: Projected Tropical cyclone anomaly occurrence

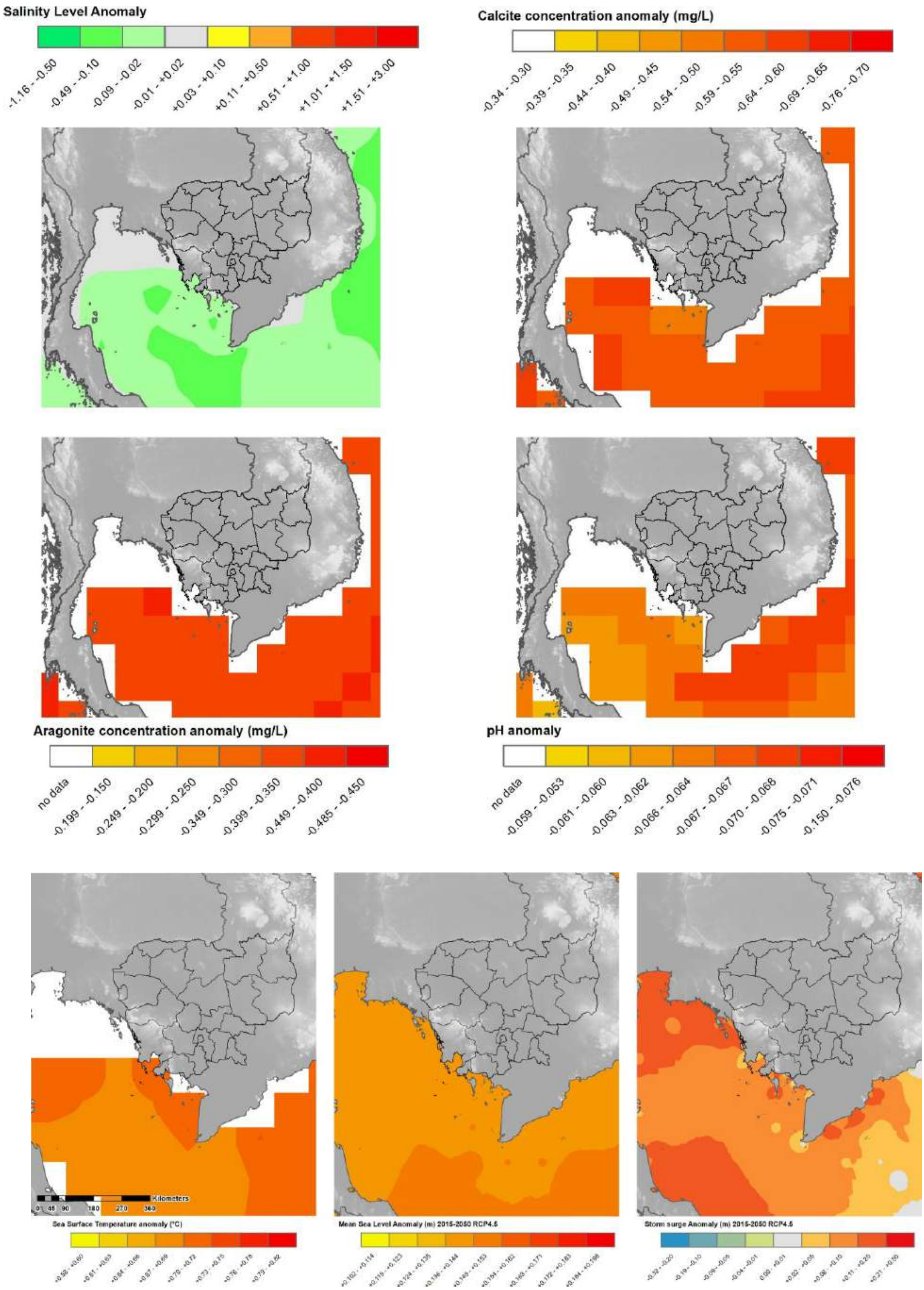


Figure 18: Projected Ocean based climate characteristics

4.2.2 TEMPERATURE

Cambodia is expected to warm steadily through mid-century. The mean annual temperature between 2020 and 2050 is projected at 28.56°C, with a significant warming trend of 0.27°C per decade. All temperature metrics follow this trend:

- Minimum temperature: ~24.51°C (rising by 0.28°C/decade)
- Maximum temperature: ~32.62°C (rising by 0.27°C/decade)
- Increase since 1995–2014 reference: ~+9.68°C in annual maximums

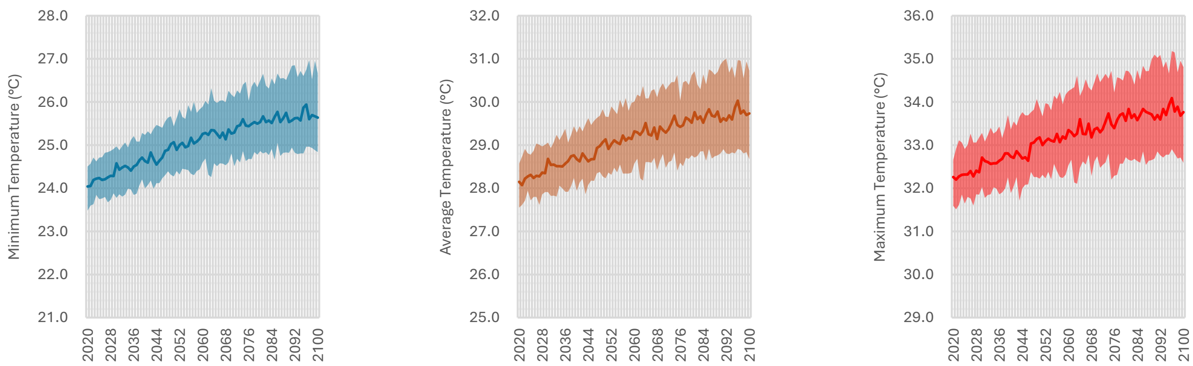
This warming is not evenly distributed across time or geography. The most intense warming is expected in April, with a rise of up to 0.94°C, followed by January and February. July, the coolest month, will still be warm, but at a more subdued rate of 0.69°C. Spatially, the northeast interior is projected to warm more quickly than the southwestern coastal areas, with May to June showing the sharpest regional increases.

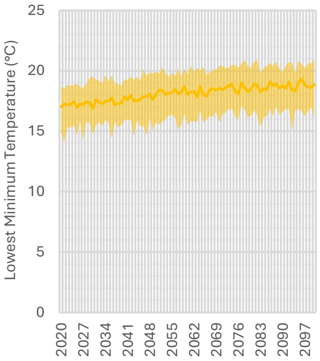
Temperature extremes are also shifting notably:

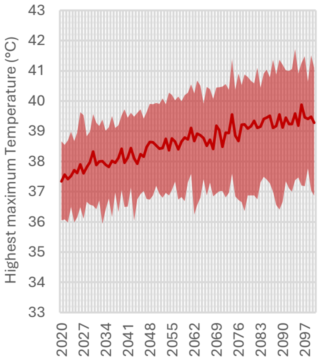
- Warm nights (>20°C) will increase to around 347 days annually, rising by 2.93 days per decade
- Days >25°C will nearly saturate the calendar at ~364 days annually
- Days >30°C: projected to increase to ~309 days, with a trend of +8.14 days per decade
- Days >35°C: expected to rise to ~67 days, with a substantial +9.32 days per decade
- Days >40°C—previously rare—are becoming more frequent, projected at 0.11 days/year, increasing by 0.1 days per decade

The highest daily maximum temperatures are anticipated to rise to around 38.0°C, with inland central regions seeing increases of up to 1.7°C. Additionally, the warm spell duration index—a measure of prolonged heat events—is projected to increase significantly to 47.57 days annually, with strong trends in coastal zones, implying longer, sustained periods of heat.

Figure 19. Projected national temperature character changes







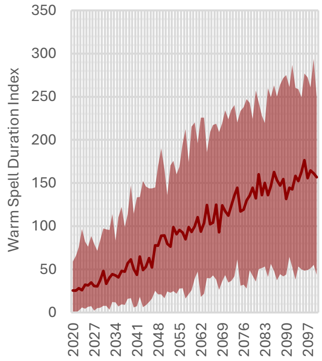
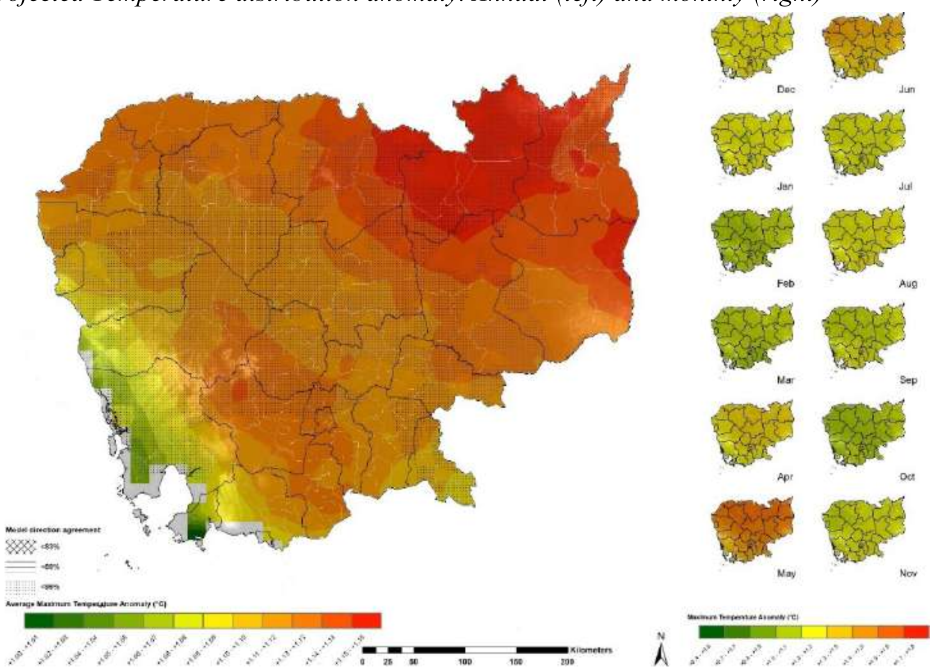


Table 6. Trends in future national temperature character changes

	Min Temperature	Mean Temperature	Max Temperature	Daily Min-Temperature	Daily Max-Temperature	Summer Days (Tmax > 25°C)C	Days above 30°C	Days above 35°C	Nights above 20°C	Warm Spell Duration Index
Mean 2020-2050	24.51	28.56	32.62	17.48	38.00	364.39	308.91	67.32	347.22	47.57
95% confidence interval	24.41 4.6°C	28.47 28.65°C	32.53 32.71°C	17.37 17.58°C	37.88 38.12°C	364.32 364.46 days	306.18 311.63 days	63.99 70.64 days	346.23 348.21 days	41.36 53.79 days
Statistical Trend	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant	Significant
Trend (change per decade)	0.28°C	0.27°C	0.27°C	0.26°C	0.33°C	0.17 days	8.14 days	9.32 days	2.93 days	17.85 days

Figure 20: Projected Temperature distribution anomaly. Annual (left) and monthly (right)



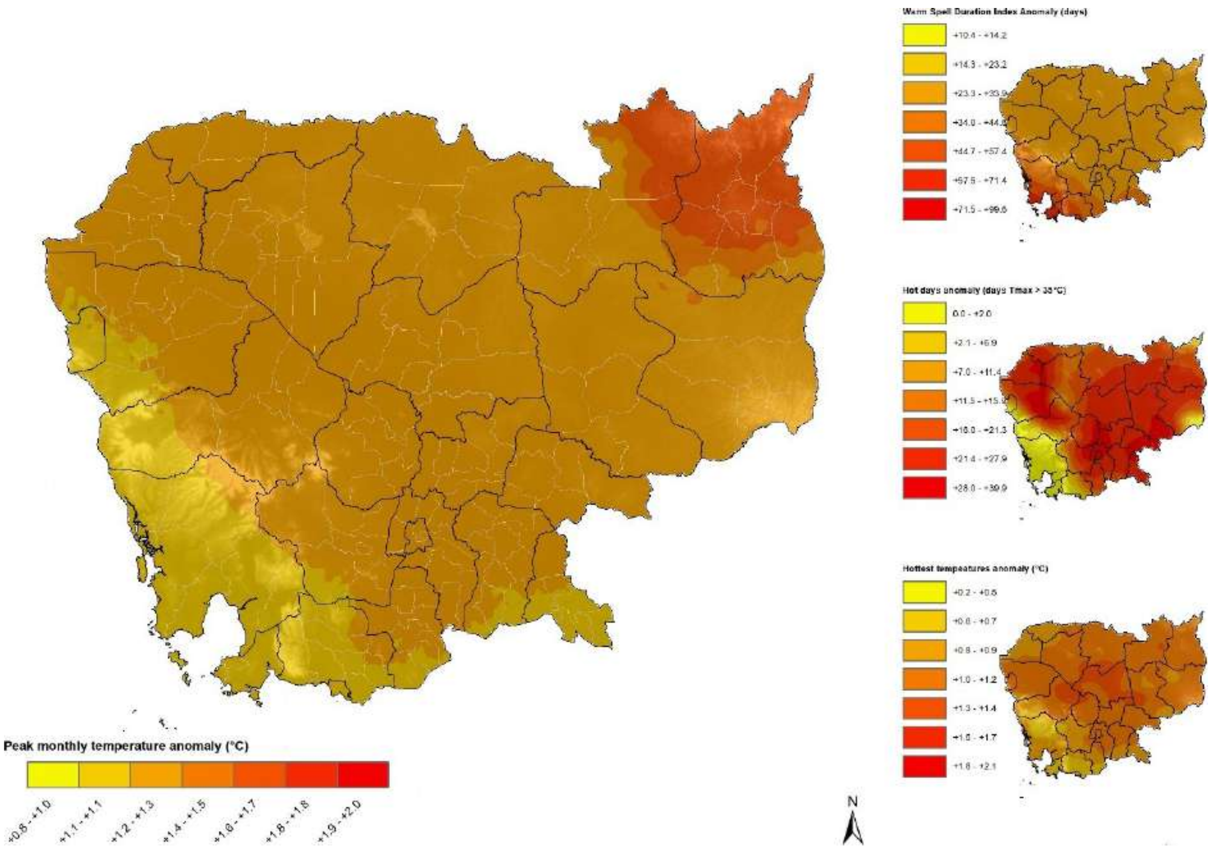


Figure 21: Projected heatwave and extreme temperature characteristics. Peak monthly temperatures (left), extreme temperature characteristics (right)

4.3 CLIMATE CHANGE-RELATED HAZARD INDICES

In assessing climate risks for the sectors, a comprehensive analysis of climate hazard indicators is crucial to understanding potential impacts and planning resilience measures. This assessment below comprises the hazard component of the CRVA methodology and follows a structured framework to gauge current and future climate hazards, ensuring alignment with international standards and sector-specific needs. Hazard components are the primary way of expressing the current and future projected climate and meteorological risks.

Climate Indicator	Reason for Inclusion	Distribution in Cambodia
Annual rainfall volume	Assesses overall water resource availability for human consumption, agriculture, and ecosystems; indicates long-term trends towards drought or wetter conditions, impacting water security planning.	The lower rainfall volumes are noted in the central inland areas leading to a higher hazard index for the water insecurity risk.
Peak 1-day rainfall	Essential for assessing flash flood risk, the capacity and potential failure points of stormwater drainage infrastructure (culverts, pipes), and rapid soil erosion potential.	The higher hazard areas are noted in the coastal areas where higher rainfall contributes to severe event hazards.
Peak 5-day rainfall	Indicates risk from sustained heavy rainfall leading to larger riverine flooding, widespread ground saturation (increasing landslide risk), and prolonged stress on water management systems.	The peak rainfall locations along the coast result in increased extreme event hazards

Climate Indicator	Reason for Inclusion	Distribution in Cambodia
Peak monthly rainfall	Identifies periods of extreme seasonal wetness that can saturate catchments, elevate river levels over time, and lead to broader-scale inundation or waterlogging issues.	The coastal areas and the inland northeastern areas see increased monthly rainfall volumes leading to increased extreme event hazards.
Rainfall days above 20mm	Measures the frequency of heavy rainfall events, indicating the likelihood of localized flooding, stormwater system overwhelmed, increased soil erosion, and runoff-related water quality issues.	The 20 mm day's peak in the coastal and northeastern areas resulted in an increased extreme event hazard.
Overland flow	Quantifies surface water runoff during rainfall events, directly informing assessments of flash flood potential, soil erosion rates, and the transport pathway for pollutants into waterways.	Overland flows are highest in the coastal and northeastern areas resulting in more severe extreme events in these locations.
Groundwater Levels & Recharge Rates	Assesses the health and sustainability of critical underground water reserves, which buffer against surface water shortages; declining levels/rates signal risks to long-term water security.	Groundwater recharge is lowest in the inland and central areas leading to increased water security hazards.
Annual rainfall variability index	Measures year-to-year fluctuations in rainfall, indicating the degree of unpredictability which poses risks to agricultural planning, water resource management reliability, and infrastructure design.	Higher rainfall variability is noted in the northeastern inland areas and the coastal southwestern areas. These areas have higher water security hazards.
SPEI index	Provides a comprehensive drought assessment by integrating precipitation and potential evapotranspiration (water loss due to heat), crucial for understanding agricultural, ecological, and hydrological drought severity and risk.	The drought index shows peak hazard in the eastern and northern areas leading to higher hazards.
Consecutive dry days	Directly measures the duration of dry spells, indicating drought intensity and posing risks to agriculture (crop stress/failure), water supply depletion, increased wildfire danger, and ecosystem health.	The consecutive dry days lead to higher water security hazards in the northeastern areas.
Aridity index	Assesses the fundamental long-term balance between precipitation and evaporative demand, indicating background water scarcity levels, desertification risk, and suitability for different land uses and ecosystems.	The aridity is highest in the northwestern and northeastern areas leading to higher water security hazards.
Evaporation index	Quantifies the rate of water loss to the atmosphere, which exacerbates drought conditions by depleting soil moisture and surface water; important for irrigation planning and water balance studies.	The evaporation index is highest to the northeast and southwest leading to increased water stress hazard.
Average maximum temperature	Indicates the typical level of daytime heat stress, relevant for assessing impacts on human health, labour productivity, energy demand for cooling, crop development cycles, and ecosystem functioning.	The maximum temperature hazard is highest in the central and northern areas in particular.
Monthly temperature peak	Identifies the periods of highest thermal stress within a month or season, crucial for assessing peak energy demand, acute health risks, and impacts during sensitive agricultural phases (e.g., flowering).	The peak monthly temperatures are highest in central and northern areas contributing to heatwave hazards.

Climate Indicator	Reason for Inclusion	Distribution in Cambodia
Days over 35°C	Measures the frequency of exposure to extreme heat conditions, directly quantifying risks to human health (heatstroke), livestock, crop yield reduction, and stress on cooling infrastructure. (Threshold may vary by region).	The days over 35°C contribute to the heatwave and extreme temperature hazards. These are highest in the northern and central areas.
Highest daily temperature	Represents the absolute maximum heat stress experienced, critical for understanding physiological tolerance limits (humans, plants, animals), infrastructure design (thermal expansion), and defining worst-case heat scenarios.	Peak temperature hazard is highest in the inland areas away from the coast in the southwest.
Heatwave	Assesses risks from prolonged periods of extreme heat, which have cumulative and often severe impacts on human mortality, critical infrastructure (energy grid failure), agriculture, and wildfire potential.	Heatwave hazards are higher in the northwestern area leading to an increased duration of warmer days.
Lowest daily temperature	Indicates the risk of frost damage to crops and sensitive ecosystems, defines minimum temperature tolerance for infrastructure (e.g., freezing pipes), influences species ranges, and impacts heating energy demand.	The lower minimum temperature hazard is noted to the south of the country and contributes to changes in crop germination and agriculture hazards.
Tropical cyclone occurrence	Measures the frequency, intensity, and track of tropical cyclones, assessing the risk of catastrophic damage from high winds, torrential rainfall, and associated storm surges in vulnerable regions.	Extreme event hazard as a result of tropical cyclone occurrence is highest in the southern coastal areas.
Storm surge	Quantifies the abnormal rise in sea level generated by storms, crucial for assessing the risk of extreme coastal flooding, inundation depth and extent, erosion, and damage to coastal infrastructure, independent of tide levels.	The storm surge hazard is highest in the southern coastal areas and contributes to the ocean-based hazard index.
Coastal flood risk	Integrates multiple factors (sea level rise, tides, storm surge, wave action, and sometimes river outflow) to provide a holistic assessment of the likelihood, depth, and extent of flooding in coastal zones.	The coastal flood index contributes to the water contamination hazard.
Sea level rise	Measures the long-term increase in average ocean height, fundamental for assessing risks of permanent inundation of low-lying areas, increased coastal erosion, saltwater intrusion into freshwater sources, and amplified storm surge impacts.	Sea level rise hazard is noted predominately in the southern coastal areas and contributes to the saline intrusion hazard.
Sea surface temperature	Indicates ocean heat content, which influences marine ecosystem health (e.g., coral bleaching risk), the development and intensity of tropical cyclones, fisheries distribution, and regional weather patterns.	The sea surface temperatures are higher in the northern areas and contribute to the coastal environment hazard index.
Ocean acidification	Measures the decrease in ocean pH due to absorbed atmospheric CO2, assessing the chemical stress and risk posed to marine organisms with shells or skeletons (corals, shellfish, plankton), impacting fisheries, aquaculture, and marine biodiversity.	The ocean acidification index contributes to the coastal environment hazard index.

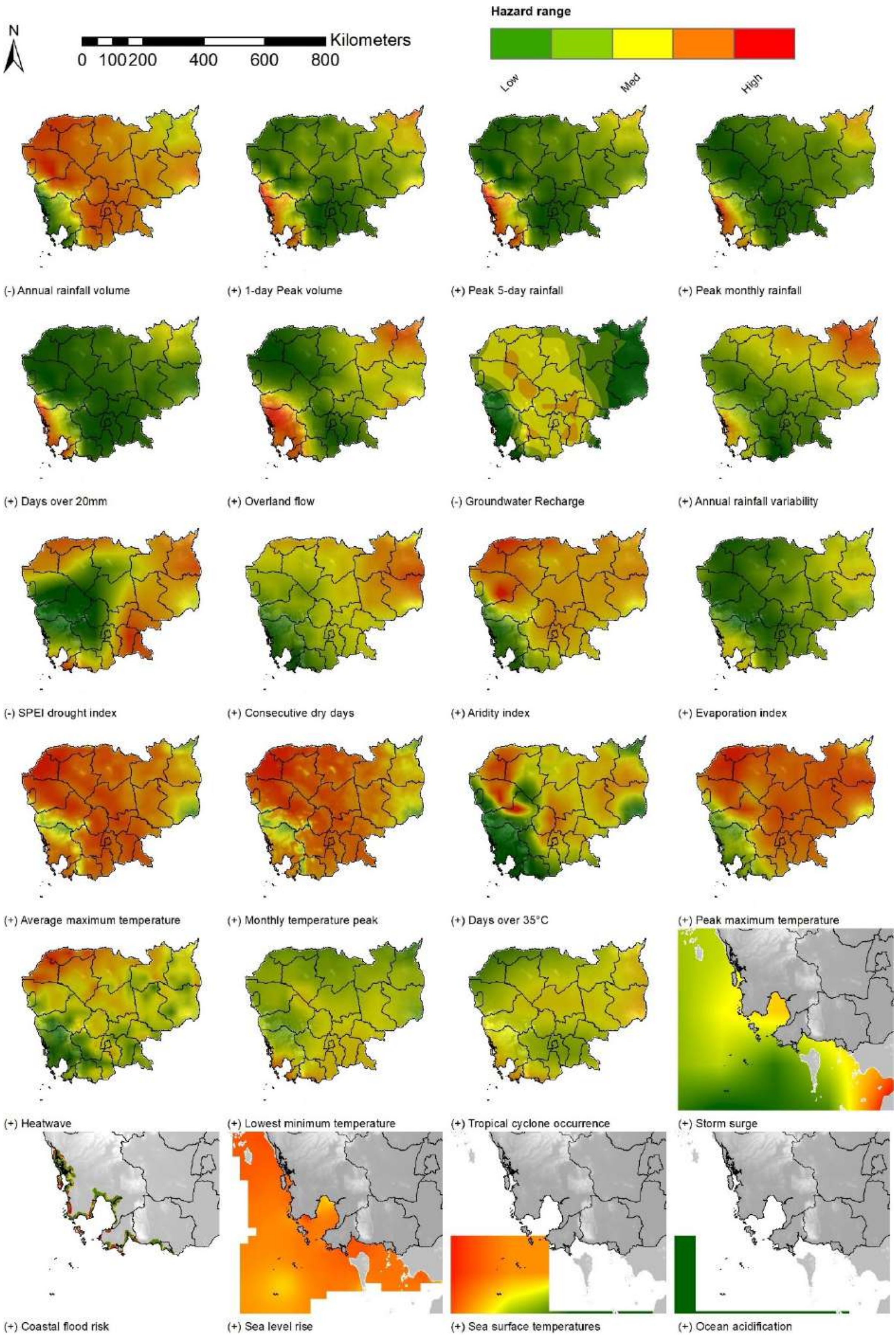
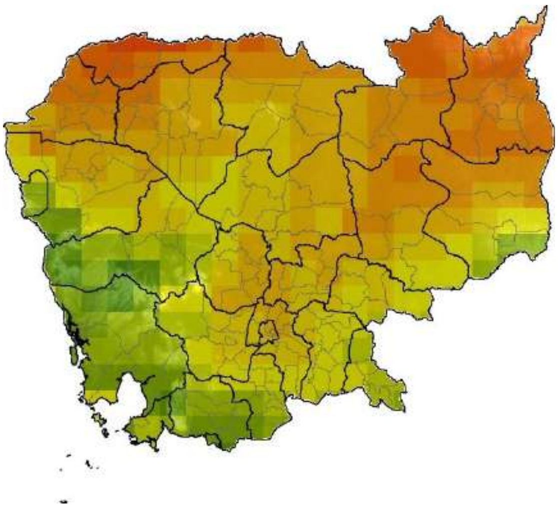
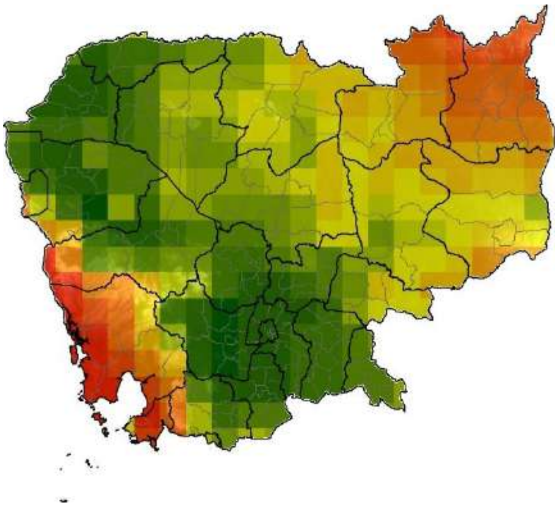
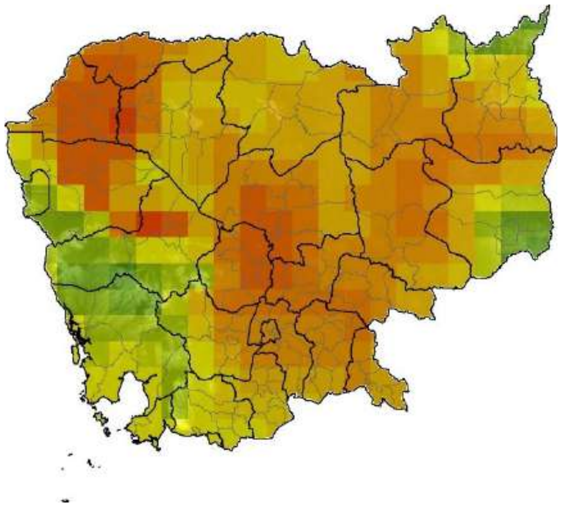
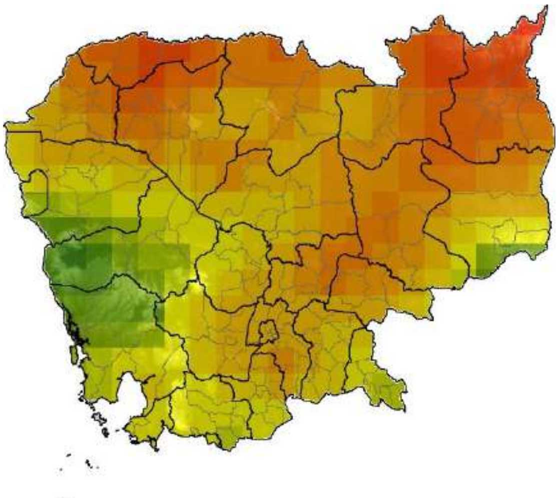


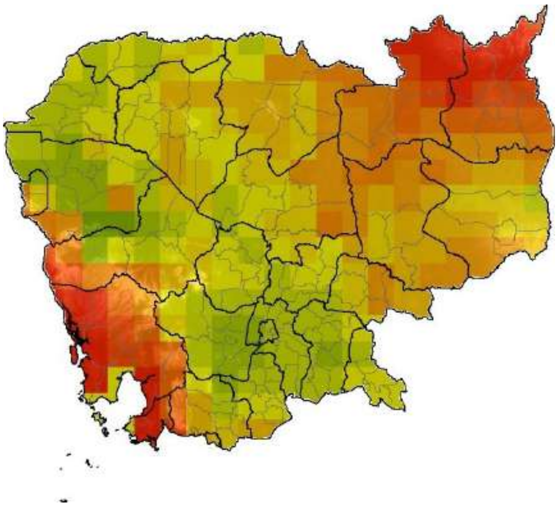
Figure 22. All hazard indicators are utilized in the different hazard indices.

4.4 CLIMATE HAZARD INDICATORS

Table 7. All hazard in indicators utilized in the different hazard indices

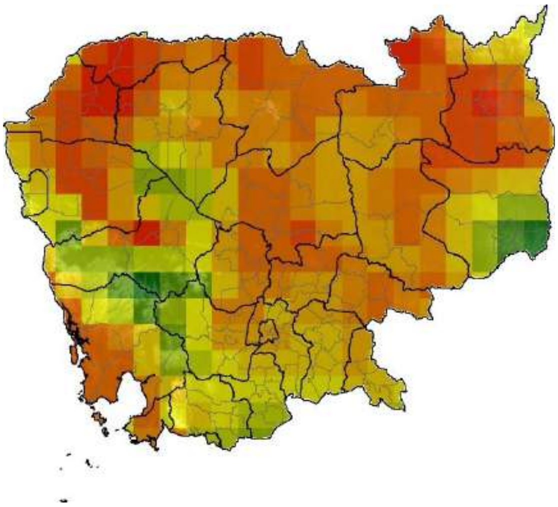
	**Sub-hazard 1(a)**:Food systems compromise from climate changes: Sub-hazard 1 (a) water insecurity from changing rainfall patterns and meteorological drought. Sub-hazard 1(a) addresses water insecurity within food systems, driven by changing rainfall patterns and meteorological drought. This hazard is assessed through a combination of indicators, including annual rainfall volume, the drought index, the annual rainfall variability index, the number of consecutive dry days, and the aridity index. The highest hazard levels are observed in the northern and northeastern regions of Cambodia, where historical trends indicate more frequent and severe droughts and higher aridity. Additionally, the increased year-to-year variability in rainfall in these areas further exacerbates the risk of water insecurity, contributing to a heightened hazard index for these regions.
	**Sub-hazard 1 (b)** damages and losses to farm assets from more severe rainfall events from severe event occurrence change. Sub-hazard 1(b) focuses on the damage and losses to farm assets resulting from more severe rainfall events, which are driven by changes in the frequency and intensity of extreme weather occurrences. This hazard is assessed using key rainfall indicators, including the number of rainfall days exceeding 20 mm, the 1-day peak rainfall volume, and peak monthly rainfall totals. These indices reflect the potential for extreme rainfall events that could cause significant damage to agricultural infrastructure and assets, ultimately jeopardizing food security. The highest hazard levels are observed in the southwestern coastal regions and the northeastern inland areas, where the frequency and intensity of high-magnitude rainfall events are most pronounced.

	**Sub-hazard 1 (c)** crop wilting, poor germination, and livestock stress are associated with increased hot days and warm nights in a warming climate. Sub-hazard 1(c) addresses the risks to agriculture and livestock associated with rising temperatures, particularly the increase in hot days and warm nights under a warming climate. Elevated temperatures impact both crop performance—through reduced germination and increased wilting—and livestock health, by inducing heat stress. This hazard is assessed using several temperature-related indicators, including peak maximum temperature, the number of days exceeding 35 °C, the peak temperature of the warmest month, and the lowest minimum temperature. These conditions are most pronounced in Cambodia's inland regions, resulting in increased hazard levels in the central and northwestern areas. This is largely driven by the high frequency of extreme heat days concentrated in these zones.
	**Sub-hazard 2(a)**: Water insecurity and contamination from climate changes: Sub-hazard 2 (a) changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture. Sub-hazard 2(a) focuses on the impacts of changing spatial and temporal rainfall patterns, combined with altered evaporation characteristics, which together reduce the efficiency of water capture and storage. While similar to Sub-hazard 1(a), this hazard further incorporates the evaporation index, groundwater levels, and groundwater recharge rates, all of which have longer-term implications for national water resilience. Although hazard patterns largely overlap with previous sub-hazards, the inclusion of groundwater and evaporation dynamics shifts the area of highest risk slightly further south. The most severe hazards are now observed in the northeastern and northern regions, with increasing risk also noted in central parts of the country due to these additional stressors.



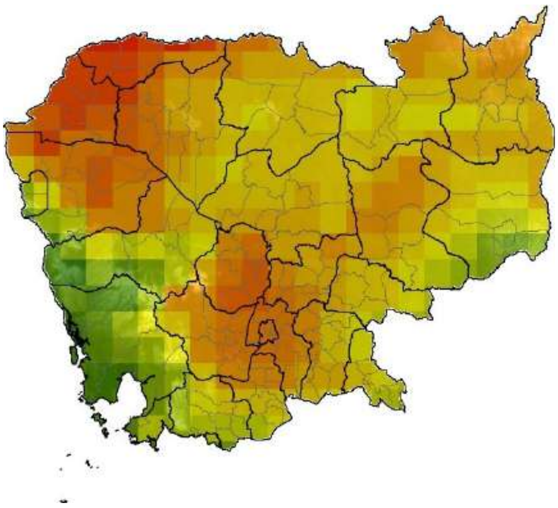
Sub-hazard 2 (b) increased severe events and overland flows resulting in contamination of water resources.

Sub-hazard 2(b) addresses the increased risk of water resource contamination resulting from severe weather events and overland flows. This hazard focuses on the degradation of water quality due to both extreme rainfall and water scarcity conditions. Key indicators include peak one-day and five-day rainfall events, the number of days with precipitation exceeding 20 mm, and the extent of overland flow, all of which can mobilize pollutants into water systems. In parallel, limiting factors such as the drought index and peak monthly temperatures are also assessed, as they influence water availability and exacerbate contamination risks. The highest levels of hazard are identified in Cambodia's coastal southwestern and northeastern regions, where both flood-related and drought-related drivers converge to compromise water quality.



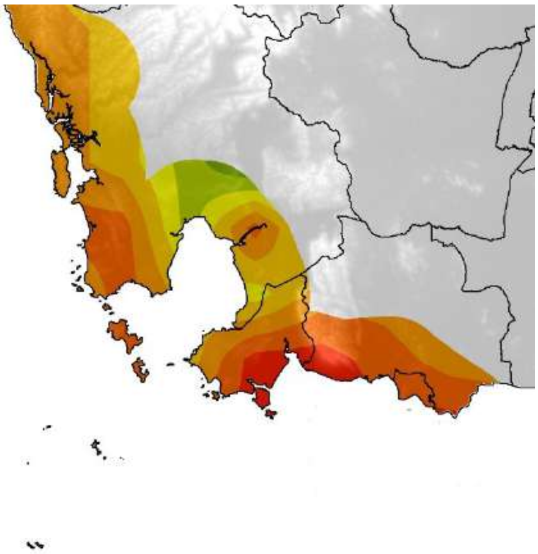
Sub-hazard 3: Forestry losses or compromise from climate changes: Sub-hazard 3 (a) increased temperatures and wildfire risk impacting tree health.

Sub-hazard 3(a) concerns the increased temperatures and heightened wildfire risk that threaten tree health and forest resilience in Cambodia. Key climate indicators used to assess this hazard include the number of days with temperatures exceeding 35 °C, the frequency of heatwave events, peak monthly temperatures, and the average maximum temperature. These factors collectively increase the severity and likelihood of wildfire occurrence, thereby compromising the ability of forest ecosystems to recover and maintain resilience. Elevated wildfire-related hazards are particularly evident in the northwestern and northeastern regions of the country, with a moderate level of risk also observed in central areas.



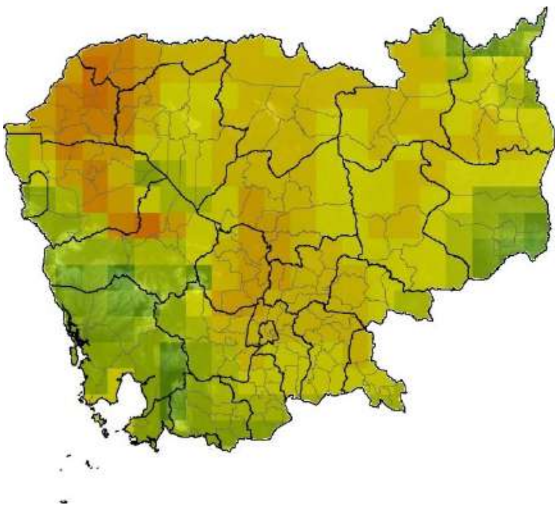
Sub-hazard 3 (b) decreases water availability by limiting forest growth.

Sub-hazard 3(b) relates to the reduction in water availability that limits forest growth and compromises overall ecosystem health. Changes in rainfall patterns and declining moisture availability directly affect vegetation resilience and long-term forest sustainability. This hazard is assessed using key indicators such as total annual rainfall volume, the drought index, and the aridity index. The highest levels of risk are identified in the northwest and central southern regions of Cambodia, where persistently low rainfall and pronounced drought conditions are prevalent. These factors contribute to decreased water availability, posing a significant threat to ecosystem function, forest regeneration, and biodiversity maintenance.



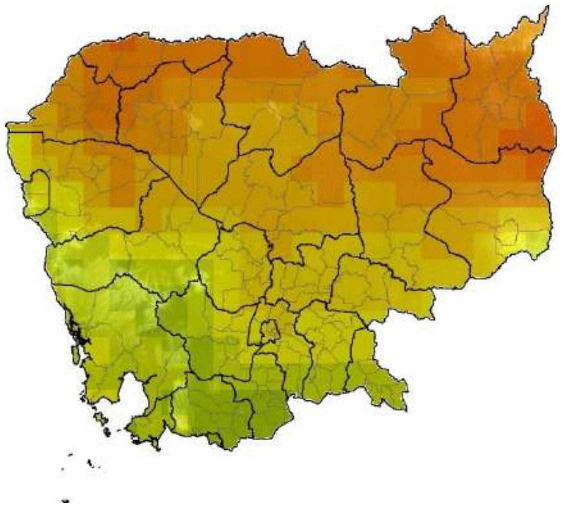
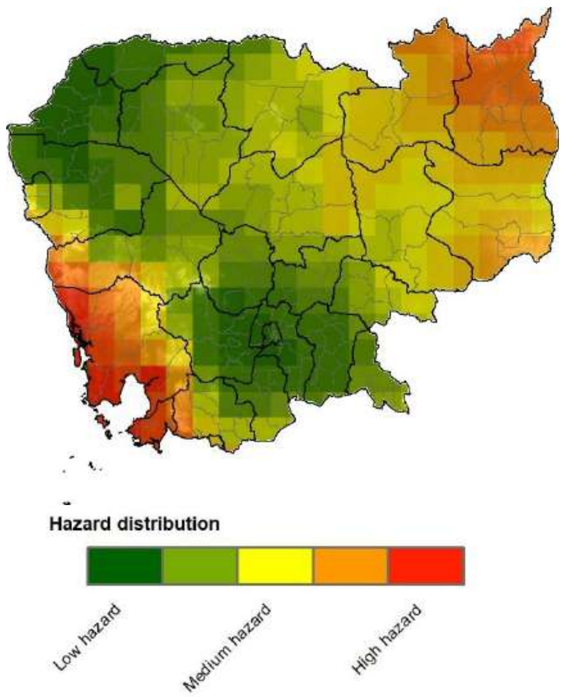
Sub-hazard 4: Compromised coastal environment from climate changes: Sub-hazard 4 (a) physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations.

Sub-hazard 4(a) addresses the physical impacts of climate change on Cambodia's coastal environment, specifically focusing on the risks posed to coastal infrastructure and populations. This hazard considers the vulnerability of coastal zones to sea level rise, storm surge, tropical cyclone occurrence, and coastal flooding or inundation. The southern coastal region is particularly at risk due to the increasing frequency and intensity of tropical cyclones, coupled with elevated coastal inundation potential. These combined factors contribute to a heightened level of coastal hazard, threatening both human settlements and critical infrastructure along the coast.



Sub-hazard 5: Increasing impacts on Human Health from climate changes: Sub-hazards (a) increasing heat stress from notable rising heat index and extreme heat waves.

Sub-hazard 5(a) focuses on the increasing impacts of climate change on human health due to rising heat stress, driven by a notable increase in the heat index and the occurrence of extreme heat waves. Higher temperatures are expected to significantly reduce human thermal comfort, particularly in urban areas where the urban heat island effect amplifies heat exposure. The highest levels of heat-related hazard are observed in the northwest of Cambodia, with elevated risks also present—though to a lesser extent—in the northern and central regions. This assessment is based on extreme heat indicators, including the number of days exceeding 35 °C, the frequency and

	intensity of heat waves, and peak monthly temperatures.
	**Sub-hazard5 (b)** heightened incidence of vector and water-borne diseases due to changing climate suitability factors. Sub-hazard 5(b) addresses the heightened incidence of vector- and water-borne diseases driven by shifts in climate suitability. These diseases disproportionately affect communities with limited resilience and adaptive capacity, particularly in regions already experiencing significant climate-related stress. Vulnerable areas include those prone to both drought and water scarcity, as well as regions affected by flooding and persistent water pooling, which create favourable conditions for disease transmission. Key indicators used to assess this sub-hazard include year-to-year variability in rainfall seasonality, increases in peak maximum temperatures, rising peak precipitation events, total annual rainfall, and the aridity index. Together, these factors contribute to elevated cumulative hazard levels, particularly in the northeast and northwest regions of Cambodia, where climate conditions are increasingly conducive to outbreaks of climate-sensitive diseases.
	**Sub-hazard 5 (c)** acute impacts and disasters resulting from extreme weather events such as floods and severe storms. Sub-hazard 5(c) refers to the acute impacts and disasters resulting from extreme weather events, such as floods and severe storms. These events pose significant risks to human populations, particularly through climate extremes associated with precipitation. Key indicators include extreme single-day rainfall, the number of days with precipitation exceeding 20 mm, peak monthly rainfall, and hazards related to overland flow. In addition to these cumulative stressors, single high-impact events such as tropical cyclones and coastal flooding also play a critical role in amplifying risk. When these factors are considered together, they indicate that the highest levels of hazard are concentrated in Cambodia's coastal southwest and northeastern regions, where the combined effects of intense rainfall and storm activity are most pronounced.

4.5 DISTRICT LEVEL RESULTS

Each of the different climate hazards is ranked from 1st (highest hazard) to 178th (lowest hazard) based on the individual and cumulative climate hazard indices for each of the sub-risks. These are presented and highlight the top 10 (red), 25 (orange) and 50 (yellow) ranked districts. The current

(1990-2020) climate hazard ranks are presented as well as the future changes in ranking scores for the SPS2 and SSP5 2020-2040 scenarios respectively. These changes are represented by down red arrows indicating a lowering of rank (increased relative hazard score), orange right arrow – minimal or no change in ranking, and the up green arrow indicating a higher ranking (decreased relative hazard score). These are grouped by Province to allow for strategic-level planning.

The hazards assessed are associated with the sub-risks as follows:

- **Sub-risk 1**: Food systems compromise from climate changes
  - Sub-risk 1 (a) water insecurity from changing rainfall patterns and meteorological drought.
  - Sub-risk 1 (b) damages and losses to farm assets from more severe rainfall events from severe event occurrence change.
  - Sub-risk 1 (c) crop wilting, poor germination, and livestock stress associated with increased hot days and warm nights in a warming climate.
- **Sub-risk 2**: Water insecurity and contamination from climate changes
  - Sub-risk 2 (a) changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture.
  - Sub-risk 2 (b) increased severe events and overland flows resulting in contamination of water resources.
- **Sub-risk 3**: Forestry losses or compromise from climate changes
  - Sub-risk3 (a) increased temperatures and wildfire risk impacting tree health.
  - Sub-risk3 (b) decreases water availability limiting forest growth.
- **Sub-risk 4**: Compromised coastal environment from climate changes
  - Sub-risk4 (a) physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations.
- **Sub-risk 5**: Increasing impacts to Human Health from climate changes
  - Sub-risks (a) increasing heat stress from notable rising heat index and extreme heat waves.
  - Sub-risk5 (b) heightened incidence of vector and water-borne diseases due to changing climate suitability factors.
  - Sub-risk5 (c) acute impacts and disasters resulting from extreme weather events such as floods and severe storms.

Table 8. Region and District hazard rankings for the different sub-risks and cumulative risk for the current and future SSP2 and SSP5 scenarios [118]

Region	District	Sub-risk 1 (a)			Sub-risk 1 (b)			Sub-risk 1 (c)			Sub-risk 2 (a)			Sub-risk 2 (b)		
Bântéay Méanchey	Malai	42	→	↗	109	→	↘	99	→	→	115	↓	↓	126	↘	↓
	Mongkol Borei	37	→	↗	125	↘	→	9	→	→	64	↓	↘	123	↗	→
	Ou Chrov	31	↗	↗	140	↓	↓	27	↗	↗	113	↓	↓	132	→	↘
	Phnum Srok	9	→	→	137	↘	↘	2	↗	→	26	↑	→	111	↑	↑
	Preah Netr Preah	28	→	→	118	↘	↘	7	→	→	37	↗	→	86	↑	↑
	Serei Saophoan	21	↗	↗	147	↓	↘	5	→	→	44	↑	→	119	→	→
	Svay Chek	13	→	→	160	↘	↘	6	↗	→	62	→	→	148	→	→
	Thma Puok	7	→	→	145	→	→	17	↗	↑	29	↑	↑	117	↑	↑
Batdâmbâng	Aek Phnum	51	↗	→	90	→	↗	37	↗	→	97	↓	↓	102	→	→
	Banan	92	→	→	164	→	→	25	↗	↗	146	↓	↓	178	→	↘
	Bat Dambang	50	↗	↗	110	↗	→	11	→	→	122	↓	↓	131	→	→
	Bavel	65	→	→	148	↗	→	70	→	→	66	↘	↓	171	→	↘
	Moung Ruessei	112	→	→	102	→	↗	110	→	→	164	↓	↓	129	↘	↘
	Phnum Proek	95	→	→	122	↗	↘	153	→	→	53	↑	→	166	↘	↓
	Rotanak Mondol	147	→	→	101	→	↘	163	→	→	168	→	→	149	↓	↓
	Samlout	173	↘	↘	34	↘	→	174	→	→	173	→	→	26	→	→
	Sangkae	76	→	→	113	↓	→	61	→	↘	104	↘	↓	106	→	→
	Svay Pao	55	↑	↗	162	→	→	4	→	→	122	↓	↓	176	→	→
Kâmpóng Cham	Batheay	47	↗	↗	130	↗	↗	19	↘	→	52	→	↓	133	→	→
	Chamkar Leu	61	→	→	78	↑	→	38	↘	→	34	↘	↘	72	↗	↗
	Cheung Prey	64	→	→	120	↗	↗	18	↘	→	44	↘	↓	116	→	→
	Kampong Cham	77	→	→	99	↗	↗	53	↘	↘	11	↑	↑	79	↑	↗
	Kampong Siem	63	→	↘	95	↑	↗	50	↘	↘	17	↑	↑	88	↗	↗
	Kang Meas	68	↘	↘	141	↗	→	29	→	→	56	↑	↑	138	→	→
	Kaoh Soutin	81	→	↘	117	↗	↗	31	→	→	111	→	↗	136	↘	↘
	Prey Chhor	78	↓	↓	115	↗	→	33	→	→	39	↘	↓	97	→	→
	Srei Santhor	75	↘	↘	149	↗	→	31	↘	→	75	↑	↗	156	↘	↘
	Stueng Trang	39	↗	↗	55	↗	↗	71	→	↓	20	→	↗	58	↗	↗
Kâmpóng Chhnang	Baribour	115	→	→	107	→	→	42	→	↗	131	↓	↓	107	→	→
	Chol Kiri	58	↑	↑	126	→	↗	10	→	→	98	↓	↓	108	↗	↗
	Kampong Chhnang	55	↑	↑	134	→	→	4	→	→	122	↓	↓	126	→	↗
	Kampong Leaeng	73	↗	→	96	↑	↗	12	→	→	132	↓	↓	112	→	→
	Kampong Tralach	53	↑	↑	161	↘	→	16	↘	→	106	→	→	120	↑	↑
	Rolea B'ier	83	↗	↑	138	→	→	20	→	→	122	↓	↓	100	↗	↑
	Sameakki Mean Chey	57	↑	↑	165	→	↗	21	→	↘	93	↑	↑	151	↗	↗
	Tuek Phos	116	↗	↗	100	→	→	125	→	→	150	↓	↓	85	↗	↗
Kâmpóng Spœ	Aoral	139	→	→	93	↗	↗	158	→	→	139	↗	↑	84	↗	↗
	Basedth	129	↗	↗	176	→	→	129	→	→	83	↑	↑	170	→	↘
	Chbar Mon	101	↗	↗	178	→	→	88	↘	↘	83	↑	↑	176	→	→
	Kong Pisei	107	↗	↗	174	→	→	92	→	→	83	↑	↑	174	→	→
	Odongk	84	↗	↑	175	→	→	41	↘	↘	83	↑	↑	169	→	→
	Phnum Sruoch	135	↗	↗	163	→	→	146	→	→	133	↗	→	145	→	↘
	Samraong Tong	103	↗	↗	177	→	→	95	↘	↘	91	↑	↑	173	→	→
	Thpong	111	↗	↗	172	→	→	80	↘	↘	102	↑	↑	161	→	→
Kâmpóng Thum	Baray	69	→	↘	67	↑	↗	22	↘	→	63	↓	↓	69	→	→
	Kampong Svay	98	↘	↘	74	↗	→	24	→	→	135	↓	↓	99	→	↘
	Prasat Balangk	91	↓	↓	52	↗	→	68	↘	↘	40	↓	↓	65	→	→
	Prasat Sambour	49	→	↘	53	↗	→	28	↗	↗	114	↓	↓	66	→	→
	Sandan	52	↘	↘	38	→	→	107	↘	→	54	→	↗	28	→	→
	Santuk	59	→	→	46	→	→	57	→	↗	72	↓	→	36	→	↗
	Stoung	113	↘	↘	65	→	→	79	→	→	103	↓	↓	95	↘	↘
	Stueng Saen	81	↘	↓	72	↗	→	13	→	→	130	↓	↓	74	→	→
Kâmpôt	Angkor Chey	156	→	→	108	↘	→	141	→	→	160	→	→	103	→	↘
	Banteay Meas	167	→	→	76	↘	↘	149	→	→	160	→	→	54	→	→
	Chhuk	158	→	→	79	→	→	154	→	→	149	→	→	73	→	→
	Chum Kiri	149	→	→	123	↗	↗	148	→	→	134	↗	↗	122	→	→
	Dang Tong	166	→	→	105	→	↘	147	→	→	155	↗	→	91	→	↘
	Kampong Bay	169	→	→	44	→	→	159	→	→	141	↘	→	45	→	→
	Kampong Trach	174	→	→	71	→	→	152	→	→	163	→	→	68	→	→
	Kampot	171	→	→	22	→	→	164	→	→	143	↘	→	23	→	→

