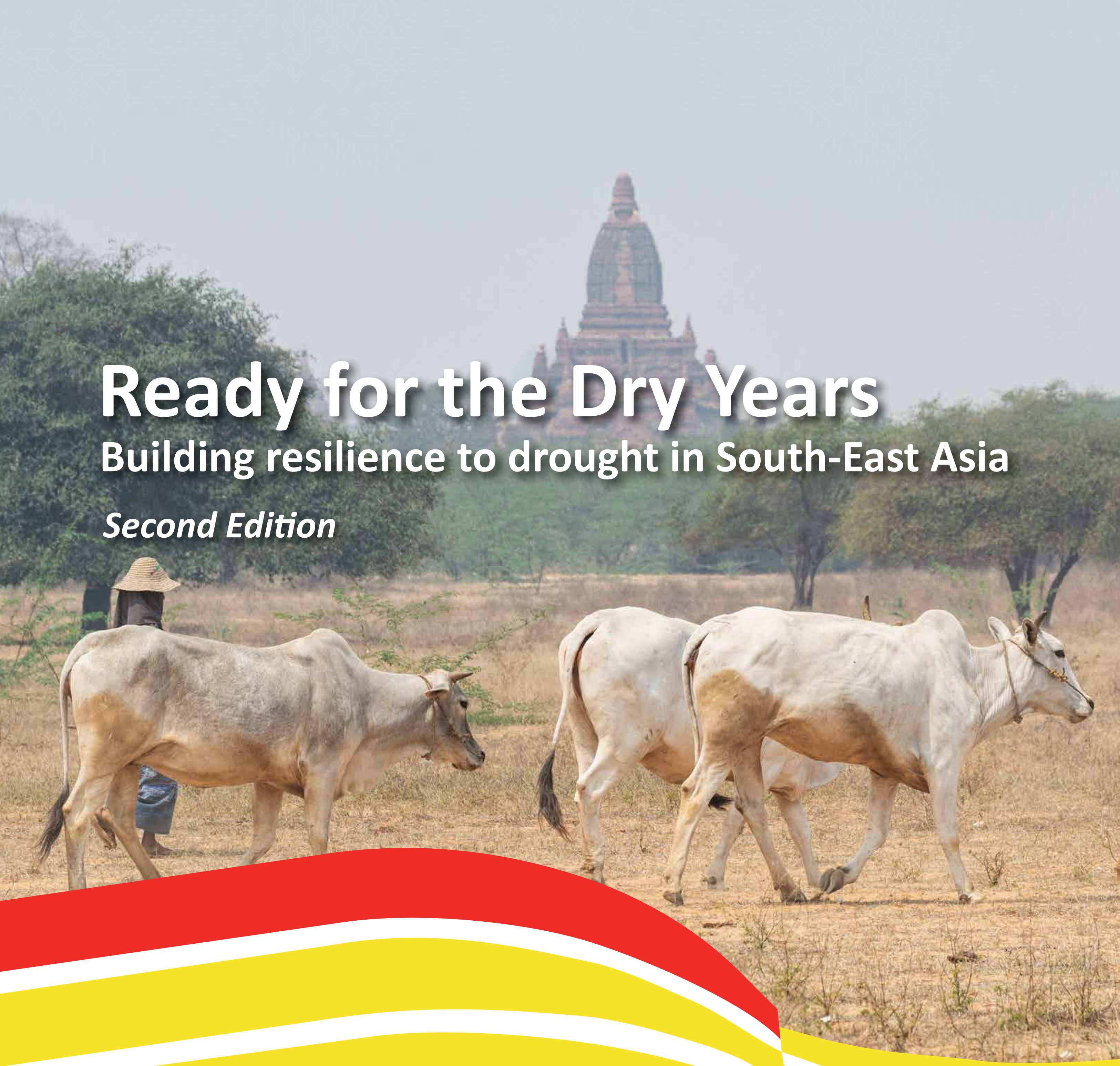

Ready for the Dry Years

Building resilience to drought in South-East Asia

Second Edition

UNITED NATIONS ESCAP

Economic and Social Commission for Asia and the Pacific

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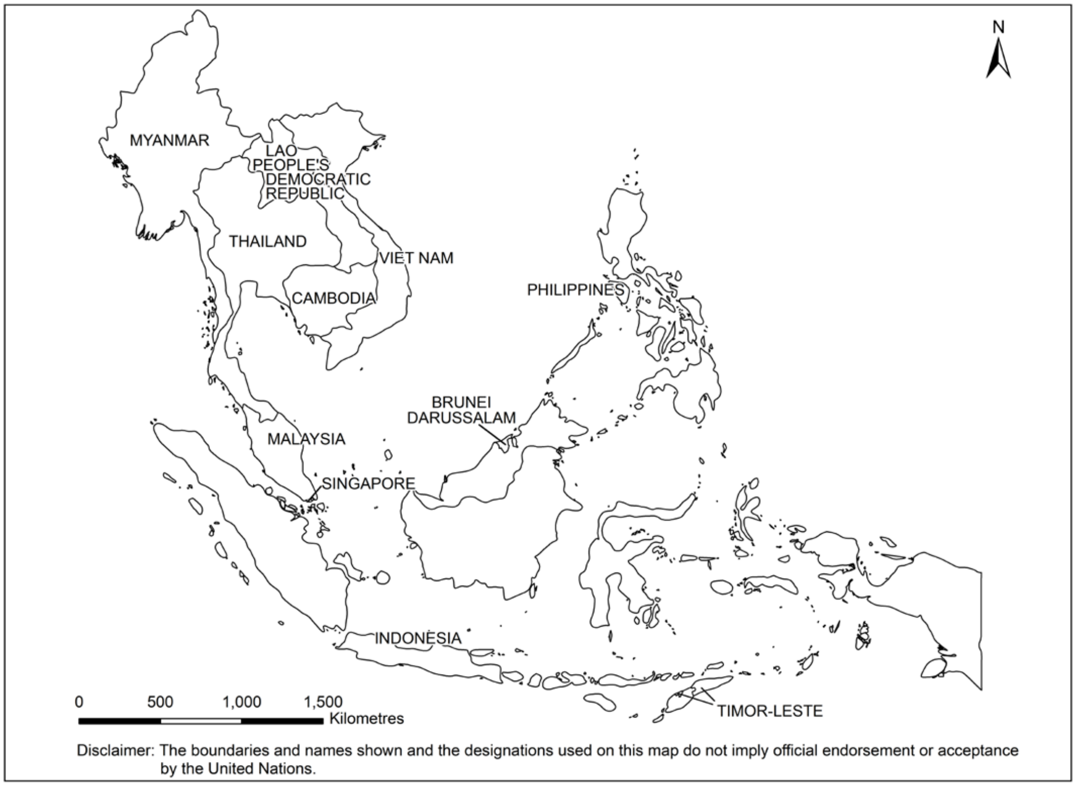

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Ready for the Dry Years

Building resilience to drought in South-East Asia

Second Edition

Armida Salsiah Alisjahbana
Under-Secretary-General of the United Nations and Executive Secretary of ESCAP

Dato Lim Jock Hoi
Secretary-General of the Association of Southeast Asian Nations

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About the cover
A herd of cattle walk through a dry field in Myanmar.

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Forewords

The ever-present threat of drought, with devastating impacts across the South-East Asia region, is a hallmark of the climate crisis. This second edition of *Ready for the Dry Years* analyses in greater detail just how and where droughts happen. It maps recurrent hotspots across South-East Asia, where drought hits hardest at the region's most vulnerable people, especially rural communities and farmers.

Drought is not an isolated event; it is just one of many other pressures on the lives and livelihoods of these communities. With different intensities and time duration, these events can undermine national development efforts. The COVID-19 pandemic is not only threatening people's health but also slowing down drought response and recovery, essentially diverting government's scarce resources to other emergency socioeconomic priorities.

Yet, droughts can often be predicted as they tend to creep up slowly and repeat. Governments can take risk-informed measures to strengthen societal resilience so that populations, sectors and key institutions have the capacity to adapt. The best way to protect people in pandemics, droughts or other disasters, is not just to offer emergency aid but to also help people become more sustainably resilient. For droughts, there is more time for proactive measures. At the country level, solution-oriented policy measures should be adapted within a national comprehensive strategy framework.

