CLIMATE RISK COUNTRY PROFILE

LAO PDR

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK

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1818 H Street NW, Washington, DC 20433
Telephone: 202-473-1000; Internet: www.worldbank.org

© 2021 Asian Development Bank
6 ADB Avenue, Mandaluyong City, 1550 Metro Manila, Philippines
Tel +63 2 8632 4444; Fax +63 2 8636 2444
www.adb.org

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This profile is part of a series of Climate Risk Country Profiles that are jointly developed by the World Bank Group (WBG) and the Asian Development Bank (ADB). These profiles synthesize the most relevant data and information on climate change, disaster risk reduction, and adaptation actions and policies at the country level. The profile is designed as a quick reference source for development practitioners to better integrate climate resilience in development planning and policy making. This effort is co-led by Veronique Morin (Senior Climate Change Specialist, WBG), Ana E. Bucher (Senior Climate Change Specialist, WBG) and Arghya Sinha Roy (Senior Climate Change Specialist, ADB).

This profile was written by Alex Chapman (Consultant, ADB), William Davies (Consultant, ADB) and Ciaran Downey (Consultant). Technical review of the profiles was undertaken by Robert L. Wilby (Loughborough University). Additional support was provided by MacKenzie Dove (Senior Climate Change Consultant, WBG), Jason Johnston (Operations Analyst, WBG), Yunziyi Lang (Climate Change Analyst, WBG), Adele Casorla-Castillo (Consultant, ADB), and Charles Rodgers (Consultant, ADB). This profile also benefitted from inputs of WBG and ADB regional staff and country teams.

Climate and climate-related information is largely drawn from the Climate Change Knowledge Portal (CCKP), a WBG online platform with available global climate data and analysis based on the latest Intergovernmental Panel on Climate Change (IPCC) reports and datasets. The team is grateful for all comments and suggestions received from the sector, regional, and country development specialists, as well as climate research scientists and institutions for their advice and guidance on use of climate related datasets.

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FOREWORD

Climate change is a major risk to good development outcomes, and the World Bank Group is committed to playing an important role in helping countries integrate climate action into their core development agendas. The World Bank Group (WBG) and the Asian Development Bank (ADB) are committed to supporting client countries to invest in and build a low-carbon, climate-resilient future, helping them to be better prepared to adapt to current and future climate impacts.

Both institutions are investing in incorporating and systematically managing climate risks in development operations through their individual corporate commitments.

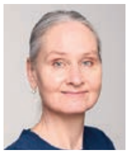
For the World Bank Group: a key aspect of the World Bank Group's Action Plan on Adaptation and Resilience (2019) is to help countries shift from addressing adaptation as an incremental cost and isolated investment to systematically incorporating climate risks and opportunities at every phase of policy planning, investment design, implementation and evaluation of development outcomes. For all International Development Association and International Bank for Reconstruction and Development operations, climate and disaster risk screening is one of the mandatory corporate climate commitments. This is supported by the World Bank Group's Climate and Disaster Risk Screening Tool which enables all Bank staff to assess short- and long-term climate and disaster risks in operations and national or sectoral planning processes. This screening tool draws up-to-date and relevant information from the World Bank's Climate Change Knowledge Portal, a comprehensive online 'one-stop shop' for global, regional, and country data related to climate change and development.

For the Asian Development Bank (ADB): its Strategy 2030 identified "tackling climate change, building climate and disaster resilience, and enhancing environmental sustainability" as one of its seven operational priorities. Its Climate Change Operational Framework 2017–2030 identified mainstreaming climate considerations into corporate strategies and policies, sector and thematic operational plans, country programming, and project design, implementation, monitoring, and evaluation of climate change considerations as the foremost institutional measure to deliver its commitments under Strategy 2030. ADB's climate risk management framework requires all projects to undergo climate risk screening at the concept stage and full climate risk and adaptation assessments for projects with medium to high risk.

Recognizing the value of consistent, easy-to-use technical resources for our common client countries as well as to support respective internal climate risk assessment and adaptation planning processes, the World Bank Group's Climate Change Group and ADB's Sustainable Development and Climate Change Department have worked together to develop this content. Standardizing and pooling expertise facilitates each institution in conducting initial assessments of climate risks and opportunities across sectors within a country, within institutional portfolios across regions, and acts as a global resource for development practitioners.

For common client countries, these profiles are intended to serve as public goods to facilitate upstream country diagnostics, policy dialogue, and strategic planning by providing comprehensive overviews of trends and projected changes in key climate parameters, sector-specific implications, relevant policies and programs, adaptation priorities and opportunities for further actions.

We hope that this combined effort from our institutions will spur deepening of long-term risk management in our client countries and support further cooperation at the operational level.



Bernice Van Bronkhorst
Global Director
Climate Change Group
The World Bank Group

Preety Bhandari
Chief of Climate Change and Disaster Risk Management Thematic Group
concurrently Director Climate Change and Disaster Risk Management Division
Sustainable Development and Climate Change Department
Asian Development Bank

KEY MESSAGES

- Lao PDR faces projected warming of 3.6°C by the 2090s against the baseline conditions over 1986–2005, under the highest emissions pathway (RCP8.5).
- Rises in annual maximum and minimum temperatures are expected to be more rapid than the rise in average temperature and will likely amplify pressure on human health, livelihoods, and ecosystems.
- Lao PDR is amongst the most vulnerable countries to projected climate change trends, as its communities face significant climate-related hazards that are exacerbated by poverty, malnourishment, and high exposure of poor and marginalized communities.
- Increased incidence of extreme heat represents a major threat to human health, especially for outdoor laborers and, given rapid ongoing urban migration, potentially for urban populations as well.
- Without action, the population annually exposed to river flooding is projected to double to over 80,000 people by the 2030s. However, flooding impacts could be even greater as the potential for increased loss and damage from flash flooding and landslides are poorly understood.
- A significant adaptation effort is required to address reductions in yields driven by projected increases in the incidence of extreme heat during the growing season of staple crops such as rice, particularly for poorer communities operating subsistence and rain-fed agriculture.
- The impacts of climate change are likely to fall disproportionately on the poorer and more marginalized communities. Inequality is widening in Lao PDR and evidence suggests that this may further amplify the impacts of climate-related disasters.

COUNTRY OVERVIEW

Lao People's Democratic Republic (Lao PDR), is a landlocked country in Southeast Asia, located between latitudes 14° and 23°N and longitudes 100° and 108°E. The nation, which shares borders with five other countries, lies in the lower Mekong River Basin of Southeast Asia. The country stretches 1,700 kilometers (km) from north to south and 100 km to 400 km from east to west, with a total surface area of 236,800 km^2. Approximately 80% of the country's land area is mountainous. The remaining 20% is low lying plains along the Mekong River and threatened by annual floods. The altitude ranges from 104 m above sea level in Attapeu to 2,820 m in Xiengkhuang, at Phoubia Mountain. More than two-thirds of the population lives in the southern and central parts of the country.[1]

Lao PDR is endowed with abundant natural resources, such as water, forests, minerals and biodiversity. Relative to other Asian nations, many of these assets remain in a comparatively healthy state. However, since the turn of

[1] Lao PDR (2013). Second National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/Laonc2.pdf

the 21st century, exploitation of natural resources has accelerated, including construction of a cascade of new hydropower dams on the Mekong River and its tributaries. Lao PDR's topography and landlocked location makes the country heavily dependent on road transportation for trade and economic growth. The country's East-West and North-South economic corridors connect Lao PDR with its Southeast and East Asian neighbors. Lao PDR is classified as a lower middle-income country with a GDP of $17 billion and a total population of 6.9 million people as of 2017. According to the Ministry of Planning and Investment, the per-capita income grew from $490 in 2005 to $1,069 in 2010, highlighting the country's pace of change. There is also an evident shift from agricultural work towards the service sector however agriculture remains the dominant employer, accounting for 73% of the labor force in 2012. Flood and drought events occur frequently in Lao PDR. Poverty and malnutrition remain prevalent (**Table 1**) and with such a large proportion of Lao PDR's population relying on agricultural activities as the primary source of livelihood, climate change is likely to impact on the country and its inhabitants strongly. In 2016, Lao PDR ratified its Nationally Determined Contribution (NDC) to the Paris Climate Agreement and launched its climate change action plan. Lao PDR's Second National Communication to the UNFCCC (NC2) (2013) identifies the impacts of climate change to be particularly important to the country's water and forestry resources, agriculture, energy and health sectors.[2]

TABLE 1. Key indicators

Indicator	Value	Source
Prevalence of Stunting in Children Under Five Years of Age[3]	33.1% (2019)	FAO, 2020
National Poverty Rate[4]	18% (2019)	World Bank, 2020
Share of Income Held by Bottom 40%[5]	20% (2019)	World Bank, 2020
Net Annual Migration Rate[6]	–0.21% (2015–2020)	UNDESA, 2019
Infant Mortality Rate (Between Age 0 and 1)[7]	3.9% (2015–2020)	UNDESA, 2019
Average Annual Change in Urban Population[8]	3.3% (2015–2020)	UNDESA, 2018
Dependents per 100 Independent Adults[9]	56.8 (2020)	UNDESA, 2019
Urban Population as % of Total Population[10]	36.3% (2020)	CIA, 2020
External Debt Ratio to GNI[11]	90.2% (2018)	ADB, 2020b
Government Expenditure Ratio to GDP[12]	21.0% (2018)	ADB, 2020b