Region	District	Sub-risk 3 (a)			Sub-risk 3 (b)			Sub-risk 4 (a)			Sub-risk 5 (a)			Sub-risk 5 (b)			Sub-risk 5 (c)			HIST	SSP2	SSP5
Bântéay Méanchey	Malai	74	↘	↓	11	→	→	105	→	→	27	↑	↗	60	→	→	155	↗	→	90	→	→
	Mongkol Borei	16	→	↘	13	→	→	105	→	→	10	→	→	34	→	→	171	→	→	56	→	→
	Ou Chrov	30	→	↘	12	→	→	105	→	→	15	→	→	44	→	↘	165	→	→	73	→	→
	Phnum Srok	1	→	→	4	→	→	105	→	→	1	→	→	14	→	→	172	↘	→	28	↗	↗
	Preah Netr Preah	17	↘	→	15	→	→	105	→	→	9	→	→	18	→	→	142	→	→	37	→	→
	Serei Saophoan	7	→	→	6	→	→	105	→	→	3	→	→	25	→	→	164	→	→	38	→	↗
	Svay Chek	12	→	→	5	→	→	105	→	→	5	→	→	26	→	→	177	→	→	43	↗	↗
	Thma Puok	21	→	→	3	→	→	105	→	→	7	↗	↗	23	→	→	178	→	→	40	↗	↑
Batdâmbâng	Aek Phnum	83	↓	↑	20	→	→	105	→	→	30	→	↑	35	↗	↗	134	→	→	70	↘	↗
	Banan	13	→	↘	34	↘	↘	105	→	→	16	↘	→	68	→	→	173	→	→	102	→	→
	Bat Dambang	18	↘	↘	23	→	→	105	→	→	12	→	→	43	→	→	170	→	→	65	→	→
	Bavel	37	↘	↘	22	→	→	105	→	→	25	→	→	62	→	→	174	→	→	97	→	→
	Moung Ruessei	100	↘	↗	57	↓	↓	30	→	→	34	↗	↑	64	→	→	119	→	→	112	↘	→
	Phnum Proek	108	↑	↑	50	↓	↓	105	→	→	128	↗	→	100	→	→	156	↗	→	148	↗	↘
	Rotanak Mondol	123	↑	↑	112	↓	↓	29	→	→	147	→	↗	113	→	→	95	→	→	176	→	→
	Samlout	167	→	→	166	→	→	21	→	→	168	→	→	134	↗	→	40	→	→	143	→	→
	Sangkae	72	↓	→	17	→	→	105	→	→	26	→	↑	45	→	→	140	↘	→	82	↓	→
	Svay Pao	11	→	→	10	→	→	105	→	→	2	→	→	51	→	→	175	→	→	72	→	↗
Kâmpóng Cham	Batheay	59	↓	↓	43	→	→	105	→	→	28	→	→	71	→	→	117	→	→	79	→	↗
	Chamkar Leu	23	↑	↗	76	↘	↘	105	→	→	40	↑	→	76	→	→	73	→	→	60	→	→
	Cheung Prey	51	→	↓	53	→	→	105	→	→	23	→	→	78	→	→	103	→	→	74	→	↗
	Kampong Cham	96	↓	↓	94	→	↘	105	→	→	60	→	→	85	→	↗	111	→	→	91	↗	→
	Kampong Siem	78	↘	↓	83	↘	↘	105	→	→	52	→	→	77	→	↗	93	→	→	80	→	→
	Kang Meas	85	↓	↓	54	↘	↘	105	→	→	45	↘	→	84	→	→	126	→	→	98	→	→
	Kaoh Soutin	96	↓	↓	77	↘	↘	105	→	→	60	↓	→	90	→	→	121	→	→	107	↘	→
	Prey Chhor	73	→	↓	73	↘	↘	105	→	→	33	↑	↗	88	→	→	90	↗	→	89	→	↘
	Srei Santhor	103	↓	↓	58	↘	↘	105	→	→	60	↓	→	87	→	→	128	↗	→	110	↘	↘
	Stueng Trang	55	↑	↗	66	↗	↗	105	→	→	85	↑	↘	73	→	→	60	→	→	45	↘	↘
Kâmpóng Chhnang	Baribour	88	→	↘	65	→	→	105	→	→	43	↑	↑	103	→	→	97	→	→	103	→	→
	Chol Kiri	39	↘	↘	19	↗	↗	105	→	→	18	→	→	82	→	→	112	→	→	68	→	↗
	Kampong Chhnang	26	→	↗	29	→	→	105	→	→	14	→	↘	79	→	→	108	↘	→	67	→	→
	Kampong Leaeng	33	→	↓	51	↘	↘	105	→	→	17	↗	↘	70	→	→	94	→	→	71	→	→
	Kampong Tralach	63	↓	↓	16	↗	↗	105	→	→	19	→	→	86	↗	→	141	↘	→	86	→	↗
	Rolea B'ier	60	↓	↓	38	↗	↗	105	→	→	24	→	→	97	→	→	107	↘	→	87	→	→
	Sameakki Mean Chey	76	↓	↘	9	↗	↗	105	→	→	20	→	↑	101	→	→	163	↘	→	94	↗	↑
	Tuek Phos	141	→	→	59	↑	↗	105	→	→	116	↗	↑	117	→	→	96	→	→	129	↗	↗
Kâmpóng Spœ	Aoral	176	↘	↘	86	↑	↑	105	→	→	153	↗	↗	160	→	→	83	→	→	172	→	→
	Basedth	146	↓	↓	52	↑	↑	105	→	→	135	↓	↓	152	→	→	131	→	→	170	→	→
	Chbar Mon	96	↓	↓	27	↑	↑	105	→	→	88	↓	↓	137	→	→	150	↗	→	140	↗	↗
	Kong Pisei	122	↓	↓	41	↑	↑	105	→	→	83	↓	↓	127	→	→	154	↗	→	147	↗	→
	Odongk	70	↓	↓	24	↑	↑	105	→	→	37	↘	→	110	→	→	168	→	→	117	→	↗
	Phnum Sruoch	160	↘	↘	70	↑	↑	28	→	→	155	→	→	164	→	→	92	↑	→	174	→	→
	Samraong Tong	111	↓	↓	37	↗	↗	105	→	→	103	↓	↓	131	→	→	152	↗	→	146	→	→
	Thpong	110	↓	↓	44	↗	↗	105	→	→	48	→	↑	128	→	→	147	→	→	137	↗	↑
Kâmpóng Thum	Baray	20	↗	→	72	→	↘	105	→	→	22	↗	→	65	→	→	63	→	→	48	→	↘
	Kampong Svay	43	→	↘	96	↓	↓	105	→	→	31	→	↗	59	→	→	77	→	→	75	↘	↘
	Prasat Balangk	40	→	↗	120	↓	↓	105	→	→	42	→	→	52	→	→	59	→	→	54	↘	↘
	Prasat Sambour	49	→	→	103	↓	↓	105	→	→	36	→	↗	48	→	→	58	→	→	46	↘	↘
	Sandan	80	↗	→	113	↘	↘	105	→	→	98	→	→	38	→	→	38	→	→	31	→	↘
	Santuk	61	↑	↗	88	→	→	105	→	→	72	↗	→	55	→	→	47	→	→	36	→	→
	Stoung	114	→	→	123	↓	↓	105	→	→	92	↗	→	58	→	→	75	→	→	95	↘	↓
	Stueng Saen	26	→	→	82	↓	↓	105	→	→	21	↗	→	56	→	→	61	→	→	52	→	↘
Kâmpôt	Angkor Chey	165	↓	↓	136	→	→	16	→	→	145	↓	↘	172	→	→	76	→	→	136	↘	↘
	Banteay Meas	171	→	↘	155	→	→	9	→	→	159	↘	→	174	→	→	54	→	→	128	↘	↘
	Chhuk	145	→	→	148	→	→	13	→	→	157	↘	→	173	→	→	53	→	→	119	→	↘
	Chum Kiri	155	↘	→	127	↗	↗	24	→	→	152	↘	→	170	→	→	69	→	→	159	→	↘
	Dang Tong	149	→	→	153	→	→	11	→	→	156	↘	→	176	→	→	55	→	→	141	→	↘
	Kampong Bay	164	→	→	159	→	→	1	→	→	169	↘	↘	178	→	→	25	→	→	93	→	→
	Kampong Trach	168	↘	↘	160	→	→	6	→	→	154	→	→	177	→	→	39	→	→	131	→	↘
	Kampot	138	↑	↑	162	→	→	5	→	→	173	→	→	171	→	→	19	→	→	66	↗	→

Region	District	Sub-risk 1 (a)			Sub-risk 1 (b)			Sub-risk 1 (c)			Sub-risk 2 (a)			Sub-risk 2 (b)			Sub-risk 3 (a)			Sub-risk 3 (b)			Sub-risk 4 (a)			Sub-risk 5 (a)			Sub-risk 5 (b)			Sub-risk 5 (c)			HIST	SSP2	SSP5
Kândal	Angk Snuol	88	↗	↗	173	↘	→	58	↘	↘	83	↑	↑	176	↘	→	86	↓	↓	33	→	→	105	→	→	60	↘	↓	112	→	→	168	↘	→	125	→	→
	Kandal Stueng	90	↑	↗	167	→	→	83	→	→	61	↗	↗	165	→	→	106	→	↓	40	↗	↑	105	→	→	91	↗	↓	122	→	→	157	→	→	132	↗	↗
	Kaoh Thum	125	→	→	139	→	→	111	→	→	51	↘	↗	141	↗	↗	143	↘	↘	74	↑	↑	105	→	→	123	↗	→	147	→	→	130	→	→	154	↗	↗
	Khsach Kandal	46	↗	↑	152	→	→	45	↘	→	83	↗	→	150	→	→	120	↓	↓	32	↗	↗	105	→	→	60	↗	↗	93	→	→	158	→	→	108	→	→
	Kien Svay	89	→	↗	142	→	→	74	→	→	57	↘	→	139	→	↗	119	↘	↘	49	↑	↑	105	→	→	96	↑	↗	118	→	→	138	→	→	121	↗	↗
	Leuk Daek	114	→	→	127	→	→	98	↗	→	50	↘	↗	126	↗	↗	136	↘	↘	78	↑	↑	105	→	→	117	↗	→	136	→	→	124	→	→	144	→	↗
	Lvea Aem	72	→	↗	144	→	→	64	→	→	71	↗	→	140	→	↗	118	↓	↓	42	↑	↑	105	→	→	76	↑	↗	104	→	→	151	→	→	114	↗	↗
	Mukh Kampul	35	↗	↗	156	→	→	36	↘	→	83	↗	→	156	↘	→	126	↓	↓	36	→	→	105	→	→	60	↘	→	81	→	→	146	→	→	101	→	↗
	Ponhea Lueu	62	↗	↗	171	→	→	26	→	→	83	↑	↑	164	→	→	75	↓	↓	21	→	→	105	→	→	32	→	↗	96	→	→	162	↘	→	100	→	↗
	S'ang	93	↗	↗	150	→	→	87	→	→	48	↓	→	147	↗	↗	121	→	↘	46	↑	↑	105	→	→	108	↗	→	125	→	→	144	→	→	130	↗	↗
	Ta Khmau	81	↗	↗	156	→	→	73	→	→	67	↓	↓	156	↗	↗	96	→	→	40	↗	↑	105	→	→	95	↑	→	122	→	→	149	→	→	123	↗	↗
Kaôh Kong	Botum Sakor	155	→	→	5	↗	↗	156	↗	→	138	↓	↓	25	→	→	32	↑	↑	176	→	→	15	→	→	140	↗	↗	135	↗	↗	10	↗	→	27	↑	↗
	Kampong Seila	172	→	→	20	→	→	170	→	→	137	→	→	16	→	→	162	↗	↗	161	→	→	18	→	→	177	→	→	161	→	→	20	→	→	78	↑	↗
	Kaoh Kong	161	→	→	4	→	→	168	→	→	170	→	↘	3	→	→	35	↑	↑	174	→	→	14	→	→	171	↘	↘	133	→	↗	3	→	→	19	→	→
	Kiri Sakor	163	↗	↗	2	→	→	160	→	→	169	↓	↓	9	→	→	28	↑	↑	178	→	→	3	→	→	163	↘	↘	132	↗	↗	6	↗	→	18	→	→
	Mondol Seima	175	→	→	3	→	→	173	→	→	176	→	→	2	→	→	84	↑	↑	175	→	→	12	→	→	174	→	→	151	→	→	5	→	→	34	→	→
	Smach Mean Chey	169	→	→	1	→	→	162	→	→	175	→	→	1	→	→	31	↑	↑	177	→	→	11	→	→	161	→	↘	139	→	→	2	→	→	13	→	→
	Srae Ambel	164	→	→	19	→	→	167	→	→	136	↘	↓	11	→	→	135	↑	↑	167	→	→	19	→	→	170	→	→	153	→	→	13	→	→	47	↗	→
	Thma Bang	176	→	→	16	→	→	176	→	→	177	→	→	14	→	→	174	→	→	172	→	→	23	→	→	175	→	→	159	→	→	15	→	→	113	↑	→
Kep	Kaeb	169	→	→	57	→	→	157	→	→	152	→	→	57	→	→	170	↘	↘	164	→	→	8	→	→	162	→	→	175	→	→	35	→	→	115	→	↘
Krâchéh	Chhloung	106	→	↘	45	→	→	97	→	→	41	↑	↑	40	→	→	81	↑	↑	139	→	→	105	→	→	115	→	→	75	→	→	45	→	→	64	→	→
	Kracheh	44	→	→	51	↗	→	43	→	↗	30	↑	↑	43	→	↗	42	↗	↘	92	→	→	105	→	→	78	↓	↓	57	→	→	46	→	→	33	→	→
	Preaek Prasab	33	↗	↗	56	→	→	82	→	→	33	↑	↑	44	↗	↗	87	↑	→	69	↑	↑	105	→	→	105	↗	↘	67	→	→	48	→	→	44	↗	→
	Sambour	22	→	→	35	→	→	49	→	↗	36	↑	↑	29	→	→	58	↗	→	80	↗	↗	105	→	→	86	↘	↓	33	→	→	36	→	→	17	→	→
	Snuol	121	↘	↘	31	→	→	115	↘	→	108	↑	↑	32	→	→	71	↑	↑	154	→	→	105	→	→	124	↘	→	69	→	→	33	→	→	58	→	↘
Krong Pailin	Pailin	162	↘	↘	37	→	→	171	→	→	174	→	→	37	→	→	157	↗	↗	163	→	→	22	→	→	166	→	→	130	→	→	52	→	→	145	↗	→
	Sala Krau	151	→	→	114	↓	↓	165	→	→	109	↑	↑	110	↘	↓	134	↗	↗	142	↘	↘	105	→	→	149	↗	↗	116	→	→	85	→	→	175	→	→
Krong Preah Sihanouk	Mittakpheap	177	→	→	36	↘	→	152	↗	↗	160	↓	↓	75	↘	↘	29	↑	↑	173	→	→	4	→	→	109	↑	↑	165	→	→	2	→	→	55	↑	↑
	Prey Nob	157	↗	↗	8	→	→	161	→	→	153	↓	↓	7	→	→	77	↑	↑	165	→	→	2	→	→	165	↘	↘	150	↗	↗	7	→	→	15	→	→
	Stueng hav	154	↗	↗	6	→	→	155	→	→	160	↓	↓	8	→	→	26	↑	↑	168	→	→	8	→	→	150	↘	→	148	↗	↗	4	→	→	12	→	→
Môndól Kiri	Kaev Seima	122	↓	↓	27	→	→	143	→	→	157	→	→	34	→	→	148	→	→	158	↘	↘	105	→	→	151	↗	→	63	→	→	28	→	→	85	↘	↘
	Kaoh Nheaek	25	↘	↘	23	→	→	94	→	→	27	↘	↘	33	→	→	52	↑	↑	114	↓	↓	105	→	→	114	→	↓	11	→	→	27	→	→	16	→	→
	Ou Reang	165	↘	↘	24	→	→	178	→	→	171	→	→	35	↘	↘	178	→	→	170	→	→	105	→	→	178	→	→	120	→	→	23	→	→	178	→	→
	Pechr Chenda	71	↓	↓	39	→	→	166	↘	↘	105	↓	↓	61	↘	↘	172	→	↘	146	↓	↓	105	→	→	164	→	→	49	→	→	31	→	→	96	↘	↓
	Saen Monourom	145	↓	↓	30	→	→	177	→	→	145	→	↘	41	→	→	177	→	→	169	↘	↘	105	→	→	176	→	→	94	↗	→	24	→	→	162	→	↘
Otdar Mean Chey	Anlong Veaeng	8	→	→	77	→	→	104	↑	↑	5	→	→	71	→	↗	44	↑	↑	18	→	→	105	→	→	39	↑	↑	10	→	→	118	→	→	32	↗	→
	Banteay Ampil	2	→	→	143	→	↘	15	↑	↑	23	↗	→	118	↑	↑	6	↗	↗	1	→	→	105	→	→	4	↗	↑	8	↗	→	176	→	→	26	↑	↑
	Chong Kal	5	→	→	111	→	↘	8	↗	↗	4	→	↗	105	↗	↗	3	→	↑	7	→	→	105	→	→	8	→	↑	6	→	→	139	↗	→	21	→	↗
	Samraong	1	→	→	103	↗	→	23	↑	↑	3	→	→	109	↗	↑	8	↗	↑	2	→	→	105	→	→	13	↗	↑	2	→	→	159	↗	→	20	↗	↗
Phnom Penh	Dangkao	74	↑	↗	169	→	→	59	↘	↘	83	↑	↗	168	→	→	90	↓	↓	35	→	↗	105	→	→	71	↘	→	111	→	→	161	→	→	120	→	↗
	Mean Chey	43	↗	↑	156	→	→	53	↘	↘	83	↗	→	156	→	↗	96	↓	→	31	↗	↗	105	→	→	60	↑	↑	98	→	→	160	→	→	109	↗	↗
	Phnom Penh	35	↗	↑	156	→	→	53	↘	→	83	↗	→	156	→	↗	96	↓	→	27	↗	↗	105	→	→	60	↑	↑	90	→	→	168	↘	→	105	↗	↗
	Ruessei Kaev	35	↗	↑	156	→	→	53	↘	→	83	↗	→	156	→	↗	109	↓	↘	27	↗	↗	105	→	→	60	↑	↑	90	→	→	168	↘	→	106	↗	↗
Pouthisat	Bakan	109	↘	↘	104	→	→	77	↑	↑	151	↓	↓	134	↓	↓	113	↗	↗	75	↓	↓	105	→	→	41	↑	↑	61	→	→	105	→	→	111	→	→
	Kandieng	110	→	→	70	→	↗	93	↗	↗	141	↓	↓	90	↘	↘	159	↘	↘	93	↘	↓	105	→	→	101	↑	↑	66	→	→	87	→	→	104	→	→
	Krakor	137	→	→	92	→	→	128	↘	→	162	↓	↓	89	→	→	142	→	→	134	↓	↓	105	→	→	113	↗	↗	108	→	→	82	→	→	149	↘	↘
	Phnum Kravanh	159	→	→	64	↘	→	169	→	→	172	→	→	52	→	→	175	→	→	157	→	→	105	→	→	160	→	↗	145	→	→	57	→	→	177	→	→
	Sampov Meas	142	→	→	134	↘	→	75	→	↗	156	↘	↓	130	↓	→	50	→	↑	140	↓	↓	105	→	→	35	↗	↑	105	→	→	91	→	→	138	↘	↘
	Veal Veaeng	178	↘	↘	28	→	→	175	→	→	178	→	→	30	→	→	163	↗	↗	171	→	→	20	→	→	172	→	→	158	→	→	29	→	→	164	→	→
Preah Vihéar	Chey Saen	48	↘	↘	43	→	→	119	↓	↘	89	→	↘	39	→	→	53	↗	↗	117	↓	↓	105	→	→	70	→	→	42	→	→	43	→	→	42	↘	↘
	Chhaeb	38	↘	↘	29	→	→	113	↘	↘	55	↑	↘	27	→	↗	24	↑	↑	115	↘	↓	105	→	→	49	↑	↑	27	→	→	37	→	→	24	→	→
	Choam Khsant	18	→	→	47	→	→	130	↘	→	21	↑	↑	53	→	→	22	↑	↑	68	↘	↘	105	→	→	47	↑	↑	17	→	→	72	→	→	29	→	→
	Kuleaen	66	→	↘	48	→	→	135	↘	→	99	→	↘	42	→	→	62	↑	↑	122	↘	↘	105	→	→	74	↑	↑	39	→	→	56	→	→	57	→	↘
	Rovieng	70	↓	↓	49	→	→	106	↓	↘	69	↓	↓	51	→	→	67	→	↗	118	↘	↘	105	→	→	51	↗	↑	47	→	→	42	→	→	50	↘	↘
	Sangkom Thmei	79	→	↘	41	→	→	126	↓	↓	58	↘	↓	47	→	→	64	↑	↗	132	↘	↘	105	→	→	50	↑	↑	51	→	→	50	→	→	53	↘	↘
	Tbaeng Mean chey	60	↘	↓	42	→	→	124	↘	→	38	↑	→	49	↘	→	47	↑	↑	116	↘	↓	105	→	→	38	↑	↑	40	→	→	44	→	→	41	↘	↘

Region	District	Sub-risk 1 (a)			Sub-risk 1 (b)			Sub-risk 1 (c)			Sub-risk 2 (a)			Sub-risk 2 (b)			Sub-risk 3 (a)			Sub-risk 3 (b)			Sub-risk 4 (a)			Sub-risk 5 (a)			Sub-risk 5 (b)			Sub-risk 5 (c)			HIST	SSP2	SSP5
Prey Vêng	Ba Phnum	117	→	→	134	→	→	89	→	→	116	↑	↑	172	↓	↓	129	↘	↓	107	↗	↗	105	→	→	110	↘	↓	126	→	→	136	→	→	157	→	→
	Kamchay Mear	130	↓	↓	85	→	↗	39	↘	→	122	↗	↑	114	↓	↓	89	↓	↓	145	↘	↘	105	→	→	60	↘	↓	109	→	→	113	→	→	127	↘	↓
	Kampong Leav	100	→	→	134	→	→	60	→	→	96	→	→	137	→	↗	129	↓	↓	60	↑	↑	105	→	→	73	↗	↓	115	→	→	137	→	→	124	→	→
	Kampong Trabaek	127	→	→	119	→	→	100	→	→	122	↑	↑	121	→	→	140	↓	↓	106	↗	↗	105	→	→	119	↓	↓	142	→	→	122	↘	→	155	→	→
	Kanhchriech	126	↓	↓	83	↗	↗	40	→	→	122	→	↗	113	↘	↘	79	↓	↓	135	↘	↘	105	→	→	60	↘	↓	107	→	→	120	→	→	122	↘	↘
	Me Sang	131	↘	↘	112	→	→	72	→	→	122	↑	↑	162	↓	↓	116	↓	↓	133	→	→	105	→	→	90	↘	↓	123	→	→	135	→	→	152	→	↘
	Pea Reang	87	→	→	146	→	→	47	→	→	90	↗	→	135	→	↗	107	↓	↓	56	→	→	105	→	→	60	↗	↘	106	→	→	145	→	→	118	→	→
	Peam Chor	128	→	→	121	→	→	123	↗	→	73	↘	→	126	→	→	147	↓	↘	98	↑	↑	105	→	→	137	→	↘	149	→	→	115	→	→	158	→	→
	Peam Ro	108	→	↗	134	→	→	85	→	→	60	↗	↑	144	→	→	129	↘	↓	64	↑	↑	105	→	→	107	↗	→	124	→	→	129	→	→	133	↗	↗
	Preah Sdach	123	→	→	124	→	→	109	→	→	110	↑	↑	128	→	→	144	↓	↓	95	↑	↑	105	→	→	125	↘	↘	141	→	→	123	→	→	156	→	→
	Prey Veaeng	119	↘	↘	131	→	→	65	→	→	122	↗	↑	163	↓	↓	124	↓	↓	125	→	→	105	→	→	77	→	↓	114	→	→	133	→	→	151	↘	↘
	Sithor Kandal	96	↘	↘	129	→	↗	34	→	→	112	→	→	143	↘	↘	96	↓	↓	85	↘	↘	105	→	→	60	↓	↘	99	→	→	125	→	→	116	↘	→
Rötânôkiri	Andoung Meas	12	→	→	11	→	→	150	→	→	7	↑	↑	10	→	→	57	↑	↑	89	↑	↑	105	→	→	148	→	↘	9	→	→	11	→	→	6	→	→
	Ban Lung	15	→	→	13	→	→	76	→	→	11	↑	↑	13	→	→	2	↑	↑	110	→	→	105	→	→	97	↘	↘	5	→	→	16	→	→	1	→	→
	Bar Kaev	17	→	→	12	→	→	118	→	→	14	↑	↑	15	→	→	10	↑	↑	108	→	→	105	→	→	132	↘	↘	4	→	→	14	→	→	5	→	→
	Koun Mom	20	→	→	17	→	→	48	↗	↑	16	↘	↘	18	→	→	9	↑	↑	119	→	→	105	→	→	89	→	↘	7	→	→	21	→	→	9	→	→
	Lumphat	16	↘	↘	18	→	→	46	↑	↗	22	↗	→	21	→	→	15	↑	↑	105	↓	↓	105	→	→	84	↘	↘	3	→	→	22	→	→	10	→	→
	Ou Chum	14	→	→	10	→	→	122	→	→	8	↑	↑	12	→	→	4	↑	↑	97	↑	↑	105	→	→	129	↘	↓	12	→	→	12	→	→	4	→	→
	Ou Ya Dav	10	→	→	15	→	→	101	↗	↗	31	↗	↑	17	→	→	45	↑	↑	91	→	→	105	→	→	126	→	↘	1	→	→	17	→	→	7	→	→
	Ta Veaeng	4	↗	↗	7	→	→	172	→	→	1	↑	↗	4	→	→	132	↑	↑	61	↑	↑	105	→	→	167	→	→	22	→	→	8	→	→	8	→	→
	Veun Sai	6	↗	↗	9	→	→	144	→	→	2	↑	↗	5	→	→	34	↑	↑	79	↑	↑	105	→	→	143	→	→	16	→	→	9	→	→	2	→	→
Siemréab	Angkor Chum	19	→	→	80	→	→	35	↑	↑	15	↑	↑	76	→	↗	38	↗	↑	25	→	→	105	→	→	29	↗	↑	24	→	→	102	→	→	35	→	↗
	Angkor Thum	32	→	→	66	→	→	117	→	→	25	↗	↗	62	→	→	102	→	↗	45	→	→	105	→	→	81	↑	↑	32	↘	→	86	→	→	51	→	→
	Banteay Srei	45	→	→	58	↘	→	136	→	→	46	↓	→	56	→	→	105	↗	↑	71	↘	↘	105	→	→	112	↗	↑	37	↘	→	68	→	→	63	↘	→
	Chi Kraeng	97	↘	↓	63	→	→	114	→	→	59	↓	↓	70	→	→	115	↗	↗	121	↓	↓	105	→	→	100	↗	↑	54	→	→	64	→	→	84	↘	↓
	Kralanh	24	→	→	116	→	→	1	↗	→	19	↑	↗	98	↑	↑	14	↘	→	14	→	→	105	→	→	6	→	↗	19	→	↗	149	→	→	30	↗	↑
	Prasat Bakong	85	↓	↘	54	↘	→	142	→	→	76	↓	↓	46	→	→	158	→	→	84	↓	↓	105	→	→	142	↗	↑	46	↘	→	68	→	→	83	→	→
	Puok	29	→	↗	91	↘	→	62	↗	→	28	↑	↗	93	→	↗	104	↘	↑	30	→	→	105	→	→	46	↑	↑	29	→	→	116	→	→	61	→	↗
	Siem Reab	67	↘	↘	68	→	→	138	→	→	70	↓	↓	64	→	→	156	→	→	48	↘	↘	105	→	→	138	↗	↑	41	→	→	88	→	→	88	→	→
	Soutr Nikom	99	↘	↓	60	→	→	133	→	→	95	↓	↓	60	→	→	150	→	→	101	↓	↓	105	→	→	136	↑	↑	53	→	→	65	→	→	92	↘	→
	Srei Snam	11	→	→	106	→	↘	14	↗	→	9	↑	↑	92	↗	↗	5	→	↑	8	→	→	105	→	→	11	→	↑	15	→	→	132	→	→	25	→	↗
	Svay Leu	41	→	→	59	→	→	132	→	→	35	→	↘	63	→	→	69	↑	↑	90	↘	↘	105	→	→	99	↗	↑	36	→	→	71	→	→	62	↘	↘
	Varin	27	→	→	62	→	→	112	→	→	18	→	→	55	→	→	66	↗	↑	55	↘	↘	105	→	→	44	↑	↑	20	↘	→	84	→	→	39	↘	↘
Stœng Trêng	Sesan	23	→	→	21	→	→	66	↗	↗	24	↘	↘	19	→	→	36	↑	↑	128	→	→	105	→	→	75	↗	→	21	→	→	26	→	→	11	→	→
	Siem Bouk	30	→	→	32	→	→	90	→	→	49	↗	↘	24	→	→	91	→	→	111	→	→	105	→	→	94	→	→	31	→	→	34	→	→	22	→	→
	Siem Pang	3	↗	↗	14	→	→	139	→	→	6	↗	↑	6	→	→	19	↑	↑	67	↑	↑	105	→	→	118	→	→	13	→	→	18	→	→	3	→	→
	Stueng Traeng	26	→	→	25	→	→	69	↗	→	42	↓	↓	20	→	→	48	↑	↑	126	↘	↘	105	→	→	69	↗	↗	28	→	→	30	→	→	14	→	→
	Thala Barivat	40	↘	↘	26	→	→	96	→	↘	92	↓	↓	22	→	→	65	↑	↗	138	↓	↓	105	→	→	82	→	→	30	→	→	32	→	→	23	→	→
Svay Rieng	Chantrea	148	→	↘	69	→	→	127	→	→	167	↓	↓	79	→	↘	153	↓	↓	156	→	→	105	→	→	139	↓	↓	146	→	→	74	→	→	165	↓	↓
	Kampong Rou	146	→	→	82	→	→	120	→	→	166	↓	↓	82	→	→	133	↓	↓	151	→	→	105	→	→	133	↓	↓	156	↘	→	81	→	→	167	↓	↘
	Romeas Haek	140	↓	↓	81	→	↗	56	↘	→	129	↗	↑	115	↓	↓	101	↓	↓	150	→	→	105	→	→	79	↓	↓	119	→	→	110	→	→	139	↘	↓
	Rumduol	138	→	→	87	→	→	91	↘	→	147	↗	→	104	↘	↘	112	↓	↓	141	→	→	105	→	→	111	↓	↓	144	↘	→	104	→	→	150	↘	↘
	Svay Chrum	134	→	→	88	→	→	81	→	→	128	↑	↑	87	→	↗	117	↓	↓	129	↗	↗	105	→	→	104	↓	↓	143	→	→	101	→	→	134	→	→
	Svay Rieng	133	→	→	87	→	→	85	→	→	122	↑	↑	79	↗	↗	129	↓	↓	131	↗	↗	105	→	→	107	↓	↓	139	→	→	100	→	→	135	→	→
	Svay Teab	141	→	→	84	→	→	102	→	→	165	↘	↘	79	→	→	125	↓	↓	149	→	→	105	→	→	120	↓	↓	154	↘	→	99	→	→	163	↘	↘
Takêv	Angkor Borei	136	→	→	151	↘	↘	121	→	→	68	↓	→	142	↗	→	154	↘	↘	100	↑	↑	105	→	→	130	→	→	157	→	↘	114	→	→	166	→	→
	Bati	105	↗	↗	170	→	→	86	→	→	65	↑	↑	167	→	→	129	↓	↓	47	↑	↑	105	→	→	87	→	↓	129	→	→	153	→	→	142	↗	↗
	Bourei Cholsar	150	→	→	97	↓	↘	137	→	→	141	↓	↓	94	→	↘	166	↓	↓	137	↗	↗	105	→	→	144	→	→	166	→	↘	79	↘	→	173	↘	↘
	Doun Kaev	144	→	→	156	→	→	116	↗	→	94	↑	↑	146	→	→	152	↓	↓	104	↑	↑	105	→	→	127	↘	↘	162	→	→	98	→	→	169	→	→
	Kaoh Andaet	152	→	→	89	↘	↘	140	→	→	144	↓	↓	83	→	↘	170	↓	↓	144	↗	↗	25	→	→	146	→	→	168	→	↘	66	→	→	160	↘	↘
	Kiri Vong	160	→	→	75	↓	↘	145	→	→	154	→	→	48	→	↘	173	↓	↓	152	↗	↗	17	→	→	158	↘	→	168	→	→	51	↘	→	126	↓	↘
	Prey Kabbas	118	→	→	156	→	→	103	→	→	47	↓	→	156	↗	↗	137	→	→	63	↑	↑	105	→	→	121	↗	→	139	→	→	143	→	→	153	↗	↗
	Samraong	132	→	→	168	→	→	105	↗	→	74	↑	↑	160	→	→	139	↘	↓	63	↑	↑	105	→	→	122	↘	↘	155	→	→	127	→	→	161	↗	→
	Tram Kak	143	→	→	166	↘	→	131	→	→	107	↑	↑	152	→	↘	152	↓	↓	87	↑	↑	27	→	→	134	↓	↓	163	→	→	109	↗	→	168	→	→
	Treang	153	→	→	128	↓	↓	134	→	→	148	→	→	101	→	↘	161	↓	↓	131	↗	↗	26	→	→	141	↘	↘	168	→	→	80	→	→	171	↘	↘
Tbong Khmum	Dambae	102	→	→	40	→	→	78	→	→	45	↑	↑	31	→	→	46	↑	↑	124	→	→	105	→	→	102	→	↘	80	→	↘	49	→	→	49	↗	→
	Kampong Siem	55	→	→	99	↗	↗	53	↘	↘	11	→	↑	79	↑	↗	96	↓	↓	82	↘	↘	105	→	→	60	→	→	73	↗	→	89	→	→	76	→	→
	Krouch Chhmar	86	↘	↘	61	↗	→	67	→	↘	13	↗	↑	59	→	→	56	↑	→	99	↘	→	105	→	→	80	→	→	73	→	→	62	→	→	59	→	→
	Memot	120	→	→	33	→	→	108	→	→	100	↑	↑	38	→	→	54	↑	↑	147	→	→	105	→	→	131	↘	↘	95	→	→	41	→	→	69	↗	→
	Ou Reang Ov	94	→	→	94	→	↗	31	→	→	122	→	↗	96	→	→	82	↓	↓	102	→	↘	105	→	→	60	↘	→	92	→	→	106	→	→	99	→	→
	Ponhea Kraek	124	↘	↘	50	→	→	63	→	→	101	↑	↑	50	→	→	41	↗	↗	143	→	→	105	→	→	93	↓	↘	102	→	→	70	→	→	81	→	→
	Tboung Khmum	104	↘	↘	73	→	→	44	→	→	32	↑	↑	67	→	→	68	→	↘	109	→	→	105	→	→	68	↘	→	83	→	↗	78	→	→	77	→	→

4.6 CUMULATIVE MULTI-HAZARD INDEX

The combination of various climate hazards reveals significant risks in Cambodia, particularly in the coastal southwest and, to a very high degree, in the northeast. The data presented here reflects hazards at or above the 50th percentile, indicating that these regions fall within the top half of risk calculations when considering all climate hazard factors. The current period illustrates the baseline hazard index, while future scenarios (SSP2-45 and SSP5-85 for 2020-2039) highlight areas that are likely to experience the most severe hazards in the coming decades. These future projections show similar hazard areas but with a broader spatial extent and a generally higher hazard score, indicating that while the same regions will remain at risk, the magnitude and/or frequency of climate hazards are expected to increase.

It is important to note that areas not highlighted in the analysis will still face climate hazards in both current and future climate scenarios. However, these regions scored lower in the cumulative multi-hazard assessment. Additionally, this analysis focuses solely on the climate hazard component of the overall climate risk assessment, with local-scale exposures and vulnerabilities playing a significant role in determining the final climate risk outcomes.

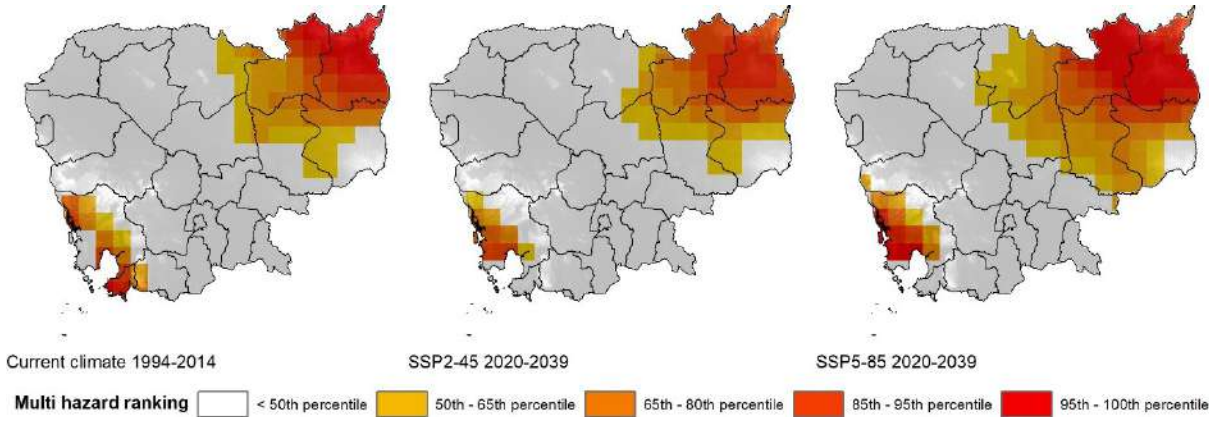


Figure 23. Mult hazard score for current climate (left), future SSP2 scenario (middle) and future SSP5 scenario (right)

5 CLIMATE EXPOSURE

A significant majority of Cambodia's population, approximately 80%, resides in rural areas, with heavy concentrations along the floodplains of the Mekong River and around the Tonle Sap Lake system. [119] This geographic distribution places a large number of people directly in zones highly exposed to recurrent riverine floods and seasonal droughts. [120] Urban populations are also significantly exposed, particularly in the capital, Phnom Penh where residents face amplified heat stress due to the urban heat island effect, where temperatures can be several degrees higher than surrounding rural areas. [121] Along Cambodia's coastline, communities are exposed to the increasing threats of sea-level rise, including inundation and storm surges. [122]

Exposure is further defined by demographics and livelihoods. The heavy reliance of the rural population on agriculture and fisheries means livelihoods are directly exposed through dependence on climate-sensitive natural resources located within these hazard-prone floodplains and coastal areas. [123] Outdoor workers, prevalent in agriculture and construction, face heightened exposure to extreme heat and its associated health risks. [124] Children, the elderly, women (particularly in female-headed households which may face specific vulnerabilities [125]), indigenous populations often residing in resource-dependent areas, and people with disabilities [126] also represent an exposed group.

Furthermore, population exposure is not static. Climate change impacts are recognized drivers of migration, primarily from rural to urban areas. [127] This dynamic process means that climate change can actively redistribute populations, potentially concentrating more people in urban centres that may already be struggling with inadequate infrastructure and services, thereby shifting and potentially amplifying exposure profiles in different locations.

Cambodia's critical infrastructure, including essential transport networks (roads, bridges, rail, ports), water supply systems, and social infrastructure like health facilities and schools, are frequently located within areas prone to climate hazards such as floodplains and coastal zones. [128] Road infrastructure is particularly vulnerable, as existing design standards often do not adequately account for projected increases in flood levels or rainfall intensity. [129] Recent patterns of urban development have also exacerbated exposure by setting up new factories, housing, and other assets in known flood-prone areas. [130]

The economic consequences of infrastructure exposure are substantial. Damage to these assets leads to direct financial losses and significant disruptions. The 2011 floods, for instance, caused an estimated $451 million in damages and $174 million in losses, with transport and agricultural infrastructure bearing a large share respectively. [131] The closure of key road corridors due to flooding or other impacts imposes considerable indirect costs on trade livelihoods and economic activity. [132]

Cambodia's coastline faces direct exposure to several climate change impacts[133]. The most significant is the projected sea-level rise. This exposes low-lying coastal areas, river mouths, and deltas to permanent inundation[134], increased frequency and extent of coastal flooding, saltwater intrusion into vital freshwater sources and agricultural land, and accelerated coastal erosion. [135] The coastline is also exposed to storm surges, the impacts of which are expected to worsen due to the combination of higher sea levels and potentially more intense storms. [136]

Coastal exposure represents a particularly challenging aspect of climate change due to the slow-onset but persistent and largely irreversible. [137]The elements exposed in these coastal zones include communities residing there, critical infrastructure such as ports, roads, and settlements [138], economically important agricultural land susceptible to salinization [139], tourism assets, and valuable coastal ecosystems like mangroves [140] which provide natural protection.

Cambodia's remaining natural forests, covering approximately 36% of the land area in 2020 [141], and its critical natural ecosystems are situated in locations exposed to various climate change impacts. Upland forests face exposure to increased drought stress and potentially higher risks of wildfires. [142] However, the most prominent example of ecosystem exposure is the Tonle Sap Lake Biosphere Reserve, including the lake itself and its vast surrounding seasonally flooded forests and floodplains. [143] This unique ecosystem is highly exposed to alterations in the Mekong River's flood pulse – the timing, duration, and volume of the annual flood – which is being affected by both climate changes of altered rainfall and temperature patterns influencing runoff, as well as the regulation of river flow by upstream hydropower dams.[5]

The agricultural sector, the backbone of Cambodia's rural economy and a major employer exhibits significant exposure to climate change. Major rice cultivation areas are predominantly located in the central lowlands and along the floodplains of the Mekong and Tonle Sap rivers. [144] This places the country's staple crop in areas highly exposed to both floods and droughts, as well as shifts in seasonal water availability. Rainfed agriculture, which is widespread, is particularly exposed to changes in rainfall patterns, including delayed monsoon onset and increased likelihood of drought during critical growing periods. [145]

This geographic and resource exposure translates directly into production exposure. Crop production faces significant risks of yield losses due to factors like heat stress during growing seasons, water stress from droughts, crop damage from floods, and potentially increased prevalence of pests and diseases favoured by changing climatic conditions. [146]

Cambodia's water resources and the infrastructure managing them are significantly exposed to climate change. The nation's surface water resources, dominated by the vast Mekong River and the interconnected Tonle Sap Lake system, are exposed to altered flow regimes resulting from both climate change impacts (changing precipitation patterns and influence of glacial melt upstream) and extensive upstream development of hydropower dam construction and operation. [147] Groundwater resources, crucial for supplementary irrigation and domestic supply, especially during the dry season, are exposed to changes in natural recharge patterns due to altered rainfall seasonality. Furthermore, increased reliance on groundwater extraction is anticipated during projected drier dry seasons, potentially leading to aquifer depletion and degradation of water quality. [148]

5.1 DAMAGE AND LOSSES ASSESSMENT

Cambodia is increasingly affected by climate-related hazards such as floods, droughts, storms, and lightning, which pose significant risks to its people, economy, and environment. Due to its geographic location, reliance on agriculture, and limited infrastructure resilience, the country remains highly vulnerable to climate impacts. Over the past decades, these hazards have caused widespread damage to crops, infrastructure, and livelihoods—particularly in rural areas. Floods are the most frequent and severe, often affecting large portions of the Mekong basin and low-lying provinces. Droughts have also become more recurrent, especially during El Niño years, resulting in water shortages and agricultural losses. Meanwhile, storms and lightning events, though less frequent, continue to cause localized destruction and fatalities. This exposure analysis supports Cambodia’s ongoing efforts to assess and manage climate risk as part of the broader Climate Risk and Vulnerability Assessment (CRVA). By identifying the historical frequency, severity, and spatial distribution of climate hazards, the analysis helps pinpoint provinces and sectors most at risk. These findings are critical for guiding national and sub-national planning, informing adaptation strategies, and strengthening resilience in line with Cambodia’s Nationally Determined Contributions (NDCs) and National Adaptation Plan (NAP).

5.1.1 OBJECTIVE

The main objective of the exposure analysis is to evaluate the frequency, magnitude, and spatial distribution of climate-related hazards and disasters in Cambodia. This analysis helps identify high-exposure areas and informs risk reduction and adaptation strategies.

5.1.2 METHODOLOGY

The methodology for this exposure analysis is designed to evaluate the frequency, severity, and spatial distribution of climate-related hazards across Cambodia, based on historical disaster records. The process integrates both national and international disaster databases and applies a consistent analytical framework to support comparability and evidence-based risk profiling.

Data Sources

This analysis relies on a combination of historical datasets from the following key sources:

- DesInventar Cambodia (1996–2020): A nationally maintained disaster loss database managed by the National Committee for Disaster Management (NCDM). It contains disaggregated records of disaster events at the subnational level, including affected populations, infrastructure damage, and event characteristics.

- EM-DAT (2000–2025): The Emergency Events Database is managed by the Centre for Research on the Epidemiology of Disasters (CRED), which provides standardized global data on natural disasters, including mortality, injury, economic loss, and geographic coverage.

Geospatial Tools: ArcGIS and QGIS were used for spatial analysis, georeferencing of disaster events, and visualization of exposure indicators by province.

Analytical Framework

The analysis followed a structured multi-step process:

- Hazard Selection: The focus was limited to climate-related hazards, including floods (riverine and flash floods), droughts, storms (including tropical cyclones), lightning, and extreme temperature events.
- Data Filtering: Events were filtered by year, province, and hazard type. Only events with associated impact data (e.g., affected population, damage to infrastructure or agriculture) were retained for indicator analysis.

Event Classification and Cleaning:

- Event types were standardized (e.g., harmonizing “riverine flood” and “flash flood” under the broader category of “Flood”).
- Administrative boundaries were verified using the latest subnational coding systems to ensure consistency across datasets.

5.1.3 RESULT BASED ON KEY QUESTIONS:

What types of events have historically affected each province in Cambodia?

The list of significant historical events represents all unique disaster types reported from 1996 to 2025 across both DesInventar and EM-DAT, including both climate-related and non-climate-related hazards.

Climate-Related Hazards

These are directly influenced by climatic conditions and are the primary focus of CRVA:

- **Flood:** Includes riverine floods, flash floods, and urban inundation.
- **Drought:** Long dry spells or rainfall deficits impacting agriculture and water supply.
- **Storm:** Encompasses tropical storms and cyclones with strong winds and rain.
- **Lightning:** Often during monsoon seasons, causing fatalities and fires.
- **Extreme Temperature:** Includes heatwaves and cold spells, increasingly significant under climate change.
- **Water-related Crisis:** Covers water scarcity, low river flows, or ecosystem-related hydrological hazards.

Other Natural Hazards (Non-Climate Related)

These are important for disaster risk management, but outside the CRVA climate scope:

- **Fire (Miscellaneous):** Includes both urban and rural fires unrelated to forest fire classification.

- **Pest Outbreak:** Large-scale insect or disease outbreaks affecting crops and food security.
- **Riverbank Collapse:** Erosion processes causing damage to settlements and roads near riverbanks.
- **Epidemic:** Disease outbreaks like dengue, cholera, or COVID-19, impacting health systems.

Technological / Man-made Hazards

These typically result from industrial activity, infrastructure failure, or human error:

- **Explosion (Miscellaneous):** Detonations or chemical accidents in industrial or residential areas.
- **Air Accident:** Aviation crashes, typically with fatalities.
- **Collapse (Industrial):** Failures of structures such as buildings, bridges, or dams.
- **Miscellaneous Accidents (General):** Other unspecified incidents not classifiable under standard categories.

5.1.4 CLIMATE-RELATED HAZARD EVENT COUNTS BY SOURCE

The table 9 presents a comparative summary of climate-related hazard event counts in Cambodia based on data compiled from two primary sources: DesInventar and EM-DAT, covering the period from 1996 to 2025. The data include six key hazard types: flood, drought, storm, lightning, extreme temperature, and water-related crises. For each hazard, the number of recorded events in both DesInventar and EM-DAT is shown, along with the combined total, offering an integrated view of the national hazard profile.

Floods represent the most dominant hazard, with a total of 3,742 events recorded—3,722 from DesInventar and an additional 20 event from EM-DAT—constituting nearly half of all climate-related hazard events in Cambodia during the study period. This confirms the high recurrence and widespread impact of floods across the country. Storms are the second most frequently reported hazard, with a combined total of 1,971 events, of which the vast majority (1,963) are documented by DesInventar and only 8 by EM-DAT. Droughts rank third, with 1,379 total events, 1,375 of which are from DesInventar, indicating their substantial impact on agriculture and water availability.

Lightning is also a significant hazard, with 1,076 events reported exclusively in DesInventar. Despite its localised nature, lightning causes considerable fatalities and property damage annually, particularly in rural areas, but is not reflected in global datasets such as EM-DAT. Meanwhile, extreme temperature events and water-related crises appear rarely in the records, with only 1 and 3 events respectively, all sourced from EM-DAT. Although their current frequency is low, these hazards are likely to become more prominent under future climate scenarios influenced by global warming and changing hydrological conditions.

Overall, the data clearly demonstrate that DesInventar provides a far more comprehensive record of climate-related hazards in Cambodia, especially for subnational and frequent events such as floods, droughts, and lightning. In contrast, EM-DAT primarily captures major, large-scale events and may underrepresent localized or recurrent hazards. Therefore, combining these two datasets enhances the accuracy and completeness of climate risk assessments, enabling more informed decision-making for national disaster preparedness and adaptation planning.

Table 9. Climate-related hazard event in Cambodia (1996-2025

Hazard Type	DesInventar	EM-DAT	Combined Total	Percentage (%)
Flood	3,722	20	3,742	45.79%
Storm	1,375	4	1,379	24.12%
Drought	1,963	8	1,971	16.87%
Lightning	1,076	0	1,076	13.17%
Extreme Temperature	0	1	1	0.04%
Water-related Crisis	0	3	3	0.01%

Which provinces experience the highest recurrence of disasters?

The bar chart illustrates the total number of climate-related hazard events recorded in selected Cambodian provinces over the period from 1996 to 2025, based on combined data from DesInventar and EM-DAT. Each bar represents the aggregate count of flood, drought, storm, lightning, and other climate-related disasters reported in a given province. The values demonstrate significant variation across provinces, reflecting both geographic exposure and the strength of local disaster reporting systems.

Kampong Cham province ranks highest, with a total of 257 recorded climate-related events, followed closely by Prey Veng (219 events) and Kandal (214 events). These provinces, all situated in the flood-prone lowland areas of the Mekong River Basin, consistently report high exposure to recurring hazards such as riverine floods and seasonal droughts. Kampong Thom and Battambang, also among the top five, show similarly high frequencies, which are likely influenced by their large agricultural areas and vulnerability to both flood and drought cycles.

The high recurrence of disasters in these provinces signals a critical need for targeted adaptation planning and improved local risk reduction strategies. These areas should be prioritized for climate resilience investments, including infrastructure improvements, early warning systems, and community-based disaster preparedness. The findings underscore the value of combining national (DesInventar) and international (EM-DAT) datasets to develop a comprehensive understanding of subnational climate exposure patterns across Cambodia.

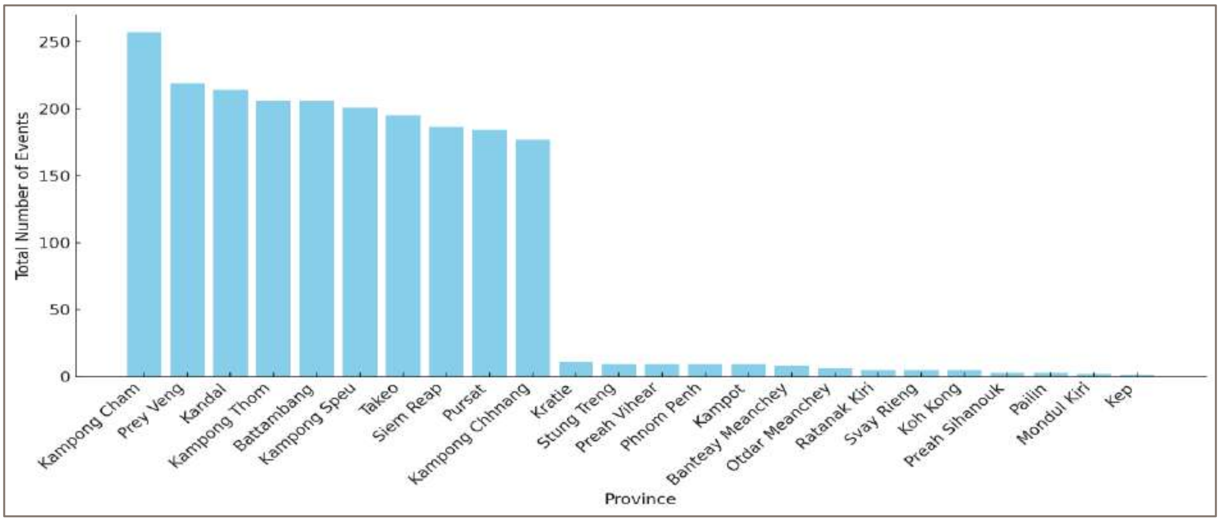


Figure 24. Total number of climate-related hazard events in selected Cambodian provinces (1996 – 2025)

What are the most frequent impacts by province (e.g., affected population, infrastructure damage, economic losses)?

The table presents a comprehensive ranking of Cambodian provinces based on their total combined impacts from climate-related hazards between 2000 and 2025, utilizing data integrated from both EM-DAT and DesInventar. The assessment includes five core impact indicators: total affected population, number of injured, number of killed, number of homeless, and total economic losses in USD. The data are structured to compare values recorded independently in EM-DAT and DesInventar, while also presenting a combined figure to reflect the cumulative burden per province.

Pursat province ranks highest overall, with an estimated 18.27 million people affected by climate-related disasters and a total economic loss of approximately USD 1.99 billion. Kratie follows closely with 16.67 million affected and over USD 1.70 billion in damages. Battambang and Kampong Chhnang also exhibit high levels of human impact and financial losses, exceeding 14 million people affected and over USD 1.7 billion in combined economic damages. These figures underscore the severe and recurring nature of disasters in provinces situated along the Mekong and Tonle Sap river systems, where floods and droughts frequently disrupt livelihoods, infrastructure, and agricultural systems.

The number of injured, killed, and homeless individuals—data captured primarily through DesInventar—adds further depth to the human toll of these hazards. Battambang, for instance, reports over 870 injuries, 78 deaths, and 8,700 homeless due to disasters over the assessment period. These values reflect both the intensity of individual events and the cumulative impact of recurring hazards on vulnerable communities.

In conclusion, the provinces most severely impacted by climate-related hazards in Cambodia are those with high exposure to hydrometeorological extremes and large, agriculturally dependent populations. The data emphasize the urgent need for integrated disaster risk reduction, targeted climate adaptation interventions, and enhanced resilience planning, particularly in Pursat, Kratie, Battambang, and Kampong Chhnang. By combining both national and international disaster records, this analysis provides a holistic view of where the human and economic costs of climate impacts are most concentrated.

Table 10. Disaster Impacts by Province in Cambodia: Human Loss, Affected Population, and Economic Damages

No	Province	Number of Injured (Person)	Number of Killed (Person)	Number of Homeless (Person)	Total Affected Population (Person)	Total Economic Loss (USD)
1	Banteay Meanchey	640	61	7800	14598913	1288100000
2	Battambang	870	78	8700	15310054	1869000000
3	Kampong Cham	600	55	6200	13322708	1578000000
4	Kampong Chhnang	720	59	6900	14197886	1711100000
5	Kampong Speu	0	0	0	10296905	300100000
6	Kampong Thom	0	0	0	8374977	1284000000
7	Kampot	0	0	0	7937320	700100000
8	Kandal	520	50	5700	13897886	1681100000
9	Koh Kong	0	0	0	3758870	160000000
10	Kratie	950	92	8900	16670799	1708100000

No	Province	Number of Injured (Person)	Number of Killed (Person)	Number of Homeless (Person)	Total Affected Population (Person)	Total Economic Loss (USD)
11	Otdar Meanchey	0	0	0	6525183	868000000
12	Phnom Penh	0	0	0	7233363	800000000
13	Preah Vihear	0	0	0	8074977	1354000000
14	Prey Veng	590	53	6000	13238526	1591100000
15	Pursat	1200	85	10500	18267436	1989100000
16	Ratanak Kiri	0	0	0	5178144	661000000
17	Siem Reap	470	48	5300	9007413	1090000000
18	Stung Treng	0	0	0	9990136	777100000
19	Svay Rieng	0	0	0	7477413	760100000
20	Takeo	450	45	5000	11657863	1100100000
21	Kep	0	0	0	300000	0
22	Preah Sihanouk	0	0	0	305817	0
23	Mondul Kiri	0	0	0	211091	0
24	Pailin	0	0	0	2259360	670000000

Which sectors are most affected by each type of event?

The table provides a detailed summary of the sectoral impacts of climate-related hazards in Cambodia, drawing from two complementary disaster data sources: DesInventar (1996–2020) and EM-DAT (2000–2025). It systematically categorizes six major climate-related hazards—flood, drought, storm, lightning, extreme temperature, and water-related crisis—and maps the corresponding affected sectors, such as agriculture, education, health, and infrastructure.

Floods emerge as the most disruptive hazard across nearly all sectors. According to DesInventar, floods have affected approximately 2 million hectares of crops and damaged 947 schools, 1,839 hospitals, and nearly 25 kilometres of roads. EM-DAT data further corroborates the severe impact of floods, reporting millions of dollars in direct economic damages and consistently high numbers of affected populations. This highlights the extensive and multidimensional burden floods impose on both public services and livelihoods.

Droughts predominantly affect agriculture, with over 1.1 million hectares of crops lost according to DesInventar. This has direct consequences on food security and rural incomes. The education and health sectors are also impacted, with more than 1,000 facilities in each category reporting damage or operational disruption during drought events. EM-DAT captures droughts primarily through broader population-level and economic loss data, emphasizing regional-scale crises.

Storms and cyclones significantly damage infrastructure, health facilities, and schools. DesInventar data indicates over 5,000 meters of roads were damaged, with 210 hospitals and 74 schools also affected. EM-DAT data reflects the intensity of storm-related economic impacts through damage valuation but lacks the sector-specific granularity of DesInventar.

Lightning hazards, though highly localized, have a distinct impact on human life. DesInventar records over 1,190 deaths and 661 injuries caused by lightning, while EM-DAT does not report on this hazard, pointing to underrepresentation in global datasets.

Extreme temperature and water-related crises appear less frequently in the dataset. EM-DAT records a few such events, noting emerging impacts on public health and water access. However, DesInventar does not yet contain detailed sectoral records for these categories, suggesting the need for improved monitoring of emerging climate risks.

In conclusion, the combined data from DesInventar and EM-DAT presents a comprehensive picture of sectoral vulnerability in Cambodia. Floods and droughts have the widest and most profound impacts, affecting all major sectors, especially agriculture, education, and health. The integration of both data sources enables a more holistic understanding of how different hazard types disrupt essential systems and services. These findings reinforce the urgency of mainstreaming disaster risk reduction and climate resilience planning into Cambodia's development policies, with tailored interventions for the most frequently affected sectors.

Table 11. Sectoral Impacts of Major Climate-Related Hazards in Cambodia: Comparison of DesInventar (1996–2020) and EM-DAT (2000–2025) Records

Hazard Type	Affected Sectors	DesInventar Records (1996–2020)	EM-DAT Records (2000–2025)
Flood	Agriculture	2,000,000 ha crops affected	Major contributor to the affected population and economic loss
	Education	947 schools damaged	$Millions in direct damage reported
	Health	1,839 hospitals affected	
	Infrastructure	24,683 m of roads damaged	
Drought	Agriculture	1,100,000 ha crops lost	4 major events
	Health	1,154 health facilities affected	Significant agricultural impact, especially in Battambang, Kampong Thom, and Kratie
	Education	1,110 education centres impacted	8 major storms reported
Storm	Infrastructure	5,458 m of roads damaged	Losses primarily from wind damage to housing and public infrastructure
	Health	210 hospitals affected	
	Education	74 schools damaged	
Lightening	Health (Fatalities and Injuries)	1,191 people killed 661 people injured	Not reported in EM-DAT
Extreme Temperature	Public Health	No records in DesInventar	1 recorded event Related to extreme heat and human health
Water-related Crisis	Infrastructure (Water access, irrigation)	Not disaggregated	3 events reported Linked to water shortages and potential irrigation disruption

What is the typical magnitude and duration of these events?