The Report highlights the truly regional nature of drought; many of the impacts are transboundary, and no country is spared. It further suggests three tracks for transformation: reduce and prevent, prepare and respond, and restore and recover. The Report shows that these policy measures will not only safeguard hard-won development gains but will also bring many positive environmental co-benefits. It also provides a framework for policymakers to take actions through regional cooperation on drought management.

Through our strengthened engagement and strategic partnership, both ESCAP and ASEAN can mobilize rapid and large-scale collaboration amongst member States, development partners, stakeholders and relevant sectoral bodies to tackle a common and shared transboundary challenge. My hope is that the Report's policy recommendations will help provide the evidence base for the *ASEAN Declaration on the Strengthening of Adaptation to Drought* and the subsequent *Regional Plan of Action.*

Armida Salsiah Alisjahbana

Under-Secretary-General of the United Nations
and Executive Secretary of ESCAP

Throughout much of South-East Asia, drought is becoming the norm rather than the exception. As this trend is projected to worsen over the coming years, the prospect of severe dry conditions threatens the rich biodiversity of the region and the well-being of millions of people. Taking into consideration that communities with low levels of socioeconomic development tend to be more vulnerable to the consequences of drought, we must make every effort to ensure that these groups are protected and that no one is left behind.

In response to this challenge, a holistic approach to understanding the impact of drought is needed, by examining the issue from socioeconomic, health, environmental, and humanitarian perspectives. The second edition of the *Ready for the Dry Years* adopts this approach. Expanding on the findings of the first edition, this Report provides a more extensive analysis, particularly in identifying vulnerability hotspots and policy tracks for countries seeking to shift from response to adaptation.

I encourage relevant stakeholders to consider the Report's recommendations in developing the *ASEAN Declaration on the Strengthening of Adaptation to Drought* and the subsequent *Regional Plan of Action*. It is also important that strategic measures and priority actions identified in the Report are incorporated in the development of the new *ASEAN Agreement on Disaster Management and Emergency Response* (AADMER) Work Programme 2021- 2025. This includes strengthening of drought forecasting, monitoring and early warning systems.

This Report represents another successful collaboration between United Nations ESCAP and ASEAN. Drought resilience features as an integral part of the *ASEAN Vision on Disaster Management 2025 and the United Nations 2030 Agenda for Sustainable Development*. Pursuing more of these complementarities is crucial to the region's progress in achieving the Sustainable Development Goals (SDGs), especially amidst a pandemic.

Combatting COVID-19 has underscored the urgency of promoting cross-sectoral cooperation in managing transboundary challenges. I hope the same sense of urgency is channelled in our efforts in mitigating the impact of drought in the region as we work towards building a more resilient ASEAN Community.

Dato Lim Jock Hoi

Secretary-General of the Association of Southeast Asian Nations (ASEAN)

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Members of the core authors team led by Sanjay Srivastava, Chief, Disaster Risk Reduction Section consisted of Kareff Rafisura, Laura Hendy, Maria Bernadet Dewi, Madhurima Sarkar-Swaisgood and Prangya Gupta (ESCAP); and Intani Nur Kusuma (ASEAN). Bradfield Lyon (University of Maine and Columbia University) conducted the climate analysis used throughout the Report, provided technical advice and final review.

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Overview

Drought is a recurring hazard in South-East Asia. As the climate changes, droughts too will change in frequency and intensity. It is essential therefore that Governments act now to strengthen resilience. As this Report points out, this disease also tends to strike hardest at the region's poorest communities. The second edition of *Ready for the Dry Years* provides the latest information on drought in a changing climate, indicates the main tracks of action for Governments and proposes a regional drought agenda.

The COVID-19 pandemic provides a strong impetus for building resilience to drought. As they now also face the COVID-19 pandemic, Governments in South-East Asia are becoming more adept at managing concurrent risks. In some respects, drought is easier to address since it is a slow-onset disaster best managed through risk-informed measures that strengthen societal resilience. Thus, faced with another catastrophic event, like COVID-19, more resilient institutions, sectors and populations can take steps to cope. But at the same time, stimulus packages driven by COVID-19 could also incorporate measures to build resilience to drought.

Over the period 2015-2020, South-East Asia faced its most severe droughts for decades. Major drought events in 2015-2016 and 2018-2020 affected over 70 per cent of the region's land area. The severity and spatial coverage were the highest since the major El Niño of 1997-1998. During the peaks, there were drought conditions in parts of every country. At some point, over 325 million people were exposed to moderate drought conditions, and over 210 million people were exposed to severe drought conditions.

On average, severe droughts occur every five years. While the recent droughts have been exceptional, this Report shows that they fit into a broader historical pattern: since 1981, severe drought conditions have covered at least one-quarter of South-East Asia's land area on seven occasions, and the drought events have become increasingly warm.

The region has a number of drought hotspots. These are areas where droughts hit poor communities with low levels of socioeconomic development. Between 15 and 25 per cent of the region's population lives in drought hotspots. The Report reveals hotspots in Cambodia, Myanmar and the Philippines where exposure to recurring drought coincides with high levels of poverty and malnutrition and where a high proportion of people rely on agricultural employment. New hotspots can be expected to emerge as a result of anthropogenic climate change. To address the intersecting vulnerabilities in all these hotspots, the region needs a comprehensive package of humanitarian and development interventions.

Tackling drought requires cross-sectoral cooperation. The Report shows the wide-ranging impacts of drought, including agricultural disruption and water shortages, as well as secondary hazards, such as forest fires, haze and salt-water intrusion. Drought also affects agricultural output, food security and poverty and has an impact on each country's macroeconomic and trade situation. Moreover, disruptions to food security and livelihoods are cumulative, reinforcing each other and persisting even after the droughts are over.

Countries need to allocate necessary funds. The impact of drought varies from country to country depending on levels of economic development and socioeconomic vulnerability. Nevertheless, across the region, Governments and humanitarian agencies need to embark on long-term cross-sectoral interventions and make the necessary budget allocations. These interventions will be cost-effective and also have additional economic, social and environmental benefits by increasing levels of food and income security and boosting productivity.

Future droughts are likely to occur in warmer conditions. The Report identifies key drivers of drought, such as El Niño, and models the ways in which anthropogenic climate change will exacerbate future droughts. The picture is inherently complex and the intensity, severity and duration of droughts may increase in some locations but decrease in others. But future droughts are projected to be generally warmer, and if greenhouse gas emissions continue to increase, the changes may be even greater.

To scale-up adaptation, a new ASEAN agenda is needed. Compared with other disasters, droughts are fairly predictable, yet policy responses still tend to be largely reactive, offering better early warning and social protection. This report argues instead for a more proactive approach along three clear tracks: reduce and prevent; prepare and respond; and restore and recover. Across all these activities, countries in South-East Asia can capitalize on their extensive experience and expertise through more extensive regional cooperation.

The new agenda can use the collective technical expertise of specialized centres. If countries are to harness advances in science and technology they can look to a number of specialized centres, supported by university networks, that can provide technical support. Their expertise will be vital, for example, for drought risk assessment, prediction, monitoring and early warning services. They can also help with innovative schemes for social protection, insurance and other risk financing solutions.

The best way to tackle drought is through a whole-of-ASEAN response. Instead of just responding to the impacts of drought, the region needs to take a longer-term, and more strategic approach, backed with appropriate financing. This should focus particularly on the drought hotspots. ASEAN has a remarkable track record of coming together to tackle common challenges with rapid and large-scale collaboration. The same spirit of cooperation is now needed to ensure that the entire ASEAN Community is ready for the dry years.

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Explanatory Notes

Analyses in the *Ready for the Dry Years: Building resilience to drought in South-East Asia* are based on data and information available up to 30 June 2020.

This publication follows ESCAP practice in references to countries. Where there are space constraints, some country names have been abbreviated.

This publication uses the ESCAP definition of South-East Asia, which includes Timor-Leste. The term ASEAN is used in this publication refer to 10 ASEAN Member countries.

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References to dollars ($) are to United States dollars, unless otherwise stated. The term “billion” signifies a thousand million. The term “trillion” signifies a million million.