2 Lao PDR (2013). Second National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/Laonc2.pdf
3 FAO, IFAD, UNICEF, WFP, WHO (2020) The state of food security and nutrition in the world. Transforming food systems for affordable healthy diets. FAO. Rome. URL: http://www.fao.org/documents/card/en/c/ca9692en/
4 World Bank (2020). Lao PDR Poverty Profile and Poverty Assessment 2020. URL: https://www.worldbank.org/en/country/lao/publication/lao-pdr-poverty-profile-and-poverty-assessment-2020 [accessed 17/12/20]
5 World Bank (2020). Lao PDR Poverty Profile and Poverty Assessment 2020. URL: https://www.worldbank.org/en/country/lao/publication/lao-pdr-poverty-profile-and-poverty-assessment-2020 [accessed 17/12/20]
6 UNDESA (2019). World Population Prospects 2019: MIGR/1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
7 UNDESA (2019). World Population Prospects 2019: MORT/1-1. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
8 UNDESA (2019). World Urbanization Prospects 2018: File 6. URL: https://population.un.org/wup/Download/ [accessed 17/12/20]
9 UNDESA (2019). World Population Prospects 2019: POP/11-A. URL: https://population.un.org/wpp/Download/Standard/Population/ [accessed 17/12/20]
10 CIA (2020). The World Factbook. Central Intelligence Agency. Washington DC. URL: https://www.cia.gov/the-world-factbook/
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12 ADB (2020b). Key Indicators for Asia and the Pacific 2020. Asian Development Bank. URL: https://www.adb.org/publications/key-indicators-asia-and-pacific-2020

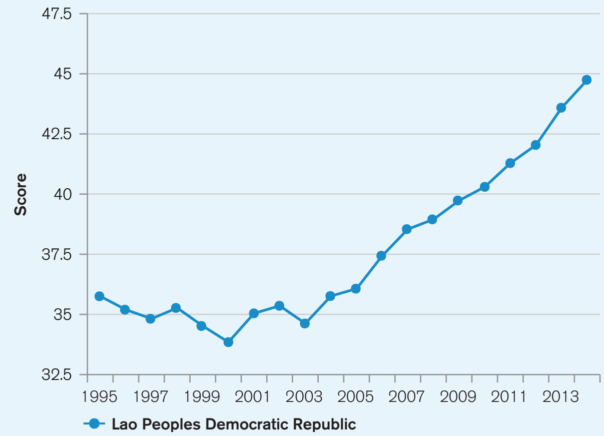
Green, Inclusive and Resilient Recovery

The coronavirus disease (COVID-19) pandemic has led to unprecedented adverse social and economic impacts. Further, the pandemic has demonstrated the compounding impacts of adding yet another shock on top of the multiple challenges that vulnerable populations already face in day-to-day life, with the potential to create devastating health, social, economic and environmental crises that can leave a deep, long-lasting mark. However, as governments take urgent action and lay the foundations for their financial, economic, and social recovery, they have a unique opportunity to create economies that are more sustainable, inclusive and resilient. Short and long-term recovery efforts should prioritize investments that boost jobs and economic activity; have positive impacts on human, social and natural capital; protect biodiversity and ecosystems services; boost resilience; and advance the decarbonization of economies.

This document aims to succinctly summarize the climate risks faced by Lao PDR. This includes rapid onset and long-term changes in key climate parameters, as well as impacts of these changes on communities, livelihoods and economies, many of which are already underway. This is a high-level synthesis of existing research and analyses, focusing on the geographic domain of Lao PDR, therefore potentially excluding some international influences and localized impacts. The core data presented is sourced from the database sitting behind the World Bank Group's Climate Change Knowledge Portal (CCKP), incorporating climate projections from the Coupled Model Inter-comparison Project Phase 5 (CMIP5). This document is primarily meant for WBG and ADB staff to inform their climate actions and to direct them to many useful sources of secondary data and research.

Due to a combination of political, geographic, and social factors, Lao PDR is recognized as vulnerable to climate change impacts, ranked 142 out of 181 countries in the 2020 ND-GAIN Index.[13] The ND-GAIN Index ranks 181 countries using a score which calculates a country's vulnerability to climate change and other global challenges as well as their readiness to improve resilience. The more vulnerable a country is, the lower its score is, while the more ready a country is to improve its resilience, the higher it will be. Norway has the highest score and is ranked 1st. **Figure 1** is a time-series plot of the ND-GAIN Index showing Lao PDR's progress.

FIGURE 1. The ND-GAIN Index summarizes a country's vulnerability to climate change and other global challenges in combination with its readiness to improve resilience. It aims to help businesses and the public sector better prioritize investments for a more efficient response to the immediate global challenges ahead



[13] University of Notre Dame (2019). Notre Dame Global Adaptation Initiative. URL: https://gain.nd.edu/our-work/country-index/

Climate Baseline

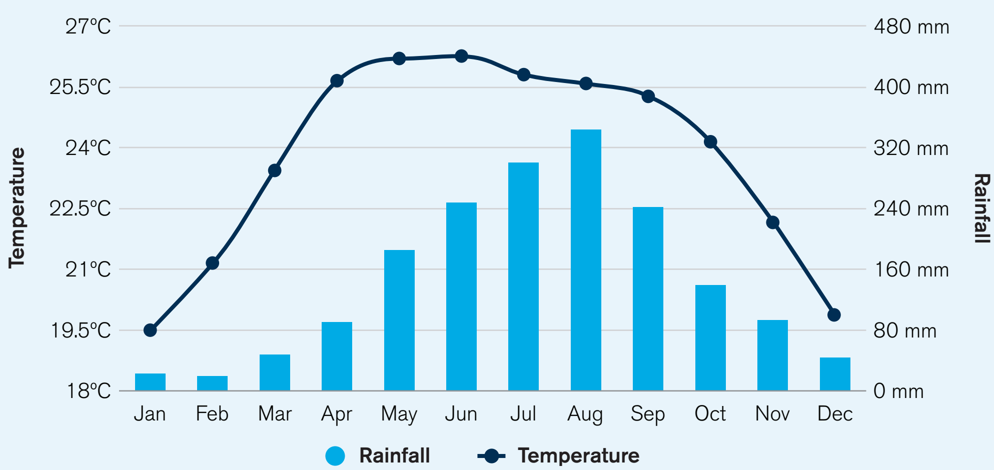
Overview

Lao PDR is characterized by a tropical climate, influenced by the southeast monsoon which brings 70% of annual rainfall and high humidity. There are two distinct seasons: the rainy season, or monsoon, from May to mid-October and the dry season from mid-October to April (**Figure 2**), presented in the latest climatology (1991–2020). Average rainfall can be as high as 3,000 millimeters (mm) per year. Mean annual temperatures of 20°C was observed in the northern and eastern mountainous areas and the plateaus, whereas temperatures are higher in the plains at 25–27°C.

Based on the country's altitude, Lao PDR can be divided into three different climatic zones. The northern mountainous areas above 1,000 meters (m) have a montane temperate and hilly sub-tropical climate. Here, temperature ranges are lower than the rest of the country. The central mountainous areas in the Annamite Chain vary in altitude between 500 to 1,000 m and are characterized by a tropical monsoonal climate with high temperatures and average rainfall totals.[14] More than 50% of the population lives in the tropical lowland plain and floodplains along the Mekong River and its main tributaries.[4] Temperature and precipitation rates have been shown to be sensitive to El Niño Southern Oscillation (ENSO), but generally to a lesser extent when compared to other Southeast Asian nations.[15,16] **Figure 3** shows observed spatial variation for temperature and precipitation across Lao PDR.

Annual Cycle

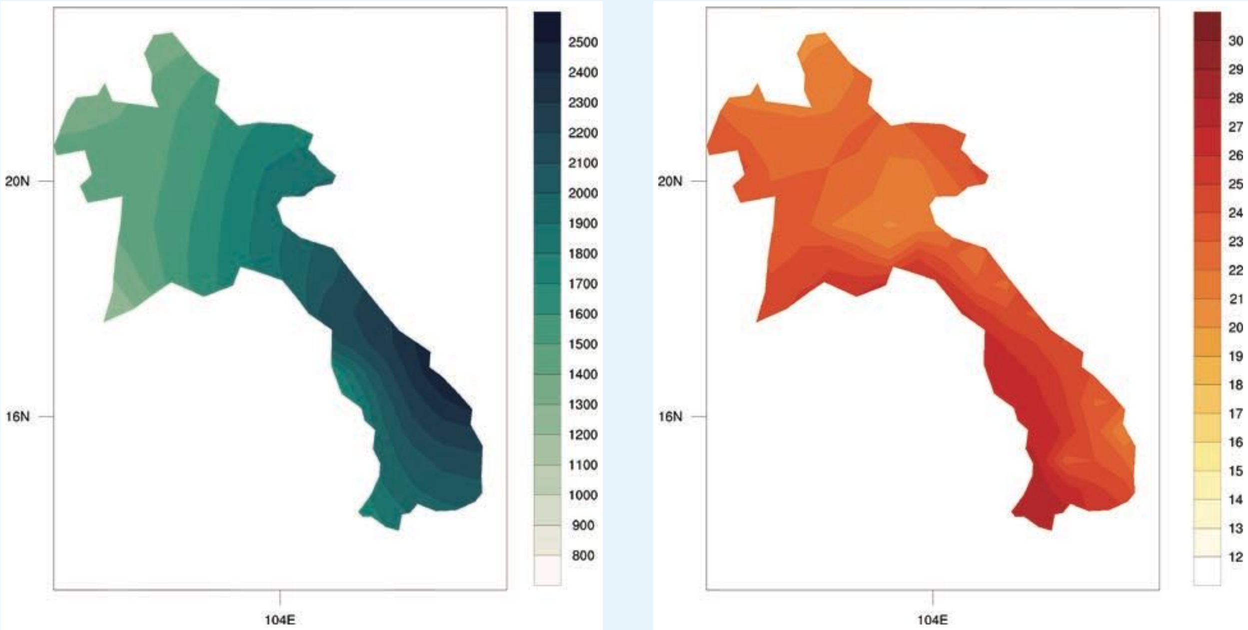
FIGURE 2. Average monthly temperature and rainfall in Lao PDR (1991–2020)[17]



[14] Lao PDR (2013). Second National Communication to the UNFCCC. URL: https://unfccc.int/sites/default/files/resource/Laonc2.pdf
[15] Villafuerte, M. Q., & Matsumoto, J. (2015). Significant influences of global mean temperature and ENSO on extreme rainfall in Southeast Asia. Journal of Climate, 28(5), 1905–1919. URL: https://journals.ametsoc.org/doi/pdf/10.1175/JCLI-D-14-00531.1
[16] Thirumalai, K., DiNezio, P. N., Okumura, Y., & Deser, C. (2017). Extreme temperatures in Southeast Asia caused by El Niño and worsened by global warming. Nature Communications, 8, 15531. URL: https://www.nature.com/articles/ncomms15531.pdf
[17] WBG Climate Change Knowledge Portal (CCKP, 2019). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/laos/climate-data-historical

Spatial Variation

FIGURE 3. Map of average annual temperature (°C) (left); annual precipitation (mm) (right) of Lao PDR, 1991–2020[18]



Key Trends

Temperature

Lao PDR's NC2 reports that data limitations obscure and add uncertainty to the evaluation of historical temperature changes. Utilizing the Berkeley Earth Dataset,[19] the rise in temperatures in the vicinity of Vientiane can be estimated at 1.03°C between the periods 1900–1917 and 2000–2017. The dataset suggests warming has accelerated rapidly since the turn of the 21st century in all regions of Lao PDR.