Climate-related hazards in Cambodia vary significantly in both magnitude and duration, depending on the type of event and geographic location. Across both national and international datasets, floods, droughts, storms, and lightning emerge as the most prominent hazards in terms of frequency, impact, and persistence.

Floods are the most frequent and impactful events. A typical flood in Cambodia affects hundreds of thousands of people and causes significant physical damage, particularly in low-lying provinces along the Mekong and Tonle Sap. Events often result in the destruction of roads, schools, and health facilities. On average, flood events last between 7 and 30 days, depending on the scale of river overflow and rainfall duration. Major flood years—such as 2000, 2011, and 2013—lasted for weeks and triggered large-scale humanitarian responses.

Droughts have slower onset but longer duration, typically lasting from 2 to 6 months, especially during El Niño years. These events severely disrupt agricultural activities, with some droughts affecting over a million hectares of crops. Although fatalities are uncommon, the economic and livelihood impacts are long-lasting, particularly in rainfed farming areas such as Kampong Thom, Battambang, and Banteay Meanchey.

Storms, including tropical cyclones, occur less frequently but have intense short-term impacts. They typically last 1 to 3 days, but damage to housing, power lines, schools, and roads can take weeks or months to repair. Notable storm events such as Typhoon Ketsana have caused tens of thousands of people to be displaced and millions in losses within a very short period.

Lightning events are highly localized and usually occur during the monsoon season (May to October). Although each event is brief, lightning strikes cumulatively result in a high number of fatalities—over 1,190 deaths reported in the past two decades—with typical incidents involving 1–3 deaths or injuries. These events are often underrepresented in global disaster databases but are well-documented in national systems like DesInventar.

Extreme temperatures and water-related crises are less frequently reported but are increasingly emerging due to climate change. Heatwaves tend to last several days to weeks, mainly in the pre-monsoon months of April and May, affecting health and productivity. Water crises, though rare, have been recorded during severe dry seasons, affecting water supply and agriculture.

In Cambodia, climate-related disasters range from short-lived but deadly events like lightning and storms to prolonged and economically disruptive hazards such as droughts and floods. Floods stand out for their widespread and recurring human and economic impact, while droughts persist longer with deep impacts on food security. This variation in both magnitude and duration underscores the importance of tailored disaster risk management strategies that address both rapid-onset and slow-onset climate threats.

Table 12. Typical Magnitude and Duration of Major Climate-Related Hazards in Cambodia

Hazard Type	Typical Magnitude	Typical Duration
Flood	Affects 100,000–500,000+ people per event Millions in economic losses Damage to roads, schools, hospitals	7–30 days
Drought	Affects 100,000–1,000,000+ people Up to 1.1 million ha crops lost Major impact on agriculture and water supply	2–6 months
Storm	Affects 20,000–100,000 people Damage to housing and infrastructure	1–3 days

	Dozens of deaths and injuries per major event	
Lightening	1–3 deaths or injuries per event Over 1,190 deaths recorded in 20 years	Instantaneous (recurring)
Extreme Temperature	Health-related effects (heatstroke, vulnerability of elderly and outdoor workers) Emerging risk	Several days to weeks
Water-related Crisis	Limited data; impacts include crop stress and water shortages during dry spells	Days to weeks (slow onset)

Are there seasonal patterns associated with these events?

Yes, there are clear and well-documented seasonal patterns associated with climate-related hazards in Cambodia. These patterns correspond closely with the country's tropical monsoon climate, which consists of two primary seasons: the wet season (May to October) and the dry season (November to April). The seasonal timing of disasters significantly influences agricultural productivity, water resource availability, and disaster preparedness.

Floods are strongly associated with the wet season, particularly from July to October, when heavy monsoonal rains and overflow from the Mekong River cause widespread inundation. Flash floods may occur earlier in the wet season during intense local rainfall, while large-scale riverine floods typically peak in September or October. Provinces along the Mekong and Tonle Sap, such as Kandal, Prey Veng, Kampong Cham, and Battambang, are most affected during this time.

Droughts occur predominantly during the dry season, from January to April, with peak severity often in March and April, just before the onset of rains. However, drought conditions may extend longer in years with delayed or failed monsoons, particularly during El Niño events. Drought impact on crops is most visible in the late dry season and early wet season planting periods.

Storms and tropical cyclones exhibit a shorter seasonal window, typically occurring between August and November, aligning with the tail end of the wet season. These events often affect coastal and inland provinces with heavy rainfall and damaging winds, as seen in past events like Typhoon Ketsana.

Lightning events are most frequent during the early and late stages of the wet season—from May to June and September to October. These months experience high atmospheric instability and convective activity, leading to intense thunderstorms.

Extreme temperatures are most common during the late dry season, especially in April and early May, when the sun is at its zenith, and humidity builds before the first rains. These months often record the year's highest temperatures, sometimes exceeding 40°C, with growing public health risks.

Water-related crises, such as shortages and low river levels, typically occur at the end of the dry season (March to May), especially in drought years, affecting drinking water access and irrigation for early wet-season crops.

Cambodia's climate-related disasters show distinct seasonal trends, with floods and storms dominating the wet season and droughts, extreme heat, and water scarcity concentrated in the dry season. Understanding these temporal patterns is essential for effective disaster preparedness, early warning system deployment, and seasonal planning in agriculture and water management.

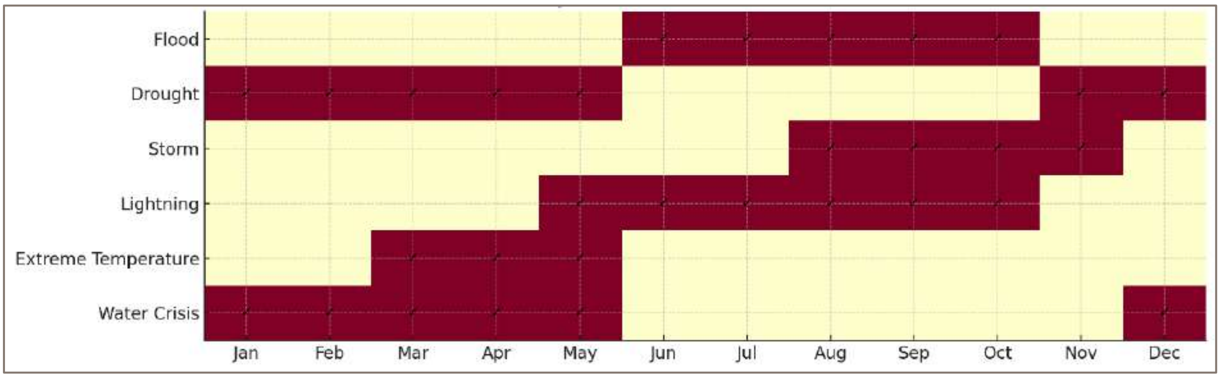


Figure 25. Seasonal Activity of Climate-Related Hazards in Cambodia

What are the long-term trends (e.g., increasing, stable, decreasing)?

The figure illustrates the long-term trends in climate-related hazard frequency in Cambodia from 1996 to 2025, using a combined dataset from DesInventar and EM-DAT. The data are presented as a 3-year rolling average, which smooths year-to-year fluctuations and allows for clearer identification of directional trends across four major hazard types: floods, droughts, storms, and lightning.

Floods display the most prominent and consistent upward trend throughout the observed period. From an average of approximately 10–12 events annually in the late 1990s, the frequency increased steadily to more than 18 events per year by the early 2020s. This shift reflects both the growing hydrological instability linked to intensified monsoon activity and improvements in event monitoring and local reporting systems. Notably, sharp increases follow known high-impact flood years such as 2000, 2011, and 2013.

Droughts exhibit a moderate but steady upward trajectory. In the late 1990s and early 2000s, annual drought events averaged 3–5 per year. By the mid-2010s—particularly during the 2015–2016 El Niño period—this average rose to 9–11 events per year. This trend points to increasing climate variability, prolonged dry spells, and heightened agricultural exposure in central and northwestern provinces.

Storms (including tropical cyclones and strong wind events) show a gradual increase in frequency, although the overall event count remains lower than for floods or droughts. From fewer than 3 events per year in the early 2000s, the rolling average rises to 4–5 events per year in the most recent decade. This trend suggests a modest intensification in storm activity and may also reflect better detection and classification of localized storm events in national records.

Lightning incidents demonstrate a consistent and notable increase over time. While only 4–5 events were reported per year in the late 1990s, by the 2020s, annual averages exceed 12 incidents. This growth may be partially attributed to more comprehensive community-level reporting in DesInventar, but it also aligns with rising convective storm activity during Cambodia's rainy season.

The trends indicate a clear intensification of climate-related hazards in Cambodia over the past three decades. Floods and droughts, in particular, have shown the most significant increases, both in frequency and duration, signalling heightened hydrometeorological risk under changing climatic conditions. The growing presence of lightning and storms further underscores the need to strengthen localized early warning systems and integrate climate risk information into provincial and national adaptation strategies. These trends provide strong evidence for prioritizing climate resilience investments in the most exposed regions and sectors.

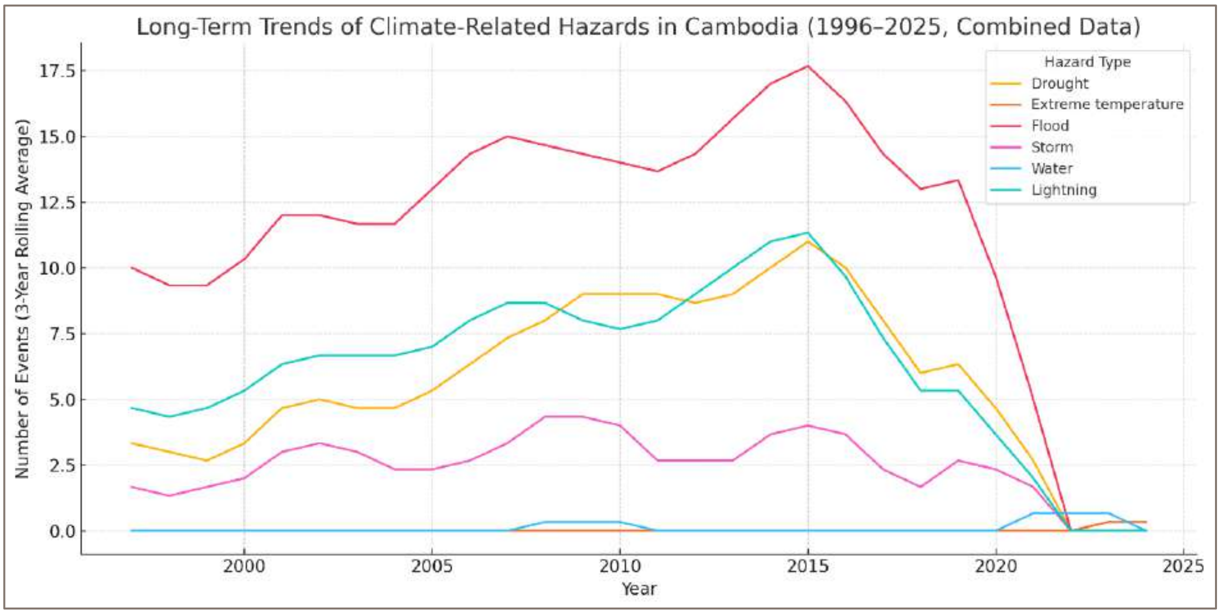


Figure 26. Long-term trends of Climate related hazard in Cambodia (1996-2025, Combined Data)

Where are the data gaps or missing records (by province or event type)?

An analysis of both DesInventar (1996–2020) and EM-DAT (2000–2025) datasets reveals significant gaps and inconsistencies in disaster event records for Cambodia, particularly concerning spatial (provincial) coverage, event types, and impact categories. These gaps have implications for the completeness of climate risk assessments and the development of evidence-based adaptation strategies.

1. Geographic (Provincial) Data Gaps

   - Underreported Provinces: Several provinces—particularly remote, mountainous, and less densely populated areas—show a low frequency of reported events despite being ecologically vulnerable. For instance:
   - Mondulkiri and Ratanakiri have sparse records in both datasets, despite their exposure to storms, droughts, and lightning.
   - Pailin, Kep, and Preah Vihear also have significantly fewer entries, suggesting potential underreporting rather than reduced exposure.
   - Urban Bias: Provinces such as Phnom Penh and provincial capitals may be overrepresented in event records due to more robust monitoring, infrastructure, and reporting mechanisms, while rural areas lack similar documentation.

2. Event Type Gaps

   - Lightning: While DesInventar records over 1,190 lightning-related deaths between 1996 and 2020, EM-DAT does not include any lightning data for Cambodia. This highlights a critical gap in global reporting for localized but deadly hazards.

- Extreme Temperatures and Water-Related Crises are underrepresented in both databases, with EM-DAT recording only one heat-related event and three water crises. These hazards are likely to become more relevant under climate change but are currently overlooked in national tracking systems.

- Slow-onset events like droughts are often under-detected, especially in EM-DAT. While DesInventar provides subnational drought records, EM-DAT's entries are sparse and lack detailed impact disaggregation, likely due to the less visible, cumulative nature of drought impacts.

- Secondary Impacts such as crop-specific losses, infrastructure breakdowns, or livestock mortality are rarely captured, limiting sector-specific vulnerability analysis.

3. Impact Data Gaps

- Missing Disaggregation: Many records, especially in EM-DAT, lack detailed breakdowns for injured, killed, homeless, or affected populations. Similarly, economic loss data is frequently missing or inconsistently reported, particularly at the subnational level.

- Sectoral Impacts (e.g., on education, health, or transportation infrastructure) are more available in DesInventar but still incomplete. Most provinces lack comprehensive sector-wise reporting, making it difficult to assess localized resilience needs.

5.2 SPECIFIC EXPOSED AREAS

5.2.1 GENDER ASSESSMENT

Climate change presents a profound and escalating risk to Cambodia's development trajectory, with its impacts profoundly shaped by existing gender inequalities. Climate change is not a gender-neutral phenomenon; rather, its effects are disproportionately borne by women and girls across various sectors due to pre-existing socio-economic disparities and traditional gender roles. Women in Cambodia face amplified vulnerabilities in agriculture, water resources, ecosystems, coastal environments, livelihoods, and human health. These vulnerabilities stem from systemic barriers such as limited access to land, credit, information, and decision-making platforms, which restrict their capacity to adapt and recover from climate shocks.

Women, particularly those residing in low-income and rural areas of Cambodia, are disproportionately affected by climate change. This is primarily because their livelihoods are often intrinsically linked to climate-sensitive resources, and they are embedded within societal structures marked by entrenched inequalities. Discriminatory cultural norms, coupled with limited access to critical assets such as land, credit, and vital information, and their persistent underrepresentation in decision-making processes, collectively erect formidable social, economic, and political barriers. These barriers severely curtail women's capacity to cope with and effectively recover from climate-induced disasters. [149]

Additionally, traditional gender roles often assign women primary responsibility for securing essential household resources such as food, water, and fuel. [150] When these resources become scarce due to a changing climate, the burden on women intensifies significantly. This increased workload and responsibility can create a reinforcing negative feedback loop, a cycle of vulnerability and disempowerment. Increased water scarcity means women and girls must spend more time and effort collecting water. [151] This additional time burden directly limits their opportunities for education, engaging in income-generating activities, or participating in community governance and decision-making processes. [152] Concurrently, their pre-existing limited access to productive resources and their marginalization from power structures mean they are less able to independently adopt adaptive strategies or influence the design of broader climate resilience initiatives. This dynamic traps women in a continuous state of heightened vulnerability, where climate impacts exacerbate existing gender inequalities, which in turn diminish their adaptive capacity, making them even more susceptible to future climate shocks. Intervention planning that does not explicitly recognize and address these underlying gendered constraints risks being ineffective and may even inadvertently worsen existing inequalities.

Climate shocks and extreme weather events lead to significant livelihood losses across Cambodia, with women particularly affected due to their concentration in climate-sensitive and informal sectors such as agriculture, the garment industry, and petty trade. [153] Approximately 70% of women in Cambodia are engaged in vulnerable employment. [154]

When livelihoods are disrupted, women's unpaid household and care work burdens increase substantially. [155] This often compels women to work harder, travel farther to secure resources, or take on additional informal jobs, frequently without adequate protection or social safety nets. [156] This situation highlights a systemic issue where climate change not only destroys existing livelihoods but also perpetuates economic inequality by excluding women from new growth sectors.

Women also face significant barriers to accessing new, climate-resilient economic opportunities within the emerging green economy. This is largely due to their traditional underrepresentation in these sectors, coupled with limited access to finance, information, and discriminatory laws and social norms. [157] Furthermore, male-dominated migration as a coping strategy can lead to an increase in women-headed households, which, while demonstrating women's resilience, also places additional responsibilities and vulnerabilities upon them. [158] Effective climate action must actively dismantle these barriers and create equitable pathways for women to participate in and benefit from a green transition, ensuring that climate resilience efforts do not inadvertently widen the gender economic gap.

Agriculture and Food Security

- Agriculture forms the backbone of rural livelihoods in Cambodia, supporting the majority of the population. [159] This sector is highly dependent on climate-sensitive natural resources, making it acutely vulnerable to changing weather patterns. Women constitute a substantial portion of the agricultural workforce, producing up to 80% of food in many developing countries. [160] Climate change, manifested through increased droughts, floods, and extreme heat, directly compromises agricultural output, leading to significant declines in crop yields. For instance, rice productivity, a staple crop, is projected to decline by 10-15% by the 2040s. [161] These impacts impose a major economic burden and exacerbate food insecurity, particularly for women who often bear the primary responsibility for ensuring their families' food security.[162]
- Women farmers frequently face significant constraints that limit their adaptive capacity. They have limited access to crucial inputs such as land ownership, with ~12% of landowners globally being women and only 12% of women-headed households in Cambodia entitled to land. [163] Furthermore, they struggle with access to credit, information on climate-smart agricultural technologies, drought-resistant seeds, and timely weather forecasts. [164] Their underrepresentation in decision-making bodies, such as forest committees and benefit-sharing mechanisms related to climate mitigation frameworks, further marginalizes their voices in shaping agricultural

policies and interventions. [165] A notable pattern observed is that women are much less likely to reduce their work hours during extreme climate events like heatwaves and droughts, even though overall agricultural labour effort declines. [166] This indicates that women's labour in agriculture is often a non-negotiable necessity for household survival, especially given their limited alternative livelihood options and primary role in food provision. This persistence, while vital for community resilience, often comes at a significant cost to their own health and well-being, a sacrifice that frequently remains unacknowledged in policy and support mechanisms.

Water Resources and Access

- Climate change profoundly impacts Cambodia's hydrological cycle, leading to increased frequency and intensity of both floods and droughts. These extremes significantly compromise the accessibility and quality of water, sanitation, and hygiene (WASH) services across the country. [167] Women and girls disproportionately bear the burden of securing water for their families, often having to travel longer distances and spend more time on this task when resources become scarce. [168]
- The scarcity and contamination of water, particularly from floods affecting water quality[169], lead to increased time burdens for women and girls. This additional time spent on water collection diverts them from other essential activities, including education or income-generating opportunities. [170] Moreover, unsafe water sources contribute to a higher incidence of water-borne diseases, which disproportionately affect women and children. [171] A deeper examination reveals that this immediate burden of water insecurity on women and girls has profound, long-term, systemic consequences. The time diverted from schooling or productive economic activities perpetuates a cycle of low educational attainment and economic marginalization for future generations. This limits human capital development, reduces economic opportunities, and reinforces existing gender inequalities, making it harder for these households to escape poverty and build resilience against future climate shocks.
- Furthermore, women in Cambodia face significant barriers in water governance. They have less access to irrigation water than men and possess limited influence in local water allocation decisions, often being underrepresented at water user meetings where such critical discussions occur. [172] Their voices are frequently excluded from broader water system planning, leading to solutions that may not adequately address their specific needs or leverage their unique knowledge as primary water managers at the household level. [173]

Ecosystems and Natural Resource Dependence

- Rural communities in Cambodia, and women in particular, are heavily reliant on natural resources derived from ecosystems such as forests and fisheries for their livelihoods and food security. [174] Climate change exacerbates the degradation of these vital ecosystems, contributing to phenomena like deforestation and biodiversity loss. [175]
- The loss of forest land, often due to commercial concessions and widespread deforestation, directly impacts women's traditional practices of food provisioning, such as the collection of non-timber forest products, and their opportunities for non-farm income. [176] This leads to heightened food insecurity and increased stress within households. Similarly, broader biodiversity loss affects food security and income, especially for women who may depend on specific species or onshore fishing activities. [177] The degradation of ecosystems, amplified by climate change, directly

undermines women's traditional roles as providers and managers of household resources. When these roles become harder to fulfil due to resource scarcity, it can lead to heightened economic stress within the household, which in turn has been linked to increased gender-based violence against women. [178]

- Compounding these impacts, women face substantial challenges related to land ownership and control over natural resources. Despite traditional inheritance rights, they often lack formal land titles. [179] Their underrepresentation in decision-making bodies concerning natural resource management, such as forest committees, further limits their ability to protect and manage these critical resources. [180]

Coastal Environments and Livelihoods

- Cambodia's extensive coastline is highly vulnerable to the multifaceted impacts of climate change, including sea-level rise, more intense ocean storms, inundation, and saltwater intrusion. [181] Coastal livelihoods, particularly those dependent on fisheries, are acutely susceptible to these environmental shifts. [182]
- Climate impacts on coastal ecosystems, such as the loss of vital mangrove forests [183], directly threaten the livelihoods of coastal communities, with distinct gendered implications. While men in these communities might possess the flexibility to shift to different, potentially more lucrative forms of fishing, such as deep-sea fishing, in response to environmental changes, women's livelihood options within community fisheries are often far more constrained. [184] They are typically limited to less profitable activities, such as post-harvest processing and sales. This disparity is often reinforced by social beliefs that deem fishing as hazardous for women, thereby restricting their economic choices and their ability to adapt to evolving coastal conditions. [185]
- Furthermore, women's participation in fishery management and broader coastal decision-making processes is significantly limited. This is often due to their disproportionate homecare responsibilities or a perceived lack of competence stemming from lower formal education levels. [186] This exclusion means that their unique knowledge of coastal resources and household needs, gained through their daily interactions with the environment, is frequently overlooked in adaptation planning, leading to less effective and less equitable interventions.

Human Health and Well-being

- Women and girls, due to their physiological characteristics, traditional caregiving roles, and socio-economic status, face specific and heightened health risks. [187] Extreme heat impacts domestic work and outdoor labour, leading to health issues such as dehydration and affecting women's reproductive health and overall quality of life. [188] Changing rainfall patterns and increased floods and droughts alter mosquito habitats and compromise water quality, leading to a rise in water- and vector-borne diseases like malaria, dengue, cholera, and diarrheal illnesses. Women are often more exposed to standing water during domestic tasks and may be physiologically more susceptible to certain vector-borne diseases, such as pregnant women being twice as likely to attract mosquitoes. [189]
- Climate change also directly impacts maternal and neonatal health, particularly when disasters limit access to essential services and healthcare. [190] Women's traditional roles as primary caregivers mean they assume additional, often immense, burdens when climate disasters lead to illness or injury within the family. This intensifies their

unpaid work and negatively affects their own health and well-being. [191] This immense, often invisible, burden of caregiving restricts their time, energy, and access to resources for their own well-being.

- The socio-economic pressures created by climate change also act as a "threat multiplier" for gender-based violence (GBV). Research indicates a surge in GBV, including intimate partner violence, conflict-related sexual violence, human trafficking, and child marriage, as social and economic stresses intensify. This reveals an often hidden layer of vulnerability that demands explicit consideration in climate and development interventions. Access to healthcare facilities can be severely limited during climate crises, and women's specific health needs, such as reproductive health services and safe sanitation facilities, are frequently overlooked in emergency responses and infrastructure planning. [192]

The climate crisis is fundamentally not "gender neutral"; its impacts are experienced differently by women and men due to existing gender dynamics, societal roles, and entrenched inequalities. [193] This differential experience means that climate change acts as a "threat multiplier," worsening existing gender inequalities. If a community already exhibits unequal access to resources, education, or decision-making power between genders, a climate shock, such as a prolonged drought or a severe flood, will not affect everyone equally. Women, who may already possess less control over land or financial assets, often bear a disproportionately heavier burden and have fewer mechanisms to cope with or recover from these impacts. This dynamic means that climate action if it is to be truly effective and equitable, must explicitly address these underlying gender inequalities. Failing to consider these gendered dimensions risks perpetuating and even deepening existing injustices, thereby undermining the very goals of sustainable development and human rights. [194]

5.2.2 SOCIAL AND CHILD PROTECTION

Cambodia's social protection system has matured however ~18% of the population still lives in poverty, and a significant portion remains at risk of impoverishment in the face of shocks like climate-related natural disasters. [195] Critically, children, pregnant women, and the elderly remain largely untargeted by existing social protection interventions, despite being identified as among the most vulnerable to climatic and economic shocks. [196] Overall access to social protection remains limited, with less than 30% of the population having access to even partial social protection.[197] The populations identified as most susceptible to the adverse impacts of climate change are precisely those least covered by existing social safety nets. This fundamental mismatch is further underscored by the overall limited social protection coverage. The current social protection system, despite its recent advancements, is not adequately designed or scaled to effectively protect the most climate-vulnerable segments of the population[198].

Rising minimum and maximum temperatures, coupled with high atmospheric moisture, create hotter apparent conditions that disproportionately affect the elderly, pregnant women, children and newborns, people with chronic illnesses and disabilities, and particularly outdoor workers. [199] These conditions exacerbate existing vulnerabilities, including poor health status, and increase the prevalence of climate-sensitive health risks. These include vector-borne diseases such as malaria and dengue fever, malnutrition, diarrhoeal diseases, and other conditions like rodent-borne diseases, respiratory tract infections, heat-related illnesses, as well as mental health impacts. [200]

Extreme climate events, including heat waves, floods, and droughts, significantly disrupt schooling. In 2024, millions of students globally had their schooling interrupted, with Cambodia specifically shortening school days due to heat waves. [201] Rising temperatures, storms, and floods can directly damage school infrastructure and supplies, impede routes to school, and create unsafe learning conditions, thereby impacting students' concentration, memory, and overall mental and physical health. 202

Prolonged school closures, particularly in fragile contexts, increase the likelihood of students not returning to the classroom and heighten their risk of child marriage and child labour, disproportionately affecting girls.[16] It is estimated that most provinces in Cambodia have at least one school susceptible to significant annual flooding, disrupting the education of approximately 1% (30,000) of Cambodian students each year.[8] This direct link from climate impact to educational disruption, which then cascades into increased child vulnerability and exploitation, with a noted disproportionate effect on girls. Climate change exacerbates existing educational inequalities and creates new, significant barriers to access and retention, particularly for already vulnerable children. Climate adaptation in the education sector must therefore extend beyond merely building resilient infrastructure to include developing flexible learning models and providing targeted social support to prevent dropouts and protect children from associated risks like child labour and early marriage.

The evidence indicates that climate impacts are not merely increasing the incidence of certain illnesses but are fundamentally challenging the capacity and resilience of the health infrastructure and workforce to deliver essential services, particularly in rural areas where health services are often poorly equipped. 203 This situation necessitates a comprehensive and proactive approach to strengthening health system resilience. Such an approach must include not only addressing direct health impacts but also investing in robust infrastructure (e.g., climate-resilient Water, Sanitation, and Hygiene (WASH) in health centres), establishing effective early warning systems for disease outbreaks, and undertaking continuous capacity-building for health professionals to manage evolving climate-sensitive health risks.

Water quality and quantity issues, particularly during dry seasons, pose significant challenges to daily activities at health centres and for villagers. This directly impacts hygiene and re-hydration efforts, making it difficult to maintain clean and safe health facilities. 204 A severe 1-in-10-year flood has the potential to trigger widespread disease outbreaks, further straining an already vulnerable health system and potentially leading to widespread health crises.205

Climate events are a significant driver of internal displacement in Cambodia. Thousands of people have been internally displaced due to floods, droughts, and storms, with this displacement compounded by limited infrastructure and resources available for adequate refuge. Between 2008 and 2023, Cambodia experienced 179 major climate displacement events, resulting in nearly 900,000 reported displacements. 206 Families forced to migrate in distress are more likely to do so without legal protections, often leading to physical separation from family members and social safety networks. This precarious situation places children and youth at heightened risks of abuse and exploitation. 207 The quantitative evidence of significant climate-induced displacement, coupled with the detailed consequences of this displacement—particularly the heightened risks of abuse and exploitation for children and youth—establishes a direct and critical causal link from climate-induced displacement to increased child protection risks. Climate-induced displacement creates complex humanitarian and social challenges that demand integrated responses. These responses must include not only emergency child protection services but also robust support for family reunification and proactive measures to prevent trafficking and exploitation of children and youth during and after displacement. Social protection systems, therefore, need to be inherently shock-responsive to effectively address these emergent and evolving needs.

Table 13. Vulnerable population groups

Vulnerable Group	Key Climate Impacts
Children & Newborns	Heat stress, increased climate-sensitive diseases (malnutrition, diarrheal diseases, vector-borne), school disruptions (closures, damage), increased child labour/marriage, abuse, exploitation due to displacement[208]
Pregnant Women	Heat stress, increased climate-sensitive diseases, limited access to health services[209]
Elderly	Heat stress, increased climate-sensitive diseases, limited access to health services[210]
People with Chronic Illnesses/Disabilities	Heat stress, exacerbated health conditions, limited access to health services[211]
Outdoor Workers / Low-Wage Earners	Heat stress, reduced labour productivity, livelihood loss, increased debt, limited access to social protection[212]
Rural/Agrarian Communities	Food insecurity, livelihood loss (crop failure, fishery decline), increased debt, distress migration, limited access to basic services due to infrastructure damage[213]
Indigenous Communities	Disproportionate impacts due to reliance on climate-sensitive livelihoods, limited adaptive capacity[214]
Displaced Populations	Loss of social safety networks, heightened risks of abuse and exploitation (especially for children/youth), lack of adequate refuge, limited access to services[215]

Table 14. Social service programs

Framework/Program	Key Objectives/Focus
National Social Protection Policy Framework (NSPPF 2024-2035)	Lifecycle risk protection, shock responsiveness, poverty reduction, comprehensive social protection system [216]
IDPoor System	Poverty identification, targeting beneficiaries for social assistance, real-time data updates, the backbone of the Social Protection Registry[217]
Child Protection Law (under development)	Coordinated and effective child protection response, alternatives to residential care[218]
3PC (Partnership Program for the Protection of Children)	Facilitate social work coordination, build NGO/Government capacity, create a national Child Protection System, family-based care, reintegration, emergency response[219]
Health National Adaptation Plan	Strengthen health system resilience to climate-sensitive risks, integrate climate considerations into health planning, and improve WASH infrastructure.[220]
Climate Smart Education Systems Initiative (CSESI)	Mainstream climate change adaptation and environmental sustainability into education sector plans, resilient infrastructure, flexible learning models[221]

5.2.3 GOVERNANCE EXPOSURE

Climate change presents a complex array of challenges to Cambodia's governance structures, impacting economic stability, policy implementation, and the capacity of both national and local authorities to respond effectively.

Economic Implications

Climate change is identified as a major risk to Cambodia's development outcomes, posing an existential threat to its goals of ending extreme poverty and promoting shared prosperity.[222] Projected climate change trends, particularly more severe floods and droughts, could reduce

Cambodia's GDP by nearly 10% by 2050. [223] A severe 1-in-10-year flood has the potential to trigger cascading impacts, including widespread disease outbreaks and broader financial instability, highlighting systemic risks to the national economy. [224] The annual expected fiscal burden from natural disasters is estimated to be 1% of annual government expenditure, posing a significant unplanned drain on public finances.[225] The evidence indicates that climate change is not merely a sectoral or environmental issue but a fundamental threat to national economic stability and public finance, with the potential to divert critical resources from long-term development priorities. This necessitates that national governance proactively integrate climate risk into its macroeconomic planning, fiscal policy, and disaster risk financing strategies to ensure financial resilience and sustainable development. This requires a strategic shift from reactive crisis management to proactive preparedness and adaptation, including exploring instruments like contingent financing and public asset insurance.[226]

Policy and Resource Constraints

Despite Cambodia's active participation with international communities in addressing climate-related issues, its response efforts are significantly challenged by limited human, technical, and financial resources. [227] The overall social protection system in the region is acknowledged as insufficiently developed to adequately meet current and future climate challenges[228]. The direct statement that "A key barrier for climate actions in Cambodia is limited resources: human, technical and financial resources" [229] points to a significant constraint on the government's ability to effectively implement comprehensive climate policies and adaptation measures, even when strategic plans are formally in place. Bridging these resource and capacity gaps is crucial for translating policy ambitions into tangible climate action, highlighting the ongoing importance of support from international development partners and global climate finance mechanisms.

Strategic Frameworks

Cambodia has developed a robust policy framework to guide its climate response. This includes the Cambodia Climate Change Strategic Plan (CCCSP), updated from 2014-2023 to 2024-2033, along with the Updated Nationally Determined Contribution (NDC) in 2020 and the Long-Term Strategy for Carbon Neutrality (LTS4CN) in 2021. [230] The new CCCSP 2024-2033 places strong emphasis on reducing greenhouse gas emissions, strengthening climate adaptation, and promoting good governance alongside digital transformation, with a particular focus on supporting vulnerable and marginalized groups, especially women and children. [231]

Additionally, the National Social Protection Policy Framework (NSPPF), updated from 2016-2025 to 2024-2035, provides an ambitious vision for a comprehensive social protection system, shifting from a pillar-based approach to a lifecycle-based approach to risk management. [232] The National Adaptation Plan (NAP) process is central to these efforts, aiming to integrate climate change adaptation into sectoral policy and budget planning, adopting a medium- and long-term approach to vulnerability reduction. [233]

Cambodia has significant policy ambition, however, the consistent highlighting of "limited resources," "insufficiently developed" systems, and "gaps in implementation"[234] creates a critical tension between these aspirational policy frameworks and the practical challenges of translating them into widespread, effective action on the ground. While robust policy frameworks are foundational, the true challenge for national governance lies in effective and equitable implementation. This requires sustained political will, innovative financing mechanisms[235], and strong cross-sectoral coordination to overcome existing capacity and resource constraints and ensure that policies translate into tangible benefits for vulnerable populations.

Decentralization and Funding Gaps

Local administrations often lac dedicated budgets for climate adaptation and have historically had limited influence over how climate funds are allocated, leading to unfunded priorities at the sub-national level. [236] The observation that "local governments—the ones dealing with the direct impacts of floods, droughts, and soil erosion—had little say in how funds were allocated or used," and that "climate adaptation remained an unfunded priority" [237] points to a critical governance gap at the sub-national level, where climate impacts are felt most acutely. Even with well-intentioned national policies, if local governments lack the autonomy, financial resources, and technical capacity, effective implementation will be severely hampered. Effective climate adaptation and social protection therefore require genuine decentralization of authority and financial resources to local levels, coupled with targeted capacity building for local leaders to integrate climate risks into their local planning and budget allocation processes, ensuring that adaptation efforts are tailored to specific community needs and vulnerabilities.

Community Engagement and Preparedness

There is a recognized "lack of preparation for disasters and education on adaptation at the community level," indicating a significant gap in local awareness. [238] Many people are currently unaware of essential pre-disaster actions for survival, which can undermine the effectiveness of early warning systems. [239] The ultimate success of localized climate activities and resilience-building efforts is highly dependent on the willingness and ability of individual communities and households to adopt supportive practices. [240] This suggests that effective climate resilience is not solely about government capacity or infrastructure; it fundamentally depends on community-level knowledge, awareness, and agency. Without this foundational understanding and preparedness, even robust early warning systems or resilient infrastructure might not translate into effective protective action when a climate event occurs. Bottom-up, participatory approaches to disaster risk reduction and climate adaptation are essential, prioritizing community education, widespread awareness-raising campaigns, and empowering local populations to take ownership of preparedness and resilience-building efforts, ensuring that interventions are culturally appropriate and locally relevant.

Infrastructure Resilience

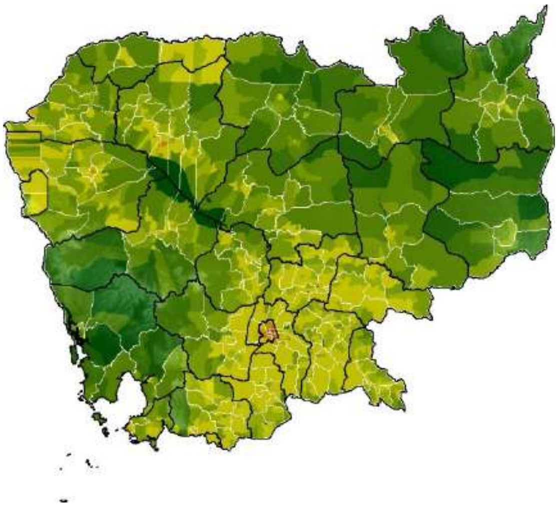
Critical infrastructure, including roads, drainage structures, irrigation systems, bridges, and culverts, is highly vulnerable to damage from heavy rainfall and flooding. This damage can render road systems impassable for extended periods, resulting in significant economic loss.[241] Floods are projected to increase losses to factories, roads, housing, and schools, and crucially, to disrupt critical services and supply chains across the country.[242] Inadequate infrastructure is explicitly identified as a factor heightening Cambodia's overall vulnerability to climate variability and change.[243]

5.3 EXPOSURE INDICATORS

In assessing climate risks for the sectors, a comprehensive analysis of exposure indicators is crucial to understanding potential impacts and planning resilience measures. This assessment below comprises the exposure component of the CRVA methodology and follows a structured framework to gauge alignment with international standards and sector-specific needs. Exposure components are the primary way of expressing the elements, assets and populations likely susceptible to current and future projected climate and meteorological risks. The exposures are listed below.

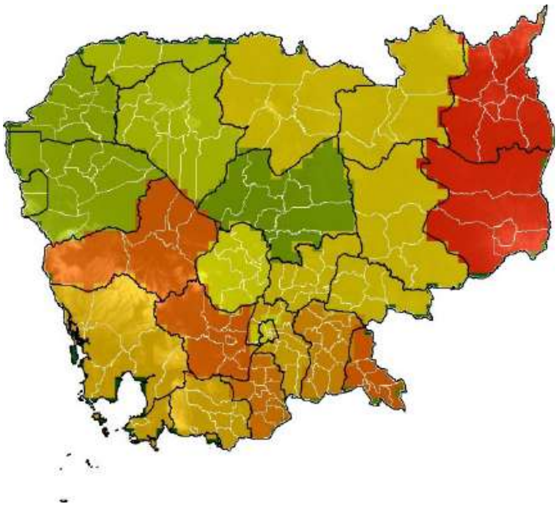
Table 15. Exposure Indicators

Exposure indicators	
• (+) Population in rural and agricultural areas[244] • (+) Economic activity[245] • (+) Infrastructure types and location[246] • (+) Gender Gap[247]	• (+) Livestock density[248] • (+) Agriculture livelihoods[249] • (+) Forested and natural areas[250] • (+) Flood susceptible landscape[251]



Population Exposure: Cambodia's population distribution is highly uneven, shaped by geography, natural resources, infrastructure, economic activity, and historical settlement patterns. Most people live in the fertile lowlands and along rivers, particularly the Mekong River and around Tonle Sap Lake, while the highlands and border areas remain sparsely populated. The country has a population of approximately 17.3 million people as of 2024, with the majority living in rural areas and a growing concentration in urban centres such as Phnom Penh.

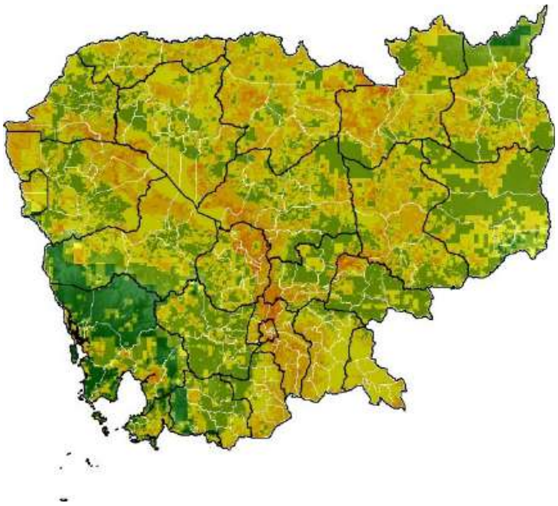
Population exposure notes the highest density in Phnom Penh and surrounding areas as well as areas of Siem Reap to the northwest of the country. The areas to the northeast areas and southwest see a notable decrease in population exposure.



Gender Development Index highlights lower gender participation in the northeast and some areas of the south and central parts of the country. Gender equality considers factors such as education and health, as well as economic participation, political representation, and leadership roles.

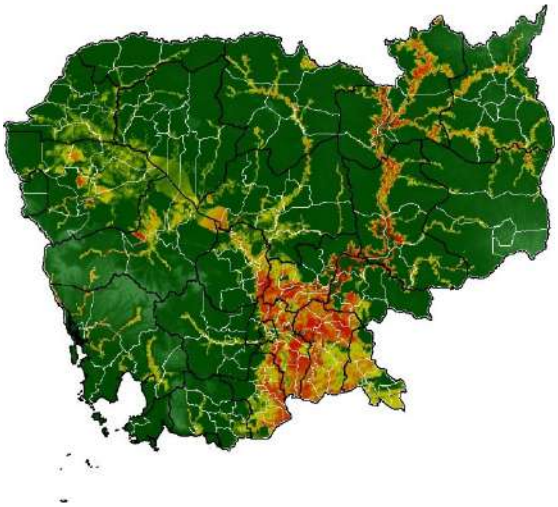
These inequalities are geographically uneven, with rural and remote provinces facing more pronounced gender disparities than urban centres like Phnom Penh.

Cambodia has made measurable progress in gender development, particularly in education and health. However, structural inequalities remain, especially in the economy and governance.



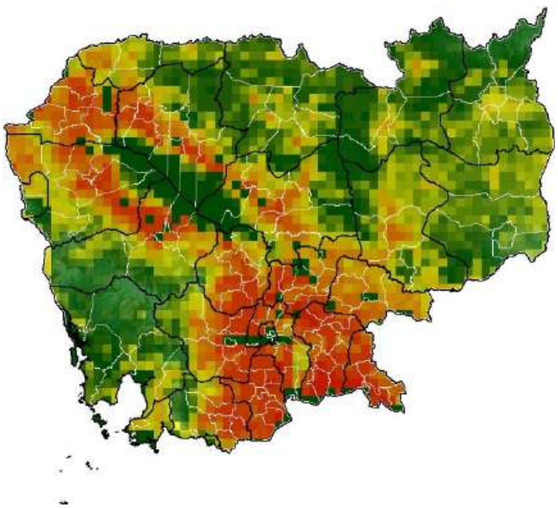
Environmental Exposure: Cambodia is highly ecologically diverse and features a rich variety of terrestrial, freshwater, and coastal ecosystems. These ecosystems support a high level of biodiversity, including many endemic and threatened species. However, Environmental exposure notes these areas are facing growing pressure and risks of loss due to agricultural expansion, deforestation, exploitation of ecosystems, illegal wildlife trade, and also climate changes.

These at-risk areas include the populated Tonle Sap and Mekong River networks. The lowest exposure is noted in the largely isolated Cardamom Mountains forested areas to the southwest of the country. However, threats of Illegal logging, land conversion, and mining persist here.



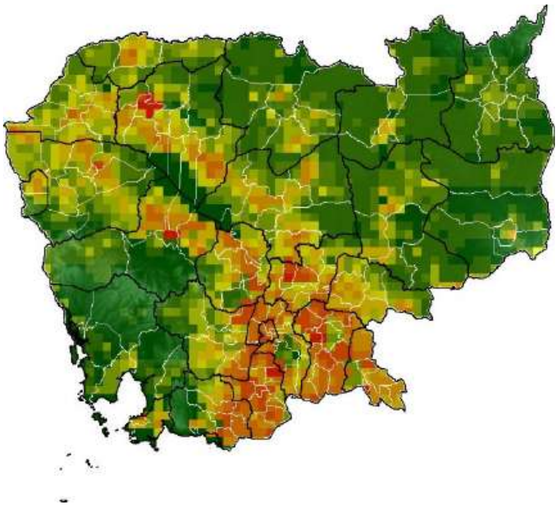
Flood susceptible areas: Cambodia is highly flood-prone, with seasonal riverine, flash, and urban flooding affecting large portions of the country.

The major floodplain and susceptible flood areas are noted along the Tonle Sap Lake system (Central Cambodia) and Mekong River (East Cambodia) networks and even more so where they converge near Phnom Phen forming a highly dynamic Delta Floodplain (Southern Cambodia).



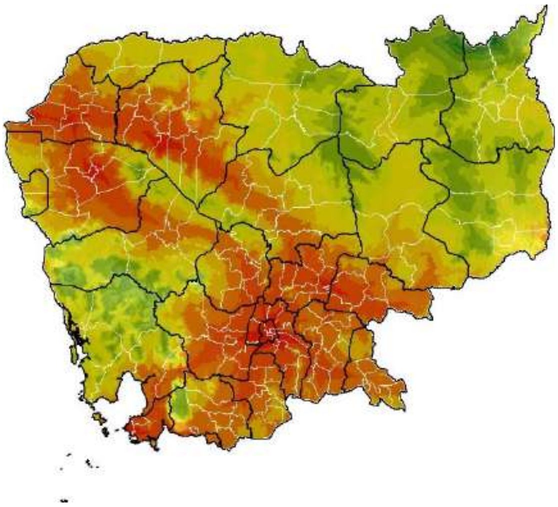
Crop-based Agriculture exposure: Agriculture remains a cornerstone of Cambodia's economy and livelihoods, employing 32% of the labour force and contributing 22% of GDP (World Bank, 2023). Crop distribution is shaped by regional hydrology, soil fertility, market access, and increasingly by climate variability. The country is broadly divided into three major agricultural zones: the Central Plains which consists of rice-dominant agriculture, upland and plateau areas consisting of cassava, maize, and cash crops, and coastal and riverine zones which focus on horticulture and industrial crops.

Crop-based Agriculture exposure is highest along the Tonle Sap Lake system and to the south by the Delta Floodplain system.



Livestock (Agriculture) exposure: Livestock Agriculture distribution is similar to the Crop based Agriculture. This sector is however largely subsistence-based but serves as a source of income, nutrition, manure, and financial security for rural populations. Livestock distribution is closely linked to agroecological zones, water availability, and access to feed resources.

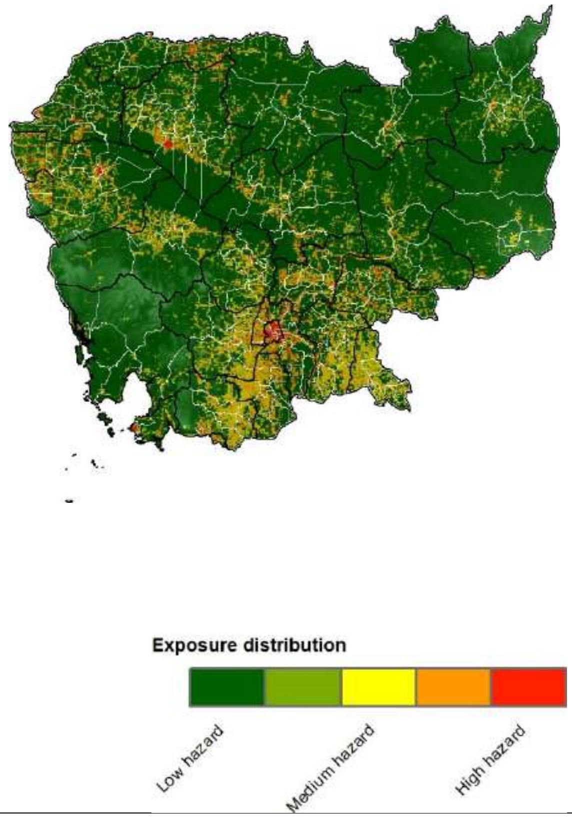
Cattle are mostly noted in Rice-growing provinces and upland grazing areas (Oddar Meanchey, Preah Vihear, Ratanakiri). Buffalo are present in floodplain areas of Kampong Thom and Pursat and remote upland zones. Goats and Sheep are present in dryland provinces (Kampong Speu, Takeo, and Preah Vihear). Chickens are present nationwide in mostly backyard systems. Ducks are most present in areas of Kandal, Takeo, Prey Veng, and Pursat.



Exposed Infrastructure follows very closely the population and economic distributions but remains highly centralized with Phnom Penh acting as the primary hub, and major corridors radiating outward to international borders, ports, and economic zones.

Cambodia's transport network is road-dominated, with the rail system currently noted as being underutilised, although there this is undergoing revitalisation all be it slowly.

Rural roads often remain gravel or earth-surfaced, and are vulnerable to flooding and erosion, especially during the monsoon season, while Urban area particularly Phnom Penh suffers severe congestion due to limited road space, rapid vehicle growth, and poor public transit options.



Economic Exposure: Cambodia's economic hubs are geographically concentrated in a few key urban and border regions, driven by factors such as infrastructure access, proximity to international borders, special economic zones (SEZs), and sectoral specialisation such as garment manufacturing, tourism, logistics, and agriculture.

Economic exposure is largely limited to the highly developed areas of Phnom Penh, Siem Reap (tourism), Poipet, and to a lesser extent Bavet and Sihanoukville (deep sea port). Additionally, developing areas include Battambang, Kampong Cham and Krong Doun Kaev.

These areas account for most of the country’s banks, corporate headquarters, and government institutions as well as developing industries and imports and exports both via land borders and through the ocean port.

5.3.1 DISTRICT LEVEL RESULTS

Each of the different climate exposures is ranked from 1st (highest exposure) to 178th (lowest exposure) based on the individual and cumulative climate exposure indices for each of the sub-risks. These are presented and highlight the top 10 (red), 25 (orange) and 50 (yellow) ranked districts. These are grouped by Province to allow for strategic-level planning.

- **Population exposure** reflects the concentration of people in both urban and rural areas. The highest levels are observed in Phnom Penh and its surroundings, as well as in the Siem Reap region in the country's northwest. In contrast, population exposure significantly decreases in the northeastern and southwestern regions.
- The **Gender Development** Index measures the differences between men and women in areas such as leadership, decision-making power, and access to resources. These gender disparities vary by location, with rural and remote areas experiencing greater inequality compared to urban centers like Phnom Penh. While Cambodia has made notable strides in gender development—especially in education and healthcare—significant structural inequalities persist, particularly in the economic and governance sectors.
- **Environmental exposure** indicates where forest integrity is weakest and natural areas are least protected. High-risk zones include the densely populated Tonle Sap and Mekong River regions. In contrast, the remote forested areas of the Cardamom Mountains in the southwest show the lowest exposure. Nonetheless, they still face ongoing threats from illegal logging, land conversion, and mining activities.
- **Flood-prone areas** are typically located within floodplains that experience regular flooding or have low elevation and gentle slopes, making them vulnerable to rising river levels. In Cambodia, the most significant floodplains and flood-prone zones are

found along the Tonle Sap Lake system in the central region and the Mekong River in the east. These risks are even greater near Phnom Penh, where the two systems converge, forming a highly dynamic delta floodplain in southern Cambodia

- **Crop-based agriculture exposure areas** are regions where rainfed crops are mainly found and contribute significantly to local livelihoods. The highest levels of crop-based agriculture exposure are observed around the Tonle Sap Lake system and the southern Delta Floodplain system.
- **Livestock-based agriculture exposure areas** are defined by a higher density of livestock, which may be affected by climate change and represent an important part of local livelihoods. Cattle are primarily found in rice-growing provinces and upland grazing regions such as Oddar Meanchey, Preah Vihear, and Ratanakiri. Buffalo are located in the floodplain areas of Kampong Thom and Pursat, as well as remote upland zones. Goats and sheep are found in dryland provinces like Kampong Speu, Takeo, and Preah Vihear. Chickens are distributed nationwide, mainly in backyard systems. Ducks are concentrated in Kandal, Takeo, Prey Veng, and Pursat.
- **Infrastructure exposure** refers to areas with a high concentration of roads and related infrastructure that are susceptible to damage from extreme climate events. In rural regions, many roads remain unpaved or surfaced with gravel, making them particularly vulnerable to flooding and erosion, especially during the monsoon season. Urban areas, such as Phnom Penh, experience significant congestion due to constrained road capacity, rapid increases in vehicle numbers, and inadequate public transportation options.
- **Economic exposure** refers to economic activities supporting livelihoods and community wellbeing, as well as industry and development. In Cambodia, it is primarily concentrated in Phnom Penh, Siem Reap (tourism), Poipet, and to a lesser extent Bavet and Sihanoukville (deep sea port), with developing centers in Battambang, Kampong Cham, and Krong Doun Kaev. These regions host most banks, corporate headquarters, government institutions, and play major roles in industry and trade.