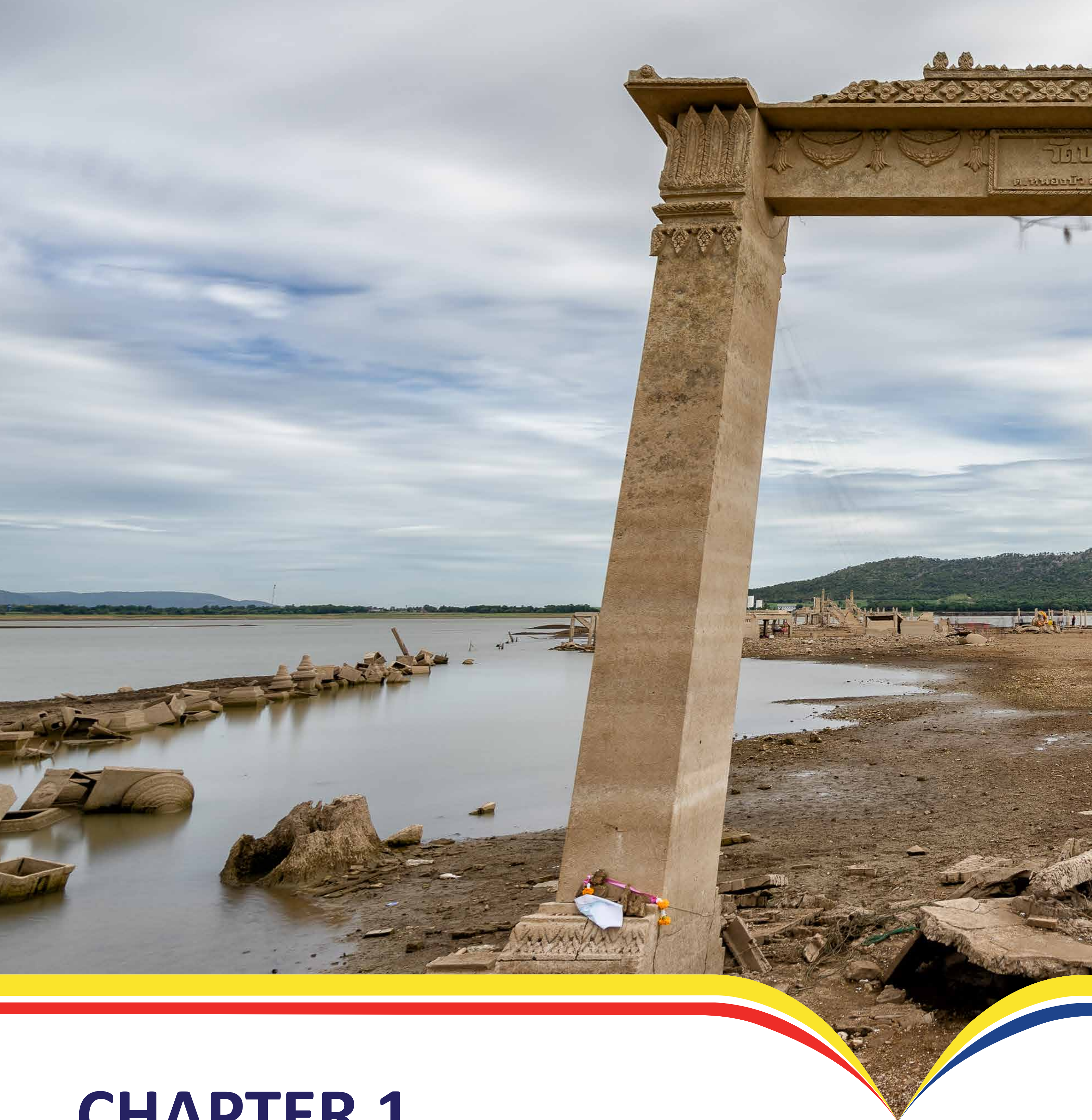
In the tables, two dots (..) indicate that data are not available or are not separately reported; a dash (–) indicates that the amount is nil or negligible; and a blank indicates that the item is not applicable.

In dates, a hyphen (-) is used to signify the full period involved, including the beginning and end years, and a stroke (/) indicates a crop year, fiscal year or plan year.

Acronyms and abbreviations

AADMER	ASEAN Agreement on Disaster Management and Emergency Response
AAL	Average Annual Loss (due to disasters)
ACDM	ASEAN Committee on Disaster Management
ACSCC	ASEAN Cross Sectoral Coordinating Committee on Disaster Risk Financing and Insurance
ADRFI	ASEAN Disaster Risk Financing and Insurance
AHA Centre	ASEAN Coordinating Centre for Humanitarian Assistance on disaster management
AMS	ASEAN Member States
APDRN	Asia-Pacific Disaster Resilience Network
APTERR	ASEAN Plus Three Emergency Rice Reserve
ARTSA	ASEAN Research and Training Center for Space Technology and Applications
ASCC	ASEAN Socio-Cultural Community
ASCN	ASEAN Smart Cities Network
ASEAN	Association of Southeast Asian Nations
ASEANCOF	ASEAN Climate Outlook Forum
ASOEN	ASEAN Senior Officials on the Environment
ASMC	ASEAN Specialised Meteorological Centre
AWGCC	ASEAN Working Group on Climate Change
AWGWM	ASEAN Working Group on Water Management
BMKG	Meteorology, Climatology, and Geophysical Agency Indonesia
CATDDO	Catastrophe Deferred Drawdown Option
CDD	Consecutive Dry Days
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
D-SLM	Drought-Smart Land Management
DHS	Demographic Health Surveys
DRAMP	Drought Resilience, Adaptation and Management Policy
DRFI	Disaster Risk Financing and Insurance
DRM	Disaster Risk Management
EbA	Ecosystem-based Adaptation
ENSO	El Niño Southern Oscillation
ESCAP	Economic and Social Commission for Asia and the Pacific
EWS	Early Warning System
FAO	Food and Agriculture Organization of the United Nations
FbF	Forecast-based Financing
GCF	Global Climate Fund

GDP	Gross domestic product
GFCS	Global Framework for Climate Services
GISTDA	Geo-Informatics and Space Technology Development Agency (Thailand)
GPCC	Global Precipitation Climatology Centre
IOD	Indian Ocean Dipole
IPCC	Intergovernmental Panel on Climate Change
MSS	Meteorological Service Singapore
NAP	National Adaptation Plan
NDMA	National Disaster Management Authorities
NDVI	Normalized Difference Vegetation Index
NHMSs	National Hydrometeorological Services
NTT	Nusa Tenggara Timur (Indonesia)
NOAA	National Oceanic and Atmospheric Administration (United States)
PAGASA	Philippine Atmospheric, Geophysical and Astronomical Services Administration
PDSI	Palmer Drought Severity Index
PSI	Pollutant Standards Index
RCC	South-East Asia Regional Climate Centre
RCP	Representative Concentration Pathway
RESAP	Regional Space Applications Programme for Sustainable Development
RIMES	Regional Integrated Multi-Hazard Early Warning System for Africa and Asia
SDGs	Sustainable Development Goals
SEADRIF	Southeast Asia Disaster Risk Insurance Facility
SHDI	Subnational Human Development Index
SOM-AMAF	ASEAN Senior Officials Meeting on Agriculture and Forestry
SPI	Standardized Precipitation Index
SSTA	Sea surface temperature anomaly
UNCCD	United Nations Convention to Combat Desertification
UNFCCC	United Nations Framework Convention on Climate Change
WMO	World Meteorological Organization



CHAPTER 1.

Climatic drivers of drought in South-East Asia

The ruins of temple Wat Nong Bua Yai have appeared only twice in 20 years, during the drought years of 2015 and 2020, as water levels have fallen in Pa Sak Jolasid dam, Lopburi Province, Thailand.

Chapter 1.
Climatic drivers of drought in South-East Asia

Key Messages

- *The recent droughts of 2015-2016 and 2018-2020 have been the most severe since the major El Niño of 1997-1998 in several parts of South-East Asia.*

- *Drought in South-East Asia is highly episodic, with considerable year-to-year variations.*

- *Severe drought conditions have covered at least one-quarter of South-East Asia's land area, seven times since 1981.*

- *Drought frequently occurs in association with El Niño Southern Oscillation (ENSO) events, but may also have other drivers. For example, in late 2019 a very strong positive phase of the Indian Ocean Dipole (IOD) developed when there was no ENSO.*

- *While drought in South-East Asia is primarily a manifestation of an extended period of below-average rainfall, above-average temperatures can exacerbate existing drought conditions and attendant impacts. This is a concern given the observed trend towards warmer climate conditions.*

South-East Asia has long experienced droughts, however it is now more critical than ever to understand the drought risk. Governments of countries in South-East Asia are facing a double burden, as the COVID-19 pandemic has emerged on the heels of two successive droughts within five years. Extensive drought conditions were recorded in the region during 2015-2016 and 2018-2020, interspersed by a period of very little drought. The geographical extent was significant, with moderate drought conditions simultaneously affecting more than 70 per cent of the land area during both time periods. This chapter analyses the behaviour of these droughts by comparing them to a longer historical context and explaining their climatic drivers. While the dominant influence of El Niño is historically well-established, the recent droughts calls attention to the complex interplay amongst large-scale drought drivers across seasonal and decadal timescales in conjunction with local conditions.