Precipitation

Lao PDR's NC2 reports a transition in the country's precipitation regime over the 20th century towards more intense precipitation periods, with the frequency of months of experiencing more than 600 mm rainfall increasing. Patterns of precipitation remain influenced by the complex relationship between Southeast Asian climate and ENSO.[20]

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[18] WBG Climate Change Knowledge Portal (CCKP, 2019). Climate Data: Historical. URL: https://climateknowledgeportal.worldbank.org/country/laos/climate-data-historical.

[19] Carbon Brief (2018). Mapped: How every part of the world has warmed – and could continue to. Infographics. 26 September 2018]. URL: https://www.carbonbrief.org/mapped-how-every-part-of-the-world-has-warmed-and-could-continue-to-warm

[20] Räsänen, T. A., Lindgren, V., Guillaume, J. H. A., Buckley, B. M., & Kummu, M. (2016). On the spatial and temporal variability of ENSO precipitation and drought teleconnection in mainland Southeast Asia. Climate of the Past, 12(9), 1889–1905. URL: https://www.clim-past.net/12/1889/2016/cp-12-1889-2016.pdf

Climate Future

Overview

The main data source for the World Banks' Climate Change Knowledge Portal (CCKP) is the Coupled Model Inter-comparison Project Phase 5 (CMIP5) models, which are utilized within the Fifth Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC), providing estimates of future temperature and precipitation. Four Representative Concentration Pathways (i.e. RCP2.6, RCP4.5, RCP6.0, and RCP8.5) were selected and defined by their total radiative forcing (cumulative measure of GHG emissions from all sources) pathway and level by 2100. In this analysis RCP2.6 and RCP8.5, the extremes of low and high emissions pathways, are the primary focus RCP2.6 represents a very strong mitigation scenario, whereas RCP8.5 assumes business-as-usual scenario. For more information, please refer to the RCP Database.

A Precautionary Approach

Studies published since the last iteration of the IPCC's report (AR5), such as Gasser et al. (2018), have presented evidence which suggests a greater probability that earth will experience medium and high-end warming scenarios than previously estimated.[21] Climate change projections associated with the highest emissions pathway (RCP8.5) are presented here to facilitate decision making which is robust to these risks.

For Lao PDR, these models show a trend of consistent warming and an increase in the intensity of heavy precipitation periods and extreme events. **Tables 2** and **3** below, provide information on temperature projections and anomalies for the four RCPs over two distinct time horizons; presented against the reference period of 1986–2005.

TABLE 2. Projected anomaly (changes °C) for maximum, minimum, and average daily temperatures in Lao PDR for 2040–2059 and 2080–2099, from the reference period of 1986–2005 for all RCPs. The table is showing the median of the CCKP model ensemble and the 10–90th percentiles in brackets.[22]

	Average Daily Maximum Temperature		Average Daily Temperature		Average Daily Minimum Temperature	
Scenario	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**	**2040–2059**	**2080–2099**
RCP2.6	1.2 (–0.5, 3.1)	1.2 (–0.5, 3.2)	1.6 (–0.3, 2.7)	1.3 (–0.2, 2.7)	1.1 (–0.2 2.5)	1.2 (–0.2, 2.6)
RCP4.5	1.5 (–0.3, 3.5)	2.0 (0.2, 4.3)	1.5 (–0.1, 3.1)	2.0 (0.4, 3.8)	1.5 (0.0, 2.9)	2.1 (0.5, 3.8)
RCP6.0	1.2 (–0.6, 3.0)	2.4 (0.4, 4.7)	1.2 (–0.4, 2.6)	2.4 (0.6, 4.3)	1.2 (–0.2, 2.5)	2.4 (0.6, 4.2)
RCP8.5	1.9 (0.1, 4.0)	3.9 (1.7, 6.6)	1.9 (0.3, 3.6)	3.9 (2.0, 6.3)	1.9 (0.3, 3.5)	4.1 (2.0, 6.2)

21 Gasser, T., Kechiar, M., Ciais, P., Burke, E. J., Kleinen, T., Zhu, D., . . . Obersteiner, M. (2018). Path-dependent reductions in CO2 emission budgets caused by permafrost carbon release. Nature Geoscience, 11, 830–835. URL: http://pure.iiasa.ac.at/id/eprint/15453/

22 WBG Climate Change Knowledge Portal (CCKP, 2020). Climate Data: Projections. URL: https://climateknowledgeportal.worldbank.org/country/laos/climate-data-projections.

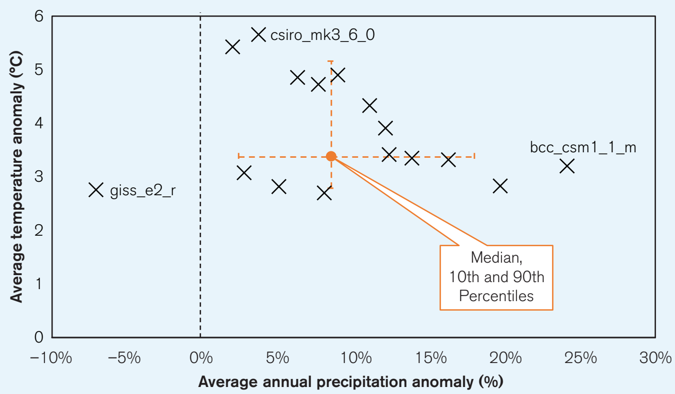
TABLE 3. Projections of average temperature change (°C) in Lao PDR for different seasons (3-monthly time slices) over different time horizons and emissions pathways, showing the median estimates of the full CCKP model ensemble and the 10th and 90th percentiles in brackets.[22]

Scenario	2040–2059 Jun–Aug	2040–2059 Dec–Feb	2080–2099 Jun–Aug	2080–2099 Dec–Feb
RCP2.6	1.0 (0.2, 2.4)	1.2 (–0.4, 2.5)	1.1 (0.1, 2.3)	1.3 (–0.1, 2.6)
RCP4.5	1.5 (0.5, 2.8)	1.4 (–0.3, 2.7)	1.9 (0.9, 3.4)	1.9 (0.3, 3.6)
RCP6.0	1.3 (0.3, 2.6)	1.0 (–0.5, 2.0)	2.5 (1.3, 4.0)	2.1 (0.4, 3.8)
RCP8.5	1.7 (0.6, 3.2)	2.0 (0.3, 3.4)	3.7 (2.4, 5.8)	3.9 (1.6, 6.2)

Model Ensemble

Climate projections presented in this document are derived from datasets available through the CCKP, unless otherwise stated. These datasets are processed outputs of simulations performed by multiple General Circulation Models (GCM) (for further information see Flato et al., 2013).[23] Collectively, these different GCM simulations are referred to as the 'model ensemble'. Due to the differences in the way GCMs represent the key physical processes and interactions within the climate system, projections of future climate conditions can vary widely between different GCMs, this is particularly the case for rainfall related variables and at national and local scales. The range of projections from 16 GCMs for annual average temperature change and annual precipitation change in Lao PDR under RCP8.5 is shown in **Figure 4**. Spatial representation of future projections of annual temperature and precipitation for mid and late century under RCP8.5 are presented in **Figure 5**.