Table 16. Region and District hazard rankings for the different sub-risks and cumulative risk for the current and future SSP2 and SSP5 scenariosscclii

Provence	District	Population exposure	Gender Development Index	Environmental exposure	Susceptible flood areas	Agriculture: Crop based	Agriculture: Livestock	Infrastructure	Economic exposure	Cumulitive Exposure
Bântéay Méanchey	Malai	73	176	27	153	78	78	54	95	83
	Mongkol Borei	67	160	40	66	55	81	28	86	70
	Ou Chrov	81	168	73	108	56	104	17	73	75
	Phnum Srok	120	151	124	95	106	86	91	141	111
	Preah Netr Preah	109	155	52	81	54	80	40	126	76
	Serei Saophoan	78	160	76	87	32	60	11	90	52
	Svay Chek	106	167	149	139	38	106	53	120	82
	Thma Puok	121	166	135	152	63	114	92	128	102
Batdâmbâng	Aek Phnum	143	154	20	61	151	116	126	149	140
	Banan	96	160	139	69	59	108	31	72	80
	Bat Dambang	89	160	96	59	68	69	37	113	77
	Bavel	69	160	126	74	73	95	84	65	84
	Moung Ruessei	122	148	102	92	101	129	104	108	117
	Phnum Proek	64	172	33	140	66	93	117	54	73
	Rotanak Mondol	103	160	98	121	111	105	87	78	109
	Samlout	129	152	132	148	147	163	137	122	148
	Sangkae	124	160	31	64	88	98	106	118	105
	Svay Pao	8	160	50	60	28	51	7	11	14
Kâmpóng Cham	Batheay	74	120	10	20	48	57	44	102	61
	Chamkar Leu	70	121	118	172	95	71	43	92	86
	Cheung Prey	34	102	133	34	44	15	30	44	28
	Kampong Cham	6	102	46	14	52	27	6	7	9
	Kampong Siem	45	102	125	46	50	59	16	52	47
	Kang Meas	49	102	21	5	51	63	51	83	62
	Kaoh Soutin	26	102	59	12	23	22	27	51	25
	Prey Chhor	37	102	162	58	109	23	21	38	59
	Srei Santhor	47	90	49	19	42	58	48	70	54
	Stueng Trang	92	114	147	75	84	126	105	105	110
Kâmpóng Chhnang	Baribour	105	124	56	56	87	52	100	101	81
	Chol Kiri	94	130	5	27	80	82	82	99	88
	Kampong Chhnang	10	130	22	55	46	20	41	18	20
	Kampong Leaeng	125	132	7	54	121	83	136	144	121
	Kampong Tralach	54	128	45	38	21	43	36	53	36
	Rolea B'ier	93	130	67	99	36	46	57	67	44
	Sameakki Mean Chey	100	126	99	151	25	113	60	88	71
	Tuek Phos	136	125	122	156	72	110	123	129	106
Kâmpóng Spœ	Aoral	151	22	142	143	122	145	134	151	139
	Basedth	42	21	160	158	15	33	56	26	21
	Chbar Mon	11	17	117	80	155	89	20	10	90
	Kong Pisei	40	30	137	155	9	16	19	17	8
	Odongk	27	26	154	164	10	35	24	25	17
	Phnum Sruoch	112	24	164	147	75	97	62	81	89
	Samraong Tong	77	17	148	120	64	87	22	37	64
	Thpong	111	31	163	159	49	103	66	106	85
Kâmpóng Thum	Baray	88	169	100	88	97	67	88	107	94
	Kampong Svay	131	175	54	79	110	99	130	133	115
	Prasat Balangk	130	174	89	144	103	128	124	135	122
	Prasat Sambour	116	178	95	102	71	92	133	124	101
	Sandan	153	171	112	132	152	135	165	150	149
	Santuk	137	173	101	103	117	140	131	139	133
	Stoung	145	170	41	83	148	124	118	142	138
	Stueng Saen	99	178	30	57	70	109	102	103	100

Provence	District	Population exposure	Gender Development Index	Environmental exposure	Susceptible flood areas	Agriculture: Crop based	Agriculture: Livestock	Infrastructure	Economic exposure	Cumulitive Exposure
Kâmpôt	Angkor Chey	36	60	143	117	11	10	65	23	11
	Banteay Meas	48	61	77	73	17	19	95	30	18
	Chhuk	61	69	140	138	76	94	111	47	79
	Chum Kiri	79	58	153	165	90	96	109	79	99
	Dang Tong	60	69	167	126	30	54	81	29	34
	Kampong Bay	14	69	146	70	108	171	55	24	112
	Kampong Trach	53	72	88	149	61	53	83	33	50
	Kampot	132	75	175	125	128	153	153	115	143
Kândal	Angk Snuol	13	84	26	116	94	24	8	8	27
	Kandal Stueng	15	78	39	40	22	30	9	13	6
	Kaoh Thum	29	73	14	18	86	49	64	69	68
	Khsach Kandal	23	80	36	17	65	41	15	48	46
	Kien Svay	12	66	11	22	114	107	12	39	96
	Leuk Daek	59	59	12	1	102	70	70	121	97
	Lvea Aem	50	57	17	23	62	62	18	49	55
	Mukh Kampul	21	88	1	15	77	34	10	40	49
	Ponhea Lueu	18	83	13	33	24	21	13	20	13
	S'ang	24	64	9	16	39	115	25	45	65
	Ta Khmau	4	69	2	31	120	84	2	5	56
Kaôh Kong	Botum Sakor	149	116	166	137	157	138	149	156	150
	Kampong Seila	146	63	174	123	135	156	114	152	147
	Kaoh Kong	177	79	169	107	175	173	160	177	174
	Kiri Sakor	166	85	176	172	163	166	155	170	167
	Mondol Seima	167	74	177	115	173	174	166	164	173
	Smach Mean Chey	91	69	128	172	160	168	141	93	153
	Srae Ambel	169	76	157	106	153	172	145	157	159
	Thma Bang	178	62	178	141	177	178	175	178	177
Kep	Kaeb	22	135	130	172	132	134	115	19	113
Krâchéh	Chhloung	113	102	70	65	118	132	121	119	129
	Kracheh	119	102	35	77	89	148	132	116	124
	Preaek Prasab	133	102	68	63	116	117	135	137	131
	Sambour	159	89	80	93	130	143	157	161	146
	Snuol	142	91	119	105	131	147	120	138	141
Krong Pailin	Pailin	68	160	107	172	162	139	144	82	142
	Sala Krau	19	165	58	127	100	74	122	31	72
Krong Preah Sihanouk	Mittakpheap	7	136	151	172	137	144	112	9	107
	Prey Nob	104	82	141	172	124	133	71	117	128
	Stueng hav	95	119	172	172	96	77	39	123	98
Môndól Kiri	Kaev Seima	163	13	120	135	165	170	161	169	168
	Kaoh Nheaek	176	9	134	118	136	159	171	175	161
	Ou Reang	172	14	170	172	169	162	138	165	162
	Pechr Chenda	171	7	159	157	149	175	164	171	166
	Saen Monourom	134	4	145	172	164	141	146	140	152
Otdar Mean Chey	Anlong Veaeng	38	153	55	146	142	122	142	61	130
	Banteay Ampil	123	150	104	163	79	136	128	136	116
	Chong Kal	148	146	71	110	99	112	129	145	119
	Samraong	115	149	83	161	119	76	140	131	114

Provence	District	Population exposure	Gender Development Index	Environmental exposure	Susceptible flood areas	Agriculture: Crop based	Agriculture: Livestock	Infrastructure	Economic exposure	Cumulitive Exposure
Phnom Penh	Dangkao	5	127	6	52	115	12	5	4	24
	Mean Chey	2	81	3	53	174	39	4	3	51
	Phnom Penh	1	77	37	94	178	28	2	1	41
	Ruessei Kaev	3	123	4	32	104	9	3	2	3
Pouthisat	Bakan	138	23	48	62	105	91	116	109	108
	Kandieng	135	19	43	49	141	85	127	111	123
	Krakor	139	27	109	98	98	79	113	114	103
	Phnum Kravanh	160	20	138	122	139	176	162	153	160
	Sampov Meas	85	17	152	113	91	66	79	60	78
	Veal Veaeng	175	28	168	134	167	157	173	173	171
Preah Vihéar	Chey Saen	147	102	66	114	133	119	170	154	144
	Chhaeb	168	92	53	131	166	161	169	172	170
	Choam Khsant	157	118	62	119	159	169	158	155	164
	Kuleaen	128	111	28	124	158	152	139	147	158
	Rovieng	154	115	75	130	144	123	156	158	145
	Sangkom Thmei	158	117	93	133	145	146	148	163	151
	Tbaeng Mean chey	144	102	78	90	129	120	150	143	137
Prey Vêng	Ba Phnum	32	49	42	28	8	4	47	35	12
	Kamchay Mear	56	44	111	13	26	48	89	43	37
	Kampong Leav	58	50	15	2	34	7	58	74	30
	Kampong Trabaek	44	46	74	30	37	14	59	34	23
	Kanhchriech	57	55	136	4	20	29	63	62	31
	Me Sang	43	47	92	37	18	17	93	32	19
	Pea Reang	52	52	60	6	16	11	67	89	32
	Peam Chor	71	65	25	7	81	32	73	64	60
	Peam Ro	30	54	18	11	35	31	32	55	35
	Preah Sdach	28	51	44	21	6	26	49	27	15
	Prey Veaeng	51	49	61	9	19	64	76	50	43
	Sithor Kandal	63	56	144	10	4	5	61	94	26
Rôtânôkiri	Andoung Meas	155	4	114	96	154	149	151	148	157
	Ban Lung	101	4	165	172	112	130	154	58	118
	Bar Kaev	114	4	171	172	113	142	143	97	125
	Koun Mom	164	8	87	100	146	167	172	167	163
	Lumphat	150	4	108	85	138	151	163	146	155
	Ou Chum	126	4	131	172	123	131	159	130	135
	Ou Ya Dav	161	12	123	112	134	164	152	162	156
	Ta Veaeng	174	11	173	109	176	177	178	176	178
	Veun Sai	162	10	113	91	172	154	177	166	175
Siemréab	Angkor Chum	90	142	127	142	41	3	52	75	29
	Angkor Thum	98	142	97	162	60	72	45	76	66
	Banteay Srei	102	142	129	154	93	100	46	68	95
	Chi Kraeng	118	138	69	129	126	88	101	134	120
	Kralanh	107	142	105	104	67	65	38	87	69
	Prasat Bakong	152	133	103	86	150	137	86	100	134
	Puok	97	145	85	111	107	73	35	96	92
	Siem Reab	117	147	91	84	143	121	75	77	127
	Soutr Nikom	141	134	90	97	125	125	97	112	126
	Srei Snam	110	142	115	128	53	101	90	110	87
	Svay Leu	127	137	79	160	161	150	125	132	154
	Varin	108	142	57	145	140	127	119	125	136

Provence	District	Population exposure	Gender Development Index	Environmental exposure	Susceptible flood areas	Agriculture: Crop based	Agriculture: Livestock	Infrastructure	Economic exposure	Cumulitive Exposure
Stœng Trêng	Sesan	165	86	64	67	156	160	168	168	165
	Siem Bouk	170	113	116	89	168	155	174	159	172
	Siem Pang	173	87	110	72	171	165	176	174	176
	Stueng Traeng	140	102	63	71	127	111	147	127	132
	Thala Barivat	156	93	16	82	170	158	167	160	169
Svay Rieng	Chantrea	86	43	32	43	83	50	98	63	67
	Kampong Rou	66	42	72	41	45	36	96	41	38
	Romeas Haek	84	33	82	44	27	37	107	42	33
	Rumduol	62	25	86	25	12	40	77	22	22
	Svay Chrum	33	32	65	29	47	75	72	21	45
	Svay Rieng	9	17	23	76	2	56	74	6	7
	Svay Teab	76	29	84	68	29	47	78	46	40
Takêv	Angkor Borei	65	45	24	3	31	44	99	91	53
	Bati	17	41	94	48	5	13	23	14	2
	Bourei Cholsar	87	53	19	8	82	55	108	98	74
	Doun Kaev	16	35	47	36	7	2	50	15	1
	Kaoh Andaet	75	37	34	24	33	8	110	84	39
	Kiri Vong	72	39	38	45	40	25	103	71	42
	Prey Kabbas	20	38	51	26	1	1	68	28	4
	Samraong	26	34	106	47	3	38	33	12	5
	Tram Kak	31	40	161	150	14	18	42	16	10
	Treang	39	36	81	42	13	6	80	36	16
Tbong Khmum	Dambae	35	102	158	101	92	102	69	57	93
	Kampong Siem	83	102	29	39	43	45	14	80	48
	Krouch Chhmar	80	102	8	51	69	90	94	104	91
	Memot	82	122	155	136	85	118	85	85	104
	Ou Reang Ov	41	102	150	35	74	42	29	56	57
	Ponhea Kraek	55	112	156	78	57	68	34	66	63
	Tboung Khmum	46	102	121	50	58	61	26	59	58

5.3.2 CUMULATIVE MULTI-EXPOSURE INDEX

The combination of various climate exposures reveals significant hotspots in Cambodia, particularly in the southeastern areas and along the major river and lake areas. This cumulative exposure aligns closely with the population but more so along the environmental, agricultural and economic exposure indicators. These areas are defined therefore as having a greater degree of exposed populations, assets, ecosystems and livelihoods to possible current and projected future climate changes and will be significant in determining the ultimate climate risks in the country.

It is important to note that areas not highlighted in the analysis will still be exposed in both current and future climate scenarios. However, these regions scored lower in the cumulative exposure assessment. Additionally, this analysis focuses on the high-level national state with local-scale exposures being less represented in the analysis.

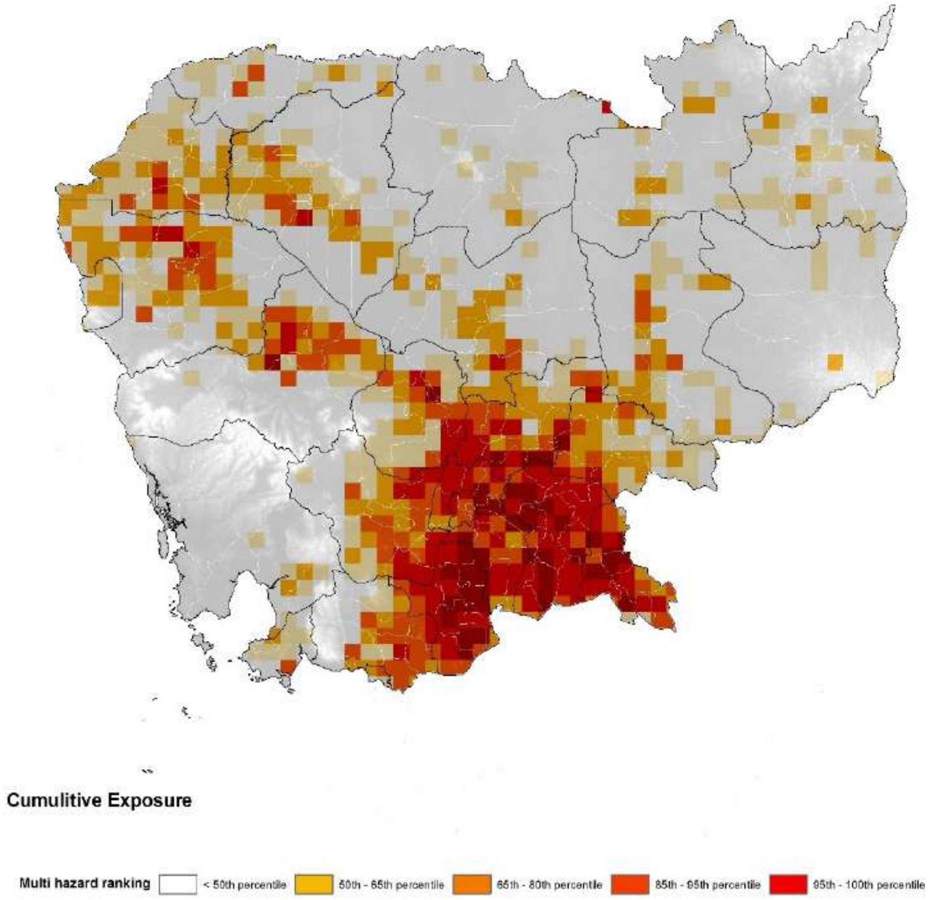


Figure 27. All exposure indices and cumulative multi-exposure index)

6 VULNERABILITY

Cambodia faces profound climate vulnerability, ranking among the most affected nations globally. Its high dependence on climate-sensitive sectors such as rain-fed agriculture and natural resources, coupled with existing socio-economic constraints, significantly amplifies climate risks. This inherent dependency renders the country and its primary sectors particularly susceptible to the adverse impacts of climate variability and change.

Table 17. Sectoral sensitivities to Climate-Related Hazards in Cambodia

Sector	Key Sensitivities
Agriculture	Rain-fed reliance, yield losses (rice 10-15% by 2040s), heat stress on crops/labour, floods, droughts, saltwater intrusion, pests[253]
Water Resources	Dependence on Mekong/Tonle Sap, upstream damming impacts, altered flow regimes (9-41% reduction in Tonle Sap sub-basins), increased floods/droughts, risks to fisheries/domestic supply
Forestry	High deforestation (1/3 forest cover lost), major GHG source, reduced ecosystem services, fire risk, impacts on dependent communities, mangrove degradation
Coastal Zone	Sea level rise, inundation, coastal erosion, saltwater intrusion (agriculture/freshwater), storms, poverty of communities
Human Health	Extreme heat (esp. outdoor/urban workers), vector/water-borne diseases (dengue, malaria, diarrhoea), malnutrition, strained health system

6.1 SECTORAL VULNERABILITY

6.1.1 AGRICULTURE SECTOR

Agriculture serves as the core driver of Cambodia's economic development, with rice being the primary crop, followed by cassava and maize. Rain-fed lowland rice systems constitute the largest share of wet season rice production and are crucial to the national economy, making the sector highly sensitive to climate variability.[254] The agricultural sector is profoundly vulnerable to climate change, facing significant threats from floods, droughts, heat stress, saltwater intrusion, pests, diseases, land degradation, and nutrient depletion.[255] Climate change impacts labour productivity, with global labour productivity during peak months already decreased by 10% due to warming, with a potential decline of up to 20% by the 2050s. The pervasive lack of adequate irrigation systems restricts most farmers to a single rain-fed crop per year, making them acutely vulnerable to increasingly volatile rainfall patterns.[256] While various adaptation strategies, such as climate-smart agriculture, improved water management, and resilient crop varieties, are being promoted and have demonstrated benefits, their widespread adoption rates remain low due to limited awareness, insufficient institutional support, and financial resource constraints.[257] This gap between the availability of proven solutions and their actual implementation at scale significantly reduces overall adaptive capacity, keeping vulnerability high despite existing knowledge and pilot successes. When climate change reduces crop yields and simultaneously makes it harder for farmers to work due to heat, it creates a dual economic impact.

6.1.2 WATER SECTOR

Cambodia's water resources are critically dependent on the natural river flow regime of the Mekong River and the flood pulse of the Tonle Sap Lake.[258] The hydrological regime is highly vulnerable to both climate change impacts and significant human development interventions, particularly the ongoing damming of the Mekong River and its tributaries, as well as deforestation.[259] Projected changes in river flow in the Tonle Sap sub-basins indicate a likely decrease in both wet and dry season flows, with mean annual projected reductions ranging from 9% to 41% by the 2030s-2090s.[260] The increased flow in the Mekong River during the wet season, influenced by climate change and upstream snowmelt, will boost water availability in the dry season but also significantly increase the risk of flooding in the wet season.[261] A large proportion of the Cambodian population still relies on natural water sources for domestic consumption, meaning droughts and other reductions to the natural water supply can have serious human consequences.[262] Hydropower production within the basin is at risk due to increased droughts. Critical infrastructure, such as roads and water supply systems, is vulnerable to more intense rainfall, increased flooding, and landslides. [263] Small-scale water management infrastructures, such as canals, ponds, and water wells, have been constructed or rehabilitated to reduce climate change-induced vulnerability. [264] The interplay between climate change and significant human development interventions creates a complex and unpredictable hydrological regime in Cambodia's vital river basins. For example, while climate change may lead to increased overall flow in the Mekong River, upstream damming can alter natural flow patterns, potentially reducing flows to critical areas like the Tonle Sap Lake. [265]

6.1.3 FORESTRY ECOSYSTEMS

Cambodia has experienced significant deforestation, losing one-third of its forest coverage over the last two decades, equivalent to 2.5 million hectares between 2001 and 2020. [266]

Forest degradation reduces the ability of natural systems to moderate local weather patterns and water flows, impacting hydrological cycles and exacerbating droughts. [267] Climate change is likely to disrupt forest productivity, decrease biodiversity, and hasten forest degradation.[268] Longer dry periods can reduce forest productivity and biodiversity, increase fire risk, and lead to atypical insect growth cycles. Nearly 4 million people, over 30% of the population, live within 5 km of forests and traditionally rely on forest resources, particularly non-timber forest products, as important safety nets during crises.[269] Illegal logging further destabilizes land and reduces its ability to regulate natural irrigation.[270] Some projections suggest significant biodiversity loss in Cambodian wetlands, with several species becoming endangered due to climate change impacts on their habitats and food sources.[271] Coastal mangroves, crucial for protection and livelihoods, have been heavily damaged by shrimp farming and charcoal production, with declines of 3-5% annually.[272] The reliance of poor rural populations on forest resources as a traditional safety net means that forest degradation, whether from climate impacts or human exploitation, directly impacts livelihood resilience, often pushing communities towards further unsustainable resource extraction. When forests degrade, the traditional safety net for communities weakens. This loss of livelihood support can force vulnerable communities to increase their exploitation of remaining natural resources, such as expanding agriculture into forest areas or intensifying extractive pressure on lakes, rivers, and mangroves as a last resort.[273] This creates a negative feedback loop where climate vulnerability and human pressures on forests exacerbate poverty and environmental degradation.

6.1.4 KEY CONSTRAINTS AND GAPS IN ADAPTATION EFFORTS

Cambodia is facing escalating climate risks that profoundly threaten its development trajectory and the well-being of its population. Cambodia's high vulnerability is a complex interplay of its inherent socio-economic sensitivities—rooted in a predominantly agrarian economy, widespread poverty, and high reliance on natural resources—and its currently limited adaptive capacities. While national policy frameworks and numerous adaptation initiatives are in place across key sectors, significant gaps persist in their widespread implementation, often due to insufficient data, limited institutional capabilities, and conflicting development priorities.

6.1.5 COASTAL AREAS

Cambodia's coastal zone faces increasing threats from sea level rise and inundation. [274] Coastal erosion and saltwater intrusion are encroaching on farmlands, contaminating freshwater sources, and jeopardizing food supply.[275] This phenomenon is accelerated by unchecked development along the ocean fronts.[276] These impacts directly affect coastal agriculture and fisheries, leading to declining yields and disrupted livelihoods. [277] The coastal zone is increasingly vulnerable to storms and storm surges, which are becoming more frequent and severe. [278] Most communities along the coastal zone live below the poverty line and rely heavily on rain-fed agriculture and other coastal resources for their sustenance, making them highly sensitive to these changes.[279] Additionally, despite significant on-the-ground efforts in ecosystem-based adaptation (e.g., mangrove restoration, dyke reconstruction) and livelihood diversification, the lack of comprehensive, localized data on saltwater intrusion and the understudied nature of sea-level rise impacts represents a critical information gap that hinders effective, data-driven adaptation planning and investment.[280] The high dependence of coastal communities on natural resources, coupled with the "exploitation of one natural asset after the next" as a coping strategy during climate-induced losses, creates a negative feedback loop.[281] Climate impacts degrade resources (e.g., fisheries, agricultural land), forcing communities to further exploit remaining natural assets (e.g., mangroves for food/fuel), which in turn reduces the natural adaptive capacity provided by healthy ecosystems.[282] This highlights that vulnerability is not just about external climate forces but also about the internal dynamics of human-environment interaction under stress.

6.1.6 HEALTH SECTOR

Human health in Cambodia is significantly impacted by climate change, with increased incidence of extreme heat posing a major threat, particularly for outdoor labourers and urban populations where the urban heat island effect compounds heat rises.[283] Climate change pressures, including increased drought, extreme rainfall, and floods, along with higher temperatures, are environmental drivers for vector-borne diseases (e.g., dengue, malaria) and water-borne diseases (e.g., diarrheal diseases, typhoid, cholera).6 Higher temperatures correlate with greater dengue incidence, and off-season rainfall enhances mosquito breeding. Disease transmission is known to worsen during and after flood events.[284] Malnutrition and food insecurity are growing health risks. Approximately 14.5% of the Cambodian population was undernourished as of 2019.[285] Cambodia's health system is strained, and primary healthcare facilities are often ill-equipped to prepare for and respond to extreme weather and climate events, lacking adequate water, sanitation, and cost-effective technologies.[286] While Health National Adaptation Plans (HNAPs) and surveillance systems are being developed, the existing "limited technical capacity of healthcare systems and personnel" and ill-equipped primary healthcare facilities constrain the effectiveness of these plans.[287] For example, provincial health departments often face limited budgets, affecting their ability to provide medication in high-risk areas.[288]

6.2 VULNERABILITY INDICATORS

A comprehensive climate vulnerability assessment for Cambodia must capture the intersection of biophysical hazards, socioeconomic fragility, and sector-specific sensitivities. Cambodia faces multiple climate risks—including floods, droughts, heatwaves, and sea-level rise—across a landscape marked by socio-economic inequalities, widespread dependence on natural resources, and limited adaptive capacity. The indicators outlined below serve to operationalise this complexity by quantifying both sensitivity and capacity at a spatially disaggregated scale, enabling targeted and evidence-based adaptation interventions across key sectors: agriculture, water, forestry, coastal environment, and health. The following vulnerability indicators were selected to cover the adaptive capacity and sensitivities of the priority sectors.

• Risk hotspots • Socioeconomic vulnerability • Climate and environmental vulnerability • Populated areas vulnerability • Subnational Human Development Index • Sub-national Gender Vulnerability Disparity Index • Education ratio	• Accessibility • Areas of rainfed crops • Drought vulnerability • Crop yield gap • Hunger and underweight children index • General health index • Vaccine coverage • Access to healthcare	• Major hazard areas include severe flooding, landslides and lightning • Ecosystem loss/degradation • NDVI change • Forest Landscape Integrity Index • Erosion rates • Electricity access • Settlement support

• National Income per capita • Dependency ratio • Deprivation trend • Life expectancy	• Infant Mortality Rate • Water stress • Water supply/demand • Groundwater vulnerability and recharge	• Mortality risk areas • Coastal sensitivity including livelihoods, tourism and ecosystem compromises

Risk hotspots

Risk hotspots identify areas with a convergence of multiple climate-related hazards such as floods, droughts, and storms. In Cambodia, where the population and agriculture are highly concentrated in the Tonlé Sap basin and Mekong floodplain, such hotspots are crucial for prioritising adaptation and disaster risk reduction investments. Mapping these areas allows for targeted infrastructure improvements and early warning systems, especially for flood-prone districts. These areas are highest in the major urban areas and along the northwest to southeast band in the central part of the country.

Socioeconomic vulnerability

This indicator captures a population's exposure and sensitivity to climate impacts based on income, livelihood stability, and access to services. This is highest in the major urban areas of Phnom Penh as some smaller areas to the northwest.

Climate and environmental vulnerability

This measures how sensitive an area is to climatic shifts and environmental degradation. In Cambodia, rapid deforestation, wetland conversion, and rising temperatures increase vulnerability, especially in forested and agricultural zones. It supports forestry, water, and ecosystem management strategies by identifying areas requiring ecological restoration or protection. The central bank from the northwest to the southeast sees the highest vulnerabilities due to ecosystem depletion and land cover coverage changes.

Populated areas vulnerability

This highlights where high population densities intersect with climate risks. In cities like Phnom Penh or coastal urban areas like Sihanoukville, rapid urbanisation without commensurate infrastructure increases susceptibility to heat stress, flooding, and disease outbreaks. This indicator is key for urban planning and public health resilience. The higher vulnerabilities follow the main population areas.

Subnational Human Development Index

The HDI provides a composite measure of education, health, and income at the subnational level. In Cambodia, disparities in HDI between Phnom Penh and rural provinces indicate varying levels of adaptive capacity. It helps prioritise development support in areas where low HDI correlates with high exposure to climate hazards. The lowest HDI is noted in areas to the northwest.

Sub-national Gender Disparity Index

This indicator examines gender-based differences in vulnerability. In Cambodia, rural women often lack the same land access and rights, credit, and decision-making power, especially in agriculture. Incorporating this metric ensures that climate adaptation strategies are inclusive and address systemic gender inequalities. Reports from the FAO highlight that women have less access to land ownership, resources, and decision-making roles in rural Cambodia.[289] The highest disparities are north in the northeast and in the central western and southern areas.

Education ratio

The proportion of the population with access to primary or secondary education influences community resilience. Education equips individuals with the knowledge needed to adopt climate-resilient practices and health-seeking behaviours. In Cambodia, low education ratios in rural provinces hinder the adoption of climate-smart agriculture and health interventions. Data from the Cambodian government's 2019 census further illustrate that literacy and educational attainment are consistently lower in rural areas, which hampers the capacity and willingness of farmers and communities to engage in climate adaptation efforts and health programs.[290] The highest education index is noted in the more developed areas and generally lower in the areas to the southwest.

National Income per Capita

This indicator reflects average economic resilience. Low-income levels in much of rural Cambodia limit households' ability to invest in adaptive strategies like irrigation, crop diversification, or healthcare. It is useful for identifying areas where economic vulnerability exacerbates climate sensitivity. The lowest income levels are noted in the northeast and central areas of the country. The heist incomes are noted in the main urban areas.

Dependency Ratio

A high dependency ratio indicates a larger proportion of the non-working (youth and elderly) population. This reduces household resilience to climate impacts, as fewer income earners must support more dependents. This is especially significant in rural farming households where labour availability affects productivity and recovery from shocks. The highest dependency ratio is noted in the northeast of the country and some southern central areas.

Deprivation Trend

Tracking changes in poverty, nutrition, and living standards over time reveals areas with persistent or worsening vulnerability. These suggest a possible increase in deprivation in some of the more remote areas of the country while the main urban areas have advancements in services compared to these rural areas.

Life Expectancy

As a proxy for public health and living conditions, life expectancy reflects the ability of populations to withstand and recover from climate-related health stresses. Lower life expectancy in some rural provinces highlights deficiencies in healthcare and sanitation, which climate change could exacerbate. The lowest life expectancy is noted in the northeast of the country.

Accessibility

This measures how easily people can access services such as markets, hospitals, or administrative centres. In flood-prone or remote regions of Cambodia, limited road access delays disaster response and restricts access to healthcare and agricultural inputs. It is essential for designing service delivery improvements. The higher access areas are present in the developed areas and along the northwest to southeast bank across the country. The more remote parts of the country have more limited accessibility.

Areas of Rainfed Crops

Rainfed agriculture dominates Cambodia's cropping systems and is highly vulnerable to rainfall variability and drought. Mapping these areas helps identify where climate-smart agricultural interventions, such as supplemental irrigation or drought-resistant crops, are most needed. The highest proportion of rainfed agriculture is present along the northwest to the southeast bank and then to the south of the country as the major agricultural areas.

Drought Vulnerability

This indicator combines exposure to drought with sensitivity due to crop type, water storage, and socioeconomic conditions. The higher vulnerabilities are noted in the central areas as well as in the northwest of the country. The southern areas have lower drought vulnerability.

Crop Yield Gap

This measures the difference between actual and potential crop yields. Large yield gaps indicate inefficiencies due to climate stress, poor soil health, farm management, or inadequate inputs. Closing yield gaps is crucial for food security and can guide targeted agricultural support in vulnerable provinces. The gap considered the yield potential of cassava, maize, rice and sugarcane and highlights higher gaps present in the southern areas of the country.

Hunger and Underweight Children Index

Child nutrition is a direct reflection of household food security and health. In Cambodia, undernutrition is prevalent in many areas and linked to climate-sensitive agricultural output. This indicator supports both agriculture and health sector planning. The highest index is noted in Phnom Penh and the more densely populated areas to the northeast as well as in the areas to the northeast.

General Health Index

This composite indicator reflects access to health services, nutrition, and disease burden. Poor health status reduces resilience to climate shocks, especially vector- and waterborne disease outbreaks. It identifies areas needing health system strengthening. The lowest health index is present in the areas to the northeast and some areas to the south.

Vaccine Coverage

Vaccination reduces the spread and severity of infectious diseases, which can increase under climate stress. In flood-prone areas, low vaccine coverage increases the risk of post-disaster outbreaks. Monitoring this ensures health systems are climate-resilient. The lowest vaccine coverage is also noted in the northeastern and northern areas of the country. The central and southern areas have the highest vaccine coverage.

Access to Healthcare

This determines how easily populations can receive medical treatment. In remote Cambodian provinces, distance and cost barriers impede timely care during climate-related health crises. Improving access strengthens community resilience. The central southern areas have the highest access to health care. The more remote areas to the east and the northeast have lower access to healthcare.

Infant Mortality Rate

High infant mortality signals poor baseline health conditions, often exacerbated by climate-related factors like malnutrition and disease. This indicator helps target health and sanitation interventions in vulnerable districts. The areas to the northeast and some areas to the south have the highest infant mortality rate.

Water Stress

This evaluates community access to water and the degree to which water is a limiting factor for livelihoods, well-being and health. Cambodia’s growing agricultural and urban demand, coupled with seasonal variability, is stressing water systems, particularly in the dry season. The highest demand is noted in some of the central areas as well as the areas, not the northwest.

Water Supply/Demand

This complements water stress by quantifying the absolute and relative levels of available water and consumption. Understanding this balance informs irrigation development, domestic water planning, and drought contingency measures. The highest difference between supply and demand is noted in the southeast parts of the country.

Groundwater Vulnerability and Recharge

This measures the susceptibility of aquifers to depletion or contamination and their natural replenishment rates. Over-extraction for irrigation and domestic use in provinces like Kampong Speu poses a long-term sustainability risk. This is vital for integrated water resource management. The central areas of the country have the highest utilisation and vulnerability of groundwater and the lowest recharge rates.

Major Hazard Areas

(Severe Flooding, Landslides, Lightning): Identifying zones frequently affected by these hazards enables pre-emptive risk reduction. Floods affect lowland rice production and urban centres, while landslides impact upland provinces like Ratanakiri. Flooding follows the main channels that run northwest to southeast of the country. Landslides are predominantly noted in the southwestern elevated areas. There is generally a high density of lightning over most of the country.

Ecosystem Loss/Degradation

Cambodia's ecosystems such as wetlands, forests, and mangroves buffer climate impacts. Their loss increases vulnerability across sectors. Monitoring degradation helps target conservation and restoration efforts, particularly relevant to agriculture and coastal protection. The major areas of ecosystem loss are noted in a band from northwest to southeast due to the expansion of the main agricultural areas.

NDVI Change

Changes in the Normalized Difference Vegetation Index (NDVI) track shifts in plant biomass and vegetation health. Declining NDVI may signal drought stress, land degradation, or deforestation. This remote sensing indicator supports land use and ecosystem management. The NDVI signal is highly varied but shows a general decrease in vegetation biomass in the central and northern areas but a small increase in the southwest of the country.

Forest Landscape Integrity Index

This measures forest health, connectivity, and human disturbance. Cambodia's forests are vital for water regulation and carbon sequestration. Declining integrity indicates rising vulnerability in both forestry and agriculture sectors. The major forested areas to the southwest of the country are mostly intact but have depleted integrity along the edges of the areas. The forests in the north are most disturbed and have generally lower integrity and minimal areas of large continuous high-integrity zones.

Erosion Rates

Soil erosion reduces agricultural productivity and increases sedimentation in waterways. In sloped or deforested areas, high erosion rates threaten food production and water quality. This indicator is essential for soil conservation planning. The central areas and the areas to the south have a very high erosion index. This is slightly lower in the northern areas of the country.

Electricity Access

Access to electricity enables irrigation, refrigeration, communications, and health services. Areas with low access are disadvantaged in implementing adaptive technologies. Expanding access is a cross-cutting adaptation enabler. The major urban areas have higher access while this remains low in much of the more rural areas.

Settlement Support services

This includes infrastructure such as drainage, housing quality, and social services. Improving settlement services and support boosts overall resilience. The highest support services are noted in the main urban areas of Phnom Penh and Battambang.

Mortality Risk Areas

These are zones where death rates due to natural hazards are elevated. Mapping them highlights critical vulnerabilities in emergency response and public health systems. The mortality rates correlate spatially with the population vulnerability with the highest rates noted along the northwest to south-east band running through the country and into the south. The areas to the northeast and southwest have lower mortality rates.

Coastal Sensitivity

(Livelihoods, Tourism, Ecosystems): This assesses how vulnerable Cambodia’s coastal zones are to disruptions resulting from sea-level rise, erosion, and extreme events. Livelihoods in fisheries and tourism are at risk, as are mangrove and coral ecosystems. It supports integrated coastal zone management and sustainable development planning. The areas around Preah Sihanouk are more vulnerable due to changes in land cover and ecological degradation than some of the areas around Chhak Kampong Som. Vulnerability also generally decreases further away from the coast.

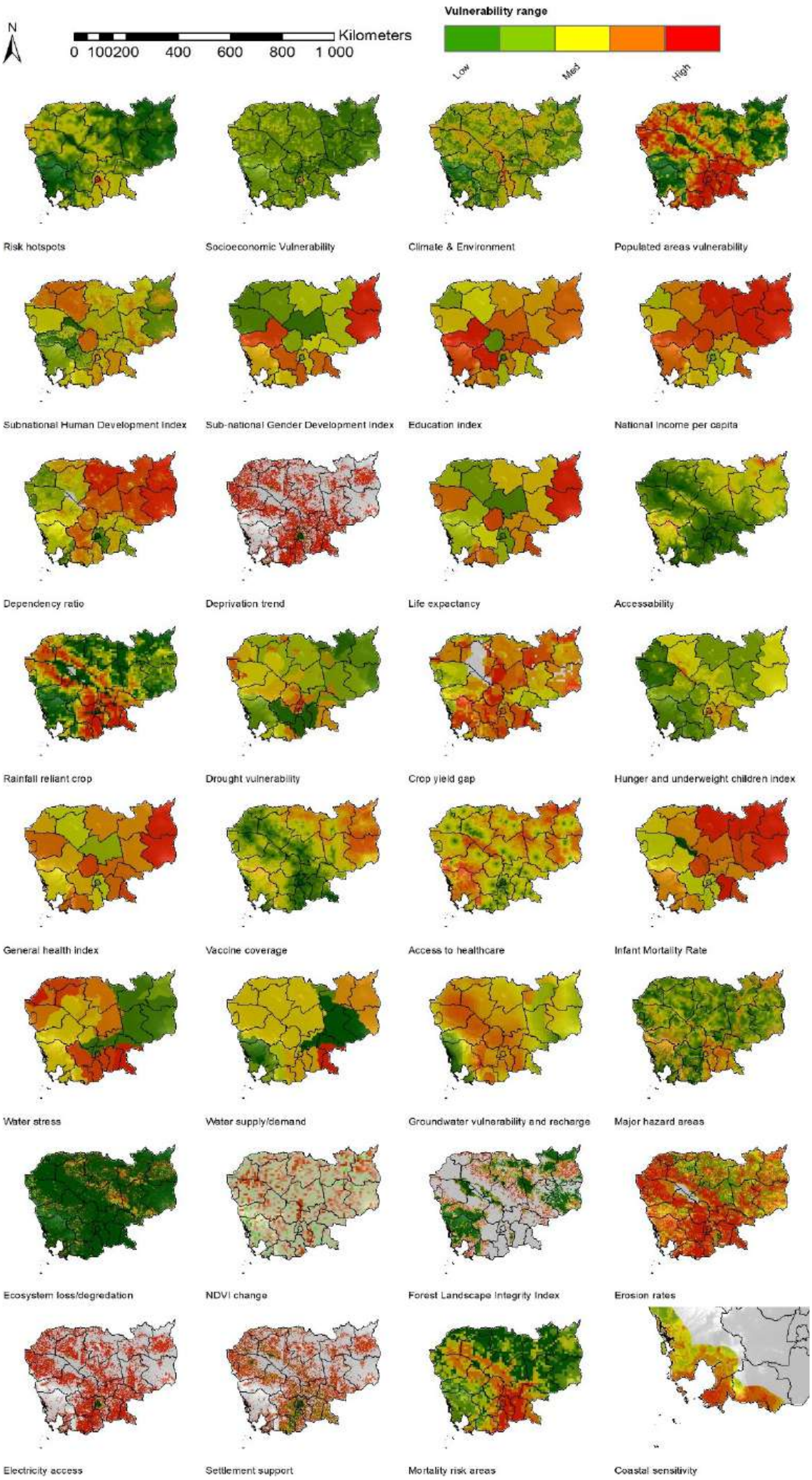


Figure 28. All vulnerability indicators are utilized in different vulnerability indices.

The combined vulnerability index considers each of the Agriculture, Disaster risk, Water, Ecosystem, Infrastructure, and Tourism sector vulnerabilities. The highest cumulative vulnerabilities are noted where there are multiple sectors are vulnerable.

- **Agriculture vulnerability**: The agriculture vulnerability index combines biophysical, climatic, and socio-economic indicators to reflect the multifaceted nature of agricultural risk in Cambodia. Areas of rainfed crops, drought sensitivity, crop yield gap, erosion, and proximity to flood areas collectively capture exposure and sensitivity to climatic extremes, with rainfed systems particularly vulnerable to rainfall variability and drought-prone areas at higher risk of crop failure. Erosion and yield gaps further indicate land degradation and production inefficiencies that limit resilience. Water stress serves as a cross-cutting constraint, affecting both crop viability and competition for limited resources. Socio-economic indicators—poverty, malnutrition, education ratio, and dependency ratio—provide insight into adaptive capacity, with poorer and less-educated populations, and households with high dependency burdens, less able to recover from or adapt to shocks. General climate stress integrates longer-term climatic variability, contextualising both chronic and acute pressures on agricultural systems. Spatially, the highest vulnerability is concentrated in central and southern Cambodia, where many of these stressors converge, while western areas show lower vulnerability, likely due to more favourable agroecological and socio-economic conditions. Northern and north-eastern regions show moderate vulnerability, suggesting targeted interventions are needed to build resilience in these transitional zones.
- **Water vulnerability**: The water vulnerability index integrates climatic, hydrological, and socio-economic indicators to provide a holistic assessment of water-related risks across Cambodia. General climate stress reflects the broader influence of temperature and rainfall variability on water systems, while water stress and water demand capture the imbalance between supply and consumption, identifying areas where water availability is under sustained pressure. Groundwater vulnerability highlights the susceptibility of subsurface resources to over-extraction or contamination, particularly important in regions reliant on wells for domestic and agricultural use. Proximity to flood areas represents exposure to hydrological extremes, which can disrupt water infrastructure and quality. Socio-economic indicators—poverty, education ratio, and dependency ratio—reflect the adaptive capacity of communities to manage water challenges, with higher vulnerability in areas where limited financial, educational, or human resources reduce resilience to both chronic stress and sudden disruptions. Spatial analysis shows the highest water vulnerability in central, northern, and northeastern Cambodia, where these stressors intersect most acutely, including high demand, climate pressure, and socio-economic limitations. In contrast, western areas exhibit lower vulnerability, likely due to more favourable climatic and hydrological conditions, combined with stronger socio-economic indicators. This index supports targeted interventions in high-risk areas to strengthen water security and adaptive capacity.
- **Forest ecosystem vulnerability**: The forest ecosystem vulnerability index integrates indicators that reflect both ecological degradation and environmental stressors, offering a comprehensive assessment of forest resilience across Cambodia. Ecosystem fragmentation, forest losses, and deforestation trends collectively indicate structural degradation and the declining integrity of forest landscapes, making ecosystems more susceptible to biodiversity loss and reduced ecological function. NDVI trends (Normalized Difference Vegetation Index) provide a proxy for vegetation health and productivity over time, with declining trends signalling stress

from land-use change or climate variability. Accessibility serves as a proxy for human pressure, with more accessible forests facing higher risks from logging, agriculture, and infrastructure development. Hydrological factors, including groundwater availability and recharge as well as water stress, are critical for forest health, particularly during dry seasons or in areas dependent on shallow water tables. Limited water availability can exacerbate the vulnerability of already stressed forest ecosystems. Spatially, the highest forest ecosystem vulnerability is observed in the southern, northern, and central regions of Cambodia, where these pressures converge. In contrast, the southwest and northeast show lower vulnerability, likely reflecting less fragmentation, better vegetation health, and reduced human disturbance. This index supports evidence-based conservation planning by identifying areas where forest ecosystems are most at risk and in need of targeted intervention.

- **Coastal area vulnerability**: The coastal area vulnerability index integrates physical, ecological, and socio-economic indicators to assess the compounded pressures facing Cambodia's coastal zones. Coastal erosion hotspots and coastal vegetation integrity reflect the direct environmental stress on shoreline stability and ecosystem health, with degraded vegetation cover and active erosion zones indicating high sensitivity to climate impacts and human disturbance. Coastal accessibility and tourism hotspots act as proxies for anthropogenic pressure, where increased development, infrastructure, and land conversion often lead to ecological degradation and increased exposure to hazards. Socio-economic dimensions, including coastal population poverty and education index, capture the adaptive capacity of communities, with poorer, less-educated populations typically having limited access to information, financial resources, and institutional support needed to manage and respond to coastal hazards. Spatially, the highest vulnerability is concentrated around Preah Sihanouk, where rapid land cover change, tourism development, and ecological degradation intersect. In contrast, areas around Chhak Kampong Som and more inland coastal zones show lower vulnerability, likely due to more stable ecosystems and lower development pressure. This integrated index provides a valuable tool for coastal planning and climate resilience strategies, allowing decision-makers to prioritise interventions where ecological stress and human vulnerability are most acute.
- **Human health vulnerability**: The human health vulnerability index combines health, infrastructure, demographic, and environmental indicators to provide a comprehensive assessment of population vulnerability to climate-related and systemic health risks. Core health indicators such as the infant mortality index, vaccine coverage, malnutrition index, general health index, life expectancy, and mortality risk areas capture both chronic and acute health burdens, particularly among vulnerable groups such as children and the elderly. Distance to health care and settlement support reflects access to essential health services and the spatial distribution of basic infrastructure, with limited access increasing vulnerability to both everyday health issues and climate-induced hazards. Water access and electricity access are critical for maintaining basic public health and sanitation systems, particularly under stress from extreme events. Socio-economic indicators—education ratio and dependency ratio—influence health resilience, with lower education and high dependency burdens reducing household capacity to prevent, respond to, and recover from illness or shocks. Major extreme hazard risks integrate environmental exposure, linking health vulnerability with hazard-prone areas. The index shows highest vulnerability in Cambodia's north-eastern and south-eastern regions, where poor infrastructure and limited services converge with elevated health

risks, while lower vulnerability is seen in more developed areas such as Phnom Penh and parts of the north-west, where health systems and basic services are stronger.

6.2.1 DISTRICT LEVEL RESULTS

Each of the different climate vulnerabilities is ranked from 1st (highest vulnerabilities) to 178th (lowest vulnerabilities) based on the individual and cumulative climate vulnerabilities indices for each of the sub-risks. These are presented and highlight the top 10 (red), 25 (orange) and 50 (yellow) ranked districts. These are grouped by Province to allow for strategic-level planning.

- **General vulnerability** includes standard social demographic factors—such as poverty, education ratio, dependency ratio, and climate stress—that can reduce a community's ability to adapt and increase sensitivity to climate impacts. The highest vulnerabilities are found especially in Phnom Penh and Kândal province, while Prey Vêng, Takêv, and Svay Rieng show moderate vulnerability.
- The **agriculture sector** assesses vulnerabilities such as rainfed crop areas, drought sensitivity, crop yield gaps, and malnutrition. Central and southern Cambodia face the highest risk due to overlapping stressors, while western regions are less vulnerable thanks to better agroecological and socio-economic conditions. Northern and north-eastern areas show moderate vulnerability, indicating a need for targeted resilience efforts.
- The **water sector** assesses vulnerability based on factors like water stress, demand, and groundwater risk. Spatial analysis indicates central, northern, and northeastern Cambodia face the highest vulnerability due to intersecting high demand, climate stress, and socio-economic challenges. Western regions are less vulnerable because of better climate, hydrology, and socio-economic conditions. This index helps guide interventions to improve water security in high-risk areas.
- The **forest sector** evaluates vulnerability factors such as ecosystem fragmentation, forest loss, deforestation trends, and NDVI trends. The highest levels of forest ecosystem vulnerability are found in the southern, northern, and central regions of Cambodia, where these pressures are concentrated. In comparison, the southwest and northeast regions display lower vulnerability, which may be associated with less fragmentation, better vegetation health, and reduced human disturbance. This index is used to support conservation planning by identifying areas where forest ecosystems face greater risks and may require targeted interventions.
- **Coastal vulnerability** assesses various factors within 25 km of coastal areas, including the Accessibility Index, Tourism hotspots, Coastal erosion hotspots, vegetation integrity, Population Education Index, and Poverty. Spatial analysis shows that higher vulnerability is present around Preah Sihanouk, where land cover change, tourism development, and ecological changes occur. In comparison, regions near Chhak Kampong Som and inland coastal zones exhibit lower vulnerability, which may be attributed to more stable ecosystems and less development activity. This integrated index serves as a resource for coastal planning and climate resilience strategies, supporting decision-makers in prioritising interventions based on ecological and human vulnerability.
- The **health sector** uses factors like infant mortality, healthcare access, vaccine coverage, general health, and water access to assess vulnerability. Cambodia's north-eastern and south-eastern regions show the highest vulnerability due to poor infrastructure and limited services, while areas like Phnom Penh and parts of the north-west are less vulnerable thanks to stronger health systems.

Table 18. Region and District vulnerability rankings for the different sectors [ccxci]

Provence	District	General Vulnerability	Agriculture sector	Water sector	Forest sector	Coastal Vulnerability	Health Sector	Cumulitive Vulnerability
Bântéay Méanchey	Malai	23	121	13	13	-	158	97
	Mongkol Borei	21	129	51	51	-	159	98
	Ou Chrov	41	143	41	41	-	168	133
	Phnum Srok	114	167	80	80	-	169	164
	Preah Netr Preah	91	142	44	44	-	166	142
	Serei Saophoan	25	125	19	19	-	162	103
	Svay Chek	103	151	45	45	-	167	151
	Thma Puok	115	164	71	71	-	172	165
Batdâmbâng	Aek Phnum	118	166	132	132	-	147	148
	Banan	97	136	56	56	-	112	117
	Bat Dambang	80	137	74	74	-	139	120
	Bavel	64	146	65	65	-	128	110
	Moung Ruessei	126	162	97	97	-	138	147
	Phnum Proek	12	111	29	29	-	123	69
	Rotanak Mondol	96	159	15	15	-	114	122
	Samlout	137	175	68	68	-	140	159
	Sangkae	104	152	106	106	-	142	136
	Svay Pao	7	103	40	40	-	161	53
Kâmpóng Cham	Batheay	60	1	136	136	-	33	16
	Chamkar Leu	85	122	83	83	-	60	89
	Cheung Prey	75	23	120	120	-	41	40
	Kampong Cham	6	15	161	161	-	127	28
	Kampong Siem	81	73	158	158	-	68	108
	Kang Meas	56	7	157	157	-	34	35
	Kaoh Soutin	63	22	153	153	-	29	39
	Prey Chhor	98	100	147	147	-	70	109
	Srei Santhor	58	21	149	149	-	30	34
	Stueng Trang	117	112	101	101	-	36	102
Kâmpóng Chhnang	Baribour	90	50	99	99	-	71	66
	Chol Kiri	65	11	114	114	-	35	18
	Kampong Chhnang	8	25	93	93	-	119	19
	Kampong Leaeng	94	48	125	125	-	58	59
	Kampong Tralach	77	9	133	133	-	53	43
	Rolea B'ier	69	35	92	92	-	57	51
	Sameakki Mean Chey	109	38	126	126	-	85	101
	Tuek Phos	139	72	96	96	-	72	118
Kâmpóng Spœ	Aoral	154	116	78	78	-	77	131
	Basedth	86	42	55	55	-	56	41
	Chbar Mon	35	131	63	63	-	150	74
	Kong Pisei	67	47	49	49	-	96	46
	Odongk	95	29	140	140	-	88	81
	Phnum Sruoch	123	74	27	27	-	66	71
	Samraong Tong	92	64	66	66	-	90	61
	Thpong	132	40	73	73	-	86	84
Kâmpóng Thum	Baray	82	41	82	82	-	37	32
	Kampong Svay	113	19	122	122	-	62	48
	Prasat Balangk	135	31	60	60	-	94	72
	Prasat Sambour	120	30	8	8	-	75	44
	Sandan	151	81	76	76	-	92	111
	Santuk	136	51	3	3	-	101	63
	Stoung	130	54	109	109	-	98	82
	Stueng Saen	52	14	105	105	-	63	17

Provence	District	General Vulnerability	Agriculture sector	Water sector	Forest sector	Coastal Vulnerability	Health Sector	Cumulitive Vulnerability
Kâmpôt	Angkor Chey	53	57	77	77	-	76	54
	Banteay Meas	37	24	72	72	-	49	25
	Chhuk	72	97	59	59	-	51	67
	Chum Kiri	99	123	17	17	-	45	77
	Dang Tong	55	44	30	30	-	50	38
	Kampong Bay	71	132	121	121	3	125	127
	Kampong Trach	40	89	86	86	6	65	56
	Kampot	148	156	146	146	9	73	158
	Angk Snuol	16	113	129	129	-	173	135
Kândal	Kandal Stueng	15	94	52	52	-	149	57
	Kaoh Thum	18	83	43	43	-	99	27
	Khsach Kandal	19	60	119	119	-	106	49
	Kien Svay	10	102	39	39	-	146	42
	Leuk Daek	26	70	69	69	-	105	31
	Lvea Aem	14	45	34	34	-	103	23
	Mukh Kampul	11	26	152	152	-	152	70
	Ponhea Lueu	42	34	141	141	-	151	92
	S'ang	13	43	50	50	-	120	24
	Ta Khmau	4	66	53	53	-	170	13
Kaôh Kong	Botum Sakor	157	158	160	160	8	137	173
	Kampong Seila	162	171	123	123	-	121	172
	Kaoh Kong	174	165	176	176	12	145	176
	Kiri Sakor	175	163	167	167	10	141	175
	Mondol Seima	176	176	177	177	13	131	178
	Smach Mean Chey	127	170	159	159	7	154	171
	Srae Ambel	165	150	154	154	11	113	168
	Thma Bang	178	172	178	178	-	118	177
Kep	Kaeb	44	157	107	107	4	38	87
Krâchéh	Chhloung	128	101	131	131	-	47	112
	Kracheh	129	77	170	170	-	91	139
	Preaek Prasab	140	88	137	137	-	83	130
	Sambour	159	124	168	168	-	93	163
	Snuol	147	141	150	150	-	81	152
Krong Pailin	Pailin	102	177	112	112	-	157	161
	Sala Krau	17	160	18	18	-	143	100
Krong Preah Sihanouk	Mittakpheap	62	174	148	148	1	174	169
	Prey Nob	116	169	117	117	5	135	162
	Stueng hav	122	173	110	110	2	160	170
Môndól Kiri	Kaev Seima	168	109	174	174	-	26	160
	Kaoh Nheaek	172	105	169	169	-	25	154
	Ou Reang	170	120	135	135	-	9	138
	Pechr Chenda	169	117	172	172	-	24	156
	Saen Monourom	153	107	164	164	-	22	143
Otdar Mean Chey	Anlong Veaeng	24	153	6	6	-	155	83
	Banteay Ampil	110	128	57	57	-	153	128
	Chong Kal	134	85	90	90	-	144	129
	Samraong	106	133	37	37	-	163	132

Provence	District	General Vulnerability	Agriculture sector	Water sector	Forest sector	Coastal Vulnerability	Health Sector	Cumulitive Vulnerability
Phnom Penh	Dangkao	5	148	95	95	-	175	119
	Mean Chey	**1**	**168**	**58**	**58**	**-**	**176**	**76**
	Phnom Penh	2	178	124	124	-	178	146
	Ruessei Kaev	3	126	142	142	-	177	105
Pouthisat	Bakan	121	49	115	115	-	104	85
	Kandieng	119	76	118	118	-	126	96
	Krakor	133	61	70	70	-	110	94
	Phnum Kravanh	158	106	143	143	-	95	144
	Sampov Meas	108	62	81	81	-	67	73
	Veal Veaeng	173	155	163	163	-	116	174
Preah Vihéar	Chey Saen	145	75	130	130	-	40	99
	Chhaeb	161	130	165	165	-	82	155
	Choam Khsant	150	108	127	127	-	59	121
	Kuleaen	105	79	100	100	-	61	65
	Rovieng	146	78	36	36	-	48	88
	Sangkom Thmei	152	90	108	108	-	52	113
	Tbaeng Mean chey	142	68	103	103	-	32	80
Prey Vêng	Ba Phnum	30	10	16	16	-	13	7
	Kamchay Mear	59	4	10	10	-	10	4
	Kampong Leav	28	13	48	48	-	23	10
	Kampong Trabaek	38	2	7	7	-	15	2
	Kanhchriech	70	3	11	11	-	11	5
	Me Sang	49	5	4	4	-	7	3
	Pea Reang	50	16	62	62	-	18	12
	Peam Chor	29	36	38	38	-	12	11
	Peam Ro	20	18	32	32	-	21	6
	Preah Sdach	27	6	23	23	-	8	1
	Prey Veaeng	46	12	20	20	-	14	9
	Sithor Kandal	78	28	89	89	-	17	22
Rôtânôkiri	Andoung Meas	156	95	25	25	-	3	75
	Ban Lung	131	92	104	104	-	6	68
	Bar Kaev	141	84	84	84	-	1	60
	Koun Mom	160	96	128	128	-	20	107
	Lumphat	155	91	145	145	-	19	104
	Ou Chum	144	87	33	33	-	2	50
	Ou Ya Dav	164	98	144	144	-	16	124
	Ta Veaeng	177	119	171	171	-	4	153
	Veun Sai	166	104	156	156	-	5	126
Siemréab	Angkor Chum	73	80	22	22	-	108	79
	Angkor Thum	76	110	2	2	-	124	78
	Banteay Srei	79	144	21	21	-	133	115
	Chi Kraeng	111	145	94	94	-	148	137
	Kralanh	87	93	47	47	-	109	90
	Prasat Bakong	138	147	116	116	-	165	157
	Puok	84	134	85	85	-	134	116
	Siem Reab	112	154	102	102	-	171	150
	Soutr Nikom	124	139	113	113	-	164	149
	Srei Snam	100	69	28	28	-	122	93
	Svay Leu	125	161	9	9	-	156	140
	Varin	93	149	1	1	-	129	91

Provence	District	General Vulnerability	Agriculture sector	Water sector	Forest sector	Coastal Vulnerability	Health Sector	Cumulitive Vulnerability
Stœng Trêng	Sesan	163	118	151	151	-	69	145
	Siem Bouk	167	115	175	175	-	78	167
	Siem Pang	**171**	**138**	**173**	**173**	-	**64**	**166**
	Stueng Traeng	143	114	155	155	-	89	141
	Thala Barivat	149	99	138	138	-	84	134
Svay Rieng	Chantrea	31	63	42	42	-	79	33
	Kampong Rou	51	32	31	31	-	55	26
	Romeas Haek	61	27	12	12	-	39	21
	Rumduol	54	17	26	26	-	44	15
	Svay Chrum	22	8	14	14	-	31	8
	Svay Rieng	9	20	24	24	-	107	14
	Svay Teab	57	55	35	35	-	74	47
Takêv	Angkor Borei	34	33	75	75	-	80	20
	Bati	33	82	54	54	-	130	64
	Bourei Cholsar	43	56	88	88	-	87	36
	Doun Kaev	32	52	67	67	-	136	55
	Kaoh Andaet	48	39	98	98	-	117	45
	Kiri Vong	36	59	91	91	-	115	62
	Prey Kabbas	39	37	61	61	-	102	30
	Samraong	47	65	46	46	-	111	52
	Tram Kak	68	127	64	64	-	132	106
	Treang	45	67	79	79	-	100	58
Tbong Khmum	Dambae	101	135	139	139	-	46	123
	Kampong Siem	74	71	166	166	-	97	114
	Krouch Chhmar	66	58	162	162	-	42	95
	Memot	107	140	111	111	-	54	125
	Ou Reang Ov	89	46	87	87	-	27	37
	Ponhea Kraek	88	53	5	5	-	28	29
	Tbong Khmum	83	86	134	134	-	43	86

6.2.2 CUMULATIVE MULTI-VULNERABILITY INDEX

The cumulative vulnerability in Cambodia arises from the interplay of multiple sectors: agriculture, water, forest ecosystems, coastal zones, and human health. Agriculture, as the backbone of rural livelihoods, is highly sensitive to climate variability, particularly changes in precipitation patterns and temperature, which affect crop yields and livestock health. Water resources face stress from both seasonal droughts and flooding, compromising availability and quality for human consumption and irrigation. Forest ecosystems, vital for biodiversity and local livelihoods, are threatened by deforestation and altered rainfall, reducing their capacity to regulate microclimates and support ecosystem services. Coastal areas, especially vulnerable to sea-level rise and increased storm intensity, experience erosion and salinization impacting fisheries and settlements. Human health is affected by increased incidences of vector-borne diseases and heat stress, compounded by limited healthcare access in vulnerable zones.