Box 1-1 – Defining drought

Unlike other natural hazards which have readily identified features and which develop fairly rapidly (e.g., flash floods or tropical cyclones), drought is typically a slow-onset phenomenon that is frequently most recognizable through its associated impacts. Those impacts, in turn, are often wide-ranging and occur over a range of timescales. For example, a single month of deficient rainfall (as defined relative to average conditions at a particular location) may serve to substantially reduce soil moisture and stress crops while having little impact on water levels in a nearby reservoir. On the other hand, as the period of deficient rainfall increases, impacts may be expected across the agriculture and water resource sectors.[a]

In addition, while soil moisture may be replenished fairly quickly as more abundant precipitation returns, there may be a considerable time lag before river and reservoir levels rebound, even following a period of above-average precipitation. As such, identifying the onset and demise of drought conditions depends on the specific impact being considered. It is for these reasons that no universal definition of drought exists.

However, whether considering deficient soil moisture or reduced streamflow or reservoir levels, a common attribute of all droughts is a prolonged period of deficient rainfall relative to average climate conditions at a particular location. Such rainfall deficits define what is referred to as meteorological drought. When these precipitation deficits are sufficient to adversely reduce soil moisture (and stress crops), the condition is referred to agricultural drought, while a prolonged period of deficient precipitation sufficient enough to reduce runoff, streamflow and groundwater is referred to hydrological drought.

Generally speaking, the difference between these three types of drought relates to the differing time periods over which the condition of deficient precipitation occurs. It also depends upon land use management and water resource management. Chapter 1 of this Report is focused on the climatic drivers of meteorological drought, as a starting point for understanding drought risk.

[a] Justin Sheffield and Eric F. Wood (2011), pp. 210.

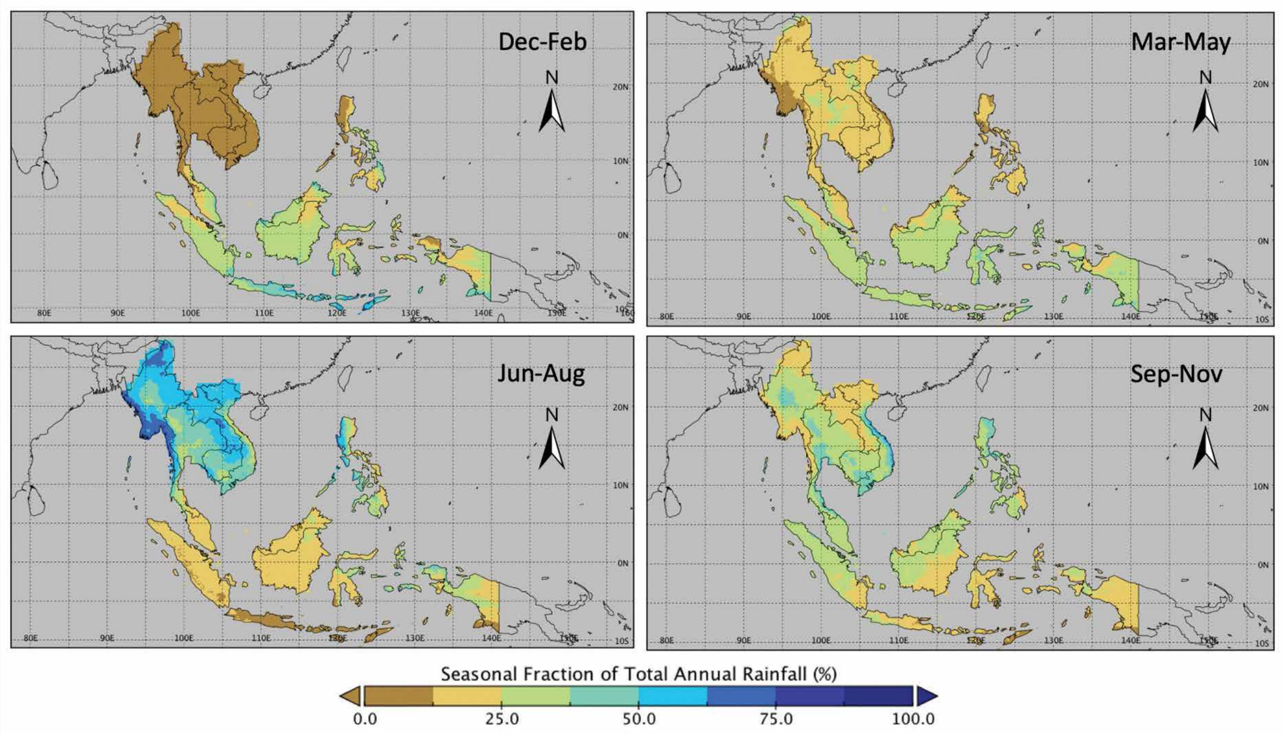
Characteristics of drought events in South-East Asia

Spatial extent

Drought has intermittently covered large portions of South-East Asia throughout 1981-2020.

The seasonality of rainfall influences the economic structure and livelihood patterns of many societies, but specially so within ASEAN countries where 34 per cent of the employed population rely on agricultural livelihoods.[1] Deviations from established climate patterns have cascading impacts on the economies and on people's lives. As a starting point, Figure 1-1 shows the seasonality of average rainfall across South-East Asia observed over the period 1981-2010. The relative wet and dry seasons across South-East Asia are associated with the movement of monsoon systems. Variations in monsoon behaviour result in departures from these mean conditions, with sustained periods of reduced rainfall leading to drought. To evaluate meteorological drought conditions across a region with such large changes in seasonal climate, the six-month Standardized Precipitation Index (SPI6) is used. The SPI6 compares accumulated rainfall over a given six-month period with the rainfall amount that would have been received historically for that period under average conditions. The SPI6 index typically ranges from -3 to +3, where negative values are associated with below average rainfall and drought, and positive values indicating wetter than average conditions. The SPI is a meteorological drought indicator, in that it tracks only accumulated rainfall relative to average conditions. Drought impacts, such as those in the agriculture or water resources sectors, are influenced by other factors, such as deficient soil moisture or reduced runoff into rivers and streams that the SPI does not measure. While increasingly negative values of the SPI are associated with increasing severity of meteorological drought, it should be kept in mind that drought impacts will vary by sector and location. In addition to the meteorological drought indicators, such as the SPI, other drought indicators, such as vegetation condition (as derived from satellite data) and river levels should also be used to monitor drought conditions.

Figure 1-1 — Seasonality of rainfall, 1981-2010

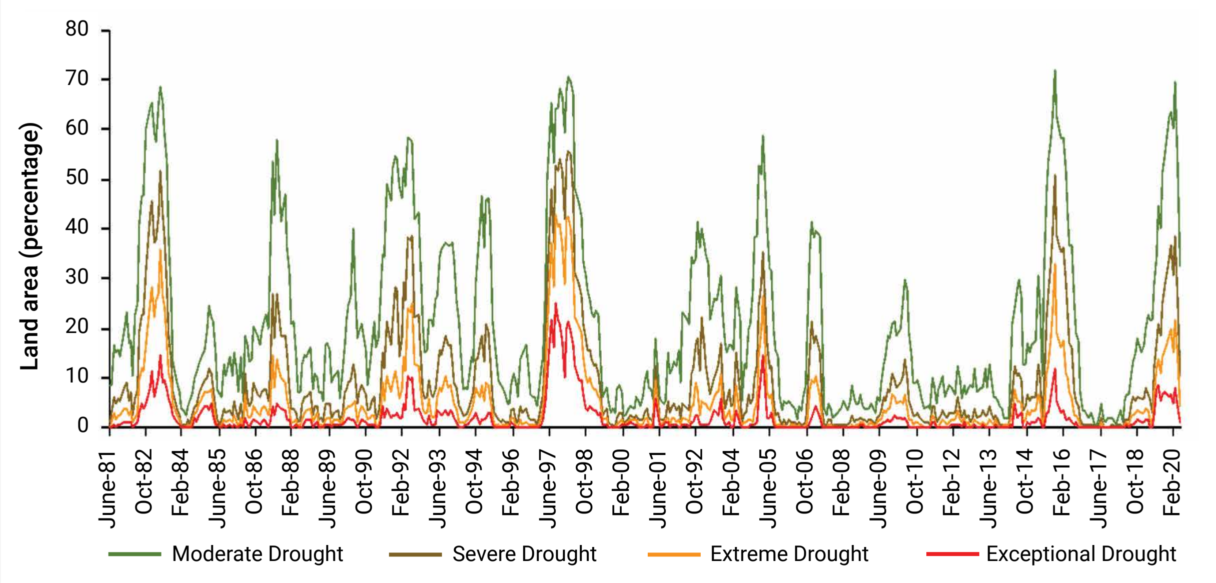


Source: Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), 1981-2010.
Note: This chart shows average rainfall as a percentage of the total annual average value for 1981-2010. Relative dry seasons are shaded brown with rainy seasons indicated by blue and green shading.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Severe drought conditions have covered at least one-quarter of South-East Asia's land area seven times since 1981.