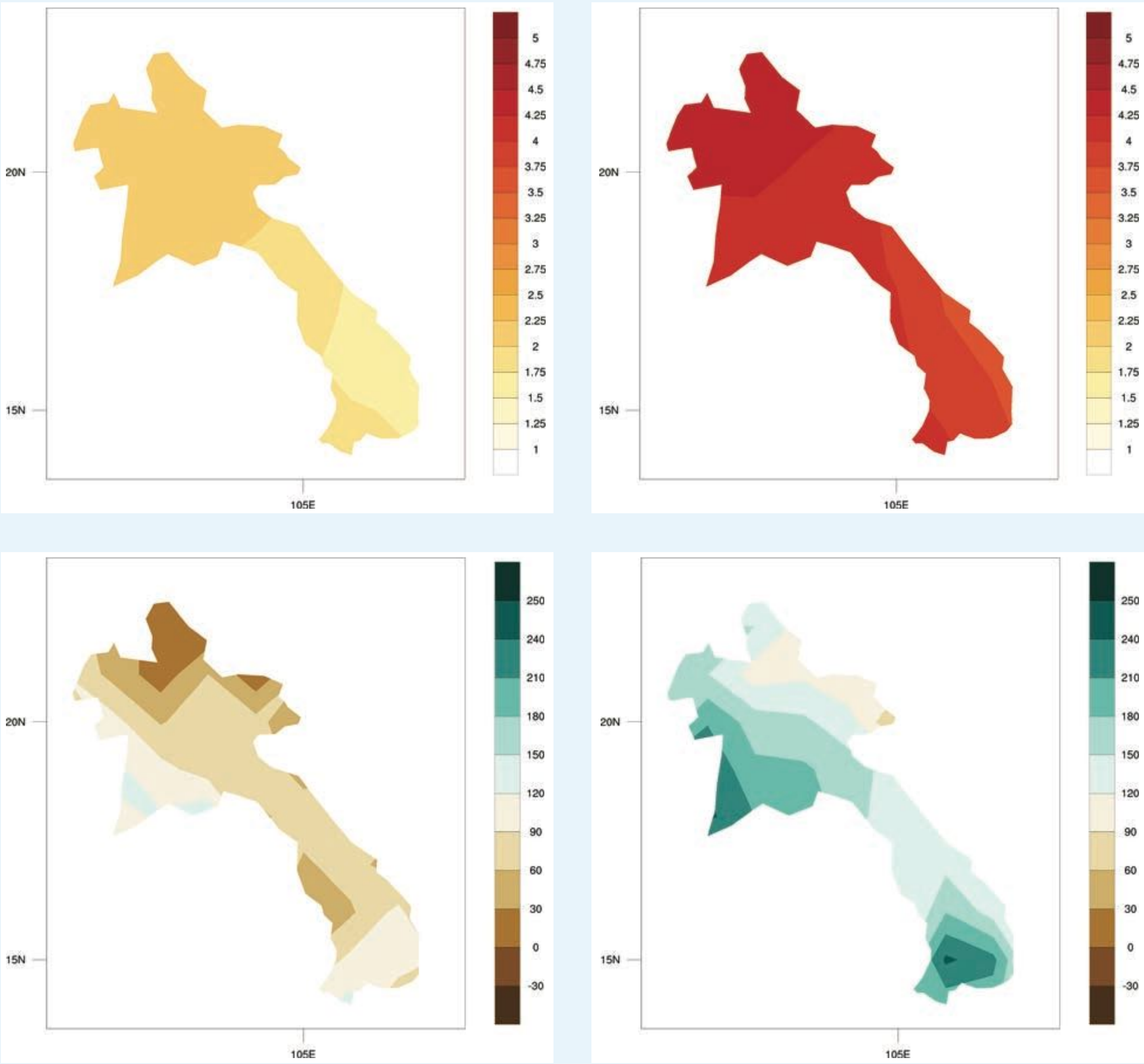
FIGURE 4. 'Projected average temperature anomaly' and 'projected annual rainfall anomaly' in Lao PDR. Outputs of 16 models within the ensemble simulating RCP8.5 over the period 2080–2099. Models shown represent the subset of models within the ensemble which provide projections across all RCPs and therefore are most robust for comparison.[22] Three models are labelled



[23] Flato, G., Marotzke, J., Abiodun, B., Braconnot, P., Chou, S. C., Collins, W., . . . Rummukainen, M. (2013). Evaluation of Climate Models. Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, 741–866. URL: http://www.climatechange2013.org/images/report/WG1AR5_ALL_FINAL.pdf

Spatial Variation

FIGURE 5. CMIP5 ensemble projected change (32 GCMs) in annual temperature (top) and precipitation (bottom) by 2040–2059 (left) and by 2080–2090 (right) relative to 1986–2005 baseline under RCP8.5[24]



[24] WBG Climate Change Knowledge Portal (CCKP 2019). Lao PDR. Climate Data. Projections. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=LAO&period=2080-2099

Temperature

Projections of future temperature change are presented in three primary formats. Shown in **Table 2** are the changes (anomalies) in daily maximum and daily minimum temperatures over the given time period, as well as changes in the average temperature. **Figures 6** and **7** display the annual and monthly average temperature projections. While similar, these three indicators can provide slightly different information. Monthly and annual average temperatures are most commonly used for general estimation of climate change, but the maximum and minimum can explain more about how daily life might change in a region, affecting key variables such as the viability of ecosystems, health impacts, productivity of labor, and the yield of crops, which are often disproportionately influenced by temperature extremes.

Temperature rise in Lao PDR is expected to be broadly in line with the global average. The CCKP model ensemble points to a rise of around 4.1°C by the 2090s over the 1986–2005 baseline, under the highest emissions pathway (RCP8.5). This reduces to 1.2°C under the lowest emissions pathway (RCP2.6). Rises in and annual minimum and maximum temperatures are expected to be more rapid than the rise in average temperature, with monthly minimum temperatures typically rising 10–20% faster. While uncertainty in the seasonal variation of temperature rises remains high, the CCKP model ensemble suggests that rises may be greatest in the hottest months of April and May.

FIGURE 6. Historic and projected average annual mean temperature in Lao PDR under RCP2.6 (blue) and RCP8.5 (red) estimated by the model ensemble. Shading represents the standard deviation of the model ensemble[25]

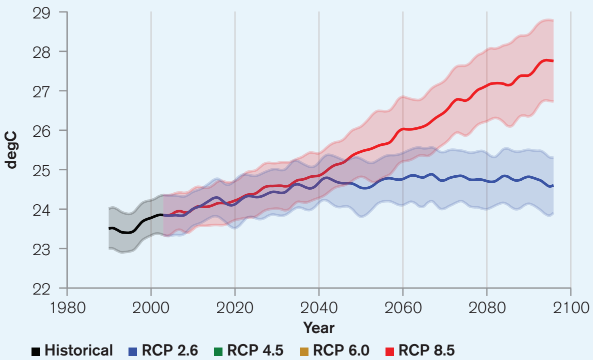
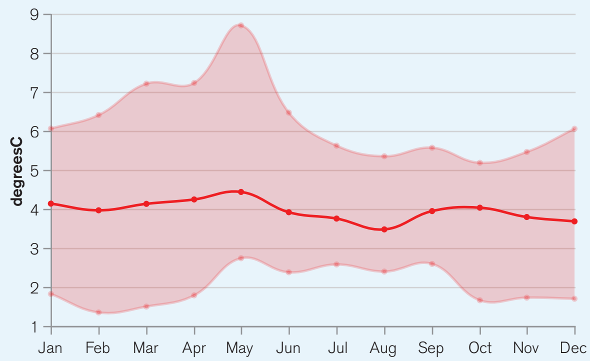


FIGURE 7. Projected change (°C) in monthly temperature, shown by month, for Lao PDR for the period 2080–2099 under RCP8.5. The value shown represents the median of the model ensemble with the shaded areas showing the 10th–90th percentiles[25]

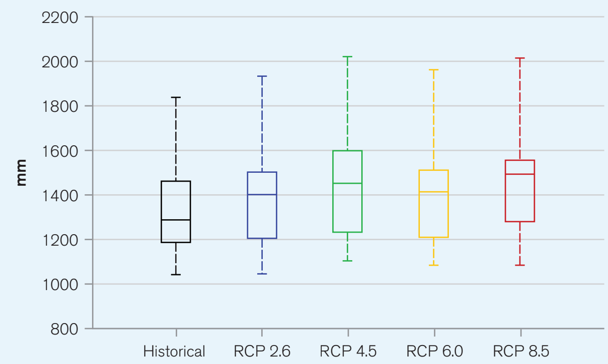


[25] WBG Climate Change Knowledge Portal (CCKP, 2019). Interactive Climate Indicator Dashboard. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=LAO&period=2080-2099.

Precipitation

Most of the ensemble models project increases in annual precipitation rates, with larger changes under higher emissions pathways (**Figure 4** and **8**). However, uncertainty in precipitation trends remains high, as reflected in the range of model estimates. This uncertainty is also seen in the small number of studies applying downscaling techniques to assessing precipitation changes.[26] One downscaling study projected annual precipitation changes in the range of –27% to 41% under 3°C of warming.[27] The poor performance of global climate models in consistently projecting precipitation trends has been linked to their poor simulation of the El Niño phenomenon.[28,29]

FIGURE 8. Projected average annual precipitation (mm) for Lao PDR in the period 2080–2099[25]



While considerable uncertainty surrounds projections of local, long-term future precipitation, some global trends are evident. The intensity of sub-daily extreme rainfall events appears to be increasing with temperature, a finding supported by evidence from different regions of Asia and are already documented in Lao PDR.[30] The CCKP model ensemble projects that the average largest 5-day cumulative rainfall could increase from around 135 mm to over 150 mm under RCP6.0 and RCP8.5 emissions pathways, respectively. However, as this phenomenon is highly dependent on localized geographical contexts and has a complex relationship with the ENSO, further research is required to constrain its impact in Lao PDR.

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26 Lacombe, G., Hoanh, C. T., & Smakhtin, V. (2012). Multi-year variability or unidirectional trends? Mapping long-term precipitation and temperature changes in continental Southeast Asia using PRECIS regional climate model. Climatic Change, 113(2), 285–299. URL: https://link.springer.com/article/10.1007%2Fs10584-011-0359-3

27 Shrestha, B., Babel, M.S., Maskey, S., Griensven, A.V., Uhlenbrook, S., Green, A. and Akkharath, I. (2013). Impact of climate change on sediment yield in the Mekong River Basin: a case study of the Nam Ou Basin, Lao PDR. Hydrology and Earth System Sciences, 17(1), pp.1–20. URL: https://www.hydrol-earth-syst-sci.net/17/1/2013/hess-17-1-2013.pdf

28 Yun, K.S., Yeh, S.W. and Ha, K.J. (2016). Inter-El Niño variability in CMIP5 models: Model deficiencies and future changes. Journal of Geophysical Research: Atmospheres, 121, 3894–3906. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2016JD024964

29 Chen, C., Cane, M.A., Wittenberg, A.T. and Chen, D. (2017). ENSO in the CMIP5 simulations: life cycles, diversity, and responses to climate change. Journal of Climate, 30, 775–801. URL: https://journals.ametsoc.org/doi/pdf/10.1175/JCLI-D-15-0901.1

30 Westra, S., Fowler, H. J., Evans, J. P., Alexander, L. V., Berg, P., Johnson, F., Kendon, E. J., Lenderink, G., Roberts, N. (2014). Future changes to the intensity and frequency of short-duration extreme rainfall. Reviews of Geophysics, 52, 522–555. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2014RG000464

Lao PDR faces high disaster risk levels and is ranked 69th out of 191 countries by the 2019 Inform Risk Index[31] (**Table 4**). Lao PDR has extremely high exposure to flooding (ranked 6th), including, riverine and flash flooding. Lao PDR also has some limited exposure to tropical cyclones and their associated hazards (ranked 47th). Drought exposure is lower (ranked 115th) but must be monitored as hydropower development on the Mekong River significantly alters the hydrology of the region. Lao PDR's overall ranking on the INFORM risk index is somewhat exacerbated by its lack of coping capacity and to a lesser extent the vulnerability of its population.