These combined sectoral stresses lead to spatial differences in vulnerability across Cambodia. The highest cumulative vulnerability is observed in the south-eastern provinces of Prey Vêng and Svay Rieng, driven by intensive agricultural dependence, water scarcity, and exposure to climate extremes. Central provinces like Kâmpóng Chhnang and Kâmpóng Thum also show high vulnerability due to similar sectoral pressures. Moderate vulnerability characterizes Batdâmbâng and Siemréab, where some adaptive capacity exists. The lowest vulnerabilities are found in Kaôh Kong, Krâchéh, and Môndól Kiri, areas with more resilient ecosystems and less exposure to climatic stressors.

It is important to note that areas not highlighted in the analysis will still be vulnerable to climate risks both currently as well into the future. However, these regions scored lower in the cumulative multi-vulnerability assessment. Additionally, this analysis focuses solely on the climate vulnerability component of the overall climate risk assessment, with local-scale hazards and exposures still playing a significant role in determining the final climate risk outcomes.

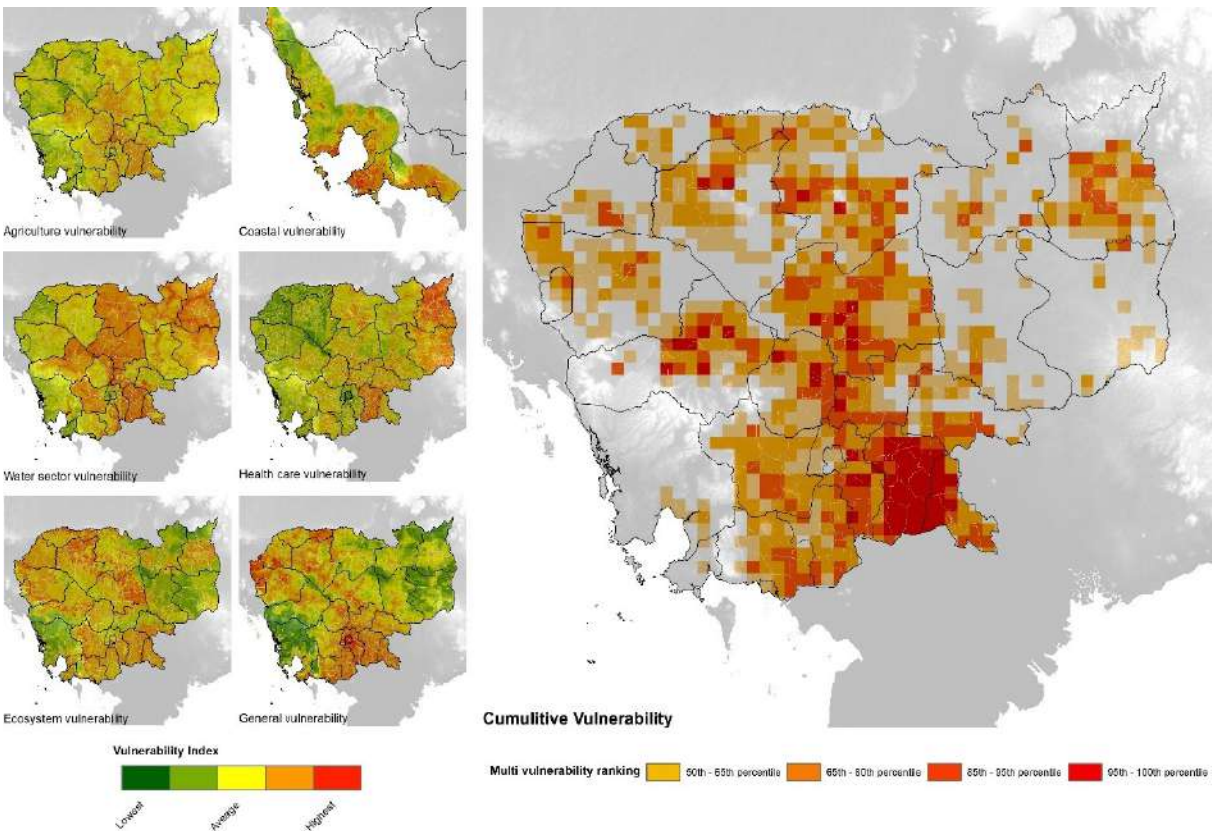


Figure 29. All Vulnerability indices and cumulative multi-vulnerability index

7 CLIMATE CHANGE RISK

In IPCC AR6, climate risk is conceptualised as the potential for adverse consequences for human or ecological systems, resulting from the interaction of climate-related hazards with the vulnerability and exposure of the affected system.[292] It is calculated as Risk = Hazard × Exposure × Vulnerability.

- Climate Hazards: These are the physical manifestations of climate variability or change and include both acute events (floods, droughts, tropical cyclones, heatwaves) and Chronic changes (annual rainfall changes, rainfall seasonality shifts, average temperatures)
- Exposure: This refers to the presence of people, ecosystems, assets, or infrastructure in places that could be adversely affected by climate hazards. These indicators are spatially georeferenced and include economic, social, and ecological assets.
- Vulnerability: This is the propensity or predisposition to be adversely affected. It is determined by both Sensitivity: How severely something is affected when exposed, and Adaptive capacity: The ability to adjust, respond, or recover.

Climate risk are the interaction of all three components where lower measures in any one will lower the overall risk, and higher measures will increase the risks. For instance, low exposure due to a lack of population, assets and livelihoods will result in lower risk even if there are higher hazards and vulnerabilities present in an area. Likewise, Lower climate hazards will lower the climate risk even when there are heightened vulnerabilities and higher exposures. This approach ensures that risks are highlighted when all three factors are present at least to a moderate degree.

This framing enables a comprehensive and systemic understanding of climate risks, moving beyond just biophysical hazards to include socioeconomic and ecological factors. This approach encourages a systems-based approach, acknowledging that climate risk is not just a function of climate, but also of societal development patterns. This framework aligns risk assessment with adaptation planning, by showing where reducing exposure or vulnerability can meaningfully lower risks—even if hazards increase.[293]

7.1 CLIMATE CHANGE RISK INDEX

Agriculture sectors assess three sub risks, Sub-risk 1 (a) water insecurity from changing rainfall patterns and meteorological drought; Sub-risk 1 (b) damages and losses to farm assets from more severe rainfall events from severe event occurrence change; and Sub-risk 1 (c) crop wilting, poor germination, and livestock stress associated with increased hot days and warm nights in a warming climate. It uses a combination of lowered average volumes (Annual rainfall volume, SPEI index, Annual rainfall variability index, Number of consecutive dry days, Aridity index) as well as changes to the extreme impact events (Rainfall days above 20mm, 1-day Peak volume, Peak monthly rainfall) as well as temperature changes for wilting considerations. The vulnerabilities focus on crop areas, yields as well as socioeconomic factors that affect farmers' and farming communities' ability to withstand and recover from climate impacts. The exposures considered were the populations, crop areas, livestock density as well as gender disparity.

The risks follow the major agricultural areas with higher risk in the more populated areas. The projected future sees an increase in risk based on projected vulnerabilities as well as changes in the seasonal rainfall patterns and the increased frequency and magnitude of rainfall and heatwave extreme events. There is a notable increased risk between the current scenario of 1990-2020 and the future events of 2020-2039 for SSP2 and SSP5.

The water sector considers the sub-risks of (a) changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture, and sub-risk 2 (b) increased severe events and saline intrusion resulting in contamination of water resources. It reviews the changes in annual and prolonged rainfall volumes as well as groundwater levels and recharge. It additionally, covers the extreme events that may lead to an increase in waterborne diseases or enhanced contamination. The vulnerability indicators covered water stress, water supply and demand as well as socioeconomic factors of Poverty, Education ratio, and Dependency ratio to estimate recovery from and resilience to extreme events. The exposure factors are populations, agricultural use, gender gap and economic activity as a proxy for water-using industries.

The water sector risks are generally moderate to high over most of the country, but this is highest in the major populated areas in the southern areas as well as in the northeast which has significant water stress issues. The projected future sees an increase in the severity of the risk though the spatial distribution of risk remains mostly consistent. The areas currently at risk of water insecurity or compromise are likely to still be at risk in the future but to a greater degree.

Ecosystem risk reviews the risk of Sub-risk3 (a) increased temperatures and wildfire risk impacting tree health and Sub-risk3 (b) decreased water availability limiting forest growth. This is done through the assessment of extreme temperatures impacting fire patterns as well as changes in water availability resulting from annual volume changes and drought intensity. The factors increasing the sensitivity of the forest areas are the ecosystem fragmentation, deforestation trends as well as biomass densities and groundwater availability. The exposure considerations were the forested and natural areas as well as areas that have seen significant land use changes as well as population proximity.

The current risk shows lowered risk in the southwestern forested and natural areas with only smaller risk noted in the forest and agricultural and developed area interfaces. The central and northern areas have significantly more risk due to the greater disruption in the natural areas' integrity impacts. The projected future sees an increase in all areas of risk, this is however high in the central and northern areas. The southwestern areas have an increase in risk, but this is only a moderate increase.

Coastal area risk considers the physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations. This is done through the projected changes in sea level rise, storm surges and severe tropical cyclone frequency changes. The coastal areas that are vulnerable to these impacts include local infrastructure, coastal tourism hotspots, erosion hotspots, as well as coastal ecosystem integrity. Additional factors considered include population incomes and education levels as proxies for adaptive capacity.

The higher risk areas are noted around Preah Sihanouk which Is more vulnerable due to local developments and population densities. Additionally, the coastal areas of Kampong Trach are at higher risk. In the areas to the north, the risk area is significantly lower, particularly further away from the coast. The projected future suggests an increase in all risk areas, but the higher risk areas are still noted in the areas around Preah Sihanouk and Kampong Trach but the areas in the north also see increased risk due to projected changes in sea level, tropical cyclone frequency and storm surges.

Health sector is exposed to several climate risks these include Sub-risks (a) increasing heat stress from notable rising heat index and extreme heat waves, Sub-risk5 (b) heightened incidence of vector and water-borne diseases due to changing climate suitability factors, and Sub-risk5 (c) acute impacts and disasters resulting from extreme weather events such as floods and severe storms. These risk areas are driven by increased severe temperatures, changes in rainfall affecting rainfall variability and extreme acute rainfall events impacting populations. Many of the vulnerability indicators relate to the population's personal capacities such as education and dependency ratios, but also particularly health indicators such as infant mortality rates, and distance to health care facilities. The exposed elements focused directly on the population as well as the gender resilience gap.

The higher-risk areas are those to the northeast of the country with the rest of the country showing low to moderate health risks in the current climate. The future scenarios show an increase of risk over the full area but particularly in the southern areas of the country. The areas to the northeast remain the highest risk areas in both projected future climate scenarios.

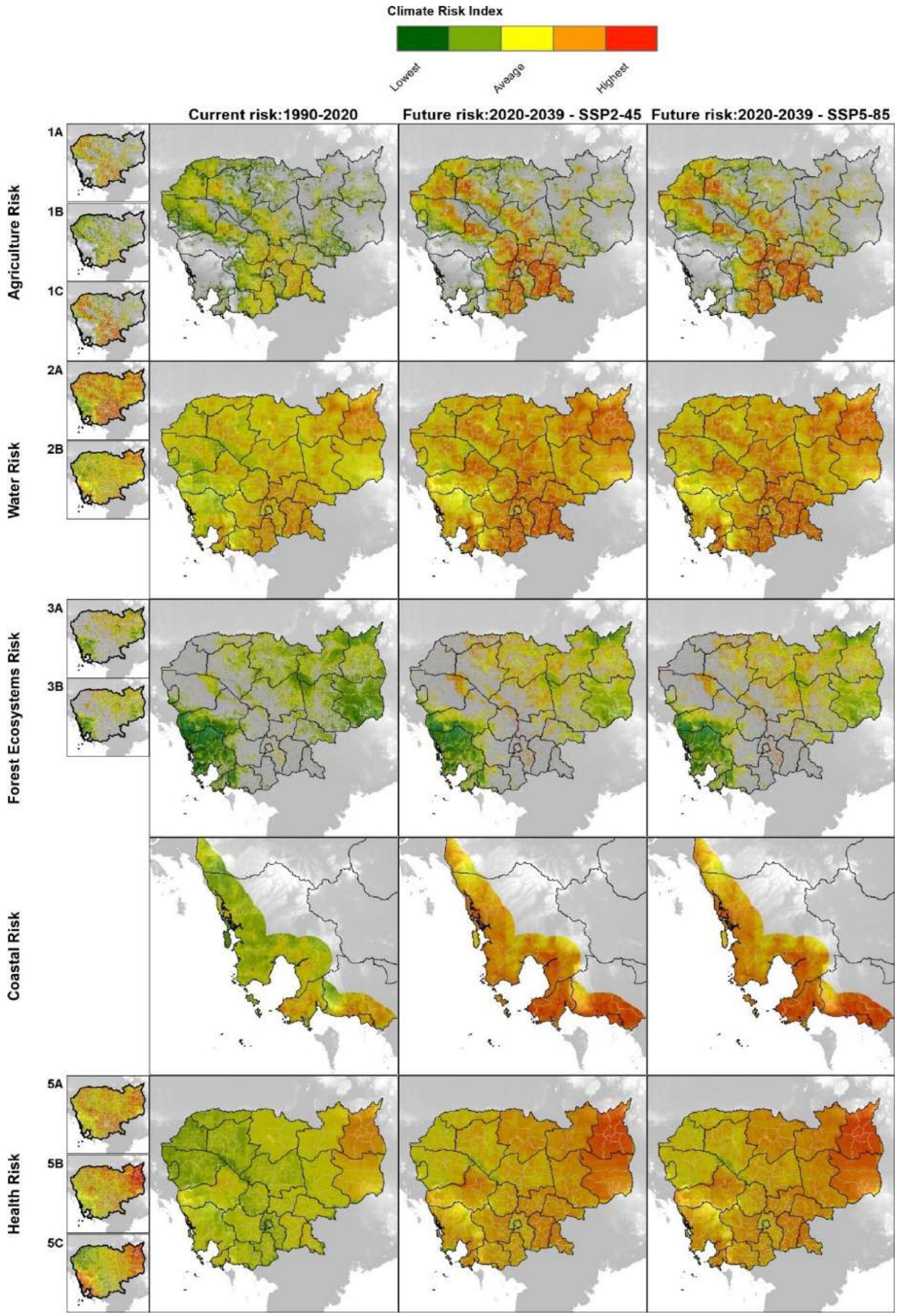


Figure 30. All sectoral risk indicators. Individual historic sub-risks (smaller panels), cumulative risk outputs for the current climate (larger panels left), future SSP2 scenario (larger panels middle) and future SSP5 scenario (larger panels right)

7.2 DISTRICT LEVEL RESULTS

Each of the different climate risks are ranked from 1st (highest risk) to 178th (lowest risk) based on the individual and cumulative climate risk indices for each of the sub-risks. These are presented and highlight the top 10 (red), 25 (orange) and 50 (yellow) ranked districts. These are grouped by Province to allow for strategic-level planning. The risks are assessed by sector and then by individual climate hazard. These are groups as follows

- **Sub-risk 1: Food systems compromised** by climate changes which considered the agricultural sector vulnerability and exposures in addition to the specific hazards per sub risk.
  - Sub-risk 1 (a) water insecurity from changing rainfall patterns and meteorological drought. Hazards include Annual rainfall volume, SPEI index, Annual rainfall variability index, Number of consecutive dry days, and Aridity index.
  - Sub-risk 1 (b) damages and losses to farm assets from more severe rainfall events from severe event occurrence change. Hazards include Rainfall days above 20mm, 1-day Peak volume, and Peak monthly rainfall.
  - Sub-risk 1 (c) crop wilting, poor germination, and livestock stress associated with increased hot days and warm nights in a warming climate. Hazards include Peak maximum temperature, Number of days above 35°C, Peak temperature of the warmest month, and Lowest minimum temperature.

  Risks are highest in densely populated agricultural regions. Projections indicate increased risks due to greater vulnerabilities, shifting seasonal rainfall, and more frequent extreme rainfall and heatwaves. Notably, risk rises between 1990–2020 and 2020–2039 under SSP2 and SSP5 scenarios.

- **Sub-risk 2: Water insecurity and contamination** from climate changes which considered the water sector vulnerability and exposures in addition to the specific hazards per sub risk.
  - Sub-risk 2 (a) changing spatial and temporal rainfall patterns and evaporation characteristics leading to lower capture. Hazards include Annual rainfall volume, SPEI index, Annual rainfall variability index, Evaporation index, and Groundwater Levels and Recharge Rates.
  - Sub-risk 2 (b) increased severe events and saline intrusion resulting in contamination of water resources. Hazards include Peak 1-day rainfall, Peak 5-day rainfall, Days over 20mm, SPEI index, Peak monthly temperatures, and Overland flow.

  Water sector risks range from moderate to high across much of the country, with the highest levels identified in densely populated southern regions and the northeast, which faces water stress. Projections indicate that risk severity will increase, although the overall geographic distribution is expected to stay relatively stable. Locations currently experiencing water insecurity or compromise are projected to continue facing these risks, likely at increased levels in the future.

- **Sub-risk 3: Forestry losses or compromise** from climate changes which considered the forest and ecosystem vulnerability and exposures in addition to the specific hazards per sub risk.
  - Sub-risk3 (a) increased temperatures and wildfire risk impacting tree health. Hazards include Days over 35°C, Heatwave, Monthly temperature peak, and Average maximum temperature.
  - Sub-risk3 (b) decreases water availability by limiting forest growth. Hazards include Annual rainfall volume, SPEI index, and Aridity index.

  Currently, southwestern forested areas face low risk, while interfaces with developed or agricultural land have minor risks. Central and northern regions experience higher risk due to greater environmental disruption. In the future, risk is expected to rise everywhere, with central and northern areas seeing the largest increases and the southwest facing a moderate rise.

- **Sub-risk 4: Compromised coastal environment** from climate changes which considered coastal vulnerability and exposures in addition to the specific hazards.
  - Sub-risk4 (a) physical impacts of sea level rise and severe ocean events on coastal infrastructure and populations. Hazards include Sea level rise, Storm surge, Tropical cyclone occurrence, and Coastal flood risk.

  Preah Sihanouk and coastal Kampong Trach are identified as higher risk areas due to local development and population density, while northern regions have lower risk, especially farther from the coast. Future projections indicate risk will increase throughout, with notably higher risks remaining in Preah Sihanouk and Kampong Trach, and rising risks in the north due to expected sea level rise, more frequent tropical cyclones, and storm surges.

- **Sub-risk 5: Increasing impacts on Human Health** from climate changes which considered the health sector vulnerability and exposures in addition to the specific hazards per sub risk.
  - Sub-risks (a) increase heat stress from notable rising heat index and extreme heat waves. Hazards include Days over 35°C, Heatwave, and Monthly temperature peak.
  - Sub-risk5 (b) heightened incidence of vector and water-borne diseases due to changing climate suitability factors. Hazards include Rainfall seasonality, Maximum temperature increases, Increased peak precipitation, Annual rainfall, and Aridity index.
  - Sub-risk5 (c) acute impacts and disasters resulting from extreme weather events such as floods and severe storms. Hazards include Extreme single-day rainfall, Number of days above 20mm, Peak monthly precipitation, Overland flow areas, Tropical cyclone occurrence, and Coastal flood risk.

  Currently, the northeast faces the highest health risks, while other regions show low to moderate risk. Future scenarios indicate increased risk across the country, especially in the south, but the northeast remains the most vulnerable.

Table 19. Region and District risk rankings for the different sectors[294]

Region	District	Food systems compromise 1994-2014	Food systems compromise SSP2 2020-2039	Food systems compromise SSP5 2020-2039	Water insecurity and contamination 1994-2014	Water insecurity and contamination SSP2 2020-2039	Water insecurity and contamination SSP5 2020-2039	Forestry losses or compromise 1994-2014	Forestry losses or compromise SSP2 2020-2039	Forestry losses or compromise SSP5 2020-2039	Compromised coastal environment 1994-2014	Compromised coastal environment SSP2 2020-2039	Compromised coastal environment SSP5 2020-2039	Increasing impacts on Human Health 1994-2014	Increasing impacts on Human Health SSP2 2020-2039	Increasing impacts on Human Health SSP5 2020-2039
Bântéay Méanchey	Malai	60	↘	↘	159	↓	↓	122						171	→	↓
	Mongkol Borei	35			133		↓	163						152		
	Ou Chrov	50			158	↗		166						170	↘	↓
	Phnum Srok	54	↑	↑	162	↑	↑	155						163	↗	↑
	Preah Netr Preah	34			128	↑	↑	136						158	↗	↑
	Serei Saophoan	18	↗	↑	114	↑		171						156		→
	Svay Chek	33	↗	↗	164	↑	↑	162						165		↗
	Thma Puok	61	↗	↗	168	↑	↑	141						172	↗	↗
Batdâmbâng	Aek Phnum	136			171			11	→					161		↑
	Banan	66		↗	161	↗	↗	130						154	↘	
	Bat Dambang	58	↗	↗	137	↓	↓	103						151	↘	
	Bavel	52			147	↑	↘	167						162		↓
	Moung Ruessei	96			172	↘	↘	85						147	→	↑
	Phnum Proek	69		↘	149	↑	↓	127						175		↓
	Rotanak Mondol	101	↘	↘	173			83						168	↗	↗
	Samlout	144	↘	↘	175			50	↘	↘				166	↑	↑
	Sangkae	99		↗	154	↘	↘	51						160	↓	
	Svay Pao	48	↗	↗	88	↘	↓	170						150		↑
Kâmpóng Cham	Batheay	15	↗	↑	34			132						61	↓	
	Chamkar Leu	110			76	↑	↑	53						58	↗	↓
	Cheung Prey	13	↗	↗	22	↓	↓	145	↗	↗				49	↘	↑
	Kampong Cham	56		→	1	↑	↑	144						108		↗
	Kampong Siem	71			45	↑	↑	98						69	→	↑
	Kang Meas	41	→	↘	51	↑	→	105						62	↓	
	Kaoh Soutin	91			30	↓		72						53	↓	↑
	Prey Chhor	51		↘	72	↓	↓	131						68	↗	
	Srei Santhor	75			50	↗	↘	114	→	→				55	↓	↘
	Stueng Trang	122	↗		85	↑	↑	42	↘	↘				42	↑	→
Kâmpóng Chhnang	Baribour	78	↗	↗	110	↓	↓	95						124	↑	
	Chol Kiri	74			71	↓	↓	94						76	↗	↑
	Kampong Chhnang	47			58	↓	↓	142						115	↗	
	Kampong Leaeng	103			139	↓	↓	57						92	↑	↑
	Kampong Tralach	11		↑	55	↑	↑	151						91	↓	↑
	Rolea B'ier	38	→		79	↗	↗	115						96		↑
	Sameakki Mean Chey	63		↗	127	↑	↑	97						129	↓	↑
	Tuek Phos	92			153		↑	75						157	↓	↓
Kâmpóng Spœ	Aoral	133			142	↑	↑	44	→					103		↑
	Basedth	44		↗	21	↑	↗	111						66	↓	↓
	Chbar Mon	87	→		83	↑	↑	176						90	↓	↓
	Kong Pisei	30			18	↑	↑	116						75	→	↓
	Odongk	5			37	↑	↑	173						46	↓	↘
	Phnum Sruoch	84	↗		87	↑	↑	93						86	↓	↓
	Samraong Tong	65	→		67	↑	↑	133						63	↓	↓
	Thpong	55		↗	82	↑	↑	121						64	↓	↑
Kâmpóng Thum	Baray	57			65	↓	↓	110						71	↑	↑
	Kampong Svay	86			126	↓	↓	79	→	→				116	↑	↓
	Prasat Balangk	98	↗	↗	106	↓	↓	58	↘	→				119	↑	↓
	Prasat Sambour	104			89	↓	↓	47	↓	↓				99	↑	↑
	Sandan	148			112	↓		10	↓	↓				106	↑	↑
	Santuk	114			93	↘		41	↘	↘				113	↑	
	Stoung	121			152	↓	↓	64	↘	↘				153	↘	↓
	Stueng Saen	42		↘	77	↓	↓	146						85	↑	↑
Kâmpôt	Angkor Chey	26			52	↘	↓	134	→	→				117	↓	↓
	Banteay Meas	14		→	23	↓	↓	156			6	→	→	94	↓	
	Chhuk	90			98	↗		78						104	↓	↓
	Chum Kiri	119			131	↑	↑	52						110	↓	↓
	Dang Tong	45	↘	↘	57	↗	↓	125			3	→	→	93	↓	↓
	Kampong Bay	128			122	↓	↓	66			1	→	→	121	↘	↓
	Kampong Trach	64		↘	75		↓	123			4	→	→	105		↗
	Kampot	139			146	↘		49	↗	↗	10	→	→	82	↑	↓

Region	District	Food systems compromise			Water insecurity and contamination			Forestry losses or compromise			Compromised coastal environment			Increasing impacts on Human Health		
		1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039
Kândal	Angk Snuol	59	↘	↘	121	↑	↑	149						176	↓	↓
	Kandal Stueng	43			42	↑	↑	126	↗	↗				142	↘	↓
	Kaoh Thum	73			68	↑	↑	107						136	→	↘
	Khsach Kandal	81	↘		64	↑	↑	118						89	↓	
	Kien Svay	115			91	↑	↑	73						140	↘	↓
	Leuk Daek	88			74	↗	↑	77	↗					126	↘	↓
	Lvea Aem	80			54	↑	↑	90						100	↓	↘
	Mukh Kampul	77			80	↑	↑	82						141	↘	→
	Ponhea Lueu	39		↗	59	↑	↑	124						144	↓	→
	S'ang	83			60	↑	↑	87	↗	↗				137	↘	↓
	Ta Khmau	109			48	↗	↑	74						149	↓	↓
Kaôh Kong	Botum Sakor	162	↗	↗	170	↓	↓	39	↗	↗	13	↗	↗	84	↑	↑
	Kampong Seila	160			144	↑	↑	31	↗	↗	12	→	→	120	↑	→
	Kaoh Kong	175			160	↓	↓	28	↑	↑	15	→	→	98	↗	↓
	Kiri Sakor	167			163	↓	↓	54	↗	↗	14	→	→	80	↑	↑
	Mondol Seima	177			169	↘		40	↑	↑	18	→	→	78	↑	↑
	Smach Mean Chey	147	↗		132	↓	↘	60	↑	↑	9	→	→	28	↘	↗
	Srae Ambel	163			111	↗		33	↗	↗	11	→	→	101	↗	↘
	Thma Bang	178			178			43			17	→	→	148	↗	↘
Kep	Kaeb	125			141	↘	↓	80			5	→	→	135	↑	
Krâchéh	Chhloung	107			107	↑	↑	68						47	↑	↘
	Kracheh	106			97	↑	↑	61						54	↑	↓
	Preaek Prasab	112			105	↑	↑	55						65	↑	
	Sambour	141	↗	↗	118	↗	↑	20	↗					45	↗	↘
	Snuol	117			145	↗		63						67		
Krong Pailin	Pailin	142			176	↗		48						173	↗	↗
	Sala Krau	85		→	138	↑	↑	104	↗					167	↑	→
Krong Preah Sihanouk	Mittakpheap	155		↗	174	↓	↓	88	↑	↑	2	→	→	127	↑	↑
	Prey Nob	145			109	↓	↓	36	↗	↑	8	→	→	73	↑	↗
	Stueng hav	150	↗	↗	94	↓	↓	38	↑	↑	7	→	→	56	↑	↗
Môndól Kiri	Kaev Seima	165			157	↓	↓	26	↘	↘				13	→	
	Kaoh Nheaek	153			95	↓	↓	17	→	↘				10		
	Ou Reang	172			166	↓	↓	24		↗				20	↑	↑
	Pechr Chenda	174			148	↓	↓	15	↘	↓				12		
	Saen Monourom	170			134	↓	↓	29	↘	↘				11		
Otdar Mean Chey	Anlong Veaeng	118			117	↗	↑	45						125	↑	↑
	Banteay Ampil	70	↗	↗	140	↑	↑	99	↗	↗				146	↑	↑
	Chong Kal	68			123	↑	↑	100	↗	↗				131	↑	↑
	Samraong	93			119	↑	↑	62						145	↑	↑
Phnom Penh	Dangkao	113			116	↑	↑	117						178		
	Mean Chey	156			100	↑	↑	109	↗	↗				132	↘	↘
	Phnom Penh	173			136	↑	↑	176						159	↘	↓
	Ruessei Kaev	124			84	↑	↑	89						174	↘	→
Pouthisat	Bakan	95			101	↓	↓	91	↘	↘				26	↑	↑
	Kandieng	105		↗	99	↓	↓	92	→	→				39	↑	↑
	Krakor	97			103	↓	↓	86						72	↗	↑
	Phnum Kravanh	149	→		167	↓	↓	35	↘	↘				79	↑	↑
	Sampov Meas	72	→	→	86	↓	↓	120						14		↗
	Veal Veaeng	171			177	↘	→	27						88	↑	↑
Preah Vihéar	Chey Saen	140			104	↓	↓	16	→					36		→
	Chhaeb	152			135	↘	↓	12	→	→				59	↑	↓
	Choam Khsant	146			130	↗	↗	13						52	↑	↑
	Kuleaen	135			120	↓	↓	22	↗	↗				48	↗	↘
	Rovieng	137			115	↓	↓	18						60		↘
	Sangkom Thmei	143			129	↓	↓	19						70	↗	
	Tbaeng Mean chey	129			90	↓	↓	32	→	→				24	↑	↗

Region	District	Food systems compromise			Water insecurity and contamination			Forestry losses or compromise			Compromised coastal environment			Increasing impacts on Human Health		
		1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039	1994-2014	SSP2 2020-2039	SSP5 2020-2039
Prey Vêng	Ba Phnum	22		→	19		→	152						35	↘	↓
	Kamchay Mear	7	↘	→	24	↓	↓	165						17	↘	↘
	Kampong Leav	16	→		10		↗	153						31		↘
	Kampong Trabaek	1	↗		15	↗	↑	172						37	↓	↘
	Kanhchriech	2			13	↓	↓	157						19		
	Me Sang	3			25	↓	↓	150						18		
	Pea Reang	23	↘	↘	20	↗		137						27		
	Peam Chor	67			43	↓	↘	154						81	↓	↘
	Peam Ro	49			11		↑	135	↗					38	↘	↘
	Preah Sdach	6			8		↗	164						32	↓	
	Prey Veaeng	28			36	→	↗	147	→	→				25		↘
	Sithor Kandal	10			27	↓	↘	119	↘	↘				23	↘	↗
Rôtânôkiri	Andoung Meas	161			7	↑	↑	3						4		
	Ban Lung	157			2			8						1	↗	
	Bar Kaev	158		→	4	↑	↑	7		→				2		
	Koun Mom	130		↗	32	↘	↓	30						8		
	Lumphat	131			41	→	↘	25	↗	↗				6		
	Ou Chum	169			3	↑	↗	1						3	→	→
	Ou Ya Dav	151			47	↘	↘	9	↘	↘				7		
	Ta Veaeng	176			29	↑	↑	6	↑	↑				9		
	Veun Sai	168			9	↑	↑	4	↗	↗				5		
Siemréab	Angkor Chum	12	↗	↗	38	↑	↑	113						109	↘	↑
	Angkor Thum	82		→	70	↘	↑	71						130	↓	
	Banteay Srei	108			102	↓		56	→	→				138	↓	
	Chi Kraeng	100			151	↓	↓	65						143		↘
	Kralanh	37	↗	↑	78	↑	↑	106						95	↑	↑
	Prasat Bakong	123	→	→	155	↓	↓	139						169	↘	
	Puok	79			108	↑	↑	81						139		↑
	Siem Reab	127			150	↓	↓	102	→	→				177	↘	
	Soutr Nikom	116			156	↓	↓	96						164		
	Srei Snam	40	↑	↑	96	↑	↑	112						111	↑	↑
	Svay Leu	138			165		↗	21						155	↓	↓
	Varin	120			124		↑	37						122	↓	↑
Stœng Trêng	Sesan	154			81	↓	↓	14	↗	↗				16		
	Siem Bouk	159			143		↗	23	→	↘				43	↑	↑
	Siem Pang	164			49	↑	↑	5	↑	↑				15		
	Stueng Traeng	132	→	→	66	↓	↓	34	→	↘				21	↑	↗
	Thala Barivat	166			125	↓	↓	2						40	↗	
Svay Rieng	Chantrea	46		→	92	↓	↓	148						114	↓	↓
	Kampong Rou	21		→	61	↓	↓	160						83	↓	↓
	Romeas Haek	19	↓	↓	33	↓	↘	129	→	↘				22		→
	Rumduol	4			12	↓	↓	174						30	↘	↓
	Svay Chrum	25			17	↗	↑	158						29	↘	↓
	Svay Rieng	62	→	↘	5		↑	108						33	→	↘
	Svay Teab	32			63	↓	↓	138	↘	↘				50	↓	↓
Takêv	Angkor Borei	17	→	↘	28		↗	169						123	↓	↓
	Bati	29		↗	26	↑	↑	128						107	↓	↓
	Bourei Cholsar	36	→	↘	73	↓	↓	176						134	↓	↓
	Doun Kaev	27			14	↑	↑	143						112	↓	↓
	Kaoh Andaet	9			31	↓	↓	175						118	↓	↓
	Kiri Vong	53			44	↓	↓	101	→	→				133	↓	↓
	Prey Kabbas	8			6		→	168						97	→	↘
	Samraong	20	↗	↗	16	↑	↑	159						102	↓	↓
	Tram Kak	31	→	→	56	↑	↑	140						128	↓	↓
	Treang	24	→		35	↓	↓	161						87	↓	↓
Tbong Khmum	Dambae	111			69	↑	↑	59						34	↑	↗
	Kampong Siem	134			40	↑	↑	76	↘	↘				77	↑	↑
	Krouch Chhmar	102			62	↑	↑	67						44		→
	Memot	126			113	↑	↑	46	↘	↓				74	→	↓
	Ou Reang Ov	76			53	↓		84						41	↘	↑
	Ponhea Kraek	89			39	↗	↑	70						57		↘
	Tboung Khmum	94			46	↑	↑	69						51		↑

7.3 CUMULATIVE MULTI-RISK INDEX

The combined multi-sector risk hotspots are influenced by the different current risks which noted the peak areas to the southeast of the country in the highly developed and populated areas, There is also an increased current risk to the northeast which has consistently exhibited lower resilience to the climate risks. Both the projected future show a significant increase in the peak risk areas but again focused in the Kâmpóng Cham, Kândal, Prey Vêng, and Tbong Khmum, as well as Rôtânôkiri, the province to the northeast. The SSP5 scenario has a similar distribution as the SSP2 scenario but just a generally higher magnitude of risk overall.

Areas not highlighted in the multi-risk analysis will still be at risk of climate risks both currently as well into the future. However, these regions scored lower in the cumulative multi-sector risk assessment. These hotspots while useful for strategic level decision making, adaptation prioritisation activities should be conducted by reviewing the individual sector risks – specifically the contributions of underlying hazards, exposures and vulnerabilities – rather than the cumulative multi-sector risk as these would be much more relevant to the objectives of various interventions. The cumulative risks below show the increase in future severity of climate risks under future scenarios. This should be used only for high-level strategic level planning

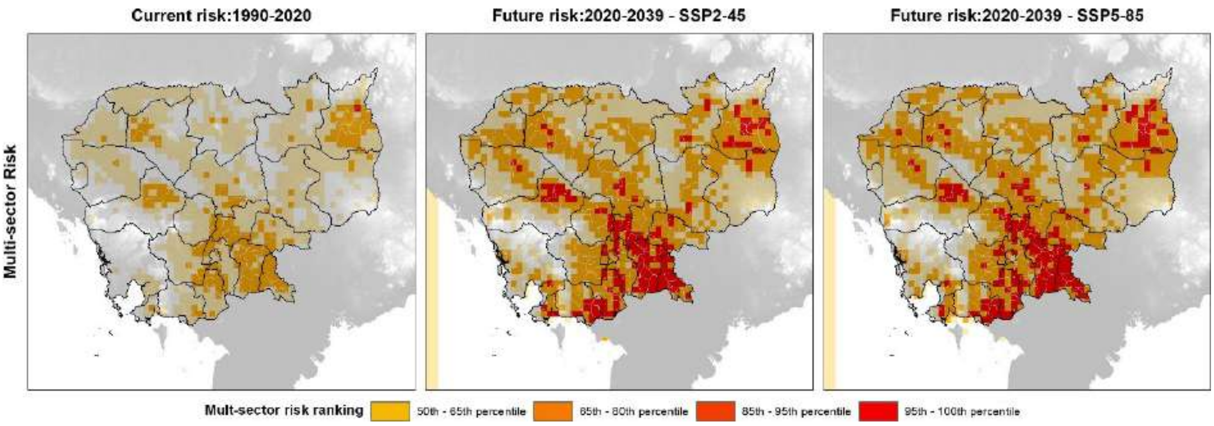


Figure 31. Mult-sector risk score for current climate (left), future SSP2 scenario (middle) and future SSP5 scenario (right)

8 ADAPTATION INTERVENTIONS

8.1 ADAPTATION PREMISES

Cambodia's Climate Risk and Vulnerability Analysis (CRVA) shows a clear and strengthening climate signal towards mid-century. Temperatures are rising, with many more days above 35°C and longer heatwaves. Rainfall is arriving in shorter and more intense bursts, separated by longer and more erratic dry spells. Coastal pressures from sea-level rise and storm surge are increasing. Together, these shifts amplify flood risk in the Mekong and Tonle Sap system and in low-lying urban areas, while drought stress and heat extremes intensify in interior provinces and the northeast highlands. Along the coast, from Koh Kong to Preah Sihanouk, Kampot and Kep, erosion, saline intrusion and storm surge compound exposure for communities, tourism assets and port infrastructure.

Risk is uneven across the country. Flood-prone plains around the Mekong and the Tonle Sap, where population, transport corridors and irrigation schemes are concentrated, face recurrent pluvial and fluvial floods that damage agriculture and fishery livelihoods. Phnom Penh and secondary cities combine drainage deficits with urban heat-island effects and fragile basic services. The northeast provinces, including Ratanakiri and Mondulkiri, contend with hotter and drier seasons, rising wildfire risk and limited access to essential services. Lightning incidents, which are under-counted in international databases, pose a notable mortality risk in several provinces. Across these landscapes, women, children, older persons, people with disabilities and low-income households bear disproportionate burdens due to gaps in land tenure, finance, access to information and care responsibilities, as detailed in the gender, social protection and governance exposure analysis in the CRVA.

Conceptually, this assessment follows the risk framing of the IPCC Fifth Assessment Report (AR5) and subsequent reports, which define climate risk as the interaction of three components: hazard, exposure and vulnerability. At the same time, much of Cambodia's earlier analytical work drew on the IPCC Fourth Assessment Report (AR4) framing, in which vulnerability itself is expressed as a function of exposure, sensitivity and adaptive capacity. To remain consistent with that body of work while aligning with the updated AR5/AR6 framework, the CRVA treats vulnerability as a composite of sensitivity and adaptive capacity and keeps exposure as its own explicit dimension. The composite risk indices used in Chapters 4 to 7 therefore combine hazard layers with exposure indicators and vulnerability indices derived from sensitivity and adaptive capacity proxies.

This chapter turns that evidence into a practical, risk-led agenda for action. It starts from the CRVA hazard, exposure and vulnerability indices and from mapped hotspots, and translates those signals into sector adaptation packages and district-level priorities so that decision-makers know where to act first and what to do. Climate risk – as quantified in the CRVA – is the main driver of prioritisation: in the multi-criteria framework that underpins this chapter, the criterion derived from the CRVA composite risk index carries at least 60 per cent of the total weight assigned to each option, while the remaining weight captures effectiveness, feasibility, gender equality and social inclusion (GESI), co-benefits, nature-based potential, urgency, readiness and long-term sustainability.

The approach applies a sector-first cost–benefit lens and then converts the resulting options into territorial priorities that can be implemented by districts. A full economic cost–benefit analysis for every option was beyond the scope of this study; instead, relative costs and benefits are captured through simple proxies in the scoring criteria (effectiveness, co-benefits, urgency, readiness and operations and maintenance sustainability) and through the indicative scale and time horizon assigned to each measure. Every measure states its objective and an indicative time horizon – short term (0–3 years), medium term (3–7 years) or long term (more than 7 years) – which is used to sequence actions within sector and territorial packages. Each measure also includes indicators for monitoring, reporting and verification so that progress can be tracked and course-corrected over time.

Finally, the adaptation options presented here are grounded in Cambodia's policy and programme landscape. The long list of measures compiles: (i) options emerging from the CRVA sector and hotspot analysis; (ii) priorities identified in national frameworks such as the NDC, the NAP and relevant sector strategies; (iii) the adaptation interventions and eligible activity types defined under the LGCC-III programme, including its Investment Menu and Feasibility Study; (iv) lessons from previous LGCC phases; and (v) results from a dedicated consultation workshop with provincial, district and municipal representatives. The chapter is therefore designed not only as an analytical output, but as a bridge between the CRVA evidence, Cambodia's existing adaptation commitments and the pipeline of investments that can be financed through performance-based climate-resilience grants at subnational level.

8.1.1 DECISION FLOW FROM CRVA EVIDENCE TO ADAPTATION MEASURES PORTFOLIOS.

The analysis followed a clear sequence to turn the CRVA evidence into implementable priorities. It moved from a broad long list of potential adaptation measures to a focused, investment-ready pipeline, ensuring that sectoral options were also translated into territorial actions that districts and communes can operationalise.

The step-by-step process was as follows:

1. **Build the long list.** We compiled adaptation options by sector and territory, including nature-based solutions. The long list draws on: the CRVA hazard, exposure, vulnerability and risk maps; Cambodia's NDC, NAP and sector strategies; the LGCC-III Feasibility Study and Investment Menu; experience from earlier LGCC and LoCAL interventions; and the consultation meeting with subnational governments, where provincial, district and municipal representatives identified priority local measures.

2. **Set the multi-criteria framework**. We defined the criteria, their weights and the 1-to-5 scoring scale so that the evaluation reflects Cambodia's risk profile, policy goals and programme architecture. The criterion based on the CRVA composite risk index carries at least 60 per cent of the total weight, ensuring that higher-risk districts and sectors are systematically favoured. The remaining weight balances effectiveness in reducing risk, technical and institutional feasibility, GESI considerations (building on the CRVA's gender and social inclusion analysis), nature-based potential, co-benefits, urgency, readiness and long-term operations and maintenance sustainability.

3. **Score and shortlist.** We assessed each option against all criteria using the 1-to-5 scale, multiplied scores by their respective weights to obtain a 0-to-100 weighted score, and produced a transparent shortlist and ranking. This combines quantitative evidence from the CRVA with qualitative judgement on feasibility and equity and was validated through discussions with national and subnational stakeholders to ensure realism in the Cambodian context.
4. **Package for delivery.** We grouped the highest-scoring options into sector adaptation packages and then into territorial menus for Cambodia's five main risk landscapes (coastal, Mekong/delta floodplain, Tonle Sap Basin, northern highlands and urban nodes). Each package distinguishes sector-wide programmes from district-level projects, and aligns measures with subnational mandates and with the LGCC-III Investment Menu, so that they can be taken up in district and commune plans and financed through performance-based climate-resilience grants.
5. **Establish MRV and KPIs**. For every measure we defined a set of indicative indicators for monitoring, reporting and verification, consistent with the CRVA logic and with the LGCC-III results framework. These KPIs allow progress to be tracked, learning to be captured and programmes to be adjusted over time.

6. **Document best practice and viability.** For each measure, we recorded design features adapted to Cambodian conditions, implementation viability, explicit linkage to the CRVA results and, where relevant, examples of where similar approaches have worked at comparable latitudes or in neighbouring countries. This documentation underpins the extended catalogue of measures and supports future replication and scaling.

8.1.2 DUAL-LENS: SECTORAL ANALYSIS AND TERRITORIAL TRANSLATION

The analysis of adaptation measures applies a dual lens so that options are both sectorally coherent and territorially grounded. This ensures that priorities are consistent with national policies (such as the NDC and NAP), with the LGCC-III programme architecture and Investment Menu, and with the spatial patterns of climate risk identified in the CRVA.

First, a sectoral lens is used to identify options within coherent systems. Measures are grouped under climate-resilient livelihoods (agriculture, livestock and fisheries), disaster risk reduction (DRR) for communities, water security, ecosystems and coasts, climate-resilient infrastructure (including transport and ports), tourism and coastal economies, and climate-resilient health systems. This sectoral framing aligns with the CRVA's sectoral vulnerability and risk analysis, as well as with Cambodia's adaptation priorities in national strategies and the LGCC-III program. Across these sectors, gender equality and social inclusion (GESI) are treated as cross-cutting priorities, in line with the gender, social protection and governance exposure analysis presented in the CRVA.

Second, a territorial lens is applied to translate sector measures into district-level priorities. This territorial rubric is aligned with the CRVA hotspot analysis and with the district prioritisation approach used under LGCC-III. It distinguishes five main risk landscapes: coastal areas, the Mekong and delta floodplain, the Tonle Sap Basin, the northern highlands and urban nodes. Within each landscape, the CRVA composite risk index – combining hazard, exposure and vulnerability – identifies the districts in the highest risk percentiles, and these districts are systematically favoured when assigning and sequencing measures. The territorial lens also reflects sub-national mandates and delivery capacity, recognising the roles of provinces, districts and communes in planning and implementing adaptation actions.

Every measure is therefore tagged along three dimensions: (i) sector scope (sector-wide programme or district-level project); (ii) priority landscapes and district types where impacts materialise first (for example, floodplain districts, coastal port districts, drought-prone highland districts or urban informal settlements); and (iii) the relevant LGCC-III Investment Menu category. In the adaptation measure tables, it is indicated where district implementation should start and how sector-wide actions cascade down to specific district and commune investments. Simple triggers used to determine which districts are prioritised for each measure – based primarily on the CRVA composite risk index and complemented by exposure, readiness and capacity, equity and GESI, and co-benefits – are summarised in Table 20. This dual-lens approach ensures that national and sectoral priorities informed by the CRVA are translated into concrete, risk-led and financeable local actions that can be integrated into sub-national plans and supported through performance-based climate-resilience grants.

Table 20. Criteria used to identify priority districts for implementation of adaptation measures.

Criterion	District definition/threshold	Signals & data source	Notes
CRVA composite risk (H×E×V)	District located in the ≥70th percentile of the CRVA composite risk index within its risk landscape (very high risk: ≥80th percentile)	CRVA composite risk and vulnerability maps and indices	Primary trigger for prioritisation; captures hazard, exposure, sensitivity and adaptive capacity
Asset & population exposure	Large populations and/or critical assets (e.g. ports, main roads, irrigation schemes, health centres, schools) located in flood-, heat- or storm-surge-prone zones	CRVA exposure maps, statistics, land-use and infrastructure datasets.	Focuses measures where impacts materialise first and where critical services are concentrated
Readiness & capacity	Local institutions, operations and maintenance arrangements, and core designs/permits exist or can be put in place quickly	Stakeholder validation; LGCC-III assessments of institutional capacity.	Enables feasible near-term delivery and PBCRG.
Equity (GSI)	Expected benefits for women, children, low-income households, people with disabilities and other vulnerable groups identified in the CRVA GESI analysis	GESI section of the CRVA; social and poverty data; sub-national indices	Avoids widening existing gaps and supports inclusive resilience
Co-benefits	Potential for significant health, biodiversity, livelihood and job-creation co-benefits alongside direct risk reduction.	Sector evidence, LGCC-III Feasibility Study, case studies	Supports multi-objective gains and alignment with national development and climate goals.

8.1.3 ADAPTATION CHAPTER STRUCTURE

The adaptation chapter is organised as a pipeline that moves from evidence to investments. It starts from the CRVA hazard, exposure, vulnerability and composite risk indices – including the gender, social protection and governance exposure analysis – and uses them to define clear rules for prioritising measures. These rules are then applied through a transparent multi-criteria framework to generate a shortlist and ranking, which are finally translated into sector packages and place-based actions that can be delivered by sectors, provinces and districts and financed through LGCC-III performance-based climate-resilience grants.

The Prioritisation Framework section lays out the criteria and their weights, and explains how each criterion is interpreted in the Cambodian context. It clarifies how the composite CRVA risk index – combining hazard, exposure and vulnerability, with vulnerability understood as a function of sensitivity and adaptive capacity – is operationalised in the scoring. In line with the AR5/AR6 risk framing and Cambodia's policy priorities, the criterion derived from the CRVA composite risk index carries at least 60 per cent of the total weight, ensuring that districts and sectors facing the highest climate risk are systematically favoured. The remaining weight balances effectiveness in reducing risk, technical and institutional feasibility, gender equality and social inclusion (GESI), nature-based potential, co-benefits (including health, biodiversity and jobs), urgency, readiness, and long-term operations and maintenance sustainability. Each option is scored from 1 to 5 against every criterion, where 1 is very low and 5 is very high, and the weighted sum produces a single score on a 0 to 100 scale.

The Multi-criteria Scoring Table and Shortlist section presents the full set of scores, weights and final rankings in one place, making the process auditable. It shows how evidence from the CRVA, national strategies and the LGCC-III Feasibility Study leads to priorities, by displaying the criteria in the table header, the 1–5 scores, the percentage weights, the resulting weighted scores and the final rank for each option. Two additional fields identify delivery scope, distinguishing sector-wide programmes from district-level projects, and indicate illustrative priority districts derived from hotspot analysis in each of Cambodia's main risk landscapes.

The next step is the Sector Adaptation Packages section. For each sector, it summarises the problem statement, the main climate hazards and vulnerabilities, the priority measures, and indicative KPIs for monitoring, reporting and verification. It distinguishes between climate-resilient livelihoods, DRR for communities, water security, ecosystems, forests, wetlands and coasts, climate-resilient infrastructure (transport and ports), tourism and coastal economies, and climate-resilient health systems and public health. Each package indicates the scope of measures (sector-wide programmes versus district-level projects), their indicative time horizon (short, medium or long term), and their alignment with national strategies and with the LGCC-III Investment Menu, so that they can be directly taken up in sector plans and budget submissions.

The Territorial anchoring section then uses hotspots and investment menus by locality to show how sector measures translate into district priorities. It organises the measures across Cambodia's five main risk landscapes – coastal areas, Mekong and delta floodplain, Tonle Sap Basin, northern highlands and urban nodes – and indicates which districts move first, which enabling steps are needed for implementation and how measures fit within subnational mandates. This ensures that sector choices are matched with the realities of specific provinces and districts, and that district and commune administrations can use the chapter to prepare climate-responsive investment plans under LGCC-III.

Table 30 presents the Top Ten measures with their final ratings and a concise rationale. It links back to the criteria and weights, to the CRVA risk and vulnerability findings, to the GESI analysis and to the indicative KPIs that will be tracked during implementation, giving decision-makers a ready-to-use starting portfolio of high-impact actions across sectors and landscapes.

Table 31 provides the full catalogue of Cambodia-specific adaptation measures. For each measure, it documents the design adapted to local conditions, the viability rationale, the explicit linkage to CRVA findings and to national policy frameworks, examples of where similar approaches have worked in comparable countries, key implementation notes, the relevant LGCC-III Investment Menu category and indicative KPIs and time horizon. Together, these tables form the reference library that supports prioritisation, investment preparation, scaling and replication beyond the initial Top Ten priorities.

8.2 PRIORITISATION FRAMEWORK

This chapter applies a simple and transparent, risk-led prioritisation framework to compare and rank adaptation measures across sectors and landscapes. The framework is designed to be fully consistent with the CRVA's use of the IPCC AR5/AR6 risk framing – in which climate risk results from the interaction of hazard, exposure and vulnerability. The criterion derived from the CRVA composite risk index uses exactly this logic: it captures hazard, exposure and vulnerability, with vulnerability expressed through sensitivity and adaptive capacity, as described in the analytical chapters of the CRVA.

The objective of the framework is to provide an explicit and replicable way of turning CRVA evidence into a list of climate adaptation options. For this purpose, the framework uses a set of criteria to rank the adaptation measures preliminary identified considering Cambodia's climate risk profile, national adaptation priorities and the architecture of the LGCC-III programme.

Table 21 presents the six criteria used and their relative weights:

1. **Climate Risk and vulnerability**
2. **Effectiveness in reducing risk**
3. **Technical and institutional feasibility**
4. **Gender equality and social inclusion (GESI)**
5. **Co-benefits (in mitigation, job creation, health and biodiversity)**
6. **Sustainability and local capacity**

Each adaptation option is scored from 1 to 5 for every criterion in Table 21, where 1 is very low and 5 is very high. Scores are based on a combination of quantitative evidence from the CRVA, national statistics and LGCC-III design documents, and qualitative judgement validated with stakeholders.

The scoring rules are as follows:

1. **CRVA Risk (60%).** This criterion measures how strongly the option targets districts and sectors with the highest climate risk as quantified in the CRVA composite risk index (Hazard × Exposure × Vulnerability).

    - **Score 5**: The measure primarily targets districts in the very high-risk class (for example, ≥80th percentile of the composite risk index within a risk landscape) and addresses the main hazards and drivers of vulnerability identified in the CRVA.
    - **Score 4**: The measure mainly targets high-risk districts (around the 70–80th percentiles) or combines several moderate-to-high risk districts.
    - **Score 3**: The measure focuses on medium-risk districts (around the 50–70th percentiles), with limited coverage of high-risk districts.
    - **Score 2**: The measure is only loosely connected to CRVA-identified hotspots or targets predominantly low-to-medium risk districts.
    - **Score 1**: The measure addresses hazards or locations that are not priority concerns in the CRVA or for which evidence is weak.