The SPI6 index can be used to classify different levels of drought severity. According to the index, moderate drought occurs where the index is less than -0.8, severe drought where the index is less than -1.3, extreme drought where it is less than -1.6 and exceptional drought where it is less than -2. Figure 1-2 shows the spatial extent of these four drought severities from June 1981 to April 2020.

Figure 1-2 — Percentage of land area affected by drought in South-East Asia, 1981 to 2020

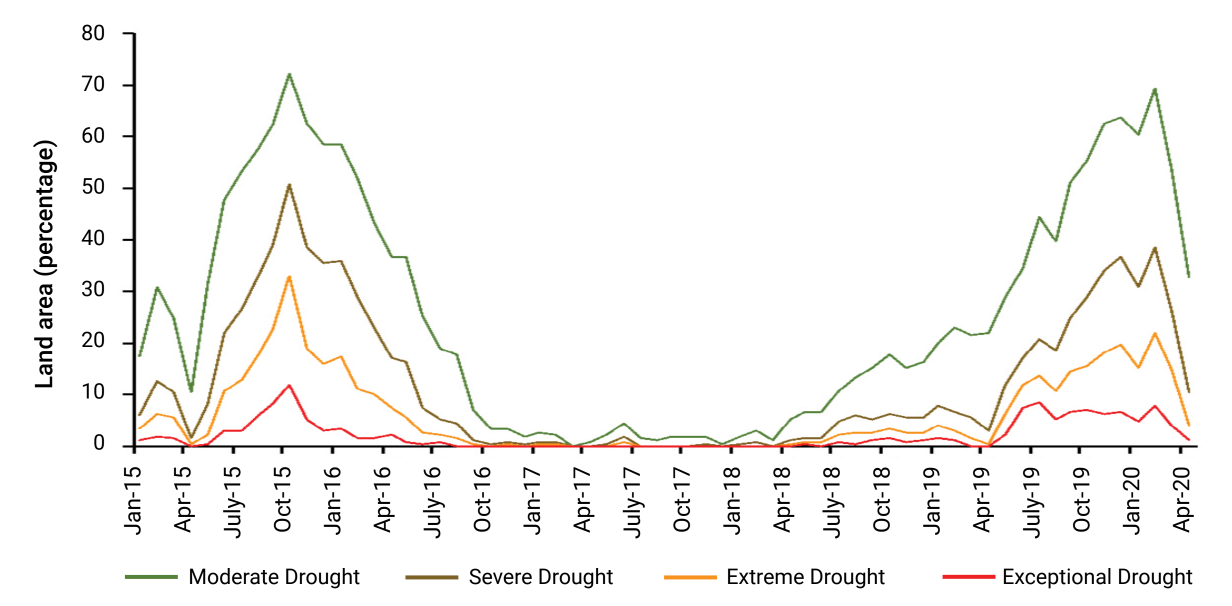


Source: Precipitation data from CHIRPS.
Note: This shows the SPI6 drought index.

The recent droughts of 2018-2020 and 2015-2016 have been the most spatially extensive since the exceptionally strong 1997-1998 El Niño.

Using the SPI6, Figure 1-2 reveals that, during 2015-2020, recorded occurrences of moderate and severe drought have covered the largest land area since 1997-1998. Figure 1-3 shows the extent of drought coverage in these five years in greater detail, using monthly values from January 2015 to April 2020. Several aspects of drought behaviour emerge from Figure 1-3. First, simultaneous drought conditions have covered large portions of South-East Asia during the past five years. For example, during the peaks in 2015 and 2020, more than 70 per cent of the land area experienced moderate drought conditions, with increasingly severe drought conditions covering less land area, as expected. These drought conditions were observed in at least a portion of every country in the region. Second, at least for this recent period, drought has been highly episodic, with the two periods of extensive drought just mentioned being interspersed by a roughly one-year period of very little drought. Third, the spatial extent of drought is seen to both increase and decrease rather rapidly across South-East Asian countries, indicating that drought typically does not display exceptionally long persistence.

Figure 1-3 — Percentage of land area affected by drought in South-East Asia, January 2015-April 2020

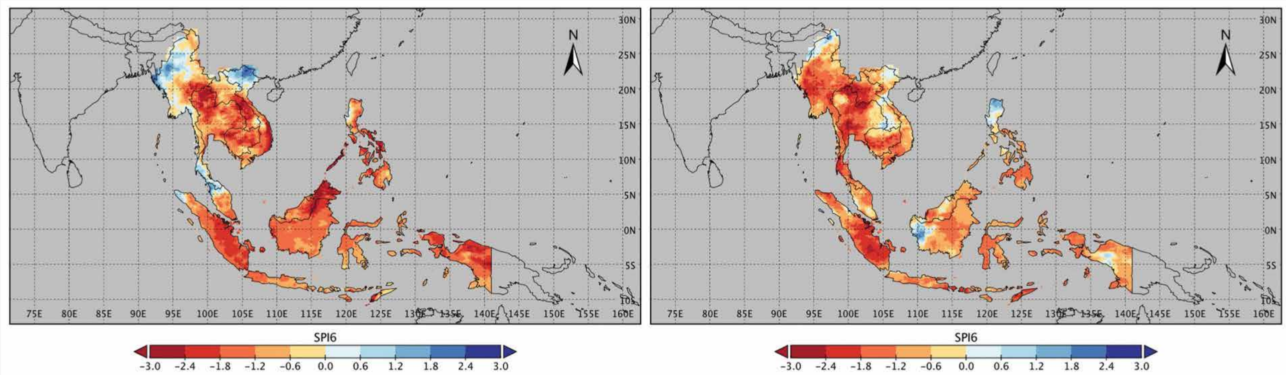


Source: Precipitation data from CHIRPS.
Note: Based on the SPI6 drought index.

Figure 1-4a shows the spatial extent of the drought, for the months when drought was most spatially extensive (October 2015 and February 2020). For moderate drought, the extent in both periods was similar. But, in 2015 more areas experienced severe drought, notably the northern parts of Thailand and north-central Lao People's Democratic Republic, along with parts of central Viet Nam, much of Brunei, and the far western and eastern areas of Indonesia. The pattern was somewhat different in 2020. For example, northern Thailand again had a severe drought, while central Lao People's Democratic Republic had slightly above average rainfall. Southern Viet Nam also saw more drought conditions in 2020, while in Indonesia the impact was greater in the west than in the east. It should also be noted that during both years, as indicated by the blue shading in Figure 1-4a, some areas had above average rainfall.