The risks of disaster linked to climate hazards in Lao PDR have been underscored by recent events. In 2011, back-to-back tropical storms affected hundreds of thousands of people and required a significant humanitarian response particularly to address issues of hygiene and sanitation created by flooding and landslides and associated infrastructure damage. Extreme flooding in 2013 affected over 350,000 people, killed thousands of livestock, and damaged 15,000 ha of rice crop as well as core national infrastructure including bridges and schools.[32] In 2015, severe drought, partly driven by a strong El Niño event, damaged tens of thousands of hectares of upland, rice, and fruit crops.[33]

The section which follows analyses climate change influences on the exposure component of risk in Lao PDR. As seen in Figure 1, the ND-GAIN Index presents an overall picture of a country's vulnerability and capacity to improve its resilience. In contrast, the Inform Risk Index identifies specific risks across a country to support decisions on prevention, preparedness, response and a country's overall risk management.

TABLE 4. Selected indicators from the INFORM 2019 Index for Risk Management for Lao PDR. For the sub-categories of risk (e.g. "Flood") higher scores represent greater risks. Conversely the most at-risk country is ranked 1st. Global average scores are shown in brackets

Flood (0–10)	Tropical Cyclone (0–10)	Drought (0–10)	Vulnerability (0–10)	Lack of Coping Capacity (0–10)	Overall Inform Risk Level (0–10)	Rank (1–191)
9.1 [4.5]	3.3 [1.7]	2.4 [3.2]	4.0 [3.6]	5.8 [4.5]	4.5 [3.8]	69

Heatwaves

Lao PDR regularly experiences high temperatures, with an average monthly maximum of around 28°C and an average May maximum of 31°C. The current median probability of a heat wave (defined as a period of three or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature) is around 3%.[34] Thirumalai et al. (2017) suggest that climate change made a 29% contribution to the extreme temperatures

[31] European Commission (2019). INFORM Index for Risk Management. Lao PDR Country Profile. URL: https://drmkc.jrc.ec.europa.eu/inform-index/Countries/Country-Profile-Map

[32] Reliefweb (2013). Lao People's Democratic Republic – Humanitarian Report. URL: https://reliefweb.int/country/lao

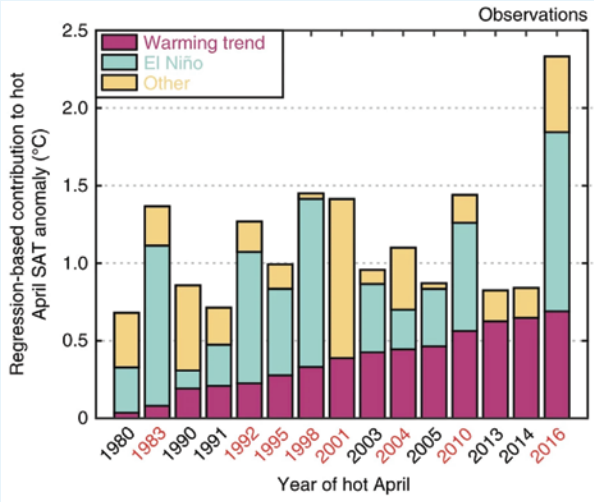
[33] Sutton, W., Srivastava, J., Rosegrant, M., Koo, J., Robertson, R. (2019). Striking a balance: Managing El Niño and La Niña in Lao PDR's Agriculture. World Bank Group. URL: https://openknowledge.worldbank.org/bitstream/handle/10986/31523/Striking-a-Balance-Managing-El-Ni%C3%B1o-and-La-Ni%C3%B1a-in-Myanmar-s-Agriculture.pdf

[34] WBG Climate Change Knowledge Portal (CCKP 2019). Lao PDR. Climate Data. Projections. URL: https://climatedata.worldbank.org/CRMePortal/web/water/land-use-/-watershed-management?country=LAO&period=2080-2099

experienced across Southeast Asia in April 2016, while ENSO contributed 49%.[16] The influence of global warming on extreme temperatures has been growing (**Figure 9**), while the contribution of climate change through its impact on the ENSO process is poorly understood.

The CCKP model ensemble projects significant increases in the annual probability of a heat wave under the different emissions pathways (**Figure 10**). General warming and increased climate variability are both almost certain to increase the probability of heatwaves compared with the historical baseline (1986–2005). Simultaneously, the general increase in temperatures also suggests a transition to a chronically heat stressed environment, with an increase in the number of days in which temperatures breach 35°C moving from approximately 40 days to 50–110 days depending on emissions pathway and climate model.

FIGURE 9. Observations: The relative contribution of El Niño (green bars) versus the long-term warming trend (red bars) towards the 15 hottest April SATs (>80th percentile) in the GISTEMP record of Mainland Southeast Asia (MSA; 1940–2016) using a regression model. The residual of the observed anomaly and the regression fit is termed as 'other' variability (yellow bars). The years in red on the x-axis indicate the eight hottest extreme April events (>90th percentile)[35]



Drought

Two primary types of drought may affect Lao PDR, meteorological (usually associated with a precipitation deficit) and hydrological (usually associated with a deficit in surface and subsurface water flow, potentially originating in the region's wider river basins). At present, Lao PDR faces an annual median probability of severe meteorological drought of around 4%, as defined by a standardized precipitation evaporation index (SPEI) of less than –2.[25] Naumann et al. (2018) provide a global overview of changes in drought conditions under different warming scenarios.[36] Projections for Southeast Asia suggest that the return periods of 12-month droughts could reduce. This trend is less significant under lower levels of global warming, but once warming reaches 2–3°C, events that presently occur only once in every hundred years may return at frequencies greater than once in every fifty years.

[35] Thirumalai, K., DiNezio, P. N., Okumura, Y., & Deser, C. (2017). Extreme temperatures in Southeast Asia caused by El Niño and worsened by global warming. Nature Communications, 8, 15531. P. 6, a. URL: https://www.nature.com/articles/ncomms15531.pdf

[36] Naumann, G., Alfieri, L., Wyser, K., Mentaschi, L., Betts, R. A., Carrao, H., . . . Feyen, L. (2018). Global Changes in Drought Conditions Under Different Levels of Warming. Geophysical Research Letters, 45(7), 3285–3296. URL: https://agupubs.onlinelibrary.wiley.com/doi/epdf/10.1002/2017GL076521

The projections of the CCKP model ensemble on meteorological drought hold some uncertainty, but generally point towards an increased annual likelihood of drought (**Figure 11**). The rise in drought probability appears not to correlate with emissions in a linear fashion. Overall, it is likely that future drought patterns will depend on the influence of climate change on monsoon and ENSO patterns.[37] However, further research is required to constrain this impact.

FIGURE 10. Projected change in the probability of observing a heat wave in Lao PDR for the period 2080–2099. A 'Heat Wave' is defined as a period of 3 or more days where the daily temperature is above the long-term 95th percentile of daily mean temperature[25]

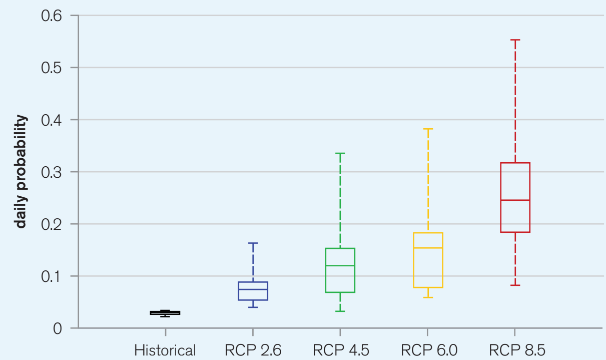
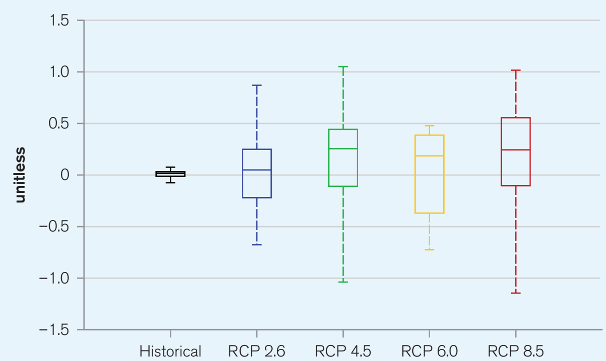


FIGURE 11. Annual probability of experiencing a 'severe drought' in Lao PDR (–2 SPEI index) in 2080–2099 under four emissions pathways[25]



Flood

The World Resources Institute's AQUEDUCT Global Flood Analyzer can be used to establish a baseline level of river flood exposure.[38] As of 2010, assuming protection for up to a 1 in 25-year event, the population annually affected by flooding in Lao PDR is estimated at 48,000 people and the expected annual damages is $159 million. Increasing urbanization and economic development and climate change are both likely to increase these figures. Climate change is expected to increase the affected population by 40,000 people and the damages by $295 million, under the RCP8.5 emissions pathway by the 2030s (AQUEDUCT Scenario B).