    Main information sources:

    - CRVA composite multi-risk index and district-level risk percentiles.
    - CRVA hazard, exposure and vulnerability maps and indices for each sector
    - Narrative risk and hotspot analysis in the CRVA analytical chapters.

2. **Effectiveness in risk reduction (15%).** This criterion measures the expected magnitude of climate risk reduction delivered by the measure and the urgency of the problem it addresses. It considers how many people or critical assets benefit, how much risk is reduced (e.g. in terms of avoided losses, reduced disruption, or improved resilience), and whether the measure responds to hazards and impacts that are already frequent or rapidly worsening. Measures that provide substantial risk reduction benefits within the next 3–5 years for a large share of exposed populations or assets are scored highest.

    - **Score 5:** The measure is expected to substantially reduce climate risk for a large share of exposed people or critical assets. Benefits are expected within the next 3–5 years.
    - **Score 4:** The measure significantly reduces risk for a sizeable population or asset base, with benefits emerging mainly in the short-to-medium term.
    - **Score 3:** The measure offers moderate risk reduction or is highly effective but only for a relatively small group or limited area.
    - **Score 2:** The measure has limited impact on overall risk, or benefits are mostly long term and uncertain.
    - **Score 1:** The measure has marginal or unclear risk-reduction benefits.

    Main information sources:

    - CRVA sector chapters describing key hazards, impacts and exposed populations/assets.
    - CRVA exposure indicators (population, livelihoods, infrastructure, environmental assets).
    - LGCC-III Feasibility Study and Investment Menu, especially the analysis of adaptation benefits and barriers by intervention type.
    - National and sectoral statistics (e.g. population, land use, infrastructure, health, agriculture).
    - Stakeholder consultations and the "Elaborate more detail on the list of adaptation options from consultation meeting" document.

3. **Gender Equality and Social Inclusion (GESI) (10%).** This criterion assesses the. extent to which an adaptation measure responds to the differentiated vulnerabilities and needs of women, children, low-income households, people with disabilities, indigenous peoples and other disadvantaged groups. It looks at whether the measure is designed to reach these groups, reduce specific inequalities identified in the CRVA, and strengthen inclusive decision-making and access to services. Measures that clearly and explicitly benefit the priority vulnerable groups, as identified in the CRVA GESI analysis and related social protection frameworks, receive the highest scores.

    - **Score 5:** The measure is explicitly designed to benefit the vulnerable groups identified in the CRVA GESI analysis, closes specific gaps and has strong potential to reduce inequality.
    - **Score 4:** The measure clearly benefits vulnerable groups, even if they are not the sole focus, and includes design features that enhance inclusion.
    - **Score 3:** The measure is broadly neutral but accessible to most groups; vulnerable populations benefit indirectly.
    - **Score 2:** Benefits for vulnerable groups are weak or uncertain, and there is a risk that existing gaps may persist.
    - **Score 1:** The measure risks excluding or disadvantaging vulnerable groups, or no information is available on inclusion.

Main information sources:

- Dedicated GESI, social protection and governance exposure sections of the CRVA.
- CRVA maps and tables on vulnerable population groups and social service coverage.
- National gender and social statistics (e.g. ID Poor data, gender indices, disability and minority data).
- LGCC-III Feasibility Study and related LGCC documentation on GESI requirements and safeguards.
- Stakeholder consultations, including inputs from women's organisations, social protection actors and local communities.

4. **Co-benefits (mitigation, health, jobs, NbS, biodiversity)** (5%). This criterion captures multi-objective gains beyond direct climate risk reduction. It considers whether the measure simultaneously: reduces greenhouse gas emissions or supports low-carbon development; improves public health outcomes; supports livelihoods and job creation; and/or enhances ecosystem condition and biodiversity through nature-based solutions. Measures that deliver strong, well-documented co-benefits across several of these dimensions score highest.

   - Score 5: The measure provides strong, well-documented co-benefits across several of these dimensions (for example, significant mitigation and biodiversity gains, plus jobs and health benefits).
   - Score 4: The measure delivers clear co-benefits in at least two dimensions.
   - Score 3: There are moderate co-benefits in at least one dimension.
   - Score 2: Co-benefits are weak, localised or uncertain.
   - Score 1: No meaningful co-benefits are expected.

   Main information sources:

   - LGCC-III Investment Menu descriptions of eligible interventions and expected development co-benefits.
   - National policy documents (NDC, CCCSP, sector climate change strategies, health and environment plans).
   - Evidence and lessons from past LGCC/LoCAL projects, other climate-related projects and relevant case studies.
   - CRVA sector chapters describing links between climate risk, health outcomes, ecosystem condition and livelihoods.

5. **Technical & institutional feasibility and readiness** (designs, permits, partners) (5%). This criterion combines technical feasibility and institutional readiness. It evaluates whether the proposed measure is technically proven in Cambodia or in comparable contexts; whether it fits within existing mandates and regulatory frameworks; and whether the enabling conditions for implementation (designs, permits, implementing agencies, partners) exist or can realistically be put in place in the short term. Measures building on technologies, approaches and institutional arrangements already used under LGCC/LoCAL or other national programmes, with clear implementing responsibilities and advanced preparation, score highest.

   - **Score 5:** The measure uses proven technologies and approaches already applied successfully in Cambodia or comparable contexts; mandates are clear; and key designs, permits and partnerships exist or can be finalised quickly.

- **Score 4:** The measure is technically sound and institutionally feasible, although some additional preparatory work is needed before full implementation.
- **Score 3:** The measure is feasible but requires significant capacity-building, institutional coordination or piloting.
- **Score 2:** The measure faces serious technical or institutional barriers that are unlikely to be resolved in the short term.
- **Score 1:** The measure is largely untested or incompatible with existing mandates and capacities.

Main information sources:

- LGCC-III Grant Design and Operations Manual (roles of NCDDS, districts, sectors; PBCRG procedures; minimum conditions).
- Existing national and sectoral guidelines, regulations and standards relevant to the measure (e.g. infrastructure, land use, environmental and social safeguards).
- Annual Performance Assessment (APA) results and other assessments of local government performance and capacity.
- Technical inputs and validation from line ministries, NCDDS and development partners.

6. **Sustainability and local capacity (O&M, finance, ownership)** (5%). This criterion assesses the likelihood that the measure will remain functional and effective over the long term. It considers whether local governments and communities have, or can realistically develop, the capacity and resources to operate, maintain and finance the infrastructure, services or practices introduced by the measure; whether Operation and Maintenance (O&M) requirements and recurrent costs are reasonable; and whether there is clear local ownership and alignment with existing planning and budgeting processes. Measures that fit well within district and commune mandates, can be integrated into regular budgets and staffing, and have strong community ownership and management arrangements score highest.

- **Score 5:** Operations and maintenance requirements are realistic and affordable for local institutions; there is clear local ownership and alignment with existing budgets and staffing.
- **Score 4:** O&M demands are manageable with some additional support or incremental budget allocations.
- **Score 3**: Sustainability is plausible but depends on future budget decisions, external support or gradual capacity strengthening.
- **Score 2:** There is a significant risk that O&M and recurrent costs will not be covered, or local capacity is likely to be overstretched.
- **Score 1:** Long-term sustainability is very unlikely without major, continuous external support.

The main sources of information have been the following:

- Lo/LGCC performance assessments and evaluations of previous phases (financing, O&M and institutional sustainability).
- District and commune planning and budgeting documents (EDCCAS, climate-responsive action plans, sector plans).
- CRVA governance and decentralisation analysis, including discussions of local capacity and funding gaps.

- Stakeholder consultations with local governments and communities on feasibility, O&M responsibilities and ownership.

Scores are multiplied by the criterion weights in Table 21 and then summed to obtain a single weighted score between 0 and 100 for each measure. This provides a clear, auditable basis for shortlisting options and sequencing investments, while keeping the framework simple enough to be updated as new evidence or stakeholder preferences emerge.

The resulting weighted scores and rankings are presented in the Multi-criteria Scoring Table (Table 22), alongside the scope of each measure (sector-wide programme or district-level project) and illustrative priority districts derived from the hotspot analysis in Cambodia's five main risk landscapes.

Table 21. Criteria and indicative weights used to rank the adaptation measures identified.

Criterion	Weight (%)
CRVA Risk (Hazard × Exposure × Vulnerability)	60%
Effectiveness (risk reduction)	15%
Gender Equity & Social Inclusion (GESI)	10%
Co-benefits (mitigation, health, jobs creation, Nature Based Solutions NbS and biodiversity)	5%
Technical & institutional feasibility	5%
Sustainability / local capacity	5%

8.3 MULTI-CRITERIA SCORING TABLE AND SHORTLIST

This section operationalises the prioritisation framework described in Section 8.2 by applying it to the long list of adaptation measures identified through the CRVA and national/sub-national consultations. The objective is to move from a broad portfolio of options to a transparent, evidence-based shortlist that can guide LGCC-III investments and inform national and sub-national planning.

The process is implemented in two steps. A first table that presents the consolidated list of adaptation measures emerging from the national and local stakeholders' workshop. Each original measure from the consultation is reformulated in a standard structure that links: (i) the main climate risk or CRVA sub-risk addressed; (ii) the relevant sector or system; and (iii) a concise description of the concrete adaptation action. This ensures a clear line of sight between the evidence presented in the analytical chapters of the CRVA and the proposed interventions, and makes the portfolio easier to interpret across ministries, development partners and sub-national governments.

A second table that applies the multicriteria prioritisation framework to these measures, using the six criteria and weights defined in Section 8.2: 1) CRVA Risk; 2) Effectiveness (risk reduction & urgency); 3) Gender Equality & Social Inclusion (GESI); 4) Co-benefits (mitigation, health, jobs, NbS, biodiversity); 5) Technical & institutional feasibility and readiness; and 6) Sustainability and local capacity (O&M, finance and ownership). Each option is scored from 1 to 5 against every criterion, the scores are multiplied by the corresponding weights, and a composite score between 0 and 100 is obtained. The resulting ranking provides a clear and auditable basis for identifying priority measures and structuring a shortlist of investments that are both risk-informed and consistent with Cambodia’s national adaptation priorities and the LGCC-III programme architecture.

The following Table 22 reformulates the adaptation measures identified during the national and sub-national consultation workshop in Cambodia. Each original workshop measure is described in terms of the main climate risk or CRVA sub-risk addressed, the relevant sector or system, and a clear adaptation measure statement that links risk, sector and concrete action.

The Multi-Criteria Scoring Table (Table 23) summarises the scoring that translates Cambodia's CRVA evidence into a transparent shortlist of adaptation measures. Each option is rated from 1 to 5 against the criteria listed in the header; the figures in brackets show each criterion's weight as a percentage of the total. Scores are multiplied by their weights to produce a weighted score on a 0 to 100 scale and a final rank. Two additional fields identify delivery scope, distinguishing sectoral programs from district level projects, and indicate illustrative priority districts derived from hotspot analysis.

Table 22. Workshop derived adaptation measures linking the risk with the sector and the corresponding adaptation action with the formulation adjustments if required.

ID	**Workshop measure (title)**	**Main climate risk / sub-risk addressed (CRVA)**	**Sector / system**	**Reformulated adaptation measure (risk – sector – action)**
1	Prioritise actions to adapt to climate change (risk assessments, integration in plans, budgeting, support to communes)	Multi-hazard climate risk (floods, droughts, heat, storms) across priority sectors; weak integration of risk in local planning and finance.	Cross-sectoral governance, sub-national planning & finance	Strengthen sub-national climate risk governance by conducting district and provincial climate risk assessments, integrating CRVA evidence into Provincial Development Plans and sector strategies, aligning climate-responsive budgeting, and supporting communes to prepare and implement local adaptation plans consistent with identified hotspots and vulnerable groups.
2	Construct and rehabilitate irrigation systems/canals (rehab, new canals, drainage, FWUCs, lining)	Food systems compromised by climate change – droughts, erratic rainfall and floods affecting rain-fed agriculture and yields.	Agriculture and water resources (irrigation)	Reduce drought and flood risk to rain-fed agriculture by rehabilitating and expanding climate-resilient irrigation and drainage systems, strengthening Farmer Water User Communities, and promoting canal lining and improved conveyance to stabilise yields under increasing rainfall variability.
3	Reforestation and tree planting (watersheds, soil retention, community forestry, agroforestry, mangroves)	Forest and ecosystem degradation, erosion and hydrological imbalance, including loss of watershed function and coastal protection.	Forestry, ecosystems, watershed management, coastal ecosystems	Reduce erosion, regulate water flows and protect coastal zones by restoring degraded forestlands and watersheds, supporting community forestry and agroforestry, implementing soil retention measures, and expanding mangrove and coastal wetland restoration in line with ecosystem vulnerability hotspots.
4	Prepare safe places / evacuation shelters (mapping, construction/upgrade, equipment, accessibility, drills)	Disaster risk from floods, storms and other extremes, with high exposure of settlements and vulnerable groups.	Disaster risk management, social protection, local infrastructure	Reduce mortality and losses from floods and storms by identifying and mapping safe evacuation sites, constructing or upgrading climate-resilient shelters with WASH and basic supplies, ensuring accessible, gender- and disability-inclusive design, and conducting regular evacuation drills in high-risk districts.
5	Early Warning Information Systems (sub-national channels, monitoring stations, dissemination, training)	Acute impacts from extreme events (floods, storms, droughts) and gaps in last-mile communication and preparedness.	Disaster risk reduction, hydromet and information systems	Reduce losses from extreme floods, storms and droughts by strengthening multi-hazard early warning systems, installing and maintaining monitoring stations, and ensuring timely, understandable dissemination of alerts to districts and communes, combined with training of local officials on interpretation and response protocols.

ID	Workshop measure (title)	Main climate risk / sub-risk addressed (CRVA)	Sector / system	Reformulated adaptation measure (risk – sector – action)
6	Dissemination and public awareness on climate change (campaigns, schools, community training, materials, emergency response knowledge)	High vulnerability of households and communities due to low awareness, limited adaptive capacity and information gaps.	Cross-cutting: communities, education, DRR	Reduce community vulnerability to climate hazards by implementing sustained climate change awareness and education programmes in schools and communities, including water conservation, preparedness and emergency response, supported by locally tailored information materials in high-risk provinces.
7	Water-saving and water resource development (ponds, reservoirs, rainwater harvesting, wells, efficient agriculture, dry-season planning)	Water insecurity and drought risk for households and agriculture, especially in uplands and dry-season-stressed districts.	Water resources and agriculture (water supply, small-scale storage)	Increase dry-season water security for households and farms by constructing community ponds and small reservoirs, promoting rainwater harvesting and climate-resilient wells, and supporting water-saving agricultural practices and dry-season water-use planning in drought-prone districts.
8	Use and update PRISM and early warning tools (data update, real-time reporting, training, expanding observation points)	Inadequate risk information and monitoring, limiting timely response to floods, droughts and storms at sub-national level.	Information systems, DRM, provincial planning	Improve evidence-based climate risk management by regularly updating PRISM and related early warning tools with real-time disaster data, expanding observation points in vulnerable districts, and training provincial and district officials to maintain and use these systems for planning and emergency response.
9	Education and dissemination on agricultural practices (safe agrochemicals, IPM, soil & water management, climate-resilient crops)	Food systems under stress from climate-related pests, soil degradation, erratic rainfall and heat; low adoption of resilient practices.	Agriculture (extension services, climate-smart agriculture)	Reduce climate-related crop losses and environmental health risks by training farmers in climate-smart agronomic practices, including safe agrochemical use, Integrated Pest Management, soil and water conservation, and climate-resilient crop production tailored to local hazard profiles.
10	Strengthen capacity and local coordination mechanisms (authorities, inter-departmental coordination, disaster teams, provincial climate meetings)	Institutional vulnerability and weak coordination that limit effective adaptation and disaster response.	Governance, DRM, cross-sectoral coordination	Reduce institutional vulnerability to climate risks by building the capacity of provincial, district and commune authorities on climate risk management, strengthening coordination mechanisms among departments, establishing and training local disaster teams, and holding regular provincial climate coordination meetings.

ID	Workshop measure (title)	Main climate risk / sub-risk addressed (CRVA)	Sector / system	Reformulated adaptation measure (risk – sector – action)
11	Promote climate-resilient animal and crop breeds (tolerant varieties, resilient livestock, seed banks, diversified systems)	Climate-induced yield losses and livestock stress from droughts, floods, heat and salinity that threaten food security and incomes.	Agriculture and livestock (breeding, seed systems)	Reduce climate-related losses in crops and livestock by promoting drought-, flood- and salinity-tolerant crop varieties, resilient livestock breeds, community seed banks and diversified farming systems in districts exposed to agricultural hazards identified by the CRVA.
12	Suppress and prevent wildfires (fire breaks, training, monitoring, awareness)	Rising wildfire risk and forest degradation, especially in upland and deforested areas under hotter, drier conditions.	Forestry, DRR, community natural resource management	Reduce wildfire occurrence and impacts in vulnerable forest landscapes by establishing and maintaining fire-breaks, training rangers and communities in fire prevention and control, installing wildfire monitoring systems, and conducting targeted awareness campaigns in high-risk upland districts.
13	Strengthen public health services (surveillance, vaccination, WASH in health centres, training, emergency supplies)	Climate-sensitive health risks: heat stress, vector-borne and water-borne diseases, malnutrition, and weak health system capacity.	Health sector (primary care, public health, WASH)	Reduce climate-related health impacts by strengthening surveillance of climate-sensitive diseases, improving WASH and emergency preparedness in health facilities, training health workers on climate-linked illnesses, and ensuring adequate supplies in high-risk districts identified in the health vulnerability index.
14	Promote climate-smart agriculture including AWD (water-efficient rice, soil & crop management, integrated farm management, CSA extension)	Food systems compromised by climate change through water stress, extreme rainfall, heat and post-harvest losses in rain-fed rice and mixed systems.	Agriculture and food systems (CSA, extension, post-harvest)	Reduce climate risks to rice-based and mixed farming systems by scaling up climate-smart agriculture, including AWD and other water-efficient rice practices, soil and crop management for drought and heat, integrated crop–livestock and agroforestry systems, and strengthened climate-smart extension services in agricultural hotspots.

Table 23. Adaptation measures multi-criteria scoring. Score candidate adaptation measures for each hotspot. Scores: 1 (low) to 5 (high).

ID	Adaptation measure	1.CRVA Risk (60%)	2.Effectiveness (15%)	3.GESI (10%)	4.Co-benefits (5%)	5. Feasibility (5%)	6.Sustainability (5%)	Weight (0–100)	Rank	Scope	Priority landscapes / district types
13	Strengthen public health services for climate-sensitive diseases and emergencies	5	5	5	4	3	3	95.0	1	Sectoral programme. District health facilities	Floodplain, coastal and urban districts with high climate-sensitive disease risk and weak health coverage.
2	Construct and rehabilitate irrigation systems and canals for climate-resilient agriculture	5	5	4	4	4	3	94.0	2	District project/site.	Rain-fed and irrigated agricultural districts in the Mekong/delta floodplain and Tonle Sap Basin.
5	Multi-hazard early warning information systems and last-mile communication	5	5	4	3	4	4	94.0	3	Sectoral programme. District delivery	All hazard-prone districts, with emphasis on floodplain, coastal and storm-exposed areas.
1	Subnational climate risk assessments & integration into provincial/district plans and budgets	5	4	4	3	4	4	91.0	4	Sectoral programme. District delivery	All risk landscapes; priority to districts in the ≥70th CRVA composite risk percentile.
4	Safe places and evacuation shelters with inclusive design and equipment	4	5	5	3	4	3	83.0	5	District project/site	Floodplain and coastal districts, including urban nodes in flood hotspots.
14	Promote climate-smart agriculture including AWD and integrated farm management	4	4	4	5	4	4	81.0	6	District project/site	Rice-growing districts in the Mekong/delta floodplain and Tonle Sap Basin.
9	Education and dissemination on climate-resilient agricultural practices	4	4	4	4	4	4	80.0	7	Sectoral programme. District extension	Agricultural districts across all landscapes, especially flood- and drought-prone areas.
3	Reforestation, watershed restoration and tree planting including mangroves	4	4	4	5	3	3	79.0	8	District project/site	Degraded upland and watershed districts feeding Tonle Sap and the Mekong floodplain, and coastal mangrove belts.

ID	Adaptation measure	1.CRVA Risk (60%)	2.Effectiveness (15%)	3.GESI (10%)	4.Co-benefits (5%)	5. Feasibility (5%)	6.Sustainability (5%)	Weight (0–100)	Rank	Scope	Priority landscapes / district types
7	Water-saving measures and local water resource development (ponds, wells, rainwater harvesting)	4	4	4	4	4	3	79.0	9	District project/site	Drought-prone rural districts in the northern highlands, north-east and rain-shadow areas.
10	Strengthen capacity and local coordination mechanisms for climate-resilient planning and DRR	4	4	4	3	4	4	79.0	10	Sectoral governance programme. District delivery	All provinces and districts; initial focus on LGCC priority districts and high-risk hotspots.
11	Promote climate-resilient animal and crop breeds and diversified farming systems	4	4	4	4	3	4	79.0	11	Sectoral programme. District extension	Drought- and flood-prone farming districts, including areas affected by salinity and heat stress.
6	Dissemination and public awareness on climate change and preparedness	4	3	4	3	5	4	77.0	12	Sectoral programme. District delivery.	Nationwide; prioritise provinces and districts with high climate risk and low awareness.
8	Use and update PRISM and related early warning and disaster information tools	4	3	3	3	4	3	73.0	13	Sectoral information system. Subnational use	Nationwide coverage, with enhanced resolution and use for high-risk districts in all landscapes.
12	Suppress and prevent wildfires through fire breaks, monitoring and community brigades	3	3	3	4	3	3	61.0	14	District project/site	Forest and upland districts with high fire incidence, especially in the north-east highlands.

8.4 SECTOR ADAPTATION PACKAGES

Building on the prioritisation framework (Section 8.2) and the multi-criteria scoring of measures (Section 8.3), this section organises the shortlisted adaptation options into a set of sector adaptation packages. The aim is to move from a list of individual measures to coherent, programmatic bundles that can guide LGCC-III investments, inform national sector strategies and support the design of sub-national projects under LoCAL and related financing windows. Each package groups complementary measures that address the same cluster of climate risks and vulnerabilities, while recognising the specific mandates and comparative advantages of line ministries and sub-national governments.

The sector packages remain firmly anchored in the CRVA's risk analysis. They target the main risk landscapes and sub-risks identified in the previous chapters – including climate threats to livelihoods (agriculture, livestock and fisheries), disaster risk for communities, water insecurity, ecosystem degradation, and damage to infrastructure, tourism and coastal economies. In addition, the packages now explicitly address climate-sensitive health risks, recognising that increasing heat extremes, floods, droughts and vector-borne diseases interact with existing gaps in health and WASH services. At the same time, the packages reflect Cambodia's existing policy and institutional architecture, including the NDC, NAP, sectoral strategies and the LGCC-III Investment Menu, and are designed to be scalable through performance-based climate-resilience grants and other instruments. Gender equality and social inclusion (GESI) considerations, as well as co-benefits for mitigation, health, biodiversity and jobs, are embedded throughout the packages rather than treated as stand-alone measures.

The section is structured into seven sub-packages that mirror the main sectors and systems analysed in the CRVA and requested by stakeholders:

- Section 8.4.1 presents a climate-resilient livelihoods package, covering agriculture, livestock and inland fisheries.
- Section 8.4.2 outlines a community-centred disaster risk reduction package, focusing on early warning, shelters and preparedness.
- Section 8.4.3 introduces a water security package that integrates surface water, groundwater and small-scale storage.
- Section 8.4.4 describes an ecosystem-based package for forests, wetlands and coasts.
- Section 8.4.5 develops a climate-resilient infrastructure package, emphasising transport and port systems.
- Section 8.4.6 presents a tourism and coastal economies package, combining nature-based solutions, resilient infrastructure and livelihood diversification.
- Finally, Section 8.4.7 sets out a climate-resilient health and social services package that strengthens surveillance, health facilities, WASH and community-based measures to address climate-sensitive health risks.

Each sub-section briefly recalls the key climate risks and vulnerabilities for the sector, then describes the core measures included in the package and how they complement each other across scales (national, provincial and district). This provides a bridge between the evidence-based prioritisation in Section 8.3 and the more spatially explicit "territorial anchoring" of adaptation portfolios presented in Section 8.5.

8.4.1 CLIMATE-RESILIENT LIVELIHOODS (AGRICULTURE, LIVESTOCK, FISHERIES)

Agriculture, livestock and inland fisheries remain at the core of rural livelihoods in Cambodia, especially in the Mekong and Tonlé Sap plains, the northeast uplands and the coastal hinterland. A large share of households still depends directly on rain-fed rice, mixed crop–livestock systems and capture fisheries for food security and income, often with limited diversification and thin safety nets. These production systems are already under pressure from market and land-use changes; climate change adds an additional layer of stress that interacts with existing poverty, land tenure insecurity and gender inequalities.

The CRVA shows that climate risks to livelihoods are driven by the combined effects of increasing temperatures, more frequent and intense extreme events and changes in rainfall patterns. In the rice-based lowlands and floodplains of the Mekong and Tonlé Sap systems, farmers face a double exposure to floods and droughts, including late-onset rains, dry spells during critical growth stages and damaging floods that destroy crops and assets. In interior and upland areas, prolonged dry seasons, heat stress and soil erosion on sloping lands undermine crop productivity, pasture quality and forest-based livelihoods. For inland fisheries and aquaculture, changing flood regimes, higher water temperatures and more frequent droughts alter habitats, migration patterns and spawning grounds, with knock-on effects on food security for communities that rely on fish as a primary source of protein.

Vulnerability is heightened by structural constraints in rural areas. Many smallholders lack access to climate-resilient seeds and breeds, irrigation and on-farm water storage, advisory services and financial instruments that could buffer climate shocks. Poor households, women-headed households and ethnic minorities are particularly exposed, as they tend to farm marginal lands, depend heavily on climate-sensitive wage labour or natural resource extraction, and have limited voice in local decision-making. Livestock keepers face increasing risks from heat stress, water scarcity and disease outbreaks, often without adequate veterinary support. In fisheries-dependent communities around the Tonlé Sap and along the Mekong, climate impacts on fish stocks are compounded by pressures from overfishing and habitat degradation.

Against this backdrop, the climate-resilient livelihoods package brings together a set of measures that address these intertwined risks across crops, livestock and fisheries in a coherent way. It prioritises investments and reforms that stabilise yields under climate variability, diversify income sources, strengthen natural resource management and enhance the adaptive capacity of vulnerable groups. The package is designed to align with national strategies for agriculture and rural development, while providing practical entry points for LGCC-III and sub-national governments to support climate-resilient livelihoods in the districts identified as hotspots by the CRVA.

The Table 24 below summarises the core measures included in the climate-resilient livelihoods package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and a set of indicative key performance indicators (KPIs) that can be used for monitoring and results-based management. The IDs refer to the measure numbering used in Section 8.3.

Table 24. Adaptation measures package focused on Climate Resilient Livelihoods. Source: CRVA analysis.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus (CRVA risk landscapes / district types)	Indicative KPIs
7	Climate-smart rice systems in flood- and drought-prone plains	Agriculture – rice systems, extension services	Mekong floodplain and delta districts; Tonlé Sap floodplain and adjoining lowlands with high composite risk for agriculture and recurrent flood–drought stress.	• Hectares of rice under climate-smart practices (e.g. AWD, drought/flood-tolerant varieties). • Number of farmers (women/men) adopting climate-smart rice practices. • Change in average rice yield variability between seasons in target districts. • Reduction in irrigation water use per hectare in participating schemes. • Number of Farmer Water User Communities using seasonal climate information for planning.
8	Diversified climate-resilient cropping and agroforestry systems	Agriculture (mixed cropping), forestry, rural livelihoods	Interior plateaux and northeast uplands; erosion-prone slopes around Tonlé Sap and Mekong tributaries; districts with high sensitivity of rain-fed cropping systems.	• Hectares under diversified cropping and agroforestry systems. • Percentage of target households with at least three climate-resilient income sources. • Number of community groups engaged in tree planting and agroforestry. • Observed increase in vegetative cover or ground cover on target slopes (proxy for reduced erosion). • Number of women farmers participating in diversification and agroforestry activities.
9	Climate-resilient livestock systems (shade, water, fodder and breeds)	Livestock production, veterinary services, rural livelihoods	Northeast highlands and interior plains with high exposure to heat extremes and drought; districts with significant smallholder livestock assets.	• Number of livestock-keeping households with improved shade and watering facilities. • Hectares established with drought-tolerant fodder crops or improved pasture. • Livestock mortality rate in target areas during heatwaves and droughts. • Number of communes with trained para-veterinarians or strengthened veterinary services. • Proportion of livestock herd using climate-resilient breeds in participating communities.
10	Climate-resilient inland fisheries and aquaculture in Tonlé Sap and Mekong systems	Fisheries and aquaculture, food systems, ecosystems	Tonlé Sap Lake and floodplain districts; Mekong floodplain and riverine districts with high dependence on inland fisheries and aquaculture.	• Number of households adopting climate-resilient aquaculture practices. • Hectares of restored or protected fish habitats and refuges. • Number of community fisheries with climate-informed management plans. • Change in fish production or income stability among target households. • Number of cold-chain or improved processing facilities supported in hotspot districts.
11	Index-based climate insurance bundled with climate advisory services	Agricultural finance, risk transfer, extension services	Rain-fed agricultural hotspots across Mekong and Tonlé Sap fringes, interior plateau and northeast districts exposed to recurrent droughts and floods.	• Number of smallholder farmers (women/men) covered by index-based climate insurance products. • Total sum insured and number of claims paid after eligible climate events. • Percentage of insured farmers receiving and using seasonal climate advisories. • Change in reported use of negative coping strategies after climate shocks in target areas. • Number of insurance–advisory products co-developed with local institutions or financial providers.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus (CRVA risk landscapes / district types)	Indicative KPIs
12	Community water-saving and water resource development (ponds, rainwater harvesting, wells)	Rural water supply, small-scale storage, agriculture	Drought-prone interior and upland districts; northeast and coastal hinterland areas with recurrent dry-season water shortages for households and small farms.	• Number of community ponds, small reservoirs and climate-resilient wells constructed or rehabilitated. • Estimated additional water storage capacity created (m^3). • Number of households using rainwater harvesting systems. • Average number of days of secure domestic and productive water supply during the dry season in target communities. • Number of community-based water management plans that incorporate climate risk information.
13	Efficient irrigation and on-farm water management with strong Farmer Water User Communities	Irrigation systems, agricultural water management	Irrigated schemes in Mekong and Tonlé Sap plains; selected valleys and schemes in northeast districts with variable rainfall and infrastructure deficits.	• Kilometres of primary and secondary canals rehabilitated or lined. • Percentage reduction in conveyance and distribution losses in target irrigation schemes. • Number of Farmer Water User Communities with functional governance structures and climate-responsive O&M plans. • Water productivity in irrigated agriculture (kg of output per m^3 of water) in target schemes. • Number of farmers trained in efficient on-farm water management (disaggregated by sex).
21	Community-based eco-tourism and livelihood diversification linked to conservation areas	Tourism, conservation, alternative livelihoods	Forested and coastal conservation landscapes; community protected areas and buffer zones around national parks, mangroves and wetlands in climate-sensitive districts.	• Number of community-based eco-tourism enterprises established or strengthened. • Number of households with income from eco-tourism or associated services (disaggregated by sex and vulnerable group). • Share of participating households' income coming from non-farm/climate-diversified sources. • Area under conservation or sustainable use agreements linked to eco-tourism initiatives. • Number of jobs created for youth and women in eco-tourism and related value chains.

8.4.2 DISASTER RISK REDUCTION (COMMUNITIES)

Disaster risk reduction (DRR) is a central pillar of Cambodia's climate resilience agenda. The CRVA shows that many provinces face overlapping hazards – including riverine and pluvial floods, tropical storms, strong winds, droughts and, in some areas, landslides and flash floods – that regularly disrupt lives and livelihoods. The most exposed districts are concentrated in the Mekong and Tonlé Sap floodplains, in low-lying coastal areas, and along key river corridors and transport routes where settlements, markets and services have expanded into flood-prone zones. Rapid urbanisation, land conversion in floodplains and inadequate drainage increase the intensity of local flooding, while climate change is expected to amplify extreme rainfall and sea-level rise, further heightening disaster risk for vulnerable communities.

Vulnerability to climate-related disasters is shaped not only by hazard exposure but also by social, institutional and infrastructural factors. Many communes lack safe, accessible shelters; early warning messages do not always reach the last mile or arrive too late; and contingency plans and evacuation routes are often incomplete or not tested. Poor households, informal urban settlers, women-headed households, children, older persons and people with disabilities are disproportionately affected, as they tend to live in the most hazardous locations, have fewer resources to prepare and recover, and face barriers in accessing information and assistance. Local authorities, for their part, frequently operate with limited staffing, budgets and technical tools to assess risk, plan DRR investments and coordinate emergency response across sectors and administrative levels.

The community-centred DRR package addresses these challenges by combining improvements in multi-hazard early warning and information systems, inclusive shelters and evacuation planning, climate-risk-informed planning and budgeting, and strengthened awareness, preparedness and local governance. The package seeks to ensure that risk information generated by the CRVA, and related platforms is translated into concrete preparedness and response capacity at community level, with a strong focus on gender equality and social inclusion. It provides a framework for aligning support from national DRR institutions, LGCC-III performance-based climate-resilience grants and other partners to reduce loss of life, damage to assets and long-term setbacks for vulnerable households in Cambodia's climate hotspots.

The Table 24 below summarises the core measures included in the community-centred disaster risk reduction package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs) for monitoring and learning. The IDs refer to the measure numbering used in Section 8.3.

Table 25. Adaptation measures package focused on Disaster Risk Reduction.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus (CRVA risk landscapes / district types)	Indicative KPIs
2	Multi-hazard early warning systems with last-mile communication and SOPs	Disaster risk reduction, meteorological and hydrological services, information systems	All hazard-prone districts, with emphasis on Mekong and Tonlé Sap floodplains, coastal districts and storm-exposed areas, including urban nodes in flood hotspots.	• Number of provinces and districts covered by operational multi-hazard early warning systems. • Percentage of target communes receiving timely, actionable warnings through at least two communication channels. • Number of standard operating procedures (SOPs) for early warning and response adopted and tested at sub-national level. • Reported reduction in lead time between hazard detection and community warning dissemination. • Number of evacuation drills conducted with participation of women, children, older persons and people with disabilities.
3	Inclusive resilient shelters and evacuation routes	DRR infrastructure, public buildings, local planning, GESI	Floodplain and coastal districts, including urban nodes and peri-urban settlements in flood and storm hotspots.	• Number of multi-purpose resilient shelters constructed or upgraded to agreed safety and accessibility standards. • Number of kilometres of clearly signposted evacuation routes established or upgraded. • Proportion of shelters with separate, safe spaces and facilities for women, children and people with disabilities. • Number of communes with updated evacuation plans and shelter management committees. • Number of people using designated shelters during drills and actual events (disaggregated by sex and age).

ID	Adaptation measure	Sector / sub-sector	Main territorial focus (CRVA risk landscapes / district types)	Indicative KPIs
4	Provincial and district climate risk assessments integrated into planning and budgeting	Sub-national planning and budgeting, DRR and climate governance	All risk landscapes, with priority to districts in the ≥70th percentile of the CRVA composite risk index and LGCC-III priority provinces.	• Number of provinces and districts that have completed climate and disaster risk assessments using CRVA and local data. • Number of development plans and annual investment plans that explicitly integrate climate and disaster risk analysis. • Share of sub-national public investment budget allocated to risk-reducing measures in hotspot districts. • Number of staff trained in risk-informed planning and budgeting (disaggregated by sex). • Frequency of updates of risk information and its use in budget hearings and plan revisions.
5	Strengthening PRISM and climate–disaster information systems	National and sub-national information systems, DRR, planning	Nationwide coverage, with enhanced spatial resolution and regular use in all high-risk districts across risk landscapes.	• Functionality of PRISM and related platforms measured by data completeness, update frequency and system uptime. • Number of provinces and districts regularly using PRISM products in planning and emergency operations. • Number of datasets (hazard, exposure, vulnerability, losses) integrated and harmonised in the national system. • Number of staff trained in interpreting and using climate and disaster information products. • Instances where PRISM outputs are referenced in official DRR and investment planning documents.
6	Climate risk awareness, education and community preparedness	DRR, education, community development, communication	Nationwide, with priority to high-risk provinces and districts where awareness and preparedness levels are low, including remote rural areas and informal urban settlements.	• Number of schools and communities implementing climate and DRR education activities. • Number of community-based preparedness plans developed and updated with local participation. • Percentage of surveyed households in target areas that can correctly identify evacuation procedures and safe behaviours. • Number of communication campaigns and materials tailored to women, youth and marginalised groups. • Reported increase in preparedness actions taken by households before forecast extreme events.
25	Capacity building and coordination for gender-responsive local climate governance	Local governance, institutional capacity, GESI, DRR and climate change	All provinces and districts, with initial focus on LGCC-III priority areas and districts with high composite climate risk and weak institutional capacity.	• Number of district and commune officials trained on climate and disaster risk, gender-responsive planning and DRR. • Number of functioning district and commune climate/DRR committees meeting regularly with documented actions. • Evidence of women's and vulnerable groups' representation in local climate and DRR decision-making bodies. • Number of local by-laws, guidelines or procedures issued to mainstream DRR and climate resilience in local governance. • Increase in the proportion of locally managed budget allocated to DRR and adaptation priorities.

8.4.3 WATER SECURITY

Water security is a critical dimension of climate resilience in Cambodia. The CRVA highlights that many provinces face the twin challenges of seasonal water scarcity and damaging floods, with strong spatial heterogeneity across risk landscapes. In the Mekong and Tonlé Sap plains, farmers and rural communities depend on a mix of rain-fed and irrigated agriculture, small ponds and shallow wells, all of which are sensitive to delayed monsoon onset, dry spells and extreme floods. In upland and interior districts, longer dry seasons, rising temperatures and highly variable rainfall increase the frequency of droughts and put pressure on limited surface water sources. Coastal and northeast districts rely heavily on groundwater, where over-abstraction and saline intrusion already pose risks to drinking water supplies and wellfields.

Urban and peri-urban areas face their own water security challenges. Rapid population growth, expanding industrial zones and high levels of non-revenue water strain existing water-supply systems, particularly during droughts and heatwaves. At the same time, inadequate drainage infrastructure and land-use change in floodplains exacerbate pluvial and fluvial flooding, damaging water and sanitation infrastructure and disrupting services. Climate projections suggest that extreme rainfall events will become more intense in many parts of the country, while higher temperatures and evapotranspiration will increase water demand in agriculture, ecosystems and cities. Without targeted adaptation, these trends could widen existing inequalities in access to safe and reliable water for households, farms and businesses.

The water security package responds to these risks by combining measures that improve the availability, reliability and quality of water resources across rural and urban contexts. It focuses on community-level water-saving and storage, more efficient and climate-resilient irrigation and on-farm water management, strategic protection and recharge of groundwater, and reductions in non-revenue water and demand pressures in urban utilities. Together, these measures aim to reduce drought and flood risks for households and productive sectors, safeguard critical drinking-water sources and help utilities and water-resource managers cope with a more variable and uncertain climate.

The table below summarises the core measures included in the water security package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs). The IDs refer to the measure numbering used in Section 8.3.

Table 26. Adaptation measures package focused on Water Security.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus	Indicative KPIs
12	Community water-saving and water resource development (ponds, rainwater harvesting, wells)	Rural water supply, small-scale storage, agriculture	Drought-prone interior and upland districts; northeast and coastal hinterland areas with recurrent dry-season water shortages for households and small farms.	• Number of community ponds, small reservoirs and climate-resilient wells constructed or rehabilitated. • Estimated additional water storage capacity created (m^3) in target communities. • Number of households using rainwater harvesting systems for domestic and productive uses. • Average number of days of secure domestic and productive water supply during the dry season in target communities. • Number of community-based water management plans that incorporate climate risk information and gender considerations.
13	Efficient irrigation and on-farm water management with strong Farmer Water User Communities	Irrigation systems, agricultural water management	Irrigated schemes in Mekong and Tonlé Sap plains; selected valleys and schemes in northeast districts with variable rainfall and infrastructure deficits.	• Kilometres of primary and secondary canals rehabilitated, lined or improved. • Percentage reduction in conveyance and distribution losses in target irrigation schemes. • Number of Farmer Water User Communities with functional governance structures and climate-responsive O&M plans. • Water productivity in irrigated agriculture (kg of output per m^3 of water) in target schemes. • Number of farmers trained in efficient on-farm water management (disaggregated by sex).
14	Managed Aquifer Recharge (MAR) and strategic groundwater protection	Water resources management, drinking water supply, groundwater governance	Northeast highlands and coastal districts with high reliance on groundwater and evidence of over-abstraction or saline intrusion; peri-urban wellfields supplying towns and cities.	• Number of MAR structures (recharge basins, infiltration wells, check dams) constructed and functioning. • Trend in groundwater levels and salinity in monitored wellfields in target areas. • Area of wellfield protection zones established and enforced through local regulations. • Number of districts applying basic groundwater abstraction monitoring and reporting. • Number of households and service providers benefiting from more secure groundwater supplies.
15	Non-revenue water reduction and demand management in urban utilities	Urban water supply, utilities, demand management	Cities and large towns with high non-revenue water levels and recurrent dry season supply constraints, including Phnom Penh and secondary urban centres in Mekong, Tonlé Sap and coastal landscapes.	• Percentage reduction in non-revenue water (physical and commercial losses) in participating utilities. • Kilometres of water-supply network rehabilitated or pressure-managed. • Number of new or upgraded household and district meters installed. • Implementation of water demand management measures (e.g. tariff structures, public campaigns) in target cities. • Number of days per year with continuous water supply for households in target service areas, including low-income neighbourhoods.

8.4.4 ECOSYSTEMS: FORESTS, WETLANDS AND COASTS

Healthy ecosystems are a cornerstone of climate resilience in Cambodia. Forests, wetlands and coastal systems provide critical services for people and the economy: they regulate water flows, reduce flood peaks and erosion, store carbon, support fisheries and tourism, and sustain the livelihoods of many rural and coastal communities. The CRVA shows that climate change is interacting with existing pressures – such as land-use change, deforestation, drainage of wetlands and coastal development – to increase the risk of floods, landslides, sedimentation and coastal erosion. Upland catchments feeding the Tonlé Sap and Mekong floodplain are experiencing higher temperatures, longer dry seasons and more intense rainfall events, which together increase wildfire risk and accelerate soil erosion on degraded slopes.

Wetlands, riparian zones and floodplain forests have been reduced and fragmented in many areas, weakening their capacity to buffer extreme flows and support biodiversity. Around the Tonlé Sap and along major rivers, increased sediment loads and unstable riverbanks threaten agriculture, infrastructure and settlements. Along the Gulf of Thailand coast, sea-level rise, storm surges and more frequent extreme events compound the effects of mangrove clearance, sand mining and hard infrastructure on beaches and shorelines, leading to rapid coastal erosion, saline intrusion and loss of natural storm protection. These changes directly affect poor and resource-dependent communities, including small-scale fishers, farmers in floodplain and delta areas, and households relying on forest products and eco-tourism.

The ecosystems package responds to these challenges by prioritising measures that restore and protect critical forests, wetlands and coastal habitats, while enabling sustainable and climate-resilient use of natural resources. It combines watershed and riparian restoration with wildfire risk management in upland catchments, large-scale mangrove and coastal wetland restoration with enforced setbacks and integrated coastal zone management, and targeted protection of coastal and port infrastructure using nature-based solutions (NbS) combined with necessary grey works. In addition, the package supports community-based eco-tourism and diversified livelihoods linked to conservation areas, creating incentives for local stewardship of ecosystems. Together, these measures aim to reduce hazard intensity and exposure, safeguard biodiversity and strengthen the resilience of communities and key economic sectors that depend on Cambodia's natural capital.

The Table 27 below summarises the core measures included in the ecosystems package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs). The IDs refer to the measure numbering used in Section 8.3.

Table 27. Adaptation measures package focused on Ecosystems, Forests, Wetlands and Coasts.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus	Indicative KPIs
16	Watershed and riparian restoration with wildfire risk management	Forestry, watershed management, DRR, ecosystems	Degraded upland and watershed districts feeding the Tonlé Sap and Mekong floodplains, and upland areas with high wildfire risk, especially in the northeast and northern highlands.	• Hectares of riparian buffers, floodplain forests and upland forests restored or protected. • Number of community forestry groups and watershed committees actively managing restoration and wildfire prevention. • Number of kilometres of riverbank stabilised with vegetation or bioengineering techniques. • Change in reported wildfire incidence and burned area in target districts. • Evidence of reduced sedimentation or landslide events affecting downstream infrastructure and agricultural areas.
17	Mangrove and coastal wetland restoration with enforced setbacks and ICZM	Coastal ecosystems, fisheries, coastal planning and regulation	Coastal districts along the Gulf of Thailand, including Koh Kong, Preah Sihanouk, Kampot and Kep, focusing on mangrove belts, estuaries, tidal flats and low-lying settlements exposed to erosion and storm surges.	• Hectares of mangroves and coastal wetlands restored, conserved or placed under community/co-management agreements. • Number of coastal districts implementing integrated coastal zone management (ICZM) plans with enforced setback lines. • Change in shoreline position or rate of coastal erosion at monitored sites. • Number of households and critical assets benefiting from improved natural coastal protection. • Number of enforcement actions or incentives supporting compliance with coastal zoning and setback regulations.
20	Protection of coastal and port infrastructure and tourism hubs using NbS and targeted grey works	Ports, transport, tourism infrastructure, coastal protection	Major ports, industrial zones and tourism hubs along the Gulf of Thailand coast, including Sihanoukville and other strategic coastal nodes exposed to sea-level rise, storm surges and erosion.	• Kilometres of coastline around ports and tourism hubs protected or stabilised using combined NbS and grey solutions. • Reduction in days of disruption or damage costs to port and tourism operations due to coastal flooding and erosion. • Number of infrastructure projects applying climate-resilient design standards and NbS principles. • Number of people and value of assets protected by the implemented measures. • Area of adjacent mangrove, dune and beach ecosystems conserved or enhanced as part of protection schemes.
21	Community-based eco-tourism and livelihood diversification linked to conservation areas	Tourism, conservation, alternative livelihoods, community development	Forested and coastal conservation landscapes; community protected areas and buffer zones around national parks, mangroves and wetlands in climate-sensitive districts.	• Number of community-based eco-tourism initiatives established or strengthened. • Number of households with income from eco-tourism or associated services (disaggregated by sex and vulnerable group). • Share of participating households' income originating from non-farm and climate-diversified sources. • Area under conservation or sustainable use agreements linked to eco-tourism initiatives. • Number of jobs created for youth and women in eco-tourism and related value chains.

8.4.5 CLIMATE-RESILIENT INFRASTRUCTURE (TRANSPORT & PORTS)

Cambodia's infrastructure and urban systems are increasingly exposed to climate-related hazards. The CRVA shows that recurrent riverine and pluvial floods affect key transport corridors, rural access roads and bridges, particularly in the Mekong and Tonlé Sap floodplains and coastal districts. In many urban areas, rapid expansion of built-up surfaces, encroachment into natural drainage paths and limited stormwater infrastructure lead to frequent localised flooding that disrupts mobility, damages dwellings, markets and public facilities, and affects economic activity. At the same time, heat extremes and droughts stress urban water-supply systems and increase cooling needs in cities and towns.

Critical public buildings – such as schools, health centres, markets and commune halls – often lack climate-resilient design standards, adequate elevation above flood levels and passive cooling features. This weakens the continuity of essential services during floods, storms and heatwaves, and can exacerbate health risks for students, patients and staff. Rural communities, meanwhile, depend on unpaved or poorly engineered roads that are easily damaged by intense rainfall and prolonged inundation, cutting access to markets, emergency services and evacuation routes. Many utilities face high levels of non-revenue water and ageing networks, which limit their ability to guarantee reliable supply under changing climate conditions.

The climate-resilient infrastructure and urban systems package brings together a set of measures that strengthen stormwater drainage and blue–green infrastructure in flood-prone cities, climate-proof rural access roads and bridges, and retrofit or construct public buildings to withstand floods, storms and heat extremes. It also promotes urban and household-level measures to manage heat risk and improve water-use efficiency in utilities. These interventions are closely aligned with Cambodia's urban development strategies and the LGCC-III performance-based climate-resilience grants, and are designed to complement the DRR, water security and health packages described in other sub-sections.

The table below summarises the core measures included in the climate-resilient infrastructure and urban systems package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs). The IDs refer to the measure numbering used in Section 8.3.

Table 28. Adaptation measures package focused on Climate-resilient infrastructure and urban systems.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus	Indicative KPIs
1	Urban climate-resilient drainage and blue–green infrastructure in flood-prone cities	Urban infrastructure, drainage and stormwater management, transport interfaces	Urban nodes in the Mekong and Tonlé Sap plains and coastal districts with recurrent pluvial and fluvial flooding, including Phnom Penh and major secondary cities such as Siem Reap, Battambang and Sihanoukville.	• Kilometres of drainage canals and pipes upgraded or constructed to climate-resilient standards. • Area of blue–green infrastructure created or rehabilitated (e.g. retention ponds, wetlands, green corridors, permeable surfaces). • Reduction in frequency and duration of disruptive urban flooding events in target neighbourhoods. • Number of people and critical services (schools, hospitals, markets) benefiting from improved drainage. • Number of municipalities applying integrated urban drainage and land-use plans that reflect CRVA risk information.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus	Indicative KPIs
18	Climate-proof rural access roads and bridges	Transport, rural infrastructure, DRR	Rural districts in the Mekong and Tonlé Sap floodplains, northern highlands and northeast with critical access routes exposed to floods, flash floods and erosion.	• Kilometres of rural roads upgraded with climate-resilient designs (elevated embankments, drainage, slope protection). • Number of bridges and culverts reconstructed or rehabilitated to withstand design flood events. • Reduction in days of lost access to markets, schools and health facilities during major flood events in target communes. • Number of communes with identified and maintained climate-resilient access and evacuation routes. • Share of routine maintenance budgets allocated to climate-proofed road segments in target districts.
19	Climate-proof public buildings (schools, health centres, markets and commune halls) with passive cooling	Social infrastructure – education, health, local administration, markets	Flood-prone and heat-stressed districts across all risk landscapes, including urban and rural centres where public facilities concentrate service delivery for vulnerable populations.	• Number of schools, health centres, markets and commune halls retrofitted or constructed to climate-resilient standards (elevation, structural integrity, wind and flood resistance). • Percentage of upgraded public buildings incorporating passive cooling, rainwater harvesting and safe sanitation systems. • Reduction in reported service disruptions in upgraded facilities during floods, storms and heatwaves. • Number of students, patients and community members benefiting from safer, cooler and more resilient public buildings. • Adoption of climate-resilient design guidelines and checklists by relevant line ministries and sub-national authorities.
15	Non-revenue water reduction and demand management in urban utilities	Urban water supply utilities, demand management, asset management	Cities and large towns with high non-revenue water levels and recurrent dry season supply constraints, including Phnom Penh and secondary urban centres in Mekong, Tonlé Sap and coastal landscapes.	• Percentage reduction in non-revenue water (physical and commercial losses) in participating utilities. • Kilometres of water-supply network rehabilitated, replaced or pressure-managed. • Number of domestic and district meters installed or upgraded. • Implementation of water demand management measures (e.g. tariff structures, leak reporting, public campaigns) in target cities. • Number of low-income households benefitting from more reliable water supply in target service areas.
23	Urban heat-health action plans and cooling interventions	Urban planning, health, labour and occupational safety	Major cities and rapidly growing towns experiencing increasing numbers of very hot days and pronounced urban heat-island effects, particularly in the Mekong and Tonlé Sap plains and coastal districts.	• Number of cities and towns with approved urban heat-health action plans. • Number of cooling centres, shaded public spaces or green corridors established or upgraded. • Adoption of occupational heat-safety standards and guidance for outdoor and factory workers in target cities. • Reduction in reported heat-related illnesses and productivity losses during heatwaves in pilot areas. • Area of urban green cover created or restored as part of heat-risk management interventions.

8.4.6 CLIMATE-RESILIENT HEALTH AND SOCIAL PROTECTION

Climate change is already affecting public health and social protection outcomes in Cambodia, and these impacts are expected to intensify.

The CRVA highlights that heatwaves, floods, droughts and changes in vector ecology interact with gaps in health, water, sanitation and hygiene (WASH) services to increase the burden of climate-sensitive diseases, including diarrhoeal diseases, acute respiratory infections and vector-borne diseases. Floods and storms damage health facilities and disrupt service provision, while heat extremes and degraded environmental conditions worsen occupational health risks, particularly for outdoor and factory workers in urban and peri-urban areas. At the same time, climate shocks exacerbate existing social vulnerabilities by eroding household assets, reducing income and pushing poor and near-poor households into negative coping strategies and long-term poverty traps.

Access to quality health and social protection services is uneven across provinces and districts. Remote rural areas, informal urban settlements and communities with high concentrations of poor households often have limited coverage of health facilities, WASH infrastructure and formal safety nets. Women, children, older persons, people with disabilities and ethnic minorities face additional barriers to accessing services and support, even though they are among the most exposed and sensitive to climate-related shocks and stresses. Existing social protection programmes are expanding, but their ability to respond quickly and at scale to climate shocks remains limited in many areas, and linkages with early warning systems and risk information are still at an early stage.

The climate-resilient health and social protection services package addresses these gaps by strengthening public health systems for climate-sensitive risks, improving heat-health management in urban areas, and scaling up shock-responsive and climate-informed social protection for vulnerable households. It focuses on reinforcing surveillance, preparedness and service continuity in health facilities; developing urban heat-health action plans and cooling interventions; and making cash transfer and public-works programmes more responsive to climate shocks and better targeted to climate-vulnerable groups identified in the CRVA. The package is closely aligned with national health and social protection strategies and provides a basis for coordinating investments and reforms supported by LGCC-III and development partners in high-risk districts.

The Table 29 below summarises the core measures included in the climate-resilient health and social protection package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs). The IDs refer to the measure numbering used in Section 8.3.

Table 29. Adaptation measures package focused on climate-resilient health and social protection package.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus (CRVA risk landscapes / district types)	Indicative KPIs
22	Strengthening public health services for climate-sensitive risks	Health, WASH, emergency preparedness	Floodplain, coastal and urban districts with high climate-sensitive disease risk and limited health and WASH coverage, including informal settlements and remote rural communes.	• Number of health facilities upgraded with climate-resilient WASH, waste management and backup power systems. • Number of health workers trained on climate-sensitive diseases, surveillance and emergency response (disaggregated by sex). • Functionality of early warning and contingency planning for climate-related health emergencies in target districts. • Change in incidence or outbreak frequency of selected climate-sensitive diseases in target areas. • Population covered by improved climate-resilient primary health services in hotspot districts.
23	Urban heat-health action plans and cooling interventions	Urban health, planning, labour and occupational safety	Major cities and rapidly growing towns experiencing increasing numbers of very hot days and pronounced urban heat-island effects, particularly in the Mekong and Tonlé Sap plains and coastal districts.	• Number of cities and towns with approved and operational urban heat-health action plans. • Number of cooling centres, shaded public spaces or green corridors established or upgraded in heat-stressed neighbourhoods. • Adoption of occupational heat-safety standards and guidance by enterprises and local authorities in target cities. • Reduction in reported heat-related illnesses and productivity losses during heatwaves in pilot areas. • Number of public awareness campaigns and outreach activities on heat-risk management targeting vulnerable groups.
24	Social protection and shock-responsive safety nets for climate-vulnerable households	Social protection, livelihoods, GESI	High-risk districts with high poverty rates, recurrent climate shocks and limited formal safety-net coverage, including floodplain, drought-prone and coastal areas identified as CRVA hotspots.	• Number of climate-vulnerable households (women- and child-headed, elderly, people with disabilities) covered by cash transfer and public-works programmes. • Share of social protection caseload triggered or scaled up in response to climate-related early warnings and shocks. • Average time between shock occurrence and delivery of additional support to eligible households. • Reduction in reported use of negative coping strategies after climate shocks in target areas. • Number of social protection programmes that explicitly integrate climate and disaster risk information into targeting and design.