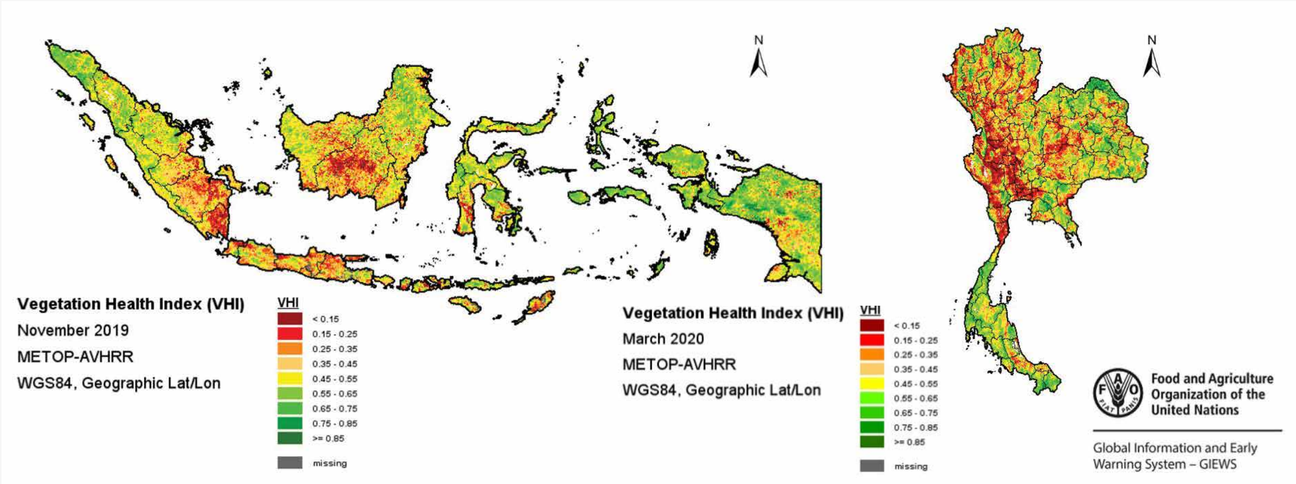
In terms of the impact of the recent drought, Figure 1-4b shows the Vegetation Health Index (VHI) for Indonesia in November 2019, and for Thailand in March 2020. The VHI is a measure of the severity of drought based on the vegetative health as estimated by satellite. The VHI combines a vegetative condition index and a temperature condition index. Poor vegetation condition and high temperatures are associated with more severe drought, which in Figure 1-4b is indicated by lower values of the VHI. In both countries, the recent drought (as captured by the SPI6) is seen to be associated with widespread stress on vegetation (shown as areas of yellow and red in the figure). Given the importance of such impacts, in addition to monitoring drought based on rainfall (as with the SPI6), routinely monitoring vegetative health can enhance early warning efforts.

Figure 1-4a — SPI6 for October 2015 and February 2020 – months of maximum extent



Source: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS).
Note: Dark shading indicates locations where severe drought (SPI6 < -1.3) for at least 6 consecutive months during 2015-16 (left) and 2018-19 (right).
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 1-4b — Vegetative Health Index (VHI) in Indonesia and Thailand during recent drought



Source: Maps were generated by the UN FAO online analysis tool, available at http://www.fao.org/giews/earthobservation/country.
Note : Maps of the VHI for Indonesia (left) for the month of November 2019 and Thailand (right) for March 2020 to indicate some of the impacts of the recent drought.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

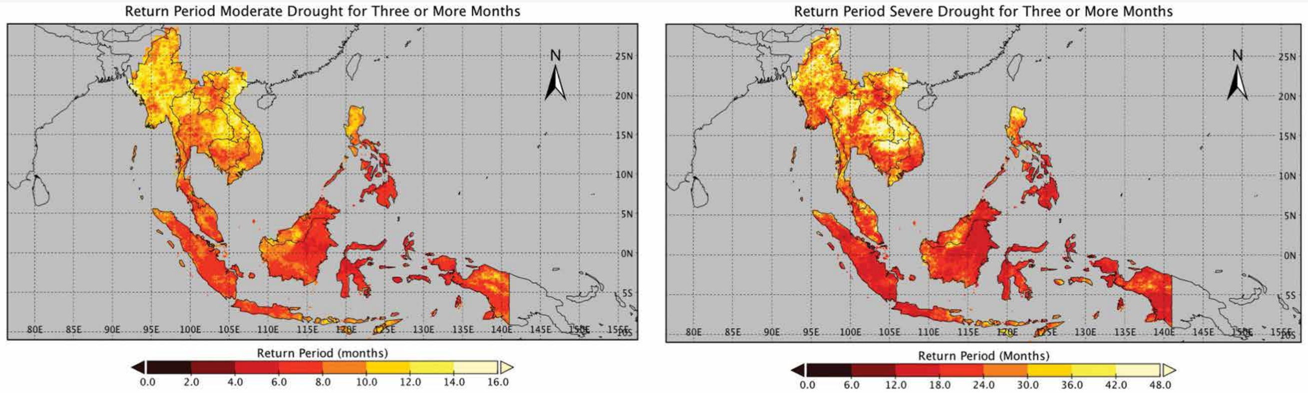
Persistence

Drought is highly episodic and dominated by inter-annual variations in rainfall. It is fairly uncommon for drought conditions to persist for more than 12 consecutive months. This is especially the case for severe or extreme drought conditions.

In most parts of the region, the SPI varies considerably from year to year, and severe or extreme drought seldom lasts longer than 12 months. In the early 1980s and late 1990s the peaks of drought extent were similar, but overall, over the past four decades for the extent of drought there has been no observable trend.

The areas with the most frequent drought are usually those closest to the equator (Figure 1-5). This includes southern Philippines and much of Brunei Darussalam, Indonesia and Malaysia. However, even for regions where the return periods are longest, drought conditions of up to three months recur roughly every 12 months for moderate drought, and every 40 months for severe drought. The drought return period is longer in southern Viet Nam, and in much of Cambodia and southern Thailand, including the lower Mekong Basin.

Figure 1-5 — Return period for moderate drought and severe drought



Source: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS).
Disclaimer:The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

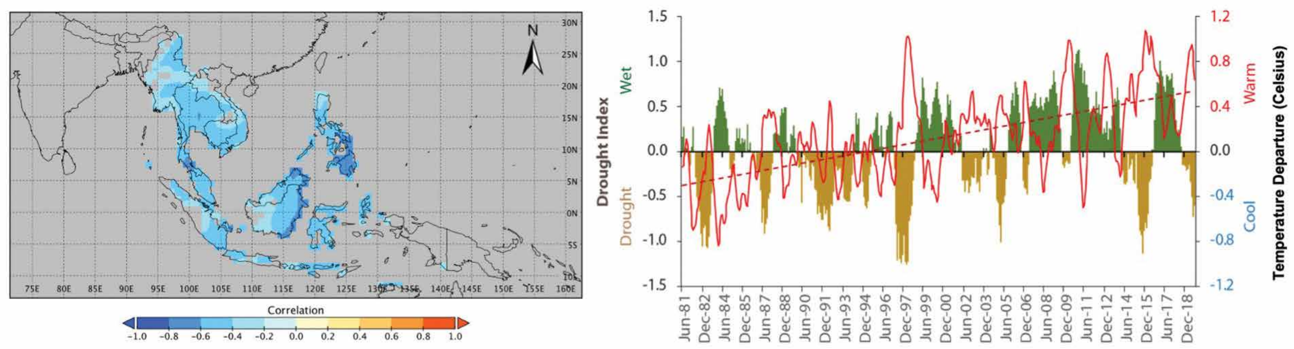
Climatic drivers of the drought characteristics

Role of temperature

While drought is primarily associated with below-average rainfall, it can be exacerbated by above-average temperatures.

Droughts can also be accompanied by high surface air temperatures which may enhance impacts. Figure 1-6 shows the correlation between temperature and the drought index for the period 1981-2019. The chart on the left maps the correlation between monthly values of the SPI6 and the corresponding monthly average maximum temperature departure from average. This map is entirely blue, indicating that across the sub-region there is a statistically significant correlation between drought conditions and above-average maximum temperature. The chart on the right shows a time series of the SPI6 (the green and brown bars) and the 'anomalous temperature' (the daily maximum temperature departure from average) – both averaged across the region. As the dotted line indicates, over this period there has been a statistically significant upward trend of 0.21°C per decade.