Paltan et al. (2018) demonstrate that even under lower emissions pathways coherent with the Paris Climate Agreement, almost all Asian countries face an increase in the frequency of extreme river flows.[39] What would historically have been a 1 in 100-year flow, could become a 1 in 50-year or 1 in 25-year event in most of South, Southeast, and East Asia. There is good agreement among models on this trend and the increased potential for major disaster level events requires adaptation attention. In conjunction, the model ensemble projects an increase of up to 23% under the highest emissions pathway in the amount of rainfall accumulated during extreme rainfall events. This phenomenon may

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37 Adamson, P. and Bird, J. (2010). The Mekong: a drought-prone tropical environment? International Journal of Water Resources Development, 26(4), pp.579–594. URL: https://www.tandfonline.com/doi/abs/10.1080/07900627.2010.519632

38 WRI (2018). AQUEDUCT Gobal Flood Analyzer. URL: https://floods.wri.org/# [Accessed: 22/11/2018].

39 Paltan, H., Allen, M., Haustein, K., Fuldauer, L., & Dadson, S. (2018). Global implications of 1.5°C and 2°C warmer worlds on extreme river flows Global implications of 1.5°C and 2°C warmer worlds on extreme river flows. Environmental Research Letters, 13. URL: https://doi.org/10.1088/1748-9326/aad985.

increase the risk of flash or surface flooding, and associated issues such as landslide. Further research is required to map spatial and temporal landslide risk under climate change. A particular issue in Lao PDR is the vulnerability of critical infrastructure, including schools, health centers, and trunk roads, with disaster response and recovery often hampered by damage resulting from floods and landslides.

CLIMATE CHANGE IMPACTS

Natural Resources

Water

Lao PDR is a water rich country, benefitting from the water resources of the Mekong River tributaries and many smaller water bodies. The Mekong River tributaries are highly important for the country as they contribute greatly to national macroeconomic development and the livelihoods of local communities. While water demand remains low in terms of per-capita public consumption, in recent years, water resources have gained greater prominence due to the increasing role of hydropower and irrigation systems. Damming of the Mekong River is underway and is expected to impact the hydrological profile and biodiversity of the river.[40] These changes are expected to have a much larger impact on the hydrology of the Mekong River Basin than projected climate change trends. However, climate change, and particularly changes to peak flows, may still have complex implications for water resources management challenges in the region, for example, by altering processes of sediment erosion and deposition.[41]

The total annual water flow in Lao PDR is estimated at 270 billion meters^3 – equivalent to 35% of the average annual flow of the entire Mekong River Basin. The monthly distribution of the flow of the rivers in the country closely follows the pattern of rainfall with about 80% received during the rainy season (May-October) and 20% in the dry season (mid-October to April).[42] The internal renewable surface water resources equate to 190.42 km^3 per year, while groundwater resources are an estimated 38 km^3 per year, all forming the base flow of the rivers.[43] Total renewable water resources are an estimated 333.55 km^3 annually, which is equal to the total flow out of the country. As of 2007, less than 2% of this was exploited, but development of new resources has been taking place rapidly in recent years.

[40] Lauri, H., de Moel, H., Ward, P. J., Rasanen, T. A., Keskinen, M., & Kummu, M. (2012). Future changes in Mekong River hydrology: impact of climate change and reservoir operation on discharge. Hydrology and Earth System Sciences, 16(12). URL: https://www.hydrol-earth-syst-sci.net/16/4603/2012/hess-16-4603-2012.pdf

[41] Shrestha, B., Babel, M. S., Maskey, S., van Griensven, A., Uhlenbrook, S., Green, A., & Akkharath, I. (2013). Impact of climate change on sediment yield in the Mekong River Basin: a case study of the Nam Ou Basin, Lao PDR. Hydrol. Earth Syst. Sci., 17(1), 1–20. URL: https://www.hydrol-earth-syst-sci.net/17/1/2013/hess-17-1-2013.pdf

[42] WEPA (2016). State of Water Environmental Issues – Lao PDR. URL: http://www.wepa-db.net/policies/state/laos/overview.htm

[43] The internal renewable surface water resource is the difference between the outflow and the inflow to the country.

Drought may also increase as a risk as national water resource development continues to be a mix of opportunities and challenges.[44] In this context, the strengthening of an Integrated Water Resource Management (IWRM) framework could be essential to support the broader goals and strategies of inclusive economic development.[45] To further strengthen IWRM, the Ministry of Natural Resources and Environment (MONRE) has developed a five-year Natural Resources and Environment Strategy 2025 (NRES). Overall, the strategy emphasizes green economic growth to ensure sustainable resilient development. To achieve the targets set in the five-year action plan, MONRE has compiled seven priority programs of which one is focused on water resources.[46]

Forestry and Land Use Change

The forestry sector contributes to both the national economy and the livelihoods of Lao people. Lao PDR's forests consist of a set of different forest types. There are subtropical montane forest areas in the north, lowland semi-evergreen dipterocarp forest on the Mekong River Plain, and dry dipterocarp forest in the southern area.[47] The ecosystem services provided by forests have been noted as particularly important to poorer smallholder farmers. In addition, forests provide resilience to the high inter-annual variability in success of rain-fed agriculture by diversifying incomes.[48]

The World Bank Group's Country Partnership Strategy Progress Report with Lao PDR recognized that the country's forests continue to be exploited in unsustainable ways, particularly through both poorly managed legal and illegal logging. Another barrier towards sustainable forestry is the culture of deforestation, which compromises the long-term sustainability of the landscape and the livelihoods of rural communities, especially in the context of climate change impacts.[49] Furthermore, recent years have seen rapid expansion of rubber monocultures and associated declines in farmer income diversification.[50] This is an example of a transition which reduces resilience to climate and other shocks[51] as well as degrading the biodiversity of the ecosystem.

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44 Matthews, N. (2012). Water grabbing in the Mekong Basin - An analysis of the winners and losers of Thailand's hydropower development in Lao PDR. Water Alternatives, 5(2), 392–411. URL: https://pdfs.semanticscholar.org/b5d0/9e75175b5b4c84a8d4eaa16fd7479542cadf.pdf

45 UNDP (2015). Natural resources sector reviews future goals. URL: http://www.la.undp.org/content/lao_pdr/en/home/presscenter/pressreleases/2015/11/10/natural-resources-sector-reviews-future-goals.html.

46 Global Water Partnership (2016). Lao WP Review of Water Resource Strategy towards 2025. URL: http://www.gwp.org/en/GWP-South-East-Asia/GWP-C-IN-ACTION/News-and-Activities/review-of-water-resource-strategy-implementation-and-integration-in-the-national-natural-resources-and-environment-strategy-towards-2025/.

47 FAO (2010). Global Forest Resources Assessment 2010. URL: http://www.fao.org/3/al547E/al547E.pdf.

48 Russell, A., Foppes, J., Behr, D., Ketphanh, S., Rafanoharana, S. (2015). How Forests Enhance Resilience to Climate Change: The Case of Smallholder Agriculture in Lao PDR. Washington DC: Program on Forests (PROFOR). URL: https://www.profor.info/sites/profor.info/files/How%20Forests%20Enhance%20Resilence%20To%20Climate%20Change%20Case%20Studies%20from%20Burkina%20Faso%2C%20Honduras%20and%20Lao%20PDR_0.pdf

49 IDA (2014). Lao People's Democratic Republic - Country Partnership Strategy Progress Report for the period FY 12–16. URL: http://documents.worldbank.org/curated/en/644931468088478994/pdf/902810CASP0P14060Box385331B00OUO090.pdf

50 Fox J., Castella Jean-Christophe, Ziegler A.D., W. S. B. (2014). Expansion of rubber mono-cropping and its implications for the resilience of ecosystems in the face of climate change in Montane Mainland Southeast Asia. In Trends and directions of land change sciences towards regional and global sustainability. Global Environmental Research. URL: http://horizon.documentation.ird.fr/exl-doc/pleins_textes/divers16-05/010067174.pdf

51 Brown, P. R., Afroz, S., Chialue, L., Chiranjeevi, T., El, S., Grünbühel, C. M., . . . Williams, L. J. (2018). Constraints to the capacity of smallholder farming households to adapt to climate change in South and Southeast Asia. Climate and Development, 0(0), 1–18. URL: https://www.tandfonline.com/doi/abs/10.1080/17565529.2018.1442798

Actions to adapt to potential climate change impacts appear necessary in order to protect ecosystem integrity and the productivity of Lao PDR's forest resources, especially given the decline in forest area over past years. Some examples of the policies and practices include: i) incorporating concerns of climate change trends in long-term forest policymaking and forest management practices; ii) expanding protected areas and linking them wherever possible to promote natural migration; iii) promoting mixed species forestry to reduce vulnerability; iv) undertaking anticipatory planting and assisting natural migration through transplanting plant species; v) promoting in situ and ex-situ gene pool conservation; and vi) strengthening forest fire prevention and management.[52]

Economic Sectors

Tourism

Over the first two decades of the 21st century, tourism has developed as an integral part of Lao PDRs' economy. In 2017, the government estimated that incoming international tourists created revenue of around $700 million, equivalent to just over 4% of GDP.[53] However, as the sector has emerged, questions have arisen regarding how to foster pro-poor development[54] as well as how to preserve cultural[55] and ecological heritage.[56] The risks presented by climate change trends to the tourism sector in Lao PDR are not well studied. Areas for examination include the compounding effect of tourism and climate on biodiversity and wildlife abundance, and on poverty reduction. There is also a need for further research and potentially risk reduction efforts on the issue of extreme heat and tourism. Past research conducted on a global level, and in other regions, has pointed towards a potential increase in the attractiveness of tourist destinations in higher latitudes, and a decline in the attractiveness of heat stressed nations, of which Lao PDR may become one.[57]

Agriculture

Climate change could influence food production via direct and indirect effects on crop growth processes. Direct effects include alterations to carbon dioxide availability, precipitation patterns and temperatures. Indirect effects include impacts on water resource availability and seasonality, soil organic matter transformation, soil erosion, changes in pest and disease profiles, the arrival of invasive species, and decline in arable areas due to flooding or desertification. On an international level, these impacts are expected to damage key staple crop yields, even on

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[52] World Bank (2010). Recommendations identified by the Government of Lao PDR in its 2010 Strategy on Climate Change of the Lao PDR. URL: http://www.lse.ac.uk/GranthamInstitute/wp-content/uploads/laws/4266.pdf [accessed: 05/07/2019].