8.4.7 TOURISM AND COASTAL ECONOMIES

Tourism and coastal economies are strategic pillars of Cambodia's development, generating employment and foreign exchange, and supporting a wide range of local businesses and services. Coastal provinces such as Koh Kong, Preah Sihanouk, Kampot and Kep host ports, industrial zones, fisheries, tourism resorts and rapidly growing towns that are tightly connected to global value chains. The CRVA shows that these coastal and near-coastal districts are increasingly exposed to climate hazards, including sea-level rise, storm surges, coastal erosion, saline intrusion and heavy rainfall events that cause flooding and infrastructure damage. These risks threaten critical logistics and trade infrastructure, tourism assets and jobs, as well as the livelihoods of small-scale fishers and coastal communities.

In parallel, ecosystem degradation – such as mangrove clearance, sand mining, unplanned construction along beaches and shorelines, and the loss of wetlands and dunes – has reduced the natural buffering capacity of coastal systems. This amplifies the impact of climate hazards on ports, tourism infrastructure and nearby settlements. Many tourism enterprises and coastal communities have limited access to climate risk information and lack the technical and financial capacity to adapt their infrastructure, business models and livelihoods. Poor households in fishing and tourism-dependent communities are particularly vulnerable, as they often live in the most exposed locations, depend on a narrow set of climate-sensitive activities and have limited savings or access to formal finance and social protection.

The tourism and coastal economies package brings together measures that protect and climate-proof key coastal and port infrastructure and tourism hubs, restore and manage coastal ecosystems as natural defences and productive assets, and promote community-based eco-tourism and diversified livelihoods linked to conservation areas. It complements the broader ecosystem and infrastructure packages by focusing on the specific needs of coastal economic systems and value chains. The package is intended to guide investments and policy reforms that sustain the long-term viability of Cambodia's coastal economies while reducing climate risk for vulnerable communities and businesses, in line with national tourism and blue economy strategies and the LGCC-III and LoCAL frameworks.

The table below summarises the core measures included in the tourism and coastal economies package, indicating their sectoral focus, main territorial focus based on the CRVA risk landscapes, and indicative key performance indicators (KPIs). The IDs refer to the measure numbering used in Section 8.3.

Table 30. Adaptation measures package focused on Tourism and coastal economies.

ID	Adaptation measure	Sector / sub-sector	Main territorial focus	Indicative KPIs
17	Mangrove and coastal wetland restoration with enforced setbacks and ICZM	Coastal ecosystems, fisheries, tourism and coastal planning	Coastal districts along the Gulf of Thailand, including Koh Kong, Preah Sihanouk, Kampot and Kep, focusing on mangrove belts, estuaries, tidal flats and low-lying tourism and fishing settlements exposed to erosion and storm surges.	• Hectares of mangroves and coastal wetlands restored, conserved or placed under community/co-management agreements. • Number of coastal districts implementing integrated coastal zone management (ICZM) plans with enforced setback lines. • Change in shoreline position or rate of coastal erosion at monitored tourism and community sites. • Number of tourism facilities and coastal communities benefitting from strengthened natural coastal protection. • Increase in tourism products and services explicitly linked to healthy mangrove and wetland ecosystems.
20	Protection of coastal and port infrastructure and tourism hubs using Nature base Solutions (NbS) and targeted grey works	Ports, transport, tourism infrastructure, coastal protection	Major ports, industrial zones and tourism hubs along the Gulf of Thailand coast, including Sihanoukville and other strategic coastal nodes exposed to sea-level rise, storm surges and erosion.	• Kilometres of coastline around ports and tourism hubs protected or stabilised using combined NbS and grey solutions. • Reduction in days of disruption or damage costs to port operations and tourism facilities due to coastal flooding and erosion. • Number of infrastructure and tourism projects applying climate-resilient design standards and NbS principles. • Number of jobs preserved or created in port and tourism-related activities as a result of resilience investments. • Area of adjacent mangrove, dune and beach ecosystems conserved or enhanced as part of protection schemes.
21	Community-based eco-tourism and livelihood diversification linked to conservation areas	Tourism, conservation, alternative livelihoods, community development	Forested and coastal conservation landscapes; community protected areas and buffer zones around national parks, mangroves and wetlands in climate-sensitive coastal and near-coastal districts.	• Number of community-based eco-tourism initiatives established or strengthened in coastal and conservation areas. • Number of households with income from eco-tourism or associated services (disaggregated by sex and vulnerable group). • Share of participating households' income originating from non-farm and climate-diversified sources. • Annual revenue generated by community-based eco-tourism and associated value chains in target sites. • Area under conservation or sustainable use agreements linked to eco-tourism initiatives.

8.5 TERRITORIAL ANCHORING (HOTSPOTS & INVESTMENT MENUS)

The previous sections have identified, scored and organised a set of priority adaptation measures into coherent sectoral packages for climate-resilient livelihoods, community-centred disaster risk reduction, water security, ecosystems, infrastructure and urban systems, tourism and coastal economies, and climate-resilient health and social protection services. This section translates those packages into territorially anchored adaptation portfolios that can guide implementation at provincial and district level. It does so by linking the multi-criteria scoring results in Section 8.3 and the sectoral packages in Section 8.4 with the CRVA hotspot analysis and the LGCC-III / LoCAL investment architecture.

The CRVA distinguishes several major risk landscapes, including the Mekong floodplain and delta, the Tonlé Sap Basin, the northeast and northern highlands, the interior plateau and the coastal belt, as well as rapidly urbanising nodes across these landscapes. Within each landscape, the composite climate risk index and sector-specific analyses highlight clusters of districts that are particularly exposed and vulnerable to climate hazards. In parallel, the LGCC-III programme and related district prioritisation exercises identify a set of priority provinces and districts for performance-based climate-resilience grants. Territorial anchoring in this context means identifying, for each adaptation measure, the types of districts and risk landscapes where it should be prioritised and clarifying whether it is best delivered as a district-level project or as part of a broader sectoral or national programme with sub-national delivery.

The adaptation measures also map closely onto the LGCC-III and LoCAL investment menus. Many measures take the form of climate-resilient local infrastructure and basic services (e.g. drainage, rural roads, small-scale water storage, shelters and public buildings), which can be financed through local investment grants. Others relate to agriculture and livelihoods, water management, ecosystems and tourism, disaster risk reduction and early warning, or local governance, planning and social protection, and can be supported through a mix of local grants, sector programmes and technical assistance. The LGCC-III and LoCAL frameworks provide the main delivery channels for district-level investments, while line ministries and national agencies lead sectoral and information-system measures that have nationwide scope but need to be used and sustained at provincial and district levels.

The Table 31 provides a consolidated view of the 25 priority adaptation measures, indicating for each of them: 1) the preferred implementation scope (district project/site, sectoral programme with district delivery, or national/system enabling measure); 2) the main CRVA risk landscapes and types of hotspot districts where the measure should be prioritised; and 3) its alignment with indicative LGCC-III / LoCAL investment menu categories.

This territorial anchoring is not a rigid blueprint, but a practical guide for sub-national authorities, national counterparts and development partners to assemble location-specific adaptation portfolios that are consistent with the CRVA evidence, responsive to local priorities and compatible with existing climate finance instruments.

The table below is designed to guide district level planning and investment pipelines. It links the what from the sector analysis to the where for delivery, so provincial and municipal teams can align designs, permits, budgets and partnerships with the specific drivers of risk in each landscape.

Table 31. Adaptation measures with territorial anchoring (hotspots and investment menus).

ID	Adaptation measure	Scope (district / programme / system)	Priority CRVA risk landscapes / hotspot district types	Indicative LGCC-III / LoCAL investment menu alignment
1	Urban climate-resilient drainage and blue–green infrastructure in flood-prone cities	District project/site – municipal investment	Urban nodes in Mekong and Tonlé Sap floodplains and coastal districts with recurrent pluvial and fluvial flooding (e.g. Phnom Penh, Siem Reap, Battambang, Sihanoukville).	Climate-resilient local infrastructure and basic services (urban drainage, roads, public spaces).
2	Multi-hazard early warning systems with last-mile communication and SOPs	Sectoral programme → district delivery	All hazard-prone districts, with emphasis on floodplain, coastal and storm-exposed areas across all risk landscapes.	DRR, early warning and climate information systems (national–local interface).
3	Inclusive resilient shelters and evacuation routes	District project/site	Floodplain and coastal districts, including urban and peri-urban settlements in flood and storm hotspots.	Climate-resilient local infrastructure and basic services (shelters, evacuation routes).
4	Provincial and district climate risk assessments integrated into planning and budgeting	Sectoral governance programme → district delivery	All risk landscapes; priority to districts in the ≥70th percentile of the composite CRVA risk index and LGCC-III priority districts.	Local governance, planning and climate-budgeting support.
5	Strengthening PRISM and climate–disaster information systems	National/system enabling measure with sub-national use	Nationwide coverage, with enhanced resolution and systematic use in high-risk districts across all landscapes.	National climate and disaster information systems supporting local DRR and planning.
6	Climate risk awareness, education and community preparedness	Sectoral DRR and education programme → district and community delivery	Nationwide; priority to high-risk provinces and districts with low awareness and preparedness, including remote rural and informal urban areas.	DRR, awareness and education campaigns at local level.
7	Climate-smart rice systems in flood- and drought-prone plains	District project/site – agricultural investment and extension	Rice-growing districts in Mekong floodplain and delta and Tonlé Sap Basin with high composite risk for agriculture and recurrent flood–drought stress.	Climate-resilient agriculture and livelihoods (rice systems, extension).
8	Diversified climate-resilient cropping and agroforestry systems	District project/site	Interior plateaux, northeast uplands and erosion-prone slopes around Tonlé Sap and Mekong tributaries.	Climate-resilient agriculture, diversification and agroforestry.
9	Climate-resilient livestock systems (shade, water, fodder and breeds)	District project/site	Northeast highlands and interior plains with high exposure to heat extremes and drought and significant smallholder livestock assets.	Climate-resilient livelihoods (livestock, fodder, animal health).

ID	Adaptation measure	Scope (district / programme / system)	Priority CRVA risk landscapes / hotspot district types	Indicative LGCC-III / LoCAL investment menu alignment
10	Climate-resilient inland fisheries and aquaculture in Tonlé Sap and Mekong systems	Sectoral programme → district and community delivery	Tonlé Sap lake and floodplain districts; Mekong floodplain and riverine districts with high dependence on inland fisheries and aquaculture.	Climate-resilient fisheries and aquaculture, value-chain support.
11	Index-based climate insurance bundled with climate advisory services	Sectoral programme → district delivery via financial and extension institutions	Rain-fed agricultural hotspots across Mekong and Tonlé Sap fringes, interior plateau and northeast districts with recurrent droughts and floods.	Risk-transfer and financial resilience instruments for smallholders (agriculture and livelihoods).
12	Community water-saving and water resource development (ponds, rainwater harvesting, wells)	District project/site – community infrastructure	Drought-prone interior and upland districts; northeast and coastal hinterland areas with recurrent dry-season water shortages.	Climate-resilient local water infrastructure (small storage, community water supply).
13	Efficient irrigation and on-farm water management with strong Farmer Water User Communities	District project/site – irrigation schemes and FWUC strengthening	Irrigated schemes in Mekong and Tonlé Sap plains and selected valleys in northeast districts with variable rainfall and infrastructure deficits.	Climate-resilient irrigation and agricultural water management.
14	Managed Aquifer Recharge (MAR) and strategic groundwater protection	District/catchment project/site	Northeast highlands, coastal districts and peri-urban wellfields with high reliance on groundwater and evidence of over-abstraction or saline intrusion.	Water resources management and protection of drinking-water sources.
15	Non-revenue water reduction and demand management in urban utilities	Sectoral utility programme with city-level investments	Cities and large towns with high non-revenue water and recurrent dry-season supply constraints, including Phnom Penh and secondary urban centres.	Urban water supply efficiency and demand management.
16	Watershed and riparian restoration with wildfire risk management	District/catchment project/site – multi-district where needed	Degraded upland and watershed districts feeding Tonlé Sap and Mekong floodplains, and upland areas with high wildfire risk.	Ecosystem-based adaptation, watershed and forest management, wildfire risk reduction.
17	Mangrove and coastal wetland restoration with enforced setbacks and ICZM	District project/site combined with coastal planning instruments	Coastal districts along the Gulf of Thailand (Koh Kong, Preah Sihanouk, Kampot, Kep) with exposed mangrove belts, estuaries and low-lying settlements.	Coastal ecosystem restoration and protection, integrated coastal zone management.
18	Climate-proof rural access roads and bridges	District project/site – rural infrastructure	Rural districts in Mekong and Tonlé Sap floodplains, northern highlands and northeast with critical access routes exposed to floods and erosion.	Climate-resilient local transport infrastructure (rural roads and bridges).

ID	Adaptation measure	Scope (district / programme / system)	Priority CRVA risk landscapes / hotspot district types	Indicative LGCC-III / LoCAL investment menu alignment
19	Climate-proof public buildings (schools, health centres, markets and commune halls) with passive cooling	District project/site – social infrastructure	Flood-prone and heat-stressed districts across all risk landscapes where public facilities concentrate service delivery for vulnerable populations.	Climate-resilient social infrastructure (education, health, local governance).
20	Protection of coastal and port infrastructure and tourism hubs using NbS and targeted grey works	Project/site in major ports and tourism hubs	Strategic coastal nodes along the Gulf of Thailand (e.g. Sihanoukville and surrounding industrial and tourism zones) exposed to sea-level rise, storm surges and erosion.	Climate-resilient economic and transport infrastructure in coastal areas.
21	Community-based eco-tourism and livelihood diversification linked to conservation areas	District project/site – community development	Forested and coastal conservation landscapes; community protected areas and buffer zones around national parks, mangroves and wetlands.	Climate-resilient local economies and livelihoods (eco-tourism, conservation-linked enterprises).
22	Strengthening public health services for climate-sensitive risks	Sectoral health programme → district health facilities	Floodplain, coastal and urban districts with high climate-sensitive disease risk and limited health and WASH coverage.	Climate-resilient health and WASH services at primary-care level.
23	Urban heat-health action plans and cooling interventions	City-level programme – municipal and health collaboration	Major cities and rapidly growing towns with increasing numbers of very hot days and pronounced urban heat-island effects.	Urban heat-risk management, public health and occupational safety.
24	Social protection and shock-responsive safety nets for climate-vulnerable households	Sectoral social protection programme → district delivery	High-risk districts with high poverty rates, recurrent climate shocks and limited formal safety-net coverage.	Shock-responsive and climate-informed social protection.
25	Capacity building and coordination for gender-responsive local climate governance	Sectoral governance and capacity-building programme → district and commune level	All provinces and districts, with initial focus on LGCC-III priority areas and high composite climate risk districts with weak institutional capacity.	Local climate and DRR governance, capacity building and coordination (including GESI).

8.6 NEXT STEPS: USING CRVA TO INFORM IMPLEMENTATION

This Climate Risk and Vulnerability Assessment is intended not as an end, but as a starting point for a more systematic and risk-informed approach to climate-resilient development in Cambodia.

The preceding sections have identified climate hotspots, analysed key hazards, exposure and vulnerability drivers, and translated the findings into a set of prioritised adaptation measures and sectoral packages with territorial anchoring. This section outlines practical next steps to use the CRVA as a living reference for planning, investment decisions and learning under the LGCC-III and LoCAL frameworks and beyond.

First, the **CRVA results need to be fully embedded in national and sub-national planning** and budgeting processes. This includes integrating the CRVA composite risk maps and sector-specific analyses into GIS-based planning tools and spatial platforms used by national and subnational authorities, so that provincial and district can overlay climate risk information with local socio-economic, land-use and infrastructure data when preparing development plans, public investment programmes and annual budget cycles, as well as into line-ministry strategies for agriculture, water resources, health, social protection, transport, urban development and tourism.
development plans, public investment programmes and annual budget cycles, as well as into line-ministry strategies for agriculture, water resources, health, social protection, transport, urban development and tourism. The prioritisation framework and territorially anchored portfolios presented in this chapter provide a practical basis for aligning climate-resilient investments with the LGCC-III performance-based climate-resilience grants and other relevant climate finance instruments. **Clear guidance, templates and training materials will be needed so that sub-national administrations** can apply the CRVA evidence in a consistent and transparent manner when preparing and screening project proposals.

Second, there is a need to **translate the priority adaptation measures into a concrete pipeline of bankable and implementable investments**. For district-level measures, this implies supporting communes, districts and provinces to identify sites, prepare pre-feasibility studies and basic designs, estimate costs and benefits, and define operation and maintenance arrangements. For sectoral and national measures, further work is required to elaborate programme concepts, clarify institutional roles, and mobilise technical assistance and funding from development partners, climate funds and domestic resources. The LGCC-III and LoCAL investment menus, together with the CRVA-based packages, can serve as a screening tool to ensure that new investments are climate-risk-informed and compatible with national adaptation priorities and safeguards.

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Third, **implementing the CRVA recommendations will require strengthened capacities and coordination mechanisms at all levels**. This includes building the skills of provincial and district planners, engineers, sector staff and commune councils in climate-risk analysis, gender-responsive and socially inclusive adaptation planning, and monitoring of climate-resilient investments. It also **requires reinforcing coordination platforms** between line ministries, the National Committee for Sub-National Democratic Development (NCDD), the National Committee for Disaster Management (NCDM), the Ministry of Environment, the Ministry of Economy and Finance, and other key institutions involved in climate change, DRR, sector planning and public finance. The district and commune climate/DRR committees envisaged in the adaptation packages can act as entry points for joint decision-making and accountability closer to communities.

Fourth, the CRVA highlights the **importance of robust climate and disaster information systems for decision-making**. Strengthening platforms such as PRISM and related hazard, exposure and loss databases – and ensuring their regular use by local governments, sector agencies and communities – is a priority next step. This includes improving data coverage and quality, enhancing interoperability between datasets, and developing user-friendly products tailored to the needs of planners, emergency managers, farmers, utilities and other stakeholders. Establishing feedback loops between users and data providers will help ensure that information products are relevant, accessible and updated as new data and knowledge become available.

Fifth, implementation will require a **clear monitoring, evaluation and learning (MEL) framework** that tracks both progress and effectiveness of adaptation measures. The indicative key performance indicators proposed for each sectoral package can be refined into a results framework with baselines, targets and data sources, aligned with national monitoring systems for climate change, DRR, the Sustainable Development Goals and Cambodia's NDC and NAP processes. Documenting lessons from early implementation in LGCC-III priority districts – including what works, for whom, and under which conditions – will be critical to adjust approaches over time and support scaling up.

Finally, the CRVA should be treated as a living document that will require periodic updates and deepening as new data, models and experiences emerge. Future iterations can incorporate improved climate projections, updated socio-economic scenarios, new hazard layers and more granular vulnerability data, including on gender and social inclusion dimensions. As Cambodia advances in the implementation of LGCC-III, LoCAL and other climate programmes, the CRVA can be used as a platform to connect local evidence with national policy and financing decisions, ensuring that climate-resilient development is grounded in the realities of communities and ecosystems across the country.

9 CONCLUSIONS AND SUMMARY OF FINDINGS

This Climate Risk and Vulnerability Assessment (CRVA) provides a scientifically rigorous, spatially explicit analysis of the current and future climate risks facing Cambodia. By integrating high-resolution climate modelling with detailed socio-economic and environmental data, this report offers an unprecedented district-level overview of the hazards, exposures, and vulnerabilities that define the nation's risk profile. The findings are intended to serve as a critical evidence base for informing the National Adaptation Plan (NAP), updating Nationally Determined Contributions (NDCs), and guiding strategic investments at both national and subnational levels.

9.1 SYNTHESIS OF KEY FINDINGS

This Climate Risk and Vulnerability Assessment shows that Cambodia is already experiencing significant impacts from climate change, with rising temperatures and increasingly variable rainfall patterns creating more frequent floods, droughts, and heatwaves. Historical data confirm a steady warming trend, particularly in night-time minimum temperatures, alongside shifts in rainfall distribution that disrupt agricultural cycles and water availability. Climate projections indicate further increases in average temperatures, greater variability in rainfall, and accelerating sea-level rise, all of which will amplify risks to livelihoods, ecosystems, and infrastructure. The sectoral analysis identifies agriculture, water resources, forestry, coastal zones, and human health as the most affected areas. Agriculture is highly exposed due to its dependence on monsoon rains, vulnerability to drought and flooding, and sensitivity to temperature extremes. Water resources face growing risks from both scarcity and flooding, with infrastructure and supply systems under strain. Forestry is threatened by shifting species distributions, forest degradation, and wildfire risks, while coastal provinces face erosion, salinization, and damage from storms and sea-level rise. Human health is increasingly at risk from vector-borne diseases, heat-related illnesses, and food and water insecurity. District-level mapping highlights that risks are unevenly distributed. The northeastern provinces of Ratanakiri, Mondulkiri, and Stung Treng are particularly exposed to heat and drought, the Tonle Sap floodplain provinces such as Kampong Thom, Battambang, and Siem Reap are highly vulnerable to flooding, and the coastal provinces of Koh Kong, Preah Sihanouk, and Kampot are facing the combined pressures of sea-level rise and storm surges. These areas represent clear national hotspots where hazards intersect with high exposure and low adaptive capacity. Socio-economic vulnerabilities intensify these risks. High levels of poverty, dependence on climate-sensitive livelihoods, limited infrastructure, and gaps in health and education systems increase sensitivity, while inequalities linked to gender, age, and social status leave certain groups more exposed. Together, these factors reinforce the urgency of strengthening resilience across both national and subnational levels.

9.1.1 CLIMATE PROJECTIONS

The climate projections for Cambodia point to a future where rising temperatures, shifting rainfall patterns, and sea-level rise will significantly intensify existing climate risks. Average temperatures are expected to increase by 1.5–2°C by mid-century under moderate scenarios and up to 3–3.5°C under high emissions, with minimum night-time temperatures rising fastest. Rainfall patterns will become increasingly unpredictable, with heavier short-duration rainfall events raising flood risks in lowland and floodplain areas, while prolonged dry spells will deepen water scarcity and threaten agricultural productivity in upland provinces. Projections also show that drought frequency and intensity will rise, creating serious challenges for rain-fed farming systems and food security. At the same time, sea-level rise of up to 70 cm by 2100 will exacerbate erosion, salinization, and flooding in Cambodia's coastal provinces, compounding the risks from tropical storms and surges. Taken together, these projections highlight that climate change will touch every sector and every region of Cambodia, but the impacts will not be evenly distributed. Agricultural systems, water resources, forests, coastal areas, and human health will be most directly affected, while poor and vulnerable populations will bear the greatest burden. The results make clear that climate change is not a distant threat but a rapidly intensifying challenge that requires urgent, well-coordinated adaptation strategies to safeguard livelihoods, ecosystems, and long-term development.

9.1.2 CLIMATE-RELATED HAZARDS

The analysis of climate-related hazards in Cambodia shows that the country is already facing increasing threats from floods, droughts, storms, heatwaves, and coastal hazards, all of which are projected to intensify under future climate scenarios. Flooding remains one of the most frequent and damaging hazards, particularly in the Tonle Sap floodplain and along the Mekong, while droughts are becoming more prolonged and severe in upland and agricultural provinces, undermining food production and water security. Heatwaves and rising average temperatures are emerging as significant hazards with direct impacts on human health, crop yields, and livestock productivity. In coastal provinces, sea-level rise, storm surges, and salinization compound the risks to infrastructure, ecosystems, and local livelihoods. These findings underscore that Cambodia's climate hazards are multi-dimensional and interconnected, requiring integrated approaches to hazard monitoring, early warning, and risk reduction that address both current threats and projected future extremes.

9.1.3 CLIMATE EXPOSURE

The assessment of climate exposure in Cambodia demonstrates that a large share of the population, infrastructure, and economic activities are situated in areas highly vulnerable to climate hazards. Rural communities dependent on rain-fed agriculture remain the most exposed, as their livelihoods are directly tied to rainfall variability, floods, and droughts. Urban centers, particularly Phnom Penh, face rising exposure from heat stress, flooding, and pressure on critical infrastructure and services. Coastal provinces are at increasing risk from sea-level rise and storm surges, threatening both settlements and economic hubs such as ports and tourism facilities. In addition, schools, health facilities, roads, and irrigation systems are concentrated in hazard-prone areas, heightening the potential for disruption during extreme events. This analysis confirms that Cambodia's exposure to climate change is extensive and geographically diverse, making it essential to prioritize investments that protect people, assets, and services in high-risk areas while strengthening the resilience of livelihoods and infrastructure.

9.1.4 CLIMATE VULNERABILITY

The analysis of climate vulnerability in Cambodia reveals that the severity of climate impacts is strongly shaped by socio-economic and institutional factors, not only by physical hazards. High levels of poverty, dependence on climate-sensitive livelihoods such as subsistence farming and fisheries, and limited access to health, education, and infrastructure reduce the ability of many communities to cope with shocks. Gender inequalities, social exclusion, and the particular vulnerabilities of children, the elderly, and people with disabilities further intensify risks. In many areas, adaptive capacity is constrained by weak local governance, limited financial resources, and gaps in technical knowledge. These conditions mean that even moderate climate hazards can cause disproportionately severe impacts for vulnerable groups and regions. Addressing vulnerability therefore requires not only physical investments and infrastructure but also inclusive social and institutional measures that build resilience and enhance the adaptive capacity of households, communities, and local governments.

9.1.5 CLIMATE CHANGE RISK

The assessment of climate change risk in Cambodia demonstrates that the interaction of increasing hazards, widespread exposure, and persistent vulnerabilities creates a complex and escalating risk landscape across the country. Floods, droughts, heatwaves, and coastal hazards are intensifying under climate change, and these hazards overlap with densely populated areas, critical infrastructure, and climate-sensitive sectors such as agriculture, fisheries, and forestry. At the same time, high poverty levels, dependence on natural resources, and limited adaptive capacity heighten the severity of impacts, particularly for rural households, women, children, and marginalized groups. District-level mapping highlights clear hotspots—including the Tonle Sap floodplain, the northeast uplands, and the coastal provinces—where climate risks converge most acutely. This confirms that climate change poses a systemic challenge that cuts across sectors and geographies, requiring urgent, integrated adaptation strategies that reduce hazard exposure, strengthen livelihoods and infrastructure, and enhance the resilience of vulnerable populations.

9.2 PRIORITISED ADAPTATION PATHWAY

The core added value of this report lies in its transition from assessment to action. Building on the climate hazard, exposure, vulnerability and composite risk indices, as well as on the gender and social protection analysis presented in the CRVA, a country-specific portfolio of adaptation measures has been developed and prioritised for Cambodia. This portfolio combines evidence from the national CRVA, results from national and sub-national stakeholder consultations, and the operational architecture of the LGCC-III and LoCAL performance-based climate-resilience grants.

The prioritisation framework that underpins this portfolio is explicitly risk-led and consistent with the IPCC AR5/AR6 framing used throughout the CRVA, where climate risk results from the interaction of hazard, exposure and vulnerability. The main criterion in the framework is the CRVA composite risk index (Hazard × Exposure × Vulnerability), which carries 60% of the total weight assigned to each option and systematically favours districts and sectors in the highest risk percentiles. The remaining weight is distributed across five secondary criteria: (i) Effectiveness in reducing risk, including urgency; (ii) Gender equality and social inclusion (GESI), anchored in the CRVA GESI analysis; (iii) Co-benefits for mitigation, health, jobs, biodiversity and nature-based solutions; (iv) Technical and institutional feasibility and readiness; and (v) Sustainability and local capacity, including operations and maintenance. Together, these six criteria ensure that prioritisation reflects both the quantitative evidence from the CRVA and Cambodia's national adaptation priorities and delivery constraints.

The list of adaptation measures was initially built from the national consultation workshop on adaptation options, complemented by existing national strategies and plans, the LGCC-III Investment Menu and Feasibility Study, and international and regional experience with climate-resilient development in comparable Asian contexts. The measures were then refined and consolidated into a coherent set of approximately 25 options that: (i) directly respond to the main climate risk "sub-risks" identified in the CRVA (for example, risks to climate-sensitive livelihoods, water security, ecosystems, infrastructure, coastal economies and human health); (ii) are compatible with the LGCC-III and LoCAL financing modalities; and (iii) reflect the concrete priorities and implementation realities expressed by sub-national governments and line ministries during consultations.

Applying the multi-criteria framework produces a ranked shortlist of measures, with the highest-scoring options presented in Table 30 as the "Top Ten" national priorities. These include, among others, climate-resilient urban drainage and blue–green infrastructure in flood-prone cities; multi-hazard early warning systems with robust last-mile communication and standard operating procedures; climate-smart agricultural and water management systems in flood- and drought-affected districts; restoration of forests, wetlands and mangroves to stabilise water regimes and protect coasts; climate-resilient rural and urban infrastructure; and strengthened health and social protection systems to address climate-sensitive diseases, heat stress and climate shocks for vulnerable households. Across these measures, GESI considerations, nature-based solutions and long-term sustainability are treated as integral design features rather than add-ons.

To provide flexibility for implementation and localisation, the full catalogue of prioritised options is presented in Table 31 and organised into sector adaptation packages: climate-resilient livelihoods (agriculture, livestock and fisheries), community-centred disaster risk reduction, water security, ecosystems (forests, wetlands and coasts), climate-resilient infrastructure and urban systems, tourism and coastal economies, and health and social protection. Each package is further anchored territorially using the CRVA hotspot analysis and the five main risk landscapes (coastal areas, the Mekong and delta floodplain, the Tonle Sap Basin, the northern highlands and urban nodes). This dual sectoral–territorial lens ensures that measures are both coherent with national sector policies and directly targeted to the districts where risks materialise most acutely.

The prioritised adaptation pathway outlined in this chapter therefore serves a dual purpose. First, it provides immediate direction by highlighting the most urgent and high-impact measures that should be implemented in the short term, especially in high-risk districts identified by the CRVA and relevant for LGCC-III and LoCAL investment windows. Second, it offers a long-term framework for sequencing and scaling up adaptation across sectors and territories, enabling Cambodia to progressively build resilience through a pipeline of bankable, locally anchored investments. By integrating this pathway into national and sub-national development planning and public finance systems, Cambodia can move from assessment to tangible, inclusive and climate-resilient development outcomes.

10 ANNEX

10.1 DOWNSCALING REPORT

The objective of downscaling intended to explain and motivate the different methods of climate downscaling295, list and justify the data sources utilized, validate296 and make an ensemble of the climate models that best capture the observed climate of Cambodia, spatially and statistically calibrate the models to better reflect the historical climate, and to prepare the current and projected climate to data for utilization in the CRVA analysis that will assess the district level climate risks for the prioritized sectors. This study improves climate projections for Cambodia by downscaling and calibrating297 climate models using ERA5 reanalysis data as no station observation data was available. ERA5 was selected for its comprehensive coverage, long historical record, high resolution298, and coupling of temperature and rainfall data.

ERA5 data was used to validate and adjust downscaled climate model outputs. Validation involved comparing downscaled data with observational datasets and using statistical metrics to assess agreement. The study primarily relied on CMIP6 climate model data under SSP2-45 and SSP5-85 scenarios to assess future climate change299. The focus was on comparing trends, magnitudes, and seasonality between the models and ERA5 to create a bias-corrected ensemble for local climate risk assessments.

The climate data was used to assess various climate hazards relevant to risk assessment. These hazards included precipitation patterns such as total rainfall, wet days, and rainfall intensity, as well as drought conditions measured by the Standardized Precipitation Evapotranspiration Index (SPEI). Extreme rainfall events, including days with over 20mm of rainfall and maximum 1-day rainfall, were also examined. Additionally, temperature variables such as maximum and minimum temperatures, and more extreme hot days, summer days, and tropical nights were analysed.

The selected climate model ensemble—comprising the models access-cm2, gfdl-cm4, hadgem3-gc31-ll, ukesm1-0-ll, and noresm2-mm—best captured Cambodia’s climate dynamics. Rainfall variability was underestimated, particularly for extremely wet and dry years. While correlation with observed data was strong, key metrics such as standard deviation and range highlighted limitations in simulating the full spectrum of rainfall events, necessitating corrections for extreme rainfall events. Additionally, wet day frequency and drought severity were adjusted, particularly in central inland areas or Cambodia, and extreme rainfall events were underrepresented due to a drizzle bias300, requiring correction. Temperature simulations exhibited small biases, with both minimum and maximum temperatures being underestimated, leading to a smaller temperature range compared to observations.

Accurate climate projections are crucial for evidence-based decision-making. The calibrated model provides more reliable climate risk assessments for Cambodia, enabling policymakers to strengthen resilience and prepare for extreme weather events and long-term climate shifts. By refining climate model outputs, this study supports informed policymaking and enhances Cambodia’s capacity to adapt to climate change.

10.1.1 INTRODUCTION

This report aims to develop a reliable climate model specifically for Cambodia to assess climate risks and inform adaptation strategies. To achieve this, the study employs climate downscaling techniques to ensure an accurate representation of Cambodia's local climate, utilizing high-quality data from ERA5 and CMIP6. A rigorous validation process was conducted to identify the best-performing climate models, followed by calibration to improve accuracy, particularly for extreme events. The resulting calibrated model provides localized climate data that can be used to assess climate risks at the district level for various sectors in Cambodia, ultimately enabling better assessment of climate risks and the development of effective adaptation strategies.

To assess climate change risks accurately, high-resolution climate data is crucial. Global Climate Models (GCMs), while valuable for understanding global climate patterns, often lack the spatial resolution needed for regional or local impact assessments. This report explains the process and motivation for downscaling, validating, and calibrating climate models using ERA5 reanalysis data to a 25km resolution, specifically using IPCC AR6 CMIP6 model data. The ultimate objective is to use these downscaled climate model outputs as a basis for climate risk assessment.

As no station observation data was available, this study used ERA5 reanalysis data for downscaling climate models. ERA5 was chosen for its comprehensive coverage, long time frame, high resolution, and coupling of temperature and rainfall data. The study employs climate model data from the Coupled Model Intercomparison Project Phase 6 (CMIP6), which provides a broad range of methodologies to assess uncertainties and future climate projections. CMIP6 builds on previous iterations, offering enhanced insights into climate system changes. The data resolution of 0.25° x 0.25° ensures consistency with observational datasets. For climate scenario analysis, the study uses CMIP6 SSP2-4.5 and SSP5-85 from the IPCC's 6th Assessment Report (AR6). This scenario reflects a trajectory where global socio-economic and technological patterns continue with moderate policy interventions, making it the preferred choice for climate finance agencies due to its alignment with current trends and feasibility.

Validation and calibration of climate models are done using the ERA5 data through statistical downscaling methods ensuring accurate representation of trends, magnitudes, and seasonality. This is done with the intention of selecting a model ensemble that is indicative of the current climate status. Bias correction and calibration are applied to align the ensemble with local conditions, leveraging ERA5's high resolution to capture localized climate hazards.

This study downscales climate models to assess various climate hazards relevant to the coming risk assessment. These hazards include metrics related to precipitation (total rainfall, wet days, rainfall intensity), drought (SPEI), extreme rainfall events (days with over 20mm, maximum 1-day rainfall), and temperature extremes (maximum and minimum temperatures, hot days, summer days, tropical nights). This downscaled data will be used to analyse potential impacts and inform adaptation strategies.

Climate model downscaling methodology

Climate model downscaling is a process that translates coarse-resolution and unvalidated and uncalibrated climate projections from GCMs into higher-resolution, more accurate climate data[301]. It is a collection of techniques that links the synoptic-scale atmospheric forcing to the local-scale climate variables of Cambodia.

This method was created to address needs in global climate change research as well as the need for more accurate spatial and temporal knowledge from Global Climate Models (GCMs)[302]. This is essential because GCMs, while providing valuable insights into global climate patterns, typically have spatial resolutions of 100 to 300 km (Recent modelling projects have however increased this resolution). This resolution is too coarse to capture the local-scale variations, such as complex topography or land use patterns, which influence climate risks[303] [304]. Downscaling bridges this gap by incorporating local-level data and processes, resulting in climate projections that are more relevant for regional and local impact assessments[305]. It also helps to remove biases in GCM outputs with respect to historical observations, ensuring that the downscaled projections are better aligned with the real world[306].

An integral part of the downscaling process is the selection of the climate models that best match the magnitude and trends of the observational data to make an ensemble of representative models. Furthermore, models are trained on global datasets to capture the synoptic dynamics and the influence of changing atmospheric compositions. They may therefore not accurately reflect the magnitude of climate parameters such as annual rainfall volumes in mm or diurnal temperatures. The calibration of the model ensemble is therefore essential to the outputs of the downscaling process.

CMIP6 Model Selection

The Coupled Model Intercomparison Project Phase 6 (CMIP6) provides a collection of GCMs that form the basis for the IPCC Sixth Assessment Report (AR6). These models incorporate improved representations of physical, chemical, and biological processes compared to previous versions, contributing to the accuracy of downscaled projections[307]. When selecting CMIP6 models for downscaling, it's important to consider the range of magnitudes, trends and seasonality of the model data relative to the observational data. These need to be as near as possible to limit the bias correction and calibration applied[308]. This narrows the range and helps in identifying models that are consistent with the latest understanding of climate sensitivity and reduces the uncertainty in downscaled projections.

Downscaling methodology selection

The choice of approach depends on the specific application and the level of risk aversion. There are two primary approaches to downscaling:

- **Dynamical Downscaling:** This approach uses Regional Climate Models (RCMs) nested within a GCM or reanalysis to dynamically simulate climate processes at a finer scale. RCMs explicitly represent physical principles, such as thermodynamics and fluid mechanics, making them suitable for capturing the effects of local topography and land use on climate variables[309]. However, dynamical downscaling can be computationally expensive and sensitive to biases in the driving GCM[310].
- **Statistical Downscaling:** This approach employs statistical relationships between large-scale climate patterns and observed local climate variables to downscale GCM outputs. Statistical downscaling methods are computationally efficient and can be applied to a wide range of GCMs and emissions scenarios. However, they rely on the assumption that the statistical relationships between large-scale and local climate variables remain consistent in the future, which may not always be the case[311]. One of the key advantages of statistical downscaling is its ability to estimate the likelihood of extreme events, such as floods and droughts, which are crucial for climate risk assessment[312].

Observational data selection

In order to accurately undertake downscaling, there must be a reliable station observational or reanalysis313 dataset that captures the daily methodological events for at least 30 years. It also needs to be at sufficient spatial resolution to improve the spatial resolution of the model data if downscaling is required or equal if calibration and bias removal are required. The process of collecting observations from the country has proved problematic and we have therefore had to rely on re-analysis data.

There are several reanalysis datasets to select, however, ERA5[314] data was selected for its consistent and complete coverage of the study areas, long time frame, temperature and rainfall coupling as well as its relatively high resolution of ~25km. ERA5 is the fifth-generation climate reanalysis dataset produced by the European Centre for Medium-Range Weather Forecasts

(ECMWF). It provides hourly data on various atmospheric, land-surface, and sea-state parameters, along with estimates of uncertainty[315]. ERA5 data is presented on regular latitude-longitude grids at 0.25° x 0.25° resolution[316], with atmospheric parameters on 37 pressure levels[317]. It is considered a state-of-the-art reanalysis product with improved accuracy and spatial resolution compared to previous generations[318]. This makes ERA5 particularly valuable for downscaling climate models and capturing the influence of local topography on climate variables[319]. However, it's important to note that ERA5 exhibits a cool bias globally, particularly in Africa[320]. This bias should be considered when using ERA5 for downscaling, especially in regions with similar biases, as it can affect the accuracy of the downscaled projections.

Validation and Calibration

After downscaling, it is crucial to validate and calibrate the downscaled climate model outputs. This ensures that the downscaled data accurately represents the observed climate and that any biases introduced during the downscaling process are minimized.

- **Validation:** This involves comparing the downscaled climate data with independent observational datasets. For example, downscaled temperature and precipitation projections can be compared with historical weather station data or local meteorological experts[321]. Statistical metrics, such as correlation coefficients, root mean square error (RMSE), and bias, are used to quantify the agreement between the downscaled data and observations[322].
- **Calibration:** If significant biases are identified during validation, calibration techniques can be applied to adjust the downscaled data. This may involve adjusting the statistical relationships used in statistical downscaling or refining the parameters of the RCM in the case of dynamical downscaling. Calibration aims to improve the accuracy and reliability of the downscaled climate projections. One of the key insights from downscaling studies is that it can significantly reduce the difference between simulated and observed climate variables, improving the agreement between model outputs and observations[323].

ERA5 reanalysis data plays a crucial role in both validation and calibration. Its high spatial and temporal resolution, along with its comprehensive coverage of climate variables, makes it an ideal benchmark for assessing the performance of downscaled climate models.

Climate Risk Assessment

The ultimate objective of this downscaling exercise is to use the refined climate model outputs for climate risk assessment. Downscaled climate data provides the foundation for understanding how climate change may impact various sectors and systems at a local level. The following sectors have been highlighted as the major sectors at risk from climate change in Cambodia[324] - Agriculture, Water Resources, Forestry, Coastal Zone, and Human Health.

- **Hazard Identification:** Downscaled climate projections can be used to identify potential climate hazards, such as extreme heat events, heavy rainfall, droughts, and coastal flooding. By analysing changes in the frequency, intensity, and duration of these hazards, risk assessments can identify vulnerable areas and populations.
- **Vulnerability Assessment:** This step involves assessing the susceptibility of different sectors and systems to the identified climate hazards. For example, a vulnerability assessment might consider the sensitivity of infrastructure to flooding or the adaptive capacity of communities to heat waves.
- **Risk Estimation:** By combining information on hazards and vulnerability, risk assessments can estimate the likelihood and potential consequences of climate

change impacts. This may involve quantifying economic losses, damage to infrastructure, or health risks.

- **Adaptation Planning:** Risk assessments inform adaptation planning by identifying strategies to reduce vulnerability and enhance resilience to climate change. This may involve infrastructure upgrades, early warning systems, or community-based adaptation measures.

Downscaled climate model outputs, validated and calibrated using ERA5 reanalysis data, provide the essential information needed to conduct comprehensive and reliable climate risk assessments. This, in turn, enables informed decision-making and effective adaptation planning in the face of current and future climate change by considering future Shared Socioeconomic Pathways (SSPs) when conducting climate risk assessments[325]. SSPs represent a range of plausible future scenarios, each with different implications for greenhouse gas emissions and socioeconomic development. This allows for adaptation interventions to meet not only current climate extremes and trends but also future scenarios making for more robust adaptation strategies.

Limitations of Downscaling

While downscaling provides valuable high-resolution climate information, it's essential to acknowledge its limitations. Downscaled climate projections are still subject to uncertainties inherent in the GCMs and the downscaling methods themselves. Even after calibration, some biases may persist in the downscaled data, particularly for variables that are challenging to model or for regions with limited observational data. It's crucial to consider these limitations when interpreting and using downscaled climate information for decision-making.

Methods applied for this analysis

For the purposes of this analysis, given that no station observation data is provided, we will use ERA5 data to validate and calibrate the climate models using statistical downscaling methods. The statistical methods will focus on the trends, magnitudes and seasonality of the models compared to the reanalysis data to select the model ensemble. From there the ensemble is bias-corrected and calibrated to meet local conditions. The higher resolution of the ERA5 data will enable the analysis to capture local hazard features.

The climate model data used is the Coupled Model Intercomparison Project Phase 6 (CMIP6)[326] [327]. The variety of modelling methodologies used in CMIP6 enables a comprehensive assessment of the uncertainties and range of future climate change projections, which is critical for informing climate policy and adaptation strategies. The CMIP6 project expands on previous phases of the Coupled Model Intercomparison Project (CMIP), which have provided valuable information on the past and future evolution of the Earth's climate system. The resolution of these data is also 0.25° x 0.25° matching the observational data.

The climate scenario data used for this assessment is CMIP6[328] SSP2-45 and SSP5-85[329] from the IPCC's 6th Assessment Report (AR6)[330] [331]. In this scenario, the world follows a trajectory where social, economic, and technological patterns largely maintain historical norms. This is the scenario preferred by climate finance agencies as it’s deemed the most likely given current efforts and technology.

10.1.2 CLIMATE MODEL DOWNSCALING

The downscaling of the climate models to the observational datasets will focus on the major climate variables averages and more extreme climate hazards to be used in the climate risk assessment. These include the following climate hazards.

Table 32. Climate hazards

SHORT NAME	CLIMATE VARIABLE	WHAT IT MEASURES	USE CASES	UNITS
pr	Precipitation	The total amount of rainfall falls over a period of time.	Studying overall water availability, climate patterns, and agriculture. Monthly analysis can also highlight changes in seasonal rainfall patterns	mm
wd	Wet days	The number of days with measurable rainfall (0.2 mm)	Understanding rainfall distribution and patterns over time.	Days
sdii	Simplified daily intensity index	Average rainfall per day on rainfall days	Evaluating rainfall intensity and its impact on soil erosion and drainage.	mm/day
spei12	Standardized precipitation evapotranspiration index (12 months)	A measure of drought and wetness based on rainfall and evaporation over a year.	Identifying drought severity or excess wetness for water resource planning and agriculture.	Index / unitless
r20mm	Days above 20mm	The number of days per year with rainfall exceeding 20 mm.	Evaluating severe rainfall events for agriculture and water management. This is also useful as a possible flooding hazard.	Days
rx1day	Maximum 1-day rainfall	The highest amount of rainfall in a single day.	Planning for flash floods and extreme rainfall events.	mm
tasmax	Average maximum daily temperature	The average of the daytime temperatures recorded each day over a year.	Identifying heat trends, planning for heatwaves, agriculture, and energy management. This however isn't an indication of extreme events.	°C
sd	Summer days above 25°C	The number of days with maximum temperatures above 25°C.	Evaluating the occurrence of warm days and its effect on tourism, agriculture, and energy use.	Days
hd35	Hot days above 35°C	The number of days with maximum temperatures above 35°C.	Evaluating extreme heat risks for human health, agriculture, and energy.	Days
tr	Tropical nights above 20°C	The number of nights when the temperature stays above 20°C.	Analysing night-time heat stress and its effects on health and ecosystems.	Days
tnn	Lowest minimum temperature	The coldest nighttime temperature recorded over a year.	Identifying cold extremes and their impacts on health, agriculture, and heating needs.	°C
txx	Highest maximum temperature	The hottest daytime	Understanding heat extremes and preparing for heat-related health	°C

	temperature each year.	and infrastructure impacts.

Individual Model validation

The validation of the climate model against ERA5 observational data reveals both strengths and limitations in its ability to replicate historical climate patterns. While annual precipitation is slightly underestimated, the model captures the overall variability, and a calibrated ensemble of models will more closely align with observed values. Temperature simulations show a warming bias, particularly for maximum temperatures, affecting the accuracy of extreme heat events. Rainfall characteristics are influenced by the drizzle effect, leading to an overestimation of wet days and an underestimation of daily rainfall intensity and extreme precipitation events. The drought index shows a strong correlation with historical records, and seasonal patterns are well represented. Simulations of warm days and hot nights are generally accurate, though nighttime temperatures exhibit a slight warming bias. Extreme heat days above 35°C are overestimated, while very hot days above 40°C are rare in both models and observations. Additionally, the model tends to overestimate minimum temperatures and underestimate extreme maximum temperatures, likely due to the way thermal variations are distributed over time. A calibrated ensemble of models will improve alignment with observations in many aspects, but some discrepancies remain, requiring further calibration for more precise climate projections.

Each model simulates different atmospheric dynamics and responses to trends and future changes in atmospheric composition. The validation seeks not to limit the inclusion of models presenting these different simulation parameters, but to rather remove models that are outliers within the simulation's local context. The major factor determining the selection of the model ensemble is highlighting severe outliers that consistently deviate from observational characteristics particularly for annual rainfall and the maximum temperatures as all the other climate characteristics will be derived from this important base.

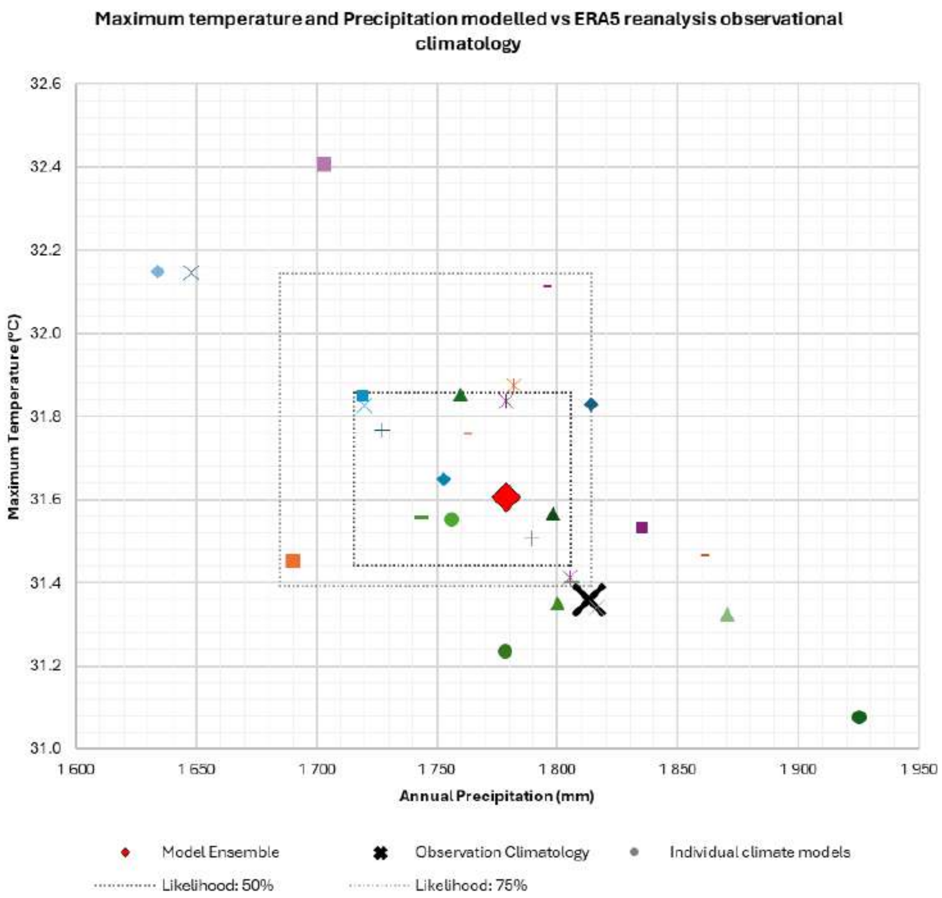
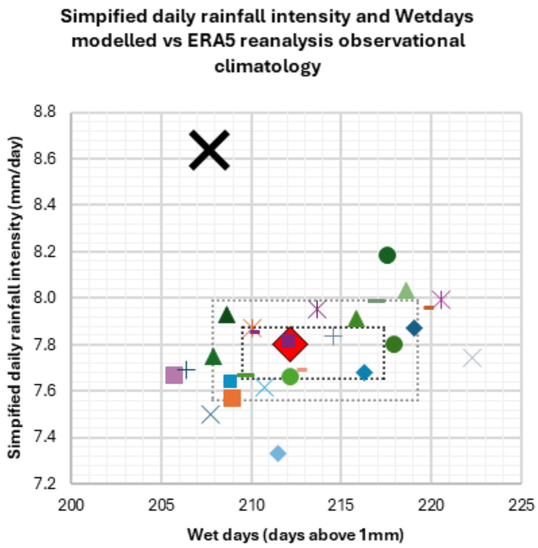
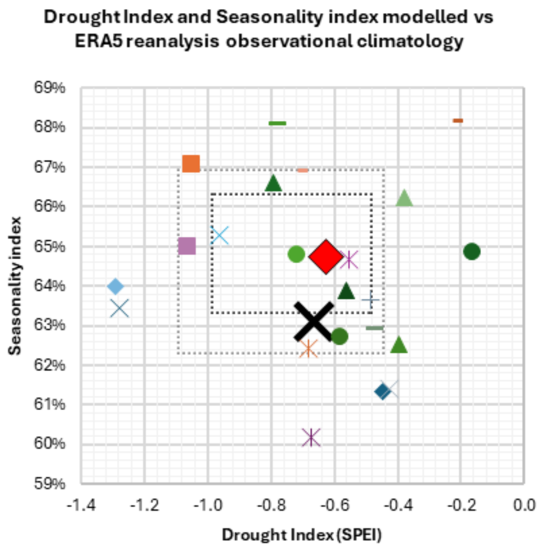


Figure 32. Model comparison to historical reanalysis data for primary variables: Annual rainfall and maximum temperature





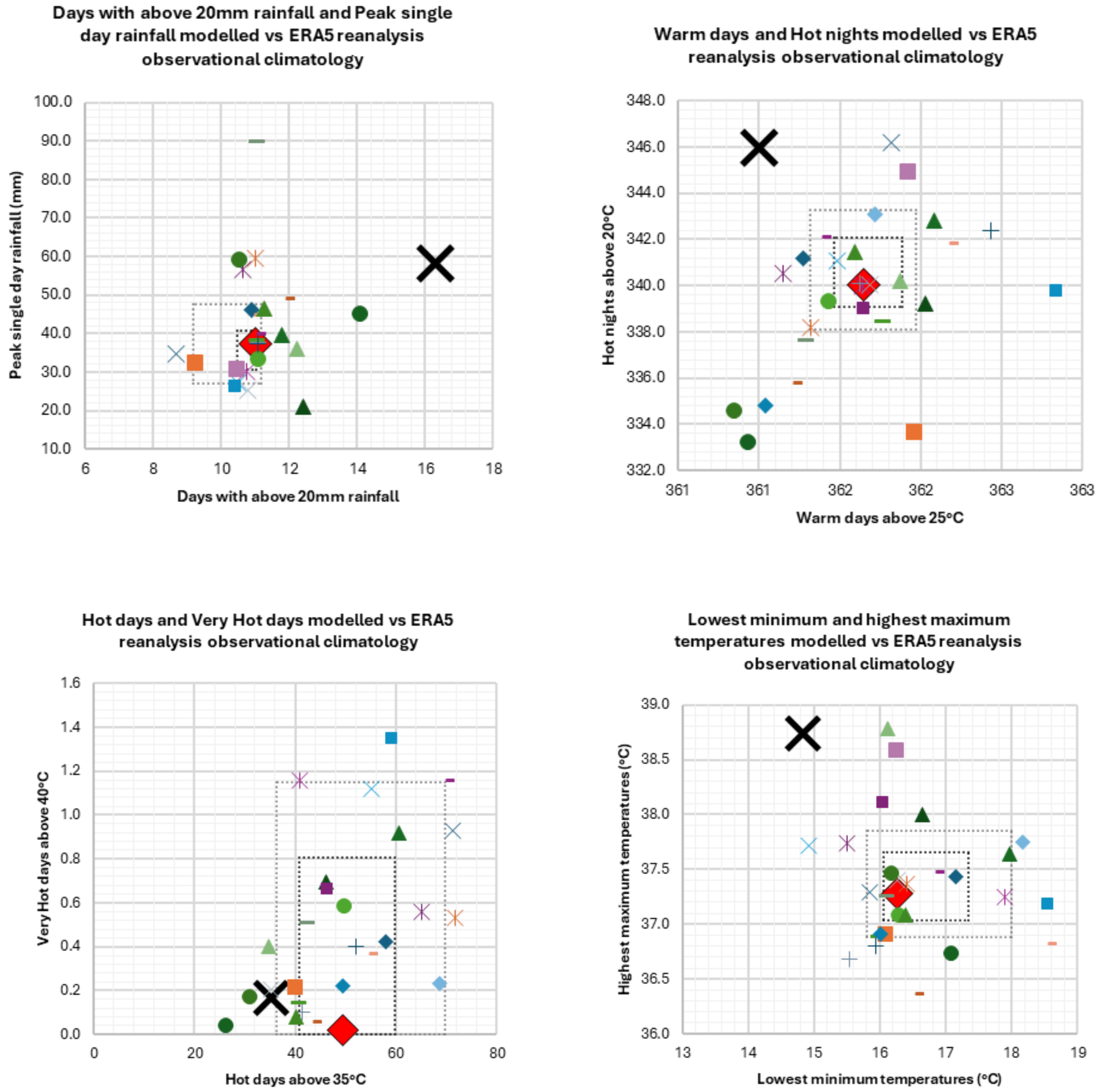


Figure 33. Model comparison to historical reanalysis data for secondary variables: Simplified daily rainfall intensity and Wet days (top left), Drought and Seasonality index (top right), Days above 20mm rainfall and Peak single day rainfall (middle left), Warm days and Hot nights (middle right), Hot days and Very Hot days (bottom left), and Lowest minimum and highest maximum temperatures (bottom right)

The ability of the models to capture the observed climate data is calculated based on the biplots and the proximity between the model and observed annual averages, but also the changes over time and variability. These are broken down into

- **Basic Descriptive Statistics:**
  - Standard Deviation – This measures the spread or variability of the model data. A higher standard deviation means the data points are more spread out from the average. The model's standard deviation is compared to that of the observed climate data to see if the model realistically simulates the variability of the climate system.