Figure 1-6 — Correlation between droughts and higher temperatures, June 1981-2019

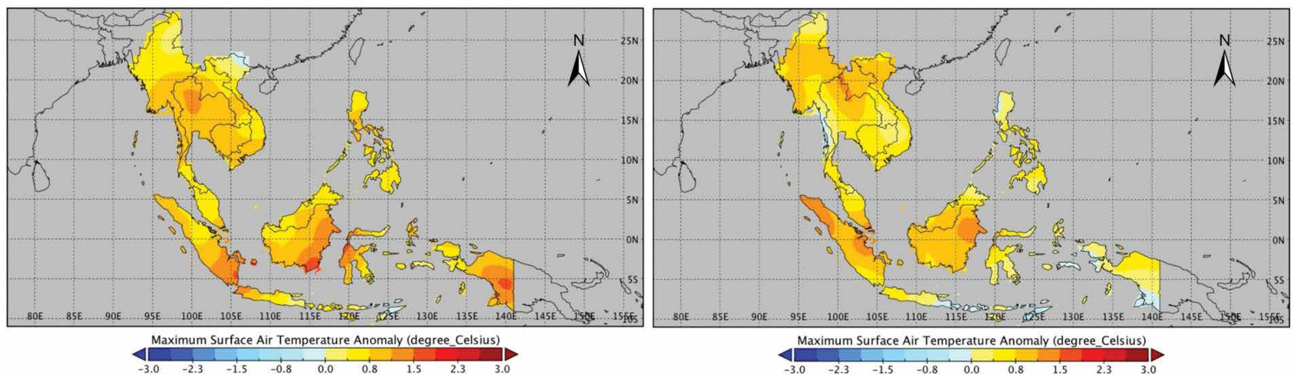


Sources: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). Temperature data from Berkeley Earth.
Notes: (Left) Correlation between monthly values of SPI6 and average daily maximum air temperature anomalies (de-trended); only statistically significant values are plotted. (Right) Time series of SPI6 (colour bars) and average daily maximum surface air temperature anomalies (red line), both averaged across South-East Asia. Temperature values have been slightly smoothed using a three-month moving average. Dashed line indicates a linear trend fit to temperature data.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Drought in South-East Asia is often accompanied by above average temperatures. Higher temperatures can further reduce soil moisture (and stress crops) though increased surface evaporation.

In both 2015 and 2019, the maximum temperatures were well above average. In terms of recent droughts, the associated maximum temperature anomalies for the peak of the drought spatial extent, in 2015 and 2019, are shown in Figure 1-7 and are consistent with this overall pattern: both years showed maximum temperatures that were well above average.

Figure 1-7 — Daily maximum surface temperature departure from average near drought peaks in 2015 and 2019, °C



Source: Temperature data from Berkeley Earth, 2015 and 2019.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Higher temperatures can increase surface evaporation (due to an increase in 'atmospheric demand' for water), leading to greater surface drying and thus, stress on crops.

The influence of El Niño

El Niño is a major factor contributing to drought in South-East Asia although El Niño's impact varies substantially with season and geographic location.

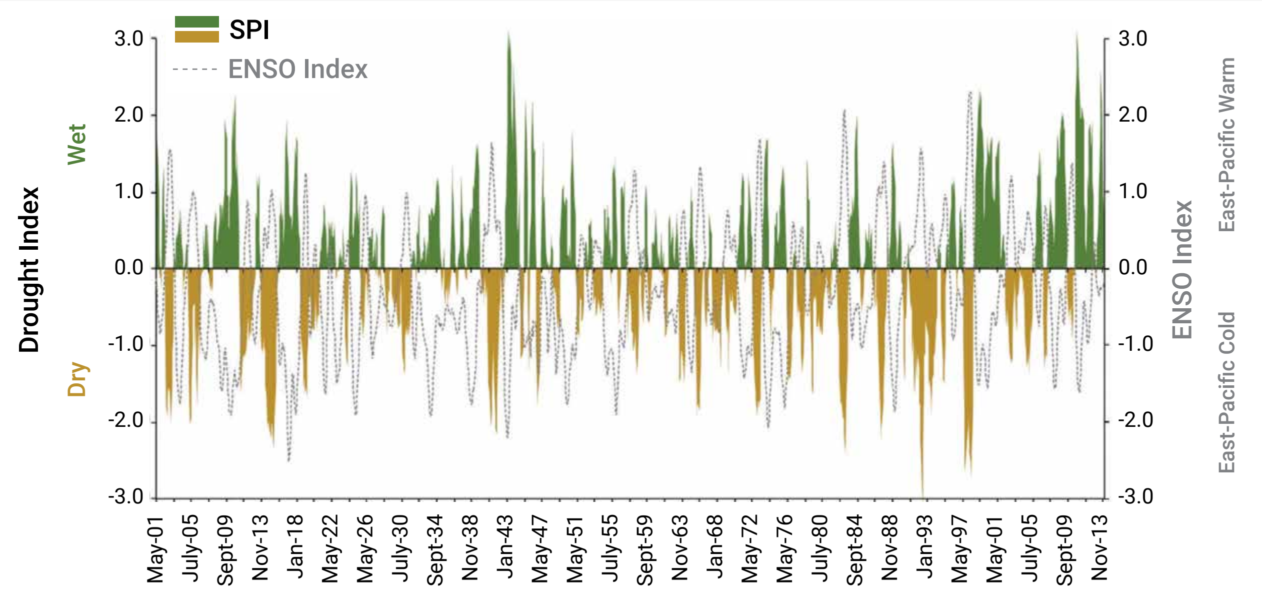
Given its location within the tropics, South-East Asia is strongly influenced by the El Niño-Southern Oscillation (ENSO).[2] Peaks in both drought and temperature tend to correspond with El Niño events. During a typical El Niño, the tropics tend to warm, with less rainfall occurring in many parts of South-East Asia.[3] The strength of the ENSO is often measured by the departure of sea surface temperature from the average in east-central Pacific, and this index is positively correlated with surface air temperatures across South-East Asia (r=0.52).

During the warm phase of ENSO (El Niño), warmer than average sea surface temperatures develop in the east-central Pacific. This tends to shift rainfall away from the western tropical Pacific towards the east, thereby influencing rainfall in the maritime continent, which is the region between the Indian and Pacific Oceans, including the archipelagos of Indonesia, Borneo, New Guinea, the Philippine Islands, the Malay Peninsula, and the surrounding seas.

During the cold phase of ENSO (La Niña), there tends to be more precipitation in the western tropical Pacific and thus more rainfall across the maritime continent. So, in many parts of South-East Asia, El Niño is likely to lead to drought, while La Niña is less likely to do so.[4] Given the relationship between drought and ENSO and the impact of drought on agriculture, ENSO information has been used to directly forecast crop yields.[5]

The relationship between drought and the ENSO is illustrated in Figure 1-8. Drought periods (brown shading) are generally related to El Niño events (positive values of the ENSO index) while wetter than average conditions generally tend to be associated with La Niña events. The correlation between the ENSO index and the SPI6 is highly statistically significant (r = -0.7).

Figure 1-8 — ENSO and drought in South-East Asia, July and September 2001-2013



Source: Precipitation data from GPCC, with sea surface temperature data from NOAA.
Note: This chart shows the SPI6 drought index based on precipitation averaged across South-East Asia (shading) and an ENSO index based on observed sea surface temperatures in the east-central Pacific (dotted line).

ENSO events develop during summer in the northern hemisphere, reaching their maximum strength during the subsequent fall or winter and then weakening during the following spring. The impact of ENSO on precipitation variability and drought within South-East Asia may thus vary from season to season. For example, in central Philippines, seasonal rainfall is often enhanced during El Niño events during late summer and early fall before it subsequently declines substantially as the fall season progresses. In parts of Indonesia, the influence of El Niño events on rainfall and drought generally tends to be more closely related with an extension of the relative dry season than with deficient rainfall during the subsequent rainy season. This has implications for drought management given the connection between the rainy season and crop calendar.

The Indian Ocean Dipole

During 2019, an exceptionally strong, positive IOD was a likely contributor to drought conditions in parts of the region.

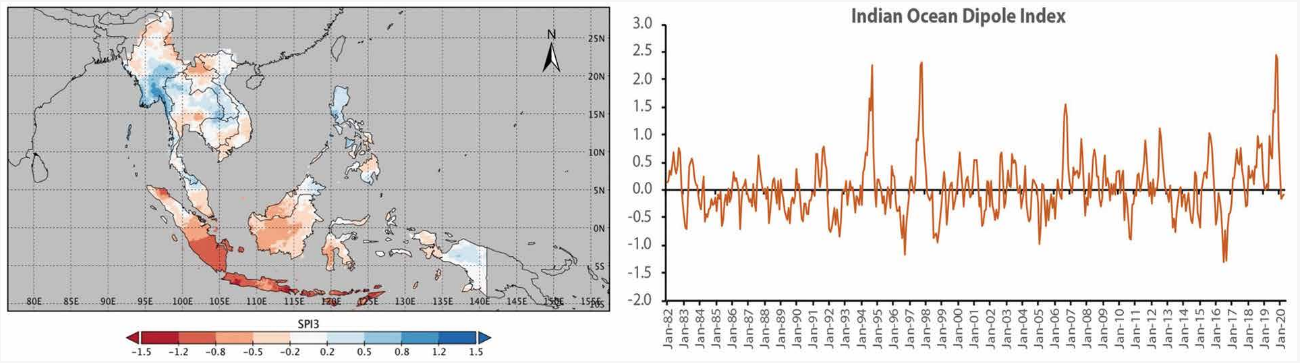
In some parts of the region, drought conditions may also result from variations in sea surface temperature in the equatorial Indian Ocean. This is captured by various measures, including the Indian Ocean Dipole (IOD), which is an index that measures the difference in anomalies between the western and eastern portions of the basin.[6]

In its positive phase, the IOD features cooler than average sea surface temperatures in the east equatorial Indian Ocean, with warmer temperatures in the west. A positive IOD pattern often results in drought in South-East Asia, particularly in the areas near and south of the equator. The IOD tends to develop during the summer season in the northern hemisphere and decay during the subsequent winter, so the resulting droughts can correspondingly be seasonal. The behaviour of the IOD is illustrated in Figure 1-9, which shows a time series of the IOD index for 1982-2020. Note that the IOD index peaked in October 2019 and probably contributed to low rainfall in parts of South-East Asia from late summer until the end of that year.