[53] Ministry of Information, Culture and Tourism (2018). Statistical report on Tourism in Laos 2017. URL: http://www.tourismlaos.org/files/files/Statistical%20Report%20on%20Tourism%20in%20Laos/2017%20Statistical%20Report%20on%20tourism%20in%20Laos.pdf [accessed: 05/07/2019].

[54] Suntikul, W., Bauer, T. and Song, H. (2009). Pro-poor tourism development in Viengxay, Laos: Current state and future prospects. Asia pacific journal of tourism research, 14(2), pp.153–168. URL: https://www.tandfonline.com/doi/abs/10.1080/10941660902847203

[55] Reeves, K. and Long, C. (2011). Unbearable pressures on paradise? Tourism and heritage management in Luang Prabang, a World heritage site. Critical Asian Studies, 43(1), pp.3–22. URL: https://www.tandfonline.com/doi/abs/10.1080/14672715.2011.537849

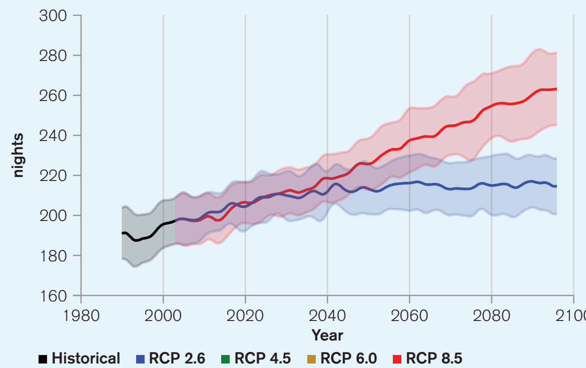
[56] Eshoo, P.F., Johnson, A., Duangdala, S. and Hansel, T. (2018). Design, monitoring and evaluation of a direct payments approach for an ecotourism strategy to reduce illegal hunting and trade of wildlife in Lao PDR. PloS one, 13(2), p.e0186133. URL: https://journals.plos.org/plosone/article/file?id=10.1371/journal.pone.0186133&type=printable

[57] Rosselló-Nadal, J. (2014). How to evaluate the effects of climate change on tourism. Tourism Management, 42, 334–340. URL: https://www.sciencedirect.com/science/article/abs/pii/S0261517713002045

lower emissions pathways. Tebaldi and Lobell (2018) estimate 5% and 6% declines in global wheat and maize yields, respectively, even if the Paris Climate Agreement is met and warming is limited to 1.5°C.[58] Shifts in the optimal and viable spatial ranges of certain crops are also inevitable, though the extent and speed of those shifts remains dependent on the emissions pathway.

Most of the agricultural area in Lao PDR is dedicated to paddy rice production, but with a growing proportion for maize. Rice remains a staple of household food security in Lao PDR and a number of studies have suggested that there are some potential benefits of climate change in terms of net primary productivity of rice plants.[48] However, the overall outlook for rice production is uncertain. Changes in the onset, duration and intensity of the rainy season, increased drought frequency, and increased incidence of heatwave, if coinciding with key phases towards the start and end of the cropping cycle, may have strong negative implications for total rice production, as well as its reliability as a source of income and calories.[59] Rice is particularly vulnerable to elevated night-time minimum temperatures.[60] As shown in **Table 2,** minimum temperatures are expected to rise much faster than average temperatures in Lao PDR. One study has suggested that the influence of climate change on temperature and rainfall patterns could depress local rice yields by around 5–20% by the 2040s, with losses typically larger on higher emissions pathways.[61] Adaptations have been identified which may somewhat alleviate these risks,[59] but financial and technical barriers may prevent uptake by the poorest and most vulnerable smallholders. **Figure 12** shows Lao PDR's nighttime temperatures are reflected through the number of nights in which temperatures are greater than 20°C.

FIGURE 12. Number of nights nighttime temperatures (T-min > 20°C) in Lao PDR through the end of the century for RCP2.6 (blue) and RCP8.5 (red) emissions pathways



A further influence from climate change on agricultural production is through its impact on the health and productivity of the labor force. Dunne et al. (2013) suggest that global labor productivity during peak months has already dropped by 10% as a result of warming, and that a decline of up to 20% might be expected by mid-century under the highest emissions pathway (RCP8.5).[62] In combination, it is highly likely that the above processes will have a considerable impact on national food consumption patterns both through direct impacts on internal agricultural operations, and through impacts on the global supply chain.

[58] Tebaldi, C., & Lobell, D. (2018). Differences, or lack thereof, in wheat and maize yields under three low-warming scenarios. Environmental Research Letters: 13: 065001. URL: https://iopscience.iop.org/article/10.1088/1748-9326/aaba48/pdf

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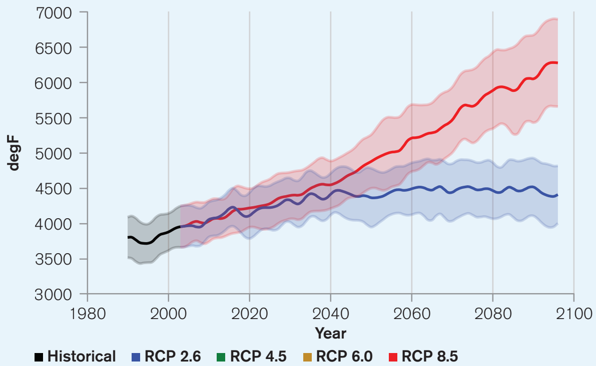
Urban

Research has established a reasonably well constrained relationship between heat stress and labor productivity, household consumption patterns, and (by proxy) household living standards.[63] In general, the impact of an increase in temperature on these indicators depends on whether the temperature rise moves the ambient temperature closer to, or further away from, the optimum temperature range. The optimum range can vary depending on local conditions and adaptations but in Lao PDR, temperature rises are almost certain to move temperatures further away from optimal levels.

While Lao PDR is experiencing rapid urbanization (**Table 1**), without adequate planning, the effects of temperature rise and heat stress in urban areas are likely to be compounded by the phenomenon of the Urban Heat Island (UHI) effect. Dark surfaces, residential and industrial sources of heat, an absence of vegetation, and air pollution[64] can push temperatures higher than those of the rural surroundings, commonly anywhere in the range of 0.1°C–3°C in global mega-cities.[65] As well as impacting on human health (see Communities) the temperature peaks that could result from combined UHI and climate change, as well as future urban expansion, are likely to damage the productivity of the service sector economy, both through direct impacts on labor productivity, but also through the additional costs of adaptation.

Research suggests that on average, a one degree increase in ambient temperature can result in a 0.5%–8.5% increase in electricity demand.[66] Notably, this serves business and residential air-conditioning systems, which are needed to meet additional cooling requirements (**Figure 13**). This increase in demand places strain on energy generation systems which is compounded by the heat stress on the energy generation system itself, commonly due to its own cooling requirements, which can reduce its efficiency.[67] Many of Lao PDR's poorer residents will not be able to afford such adaptive measures, and without support may face health risks and productivity losses. Given the increasing potential for hazards such as fluvial and flash flooding and landslides, a key factor determining

FIGURE 13. Historic and projected annual cooling degree days in Lao PDR, calculated by taking the sum of daily T – 18.3°C for two emissions pathways, RCP2.6 (Blue) and RCP8.5 (Red), showing the model ensemble median estimate and the 10th and 90th percentiles[25]



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climate impacts on urban areas will be spatial planning and other disaster risk reduction measures. A common feature of urban expansion in Asia has been to concentrate large populations of poorer communities in hazard prone areas. Effective management of this risk in the context of rapid population growth and urban migration in Lao PDR is needed to address urban climate change risks.

Communities

Poverty and Inequality

Inequalities have been widening in Lao PDR since the turn of the 21st century.[68] The Gini coefficient increased from 36 in 2012/2012 to 38.8 in 2018/2019.[69] The growth in inequality in Lao PDR is in effect slowing progress in tackling poverty, which although decreasing from 46% since 1992/1993 remains high at 18.3% in 2018/2019.[70] Climate change is very likely to present a further challenge to progress. Many of the climate changes projected are likely to disproportionately affect the poorest groups in society. Flooding and extreme heat stand out as key threats, as heavy manual labor jobs are commonly among the lowest paid whilst also being most at risk of productivity losses due to heat stress.[70] Poorer businesses are least able to afford air conditioning, an increasing need given the projected increase in cooling days. Poorer farmers and communities are least able to afford disaster insurance, local water storage, irrigation infrastructure, and technologies for adaptation.