  - Minimum and maximum values –Comparing this to the observed minimum helps assess if the model captures the lower and upper extremes of the climate variable.
- Measures of Agreement:
  - Correlation: This measures how closely the model output follows the patterns of the observed data. A correlation of 1 represents a perfect positive linear relationship, 0 indicates no relationship, and -1 a perfect negative relationship. The high correlation suggests the model captures the timing and direction of changes in the climate variable.
- Measures of Error:
  - Root Mean Squared Error (RMSE): This is a common measure of the overall error in the model. It essentially calculates the average difference between the model's predictions and the observed values, giving more weight to larger errors. Lower RMSE values indicate better model performance.
  - Relative Uncertainty Percentage: This expresses the RMSE as a percentage of the mean of the observed data. It helps to put the error into perspective relative to the magnitude of the climate variable being modelled.
  - Mean Absolute Error (MAE): Similar to RMSE, it calculates the average absolute difference between the model and observations. MAE is less sensitive to extreme errors than RMSE.
  - Mean Squared Error (MSE): This is the average of the squared differences between the model and observations. Like RMSE, it gives more weight to larger errors, but its units are squared, making it less interpretable than RMSE.
- Probabilistic Skill Score:
  - Continuous Ranked Probability Score (CRPS): This is a more sophisticated measure that evaluates the accuracy of the model's probabilistic forecasts. It considers the entire probability distribution produced by the model, not just a single deterministic prediction. Lower CRPS scores indicate better probabilistic forecasting skills.

Using these statistics provides a comprehensive understanding of a climate model's strengths and weaknesses leading to more informed decisions about which models to include in an ensemble.

Figure 34. Model performance

Validation measure	Lower	Upper	access-cm2	access-esm1-5	bcc-csm2-mr	canesm5	cmcc-esm2	cnrm-cm6-1	cnrm-esm2-1	ec-earth3	ec-earth3-veg-	fgoals-g3	gfdl-cm4	gfdl-esm4	giss-e2-1-g	hadgem3-	inm-cm4-8	inm-cm5-0	ipsl-cm6a-lr	kace-1-0-g	kiost-esm	miroc6	miroc-es2l	mpi-esm1-2-hr	mpi-esm1-2-lr	mri-esm2-0	nesm3	noresm2-lm	noresm2-mm	ukesm1-0-ll
	Ideal threshold																													
STD	0.91	1.09	1.0	0.7	1.3	1.1	0.7	0.7	0.7	0.7	0.7	1.2	1.1	0.7	1.0	1.0	0.8	0.7	1.1	1.0	1.2	0.8	0.8	0.7	0.7	0.9	1.0	0.5	0.9	1.0
Minimum	0.96	1.04	1.0	1.2	0.9	0.9	1.0	1.1	1.1	1.0	1.0	0.9	1.0	1.1	1.1	1.0	0.9	1.0	1.0	1.0	1.0	0.9	1.0	1.0	1.0	1.1	0.9	1.1	1.0	0.9
Maximum	0.97	1.03	1.0	1.0	1.1	1.0	1.0	1.0	1.0	0.9	0.9	1.0	1.0	0.9	1.1	1.0	0.9	0.9	1.0	1.0	1.0	0.8	1.0	0.8	0.9	1.0	0.9	0.9	1.0	1.0
Range	0.89	1.11	1.1	0.7	1.7	1.1	0.9	0.8	0.9	0.7	0.9	1.2	1.1	0.7	1.0	1.0	0.9	0.7	1.0	0.9	1.1	0.7	1.0	0.7	0.7	0.8	0.9	0.6	1.0	1.2
Correlation	0.9786		1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
RMSE	50.30		43	82	47	59	59	75	80	71	79	43	35	75	167	39	274	166	40	48	38	109	86	191	75	87	105	139	38	26
Uncertainty%	10.40		3	43	21	6	34	39	38	40	38	16	7	38	4	4	25	36	5	1	16	18	19	42	45	15	0	87	9	0
MAE	43.60		35	57	31	52	48	61	75	52	67	33	29	56	165	36	270	154	32	43	32	95	76	178	63	77	102	108	32	22
MSE	2 544.78		1886	6764	2170	3488	3434	5678	6399	5092	6206	1816	1202	5612	27927	1507	75297	27550	1595	2350	1480	11826	7409	36375	5551	7574	10923	19311	1417	694
CRPS	46.95		39	70	39	56	53	68	77	62	73	38	32	65	166	37	272	160	36	46	35	102	81	184	69	82	103	124	35	24

The best-performing models here and in the model/observed biplots are included in the model ensemble are noted as follows:
access-cm2: Excellent correlation (0.98), closely aligned standard deviation, and low RMSE (43.43) indicate a strong overall performance.
gfdl-cm4: Very good correlation (0.99), close standard deviation, and even lower RMSE (34.67) suggest high accuracy.
hadgem3-gc31-ll: Very good correlation (0.99), close standard deviation, and low RMSE (38.82) make it another strong contender.
ukesm1-0-ll: Very good correlation (0.98), close standard deviation, and remarkably low RMSE (26.35) point to exceptional accuracy.
noresm2-mm: Very good correlation (0.99), close standard deviation, and low RMSE (37.64) indicate strong performance.
Using a multi-model ensemble approach for climate projections offers significant benefits. This includes the better capturing of uncertainties and complexities of the climate system, leading to more robust and reliable predictions. This is crucial for informing effective climate change mitigation and adaptation strategies.

Statistical calibration

The model validation using the biplots and the error testing resulted in the creation of the model ensemble consisting of access-cm2, gfdl-cm4, hadgem3-gc31-ll, ukesm1-0-ll, and noresm2-mm models. This model ensemble represents the models that most closely match the climate-influencing factors and changes over time experienced within Cambodia. This however still requires calibration to bring it in line with magnitudes shown in the historic observational datasets.

The model results for annual rainfall indicate systematic biases and reduced variability compared to observed data. The model overestimates the lowest rainfall years while underestimating the highest rainfall years, leading to a compression of variability in simulated rainfall totals. This results in a lower range of rainfall volumes than observed, meaning the model does not fully capture extreme wet and dry years. Despite these biases, the correlation between the datasets is strong. However, this high correlation does not necessarily mean the model accurately represents extreme rainfall variability.

- Standard deviation measures how much rainfall varies from the mean. A difference of 111 mm between the observed and modelled datasets suggests that the model smooths out interannual variability, failing to fully capture fluctuations in annual rainfall totals.
- The range represents the difference between the highest and lowest annual rainfall totals, so a range of 497 mm lower in the model indicates that it does not adequately simulate extreme wet or dry conditions, reinforcing the finding that variability is underestimated.
- Root mean square error (RMSE) quantifies the average magnitude of error between observed and modelled values. The RMSE of 111.47 mm suggests that, on average, the model's annual rainfall estimates deviate by this amount from observed values, confirming that the model struggles with extreme years.
- Continuous Ranked Probability Score (CRPS) evaluates probabilistic model performance, with lower values indicating better agreement with observed distributions. A high CRPS highlights uncertainty and suggests that the model does not adequately reflect observed rainfall variability.
- The negative relative uncertainty of -0.73% confirms that the model consistently underrepresents variability in annual rainfall.

The primary uncertainty in the model arises from its inability to capture extreme dry and wet years accurately. The compression of variability, as indicated by the lower standard deviation and range, suggests that the model is overly conservative in simulating interannual rainfall fluctuations.

The assessment of modelled temperature data against observed values reveals systematic biases across minimum, average, and maximum temperature estimates.

- For minimum temperatures, the model consistently underestimates both the lowest and warmest nighttime temperatures, suggesting that it does not fully capture the variability observed in real-world conditions. Additionally, the modelled minimum temperature range is narrower than the observed range, indicating a suppression of extreme values. The root mean square error (RMSE) for minimum temperatures is 1.055, which is the highest among the three temperature categories. RMSE is a measure of the average magnitude of errors between the modelled and observed values, with larger values indicating greater deviations. This high RMSE suggests that minimum temperatures are the least accurately modelled compared to average and maximum temperatures.

- For average temperatures, the model tends to overestimate the lowest average temperatures while underestimating the highest average temperatures. This again results in a compressed temperature range compared to observations. The RMSE for average temperatures is 0.321, which is significantly lower than that of minimum temperatures. This lower RMSE indicates that the model performs better in representing average temperatures, with relatively smaller deviations from observed values.
- For maximum temperatures, the model overestimates the coolest daytime temperatures and underestimates the warmest daytime temperatures. Similar to the other categories, the modelled maximum temperature range is narrower than the observed range. The RMSE for maximum temperatures is 0.373, which is slightly higher than for average temperatures but much lower than for minimum temperatures. This suggests that while there are some discrepancies, maximum temperatures are better represented by the model than minimum temperatures.

Among the three temperature variables, the average temperature is the best modelled based on having the lowest RMSE. This indicates that the model's predictions for average temperatures are closer to observed values compared to minimum and maximum temperatures. Conversely, minimum temperatures are the least accurately represented, as indicated by the highest RMSE (1.055), highlighting significant underestimation of both cold and warm extreme temperatures. The model consistently underestimates temperature variability, with all relative uncertainty percentages being negative. This means that the model predicts a narrower range of temperatures than observed, failing to capture extreme warm and cold events effectively.

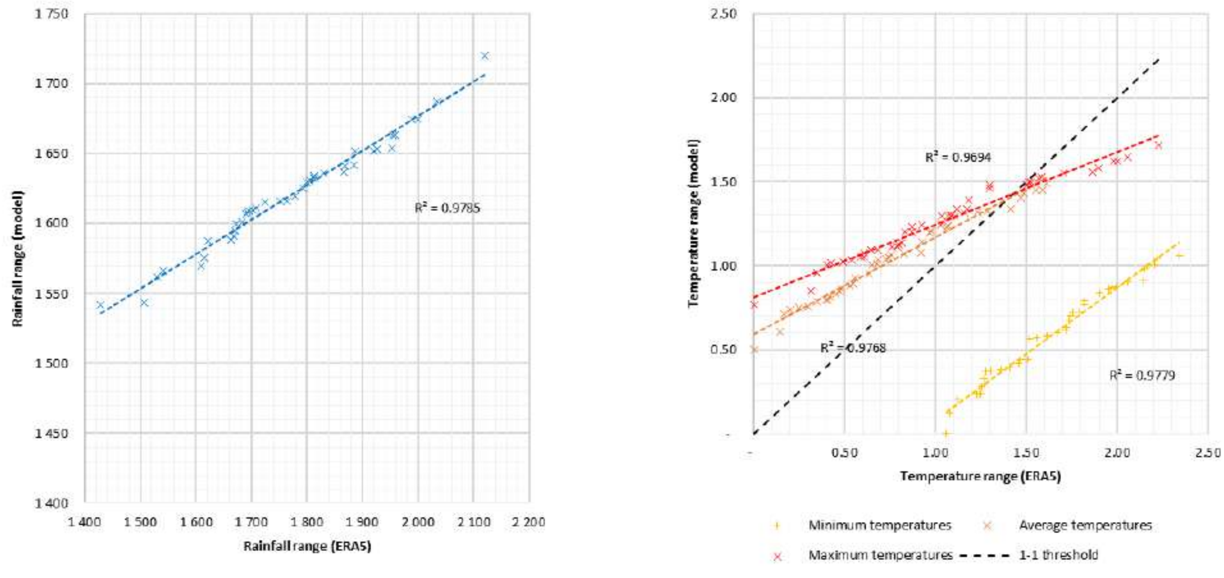


Figure 35. Model and observational relationships. Annual rainfall (left), minimum, average and maximum temperatures (right)

The calibration of the model ensemble to bring it more in line with observational magnitudes is presented below.

Table 33. Model ensembles relative to historical reanalysis data and bias factors

	Observed Median	Modelled Median	Ensemble Difference (actual)	Average Ensemble Difference	Notes
Annual Precipitation (mm)	1813	1778	34.38	1.90%	The anomaly between the observed and model ensemble is rather small with only 34mm and 1.9% difference. The climate models show a small annual rainfall volume decrease compared to the observational volumes. There is however a wide disparity among the models which cover the likely range of real-world annual volumes.
Maximum Temperature (°C)	31.36	31.61	0.25	0.79%	The anomaly between the observed and model ensemble is small with only a 0.25 °C difference. The models show a slight increase in average maximum temperatures compared to the ERA5 data. Most of the models also show this warming bias which limits how close the ensemble can get to the observed values.
Wet days (days above 1mm)	207	212	4.49	2.16%	Only a 4.5-day difference is noted between the observed and model ensemble. The climate models show an increase in the number of wet days annually compared to the observed occurrence. This is likely due to the acknowledged drizzle effect in climate models where they simulate lower magnitude rainfall days.
Simplified daily rainfall intensity (mm/day)	8.64	7.80	0.84	9.73%	The noted drizzle effect means that there is more lower volume days simulated in the models and there is a reduced average daily rainfall intensity noted in all models. Even an ensemble selecting the highest intensity models isn't able to reach the noted intensity and calibration is required. The intensity difference is moderate between the observed and model ensemble and will need to consider bias correction.
Drought Index (SPEI)	-0.66	-0.63	0.04	5.50%	The modelled drought index suggests a good correlation nationally with the historical SPEI values indicating dry conditions. The differences between the observed and model ensemble are very small.
Seasonality index	0.63	0.65	0.02	2.59%	The seasonality differences between the observed and model ensemble are very small. The seasonality index assesses the wet vs dry month magnitudes. The modelled rainfall timing and magnitude very closely match the observational values.
Days with above 20mm of rainfall	16.30	11.01	5.29	32.5%	Again, the drizzle effect of the models simulates a lower number of high rainfall days of 20mm. The models are quite clustered with only a few outliers suggesting a higher number of these large events. The differences between the observed and model ensemble are quite large and will need further bias correction.
Peak single-day	58.10	37.38	20.72	35.6%	Likewise, the peak single-day rainfall volume from the observed data is higher than the model ensemble. Though some models can reach the

	Observed Median	Modelled Median	Ensemble Difference (actual)	Average Ensemble Difference	Notes
rainfall (mm)					noted observational peak magnitudes. Again, the differences between the observed and model ensemble are quite large and will need further bias correction.
Warm days above 25°C	361.0	361	0.64	0.18%	The difference in the milder temperature extremes is quite minimal with the models being able to simulate closely the number of days exceeding 25°C annually. The baseline ensemble is only off by less than 1 day annually.
Hot nights above 20°C	346.0	340.1	5.94	1.72%	The hot nights are also very close without any bias correction, though there is a slight nighttime cooling bias that notes a decreased number of nights below 20°C compared to the observational data. The differences between the observed and model ensemble are small.
Hot days above 35°C and Very Hot days above 40°C	35.30 / 0.17	49.51 / 0.02	14.21 / 0.15	40.3% / 88.8%	The hot day's difference is moderate between the observed and model ensemble and will need to consider bias correction. The more extreme temperatures see an increase in the simulation of the number of days above 35°C compared to the historical averages. There are very few days above 40°C and the models hardly present these occurrences, and the models struggle to get very close to the observed occurrence, but these are very minimal.
Lowest minimum temperatures (°C)	14.83	16.27	1.44	9.72%	The climate models note an increase in the lowest nighttime temperatures as compared to the historical record. There is therefore a nighttime warming bias that needs to be considered. The differences are moderate between the observed and model ensemble and will need bias correction.
Highest maximum temperatures (°C)	38.74	37.28	1.46	3.78%	However, there is a decrease in the extreme maximum single-day temperatures relative to the observed temperatures. It is possible that the model spreads the thermal character over a longer hourly period and therefore has lower maximum and higher minimums. The differences are moderate between the observed and model ensemble and will need bias correction.

Spatial model adjustment

The climate model aligns well with reanalysis data in terms of spatial precipitation patterns, with higher rainfall in the coastal southwest and northeast and moderate volumes in central areas of Cambodia. However, annual precipitation is slightly underestimated, requiring a 1–5% increase in most areas, except for the central north, which is already well-calibrated. While the monthly spatial agreement is strong, peak rainfall months (May–September) are underrepresented (requiring 1–10% increases), whereas drier months are overestimated, necessitating reductions of up to 30%. Wet day frequency is generally well-matched but exhibits a less pronounced decline in the model compared to observational data, particularly in central areas, where a 10% decrease is needed. The drought index (SPEI332) lacks a strong spatial correlation, with the model underestimating the severity of inland droughts, requiring significant adjustments.

Extreme rainfall events are also underrepresented. Peak single-day rainfall intensity is poorly correlated, especially in inland areas, due to model drizzle bias, requiring increases of up to 40%.

Similarly, days exceeding 20mm of rainfall are spatially consistent but require corrections in low-occurrence central inland areas. Daily rainfall intensity follows the same pattern, with extreme events being underestimated by 5–10%.

Temperature simulations are more accurate, requiring only minor bias corrections. Annual maximum temperatures are well-aligned, with a negligible 0.25°C difference, necessitating only a 1–5% downward adjustment. Monthly variations follow a similar pattern, with a general overestimation across all months. The highest maximum temperatures are spatially consistent, with minor (<5%) increases needed in coastal areas and slight decreases inland. Warm days (>25°C) are well-matched, requiring minimal (<1%) correction, while hot days (>35°C) are slightly overestimated inland (by up to 10%). Minimum temperature simulations also perform well, with the lowest temperatures correctly placed inland, requiring only small corrections in the underrepresented southern and eastern regions. Similarly, hot nights (>20°C) are well-represented, with minor increases required in southern areas.

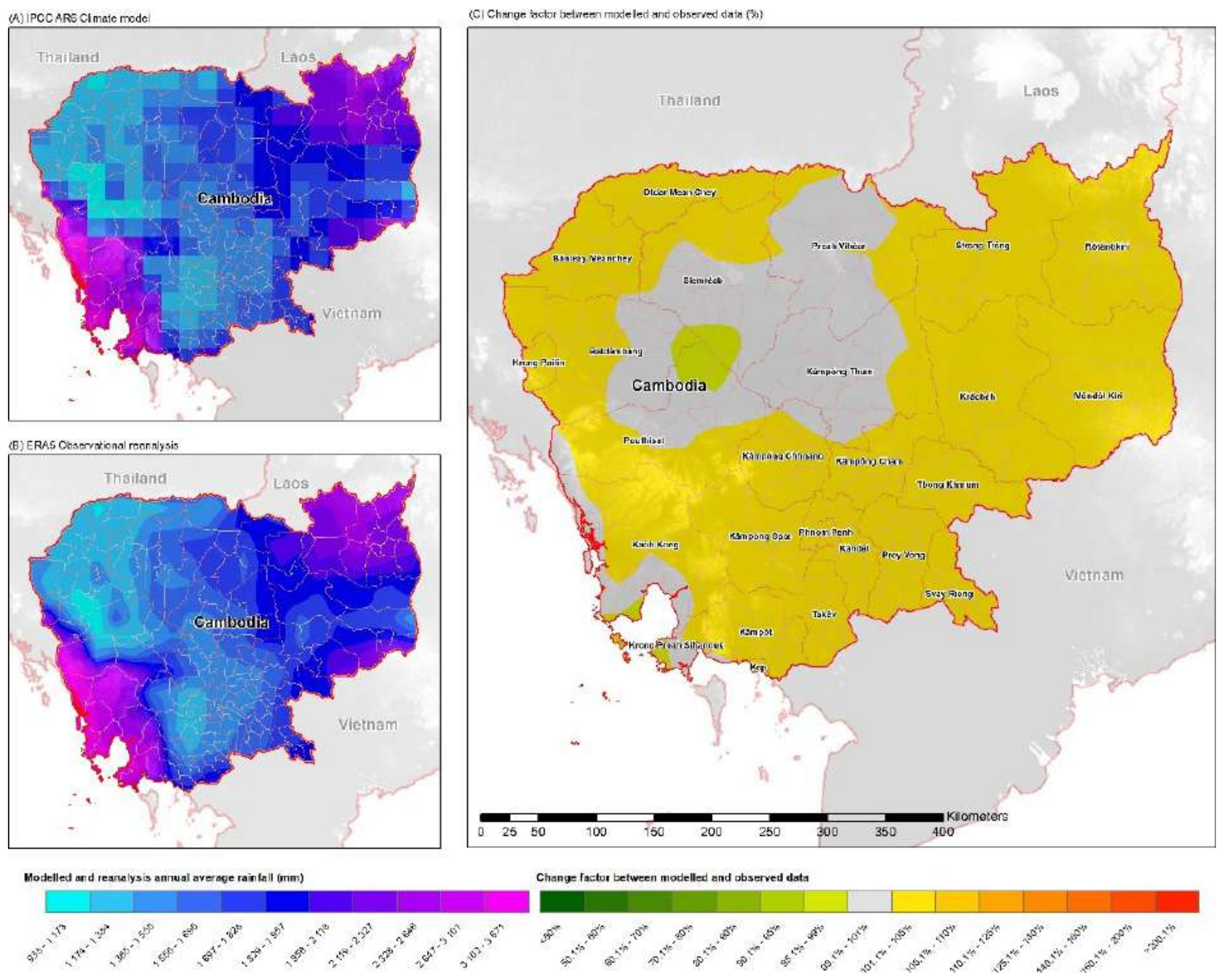


Figure 36. Main climate variable: Modelled, reanalysis data and change factors for annual rainfall

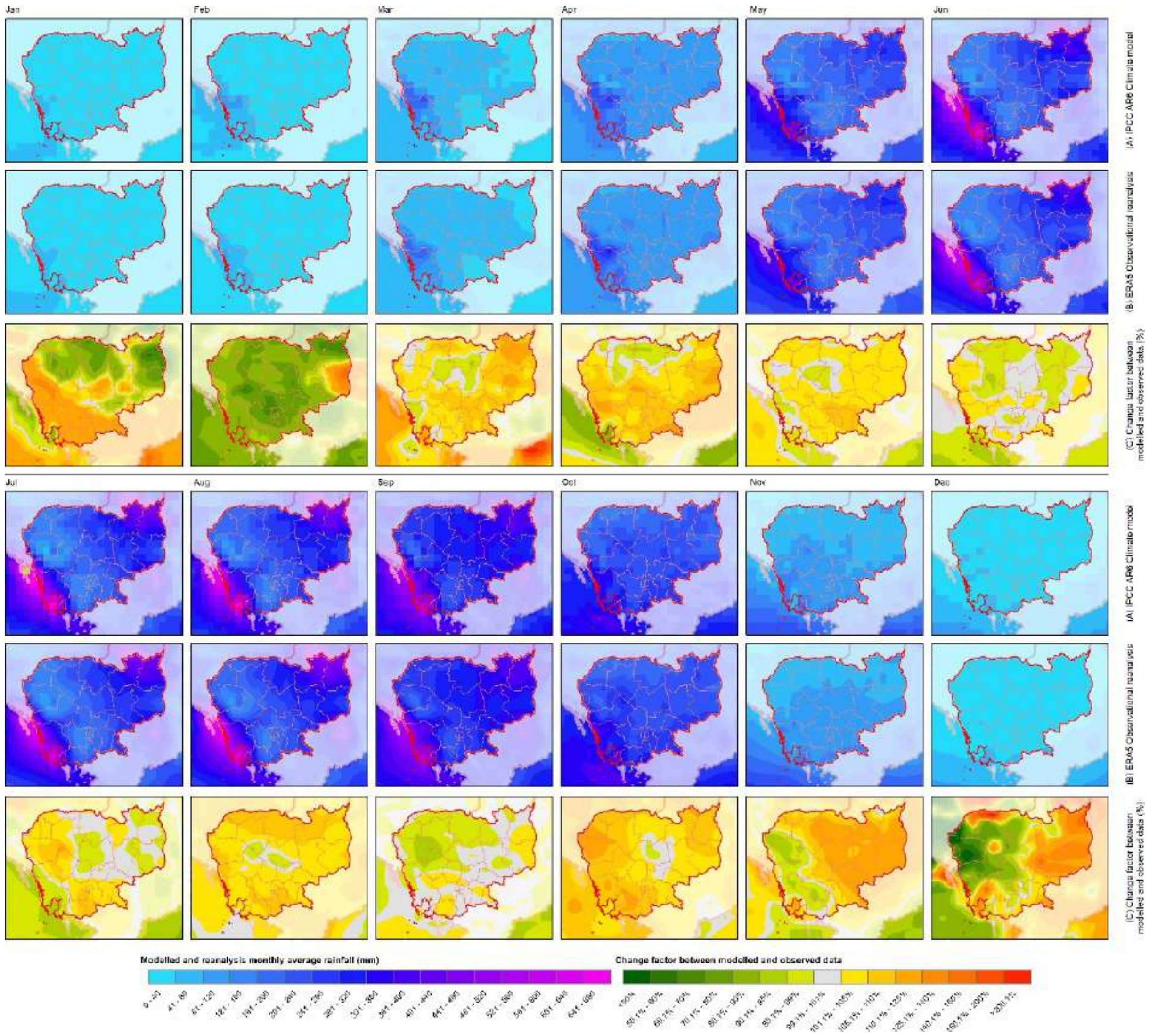


Figure 37. Change factors for monthly average rainfall

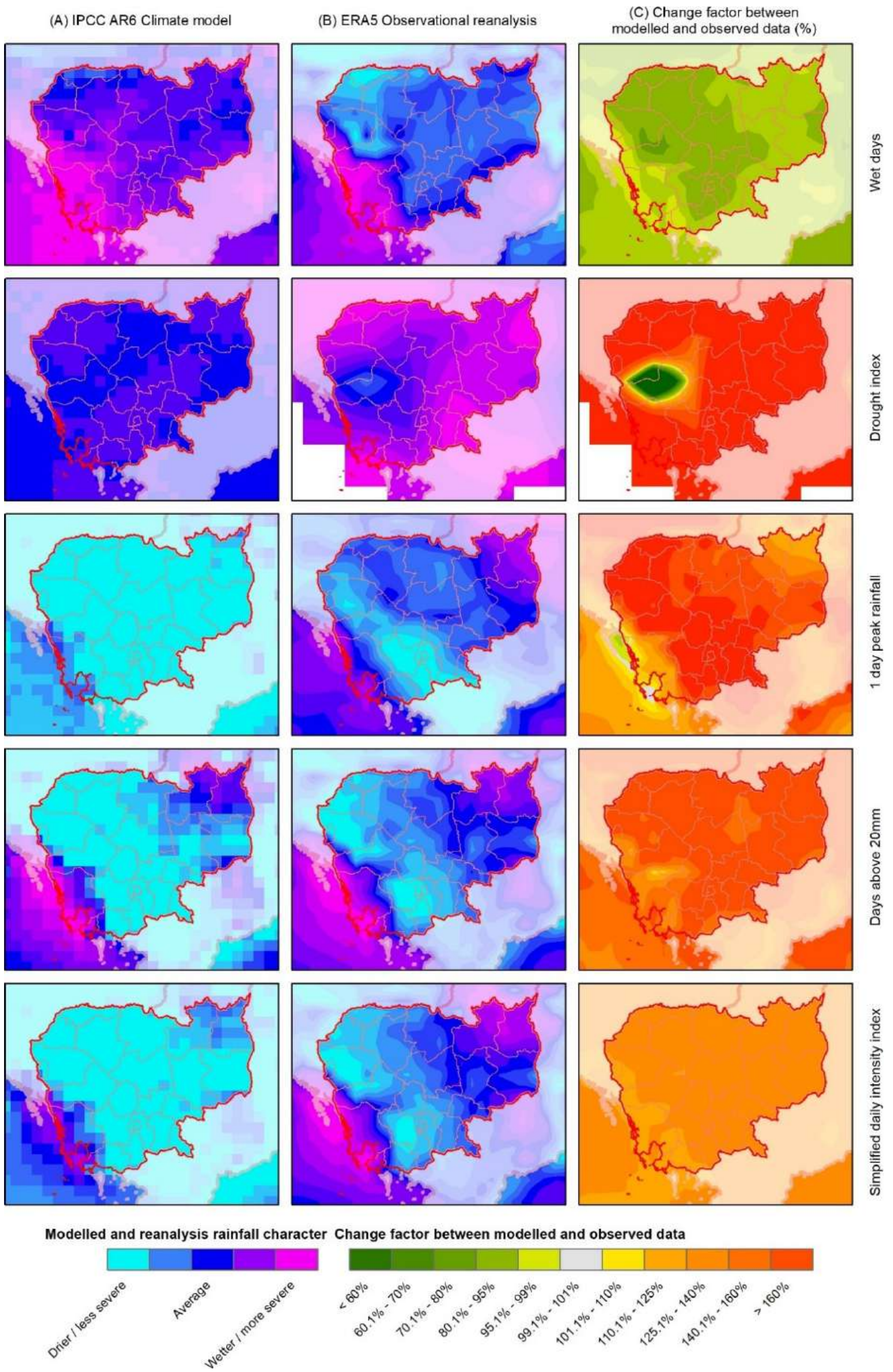


Figure 38. Secondary climate variables: Modelled, reanalysis data and change factors for rainfall characteristics

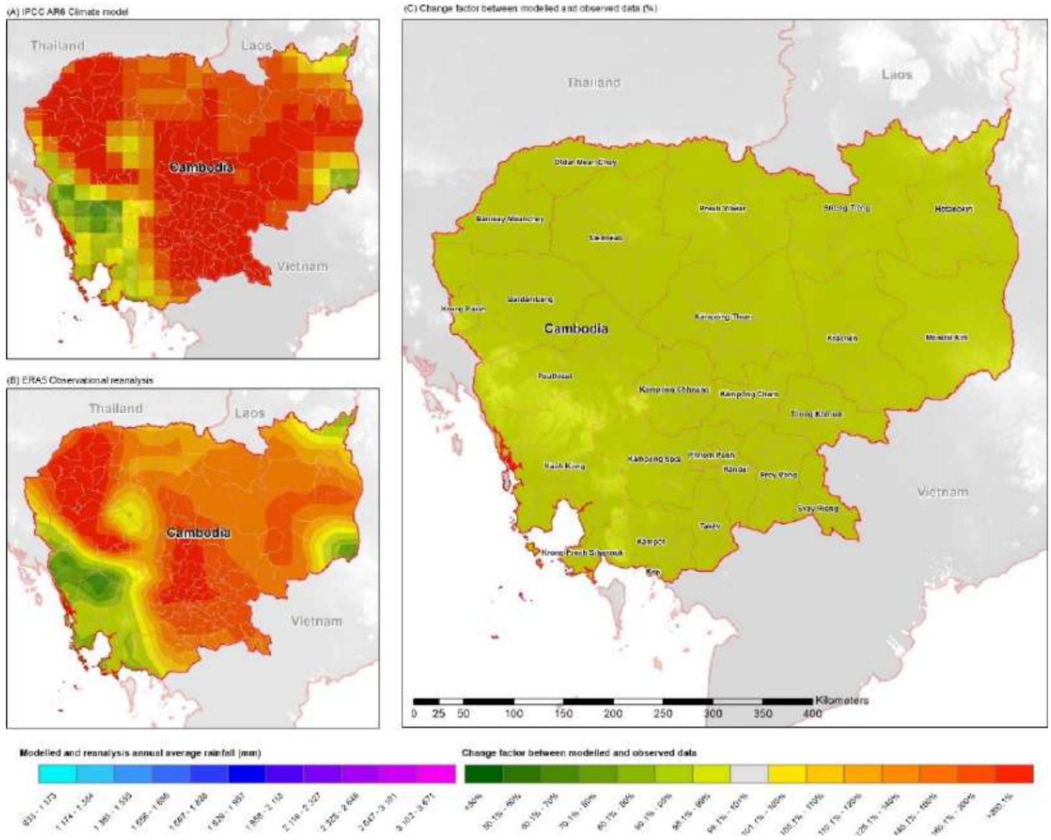


Figure 39. Main climate variable: Modelled, reanalysis data and change factors for average maximum temperature

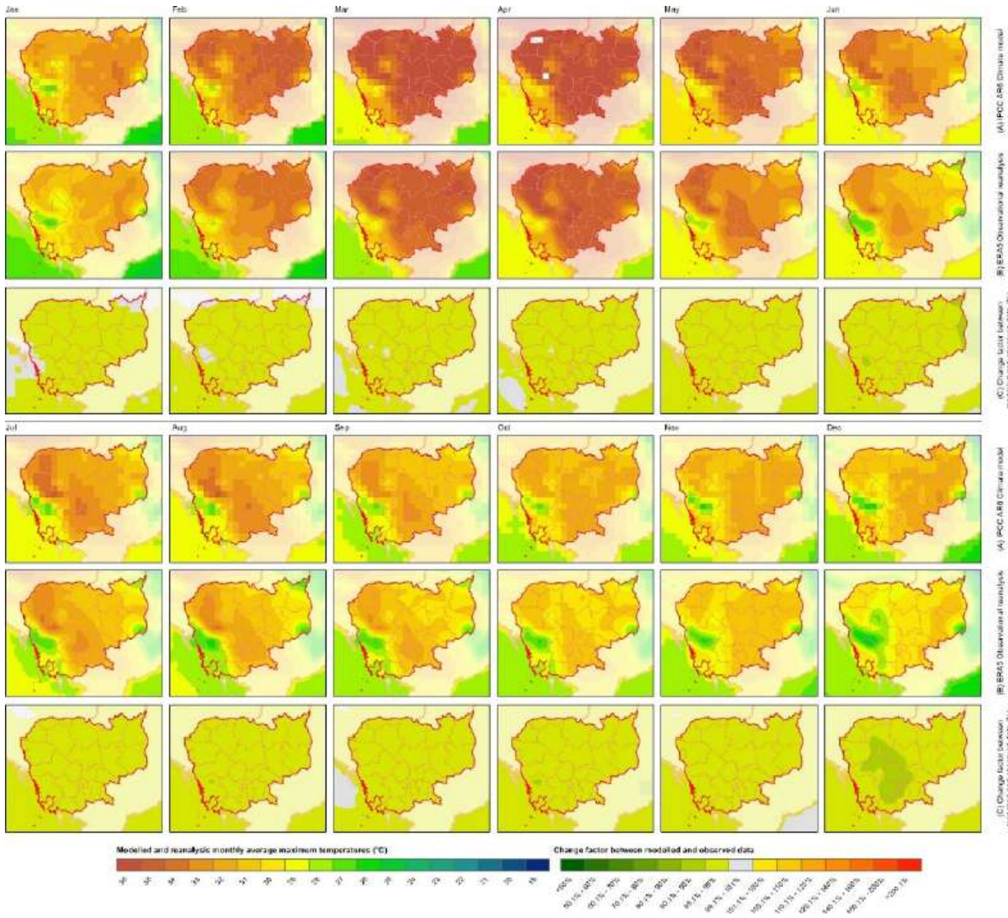


Figure 40. Change factors for monthly average maximum temperatures

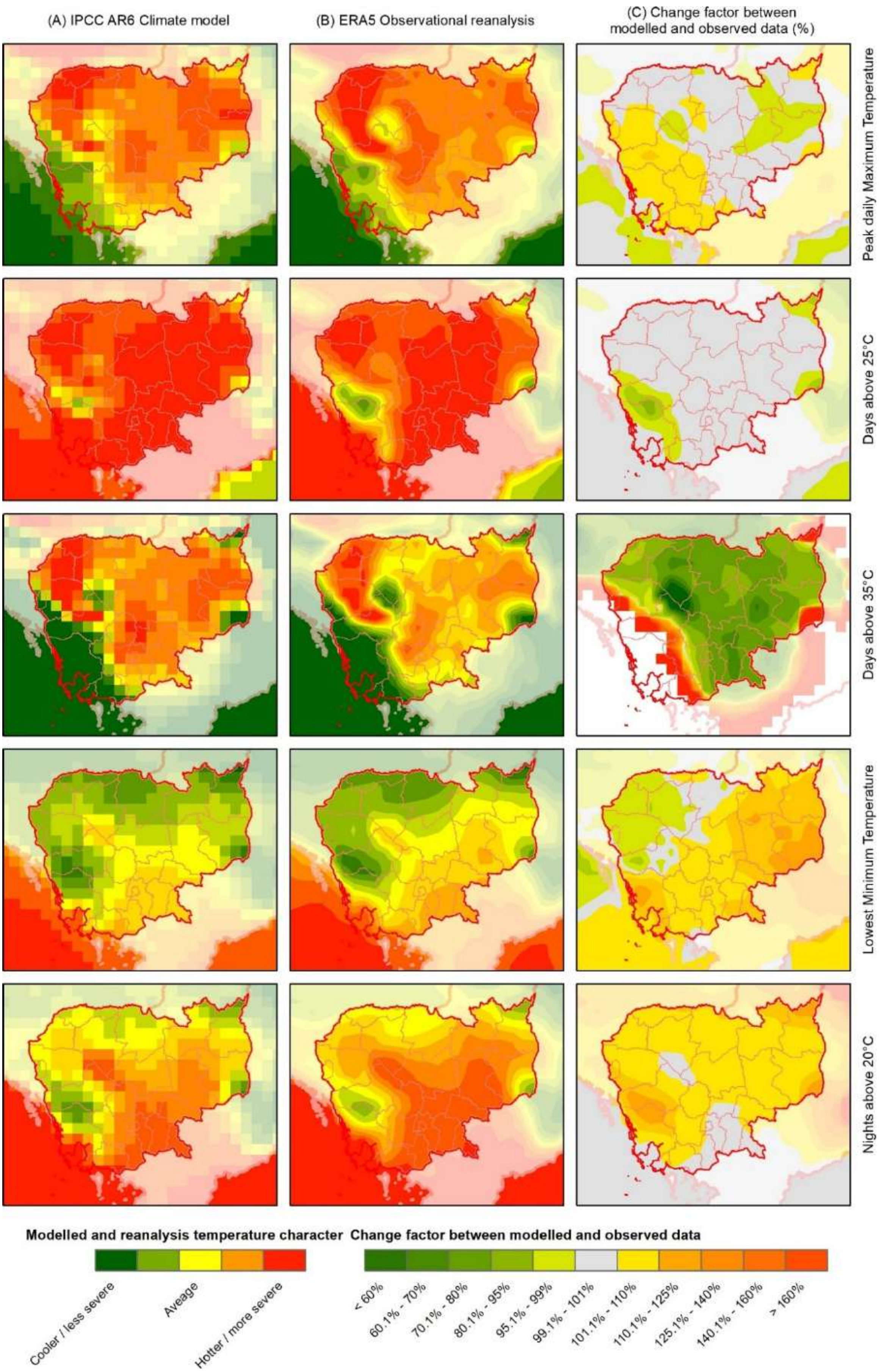


Figure 41. Secondary climate variables: Modelled, reanalysis data and change factors for temperature characteristics

Table 34. Spatial model ensemble changes factors related to historical reanalysis data and bias factors

<table>
<tr><td>Annual Precipitation (mm)</td><td>Annual: The modelled and reanalysis data share significant spatial characteristics with higher volumes being noted in the coastal areas to the southwest and the areas to the northeast. The central areas see only moderate rainfall volumes. This results in a relatively small change factor required to calibrate the climate model. We see that most of the country needs an increase of up to 1-5% or ~35mm. The exception to this is the central northern areas which are within 1% of the observed mean volumes and require no bias adjustment.</td><td>Monthly: The monthly picture is more complex than the annual average. While the spatial correlation between the modelled and the reanalysis data is very high with strong spatial agreement in months, the magnitude of the monthly rainfall does vary. The peak rainfall months of May to Sep see varied adjustments required but these are for the most part showing a small increase of 1-10% over most of the country. The lower rainfall months see a more severe change required. With up to 20-30% decreases required in some areas. These months however have significantly lower rainfall volumes, and these are representing minimal changes in actual mm’s. Over all the peak months are underrepresented in the climate models while the lower rainfall volume months are overrepresented by the models.</td></tr>
<tr><td>Wet days (days above 1mm)</td><td colspan="2">The changes in average wet days between the modelled and the reanalysis data show spatial consistency with the higher values noted in the coastal southwest area and decreases in the northeastern areas. However, the gradient of decrease noted in the observational data is more severe than is noted in the model data which has a more subtle decline in the number of wet days. This results in an overall decreased need for the model data to match the observation data but with a larger anomaly in the central areas of up to 10% decrease needed.</td></tr>
<tr><td>Drought Index (SPEI)</td><td colspan="2">The modelled and observed drought index spatially match rather poorly despite averaging out to a similar national average drought value. The more severe drought areas inland to the east and north are not matched by the model which generally shows a moderate drought over most of the country. This will require a larger change to be applied to the models to get them in line with the observed red data.</td></tr>
<tr><td>Peak single-day rainfall (mm)</td><td colspan="2">Both the spatial and magnitude correlation in peak one-day rainfall is poor. The higher magnitudes are noted along the coast in both the model and reanalysis data, but the increased intensity noted in the inland areas is not matched by the model data. This is due to the model drizzle simulation bias. This results in a required increase of the magnitude of the single-day rainfall mostly in the central inland areas of up to 40%.</td></tr>
<tr><td>Days with above 20mm of rainfall</td><td colspan="2">As is the case of the magnitude being reduced for the 1-day peak, so too is this the case for the number of days above 20mm. The spatial correlation is however better in this case with the coastal and inland peaks to the northeast being represented in both the modelled and reanalysis data. The largest discrepancy is in the lower occurrence areas in the central inland areas and this is the area that requires the largest bias correction.</td></tr>
<tr><td>Simplified daily rainfall intensity (mm/day)</td><td colspan="2">The simplified daily intensity index also follows this trend for extreme rainfall events being underrepresented in the models compared to the observational data. The spatial characteristics are similar, and both show an increase in the coastal and inland areas, but with marginally decreased magnitudes of 5-10%.</td></tr>
</table>

Maximum Temperature (°C)	Annual: there is a good spatial correlation between the observed reanalysis data and the climate model data. There are decreased temperatures noted in the coastal southwestern areas and increased temperatures noted inland and to the north. On average the temperatures differ by only 0.25°C. This results in a very low bias correction required which falls between 1 and 5% decrease to match the observed data.	Monthly: The monthly changes required are very similar to the annual maximum temperature changes with most months already being very closely aligned both spatially and from a magnitude perspective between the observed reanalysis and the model data. There is however again a general overestimation by the models for all months. A bias correction of between 1-5% is required to align the model with the observational data. Models are generally better able to simulate temperatures accurately, so this accuracy is unsurprising.
Highest maximum temperatures (°C)	The peak daily maximum temperatures see the lowest values in the coastal areas and some isolated inland areas. The rest of the country sees moderate occurrences for both the modelled and reanalysis data. The strong spatial and magnitude correlation shows only small increases of less than 5% required in the coastal area and only a small decrease noted in some areas inland.	
Warm days above 25°C	The agreement between the model and the reanalysis data is high when looking at the number of days above 25°C. This is consistent over most of the country with lower values noted in isolated areas in some small areas. This results in a very small (<1%) change factor that needs to be applied to the model to make it align with the observational data	
Hot days above 35°C	The number of days above 35 °C is spatially well correlated between the model and the reanalysis data. With the lower values noted along the coastal areas and higher values present in the inland areas. The models however do over-simulate these hot days in the land areas by up to 10% in some areas. This will need to be adjusted to bring the model data more in line with observation.	
Lowest minimum temperatures (°C)	The coolest night temperatures show their lowest values inland and to the north of the country and higher temperatures in the southern and coastal areas. The spatial correlation and magnitudes between the modelled and observed data are strong. There is only a small adjustment needed mostly in the southern and eastern areas that are underrepresented in the models currently.	
Hot nights above 20°C	The number of warm nights sees higher values in the southern areas and lower occurrences in the western areas as well as areas to the north. Both the spatial and magnitude correlate well resulting in only a moderate increase needed for the model to align with the observational data.	

10.1.3 MODEL OUTPUTS

The noted changes between the current climate and projected climate will be assessed as part of the climate hazard analysis portion of the risk assessment. Rather below however are the changes as driven by the difference between the observed climate and the historical model climate applied to the historical and ensemble projected climate models to represent local factors that may not have been present within the climate model simulation.

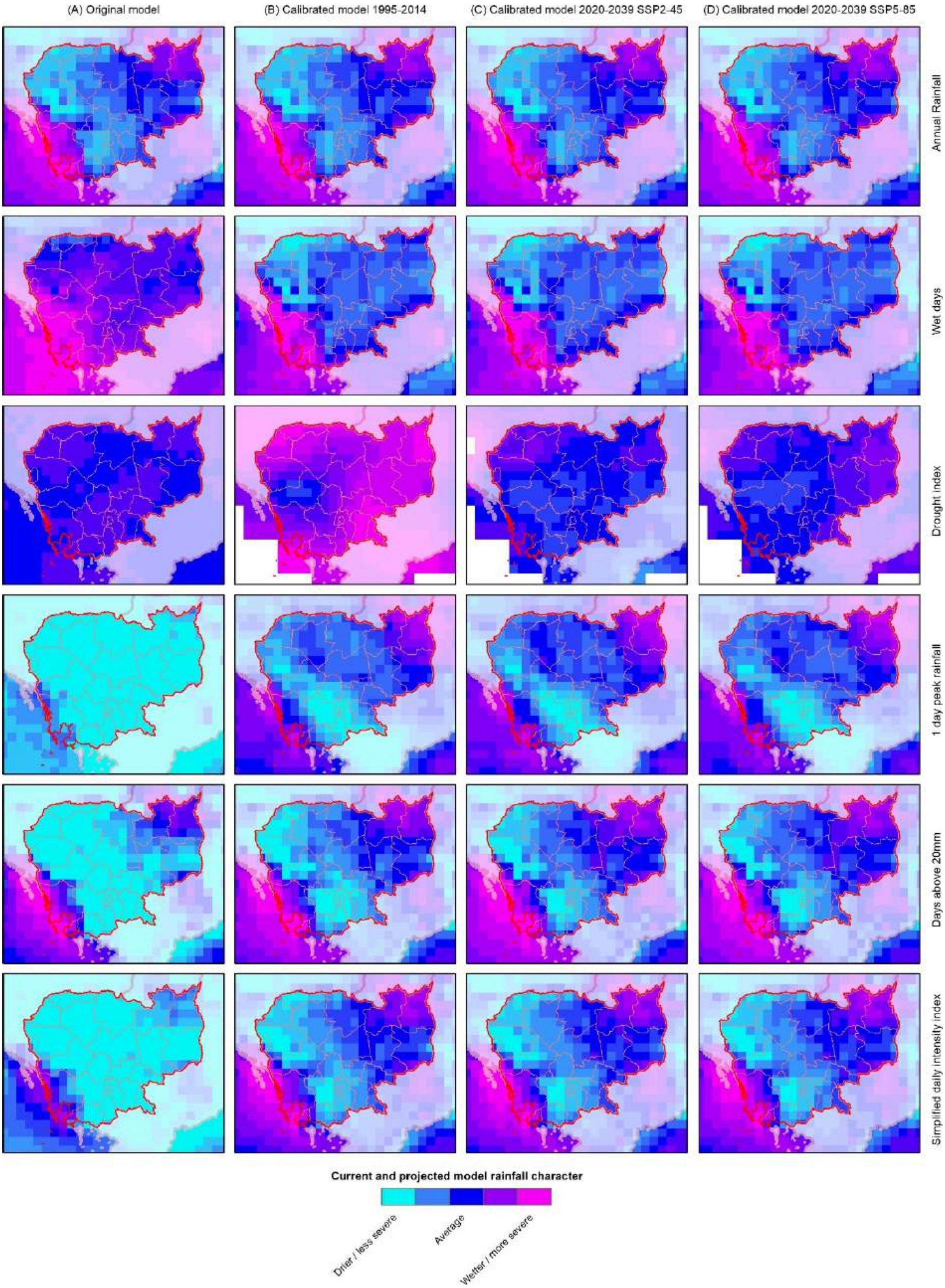


Figure 42. Calibrated climate variables: Original modelled, calibrated historical period and calibrated projected future period for rainfall characteristics.

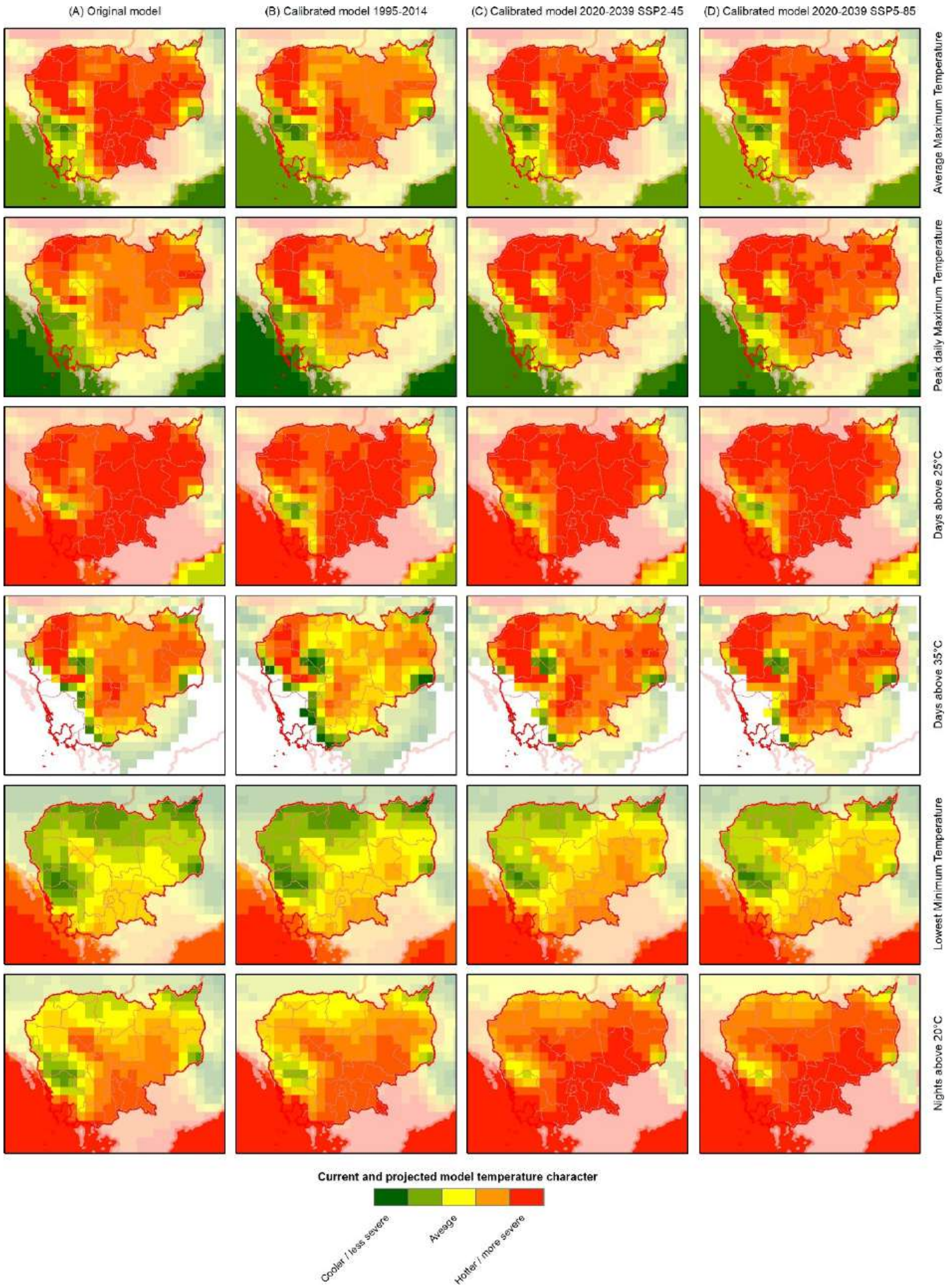


Figure 43. Calibrated climate variables: Original modelled, calibrated historical period and calibrated projected future period for temperature characteristics

The annual precipitation doesn't show significant changes between the original modelling and the calibrated modelling. The majority of the changes are however noted in the monthly profiles. The annual scale saw very few calibration requirements.

The sharp gradient of the wet days from the observational data is now shown within the calibrated model wet day data. Likewise, the sharp changes in the drought index that weren't captured within the modelled drought index are now captured in the calibrated output.

The more extreme rainfall variables also see the magnitude changes reflected in the observed data now captured within the calibrated model data with the inland areas in particular being better represented particularly for the 1-day peak and the simplified daily intensity index but also the number of days above 20mm.

The temperature characteristics are generally better captured by the models. There is rather just further detail added in some areas. The most notable difference is the calibrated current model compared to the future model. The minimal changes needed in annual temperatures are noted with very limited changes between the original and calibrated models.

There is more detail noted in the calibrated peak daily maximum temperatures as the changing temperature gradient was more noted in the observed reanalysis data and thus had a higher chance factor in smaller areas. The warm bias of the models is removed by incorporating the decreased number of days above 25 °C and 35 °C in the reanalysis data.

The change factor for the lowest minimum temperatures and the number of nights above 20 °C was relatively low. This is reflected in the minimal overall changes between the original and calibrated modelled data.

10.1.4 DOWNSCALING FINDINGS AND SUMMARY

Generally, the required temperature calibration was more limited than the rainfall changes. The climate models tend to underestimate the extreme rainfall events due to the drizzle effect in many models biasing them towards more lower magnitude rainfall events rather than fewer more severe events. The monthly temperatures also required very little calibration while the monthly rainfall calibration was mostly focused on increasing the magnitude of rainfall in the peak rainfall season.

The resolution of the climate models is 25km x 25km which is the same resolution as the ERA5 reanalysis dataset. Further downscaling the model data to a higher resolution beyond the scale of the observational data is ill-advised as the high-detail climate influences such as land cover and topography are not represented in the 25km resolution reanalysis data. This resolution is, however, sufficient to conduct climate risk assessments particularly when considering the more extreme climate variables that contribute greatly to climate hazards.

The ability to incorporate spatial calibration and bias removal provided by the reanalysis data, however, allowed for the current and projected future climate models to now better represent the local climate conditions as informed by a dependable reanalysis dataset.

10.1.5 RECOMMENDATIONS AND NEXT STEPS

The model ensemble has been created based on the statistical relationships most accurately matching the observed climate data. It has been calibrated spatially with the observed data to capture variability from area to area. The outputs of this downscaling will form the climate hazard components for each of the different risks in the upcoming CRVA work. It will represent the current as well as the projected climate down to the district level for further analysis. This report seeks only to validate and calibrate the climate models so that they are representative at this level and can be used for further risk and vulnerability analysis.

Utilization of the model ensemble (or any climate models) should consider the underestimation of the extreme events as well as the conservative ranges between wet and dry years. While the simulation of temperatures is better than rainfall, there are also biases to consider. If accurate and official climate data from stations were available from the meteorological authority, this would serve to further validate the climate models. In the case that it is not available, the selection of the quality reanalysis dataset is paramount.

The output format and resolution of the calibrated and validated model ensemble should match the ERA5 data but also be sufficient to undertake the upcoming CRVA analysis in sufficient detail.

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[10] *The indicators are subject to change based on availability and data quality*

[11] (+) greater indicator values increase risk; (-) smaller indicator values increase risk; (~) risk varied per individual type

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[297] *The process of applying and bias correction either through geographical differences, statistically anomalies or both.*

[298] *This is the grid cell size of the data. Higher resolution means greater representation of local climate influences. Climate models often have a very low resolution or 100km or more and these do not reflect local scale climate factors.*

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