ADB has highlighted that many households in Lao PDR have a high probability of falling into extreme poverty even when exposed to relatively high frequency flood and drought events.[71] For example, an event occurring once in every five years, has approximately a 50% chance of pushing a household into extreme poverty (**Figure 14**). This highlights the precarious nature of life in Lao PDR for many households under current conditions. While many households will not have the same level of exposure, climate change threatens to enhance and expand exposure through its impacts on extreme events, notably flooding and extreme temperatures. In addition, UNISDR estimates average annual losses from disaster at around 1–2% of GDP, most of which is due to flooding.[72] However, in a country where even modest hazard intensities can have significant wellbeing impacts on local communities, it is very likely that this figure underestimates the true scale of climate-related hazards. Issues such as landslide and flash flooding in remote areas are likely to be under-reported. Notably, the transport network in Lao PDR, and the communities dependent on it, are known to be vulnerable to landslide damage. Past work has also shown the high economic impact associated with landslide damage to transport infrastructure.[73]

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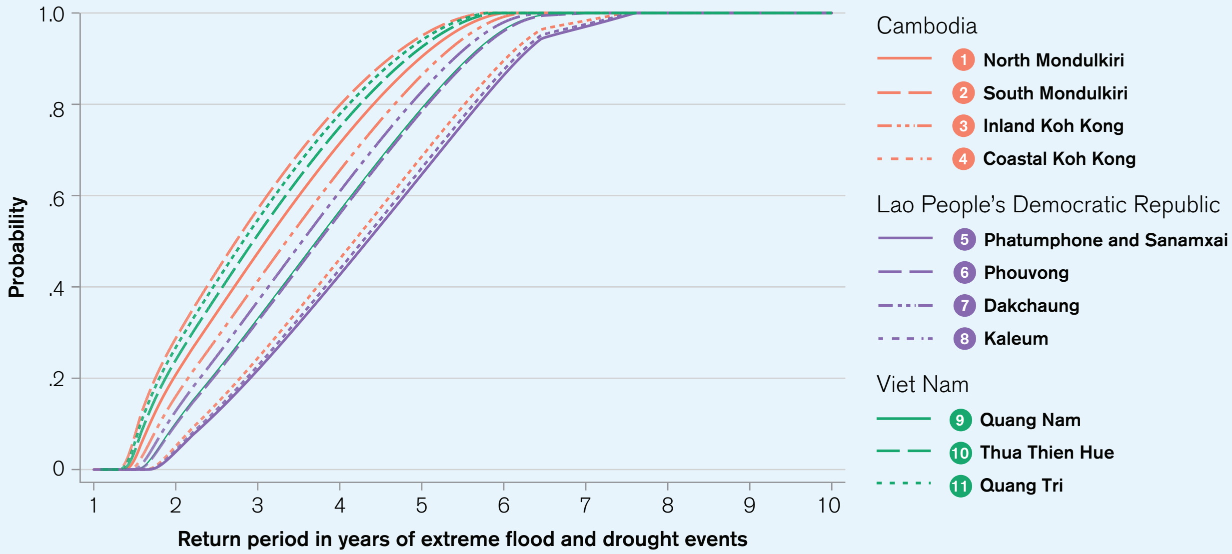
FIGURE 14. Probability of falling into extreme poverty by return period of combined flood and drought events (data from Cambodia, Vietnam and Lao PDR from ADB, 2017b)[74]



Gender

An increasing body of research has shown that climate-related disasters have impacted human populations in many areas including agricultural production, food security, water management and public health. The level of impacts and coping strategies of populations depends heavily on their socio-economic status, socio-cultural norms, access to resources, poverty as well as gender. Research has also provided more evidence that the effects are not gender neutral, as women and children are among the highest risk groups. Key factors that account for the differences between women's and men's vulnerability to climate change risks include: gender-based differences in time use; access to assets and credit, treatment by formal institutions, which can constrain women's opportunities, limited access to policy discussions and decision making, and a lack of sex-disaggregated data for policy change.[75]

[74] ADB (2017b). Risk financing for rural climate resilience in the Greater Mekong Subregion. Greater Mekong Subregion Core Environment Program. Asian Development Bank. P. 30,d. URL: https://www.adb.org/sites/default/files/publication/306796/risk-financing-rural-climate-resilience-gms.pdf

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Human Health

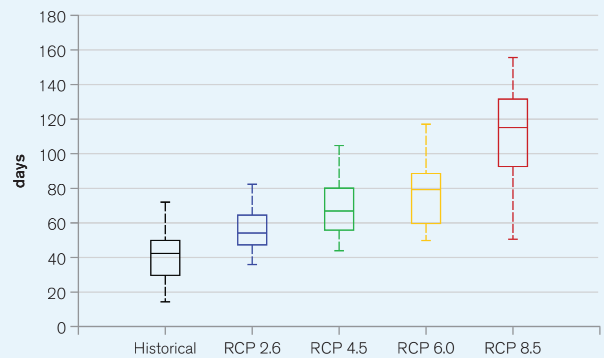
Nutrition

The World Food Program estimates that without adaptation, the risk of hunger and child malnutrition on a global scale could both increase by 20% by mid-century.[76] Springmann et al. (2016) assessed the potential for excess climate-related deaths associated with malnutrition.[77] The authors identify two key risk factors that are expected to be the primary drivers: a lack of fruits and vegetables in diets, and health complications caused by increasing prevalence of people underweight. The authors' projections suggest there could be approximately 53.8 climate-related deaths per million population linked to lack of food availability in Lao PDR by the 2050s under emissions pathway RCP8.5.

Heat-Related Mortality

Research has placed a threshold of 35°C (wet bulb ambient air temperature) on the human body's ability to regulate temperature, beyond which even a very short period of exposure can present risk of serious ill-health and death.[78] Temperatures significantly lower than the 35°C threshold of 'survivability' can still represent a major threat to human health. Climate change is expected to push global temperatures closer to this 'danger zone' both through slow onset warming and intensified heat waves. As shown in **Figure 15**, the number of days during which ambient temperatures exceed 35°C is projected to increase considerably under all emissions pathways. Honda et al. (2014) used the A1B emissions scenario from CMIP3 (most comparable to RCP6.0) to estimate that without adaptation, annual heat-related deaths in the South-Eastern Asian region, could increase 295% by 2030 and 691% by 2050.[79] The potential reduction in heat-related deaths achievable by pursuing lower emissions pathways is significant, as demonstrated by Mitchell et al. (2018).[80]

FIGURE 15. Historical (1986–2005) and projected (2080–2099) number of days per year with temperatures exceeding 35°C under four emissions pathways[25]



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Disease

The WHO highlights that climate change threatens to stall progress in reducing disease risk in Lao PDR. Malaria is a particular threat for the country, and an increase in the population at risk of around 400,000 is projected when moving from RCP2.6 to RCP8.5 by the 2040s and 2070s, respectively.[81] Similarly, the vectoral capacity for dengue fever increases under both emissions pathways, but by slightly less under RCP2.6 as compared to RCP8.5. Projections suggest an increase in the population affected by flooding, which also raises the risk of the spread of water-borne diseases. Leptospirosis is among several diseases linked to flooding in Lao PDR.[82] Global research has also linked both drought and flood to increased incidence of diarrheal disease.[83] As of 2016, diarrheal disease was responsible for 11% of all under-5 deaths in Lao PDR.[84]

POLICIES AND PROGRAMS

National Adaptation Policies and Strategies

TABLE 5. Key national adaptation policies, strategies, and plans

Policy/Strategy/Plan	Status	Document Access
Climate Change Law	Enacted	2019
Climate Change Decree	Promulgated	2019
Technology Needs Assessment (TNA)	Completed	November, 2017
Nationally Determined Contribution To Paris Climate Agreement (NDC)	Submitted	September, 2015
Plan of Action for Disaster Risk Reduction and Management in Agriculture (2014–2016)	Enacted	February, 2014
National Communications to the UNFCCC	Two submitted	Latest: June, 2013
National Adaptation Program of Action to Climate Change (NAPA)	Enacted	April, 2009

Climate Change Priorities of ADB and the WBG

ADB Country Partnership Strategy

ADB's Country Partnership Strategy (CPS) with Lao PDR, covers the period 2017–2020. The third of three strategic priorities of the CPS is identified as *sustainable natural resource management and climate resilience*. Under this priority the partnership aims to support sustainable natural resource management and climate resilience, which will underpin the country's green growth efforts and enhance returns of its natural capital. Lao PDR's Nationally

[81] WHO (2015). Climate and Health Country Profile: Lao People's Democratic Republic. World Health Organization. Geneva. URL: https://apps.who.int/iris/bitstream/handle/10665/246139/WHO-FWC-PHE-EPE-15.39-eng.pdf?sequence=1&isAllowed=y.

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Determined Contributions outline climate change mitigation and adaptation actions in agriculture, forestry and land use, water resources, energy, transport, urban development, and public health. These have been selectively incorporated in ADB operations. Disaster risk management have also been incorporated in ADB operations as appropriate. The CPS Strategic Priority 3 will help the government achieve SDGs 12, 13, and 15.

Additionally, ADB projects will improve watershed conservation by supporting better land use management and good agricultural practices. ADB projects and support will strengthen climate resilience through the preservation of fisheries, land tenure, land planning, water quality management, ecosystem conservation, climate-resilient agricultural practices, and farm waste management. Support will also help the government prepare a disaster risk management and climate change law. Lao PDR's next CPS, 2022–2025 is currently under development.

WBG Country Partnership Framework

The WBG's Country Partnership Framework (CPF) with Lao PDR, covers the period 2017–2021 and the third of three focus areas of the CPF focuses on environmental protection. The National Strategy on Climate Change will support Lao PDR's green growth development path. This will ensure the protection of the environment and responsible management of natural resources will be aligned and supported through the ongoing Second Lao Environment and Social (LENS2) Project and the Landscapes and Livelihoods (LLL) Project. Lao PDR targets an increase in forest cover to 70% and envisions the sustainable management of its forest resources. Through scale-up of the Participatory Sustainable Forest Management Project, financed in part by the Forest Investment Program (FIP), works through the Ministry of Agriculture and Forestry will be able to support the sustainable management of approximately 40 production forests and over 900 villages in sustainable livelihoods aimed at climate change mitigation. Support is also being provided through the ongoing Mekong Integrated Water Resources Management (MIWRM) program to provide needed support to key riparian areas of the Mekong River Basin, and its tributaries through the Mekong River Commission. This will support and ensure the capacity to manage the river basins across multiple sectors including the hydropower sector as well as better integrate water management factors in planning, design, and operations. In the context of the NDC Partnership, the WBG supports the government to integrate NDC objectives and green growth strategies into the National Social and Economic Development Plan (NSEDP), strengthen the government's capacity in NDC implementation and mainstream climate change into the sectoral policies and budgeting and planning processes. The WBG will also support the government's goal to achieve green growth through enhancing the country's resilience towards natural hazards and financing will be provided to help reduce the risk of flooding and enhance disaster risk financing capacity of Lao PDR.

CLIMATE RISK COUNTRY PROFILE

LAO PDR

WORLD BANK GROUP

ADB ASIAN DEVELOPMENT BANK