While the IOD and ENSO indices show some correlation, the IOD can still have a positive phase when the ENSO condition is weak or even absent. For example, during the fall of 2019, the positive phase of the IOD was the strongest for 40 years while the ENSO condition was comparatively weak.

The contribution of the IOD to drought is illustrated in Figure 1-9. Since IOD events tend to be shorter-lived than ENSO events, the three-month SPI (SPI3) was used to evaluate the associated variability in rainfall. Figure 1-9 shows, for the 1981-2020 period, the average value of the SPI3 when the IOD index was high and ENSO was weak. The figure indicates, for example, that drought in Indonesia and Timor-Leste tends to be associated with a positive IOD.[7]

Figure 1-9 — Indian Ocean Dipole, 1982-2020, and its contribution to drought



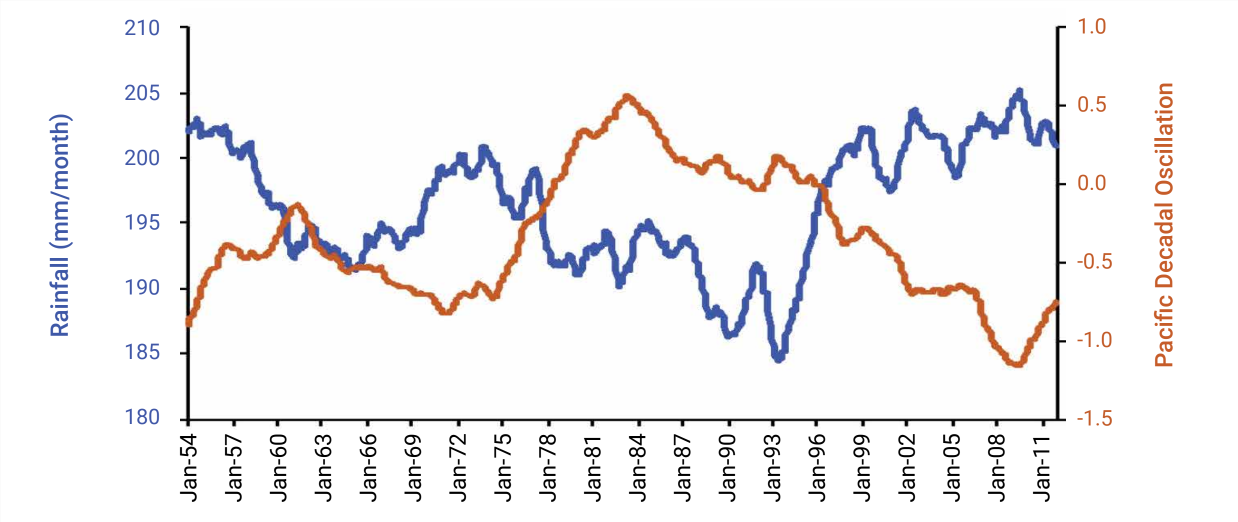
Sources: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS). IOD data from NOAA, 1981-2019.
Note: This chart shows the average SPI3 for months when the Indian Ocean Dipole was high – greater than one standard deviation above average and at least twice as strong as a normalized ENSO index value (in order to minimize the influence of the latter).
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Rainfall Variations on Longer Time Scales

On decadal time scales, rainfall averaged across South-East Asia shows a connection to the Pacific Decadal Oscillation (PDO), with the positive phase of the PDO being associated with generally reduced rainfall.

While ENSO and the IOD tend to be associated with drought on seasonal to interannual time scales (the dominant contribution to overall climate variability in South-East Asia), rainfall also exhibits variability over longer periods. This longer time scale variability is found to be associated with decadal changes in sea surface temperatures across the Pacific Ocean, often referred to as the Pacific Decadal Oscillation (PDO). As the name implies, these are changes in ocean surface temperatures (and rainfall) that are observed to vary over a period of a decade or more. Figure 1-10 shows how rainfall averaged across South-East Asia and the PDO have varied over, approximately, the past 60 years. When the PDO is in its positive phase, rainfall tends to be reduced, with increased rainfall observed during its negative phase. The PDO shifted to a negative phase in the late 1990s, which has been associated with an increase in rainfall since that time. All other factors held constant, this suggests that when the PDO again shifts to its positive phase, rainfall may be expected to decrease somewhat in portions of South-East Asia. Other factors are of course at play, particularly the influence of a warming climate in response to increasing greenhouse gas concentrations, largely as a result of human activities. The influence of anthropogenic climate change on rainfall and drought will be discussed in Chapter 3.

Figure 1-10 — Time series (1954-2011) of the PDO Index (red line) and rainfall (mm/month) averaged across South-East Asia



Source: PDO index is from NOAA, with rainfall data from GPCC.
Note: A 9-year moving average has been applied to both series to smooth the data.

Locally, drought conditions can develop or terminate independently from large-scale climate drivers, such as El Niño or the IOD, with the latter still being important influences on regional climate. This has been evident in the 2015-2016 and 2018-2019 drought events, in which drought conditions were simultaneously recorded across much of the region, albeit with varying start and end dates in different areas. (See Figures 2-1 and 2-2 in Chapter 2 for further evidence, based upon national records of SPI6 index). This variation is caused by local and regional factors, resulting in the inconsistent timing of the onset of the rainy season, for example. The influence of local-scale climate drivers highlights the fundamental importance of improving drought monitoring systems, which can sufficiently capture this variability in order to inform effective early warning systems (See Chapter 4 for a discussion on drought early warning).

Summary

Altogether, this chapter has begun to unpack the complexity of drought hazard across South-East Asia. It has shown that drought can be measured by numerous parameters, and that local manifestations of drought conditions are driven by the interaction of multiple climate systems across different temporal and spatial scales. The findings have also shown that drought risk is extensive, covering much of the land area, and culminating in two severe drought events within the past five-year period.

The next chapter builds on these findings in more depth, to present the recorded incidences of drought in each country in South-East Asia during the 2015-2016 and 2018-2020 drought events. It outlines their geographical extent, onset and duration. However, when it comes to impacts, the drought hazard itself is only one half of the picture, with the underlying socioeconomic conditions of the affected countries being important contributors.

Endnotes

[1] ASEAN (2018).

[2] C. F. Ropelewski and M. S. Halpert (1987).

[3] Michael S. Halpert and Chester F. Ropelewski (1992).

[4] B. Lyon and A. G. Barnston (2005); R. Boer and A.R. Subbiah (2005), pp. 472; Renguang Wu, Zeng-Zhen Hu and Ben P. Kirtman (2003); Harry H. Hendon (2003); J. R. E. Harger (1995).

[5] Rosamond Naylor and others (2001).

[6] N. H. Saji and others (1999).

[7] Ummenhofer and others (2013).

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CHAPTER 2.

Understanding the impacts of drought: vulnerability hotspots and convergence with the COVID-19 pandemic

Drought, forest fires and haze reduce air quality and threaten respiratory health in many South-East Asian countries.

Chapter 2.
Understanding the impacts of drought: vulnerability hotspots and convergence with the COVID-19 pandemic

Key Messages

- *Two major drought events have affected all South-East Asian countries during the past five years (2015-2020).*
- *Various hotspots of drought risk can be identified across the region, determined not only by the physical hazard itself, but also by the exposure and vulnerability of the population.*
- *Assessing subnational measures of vulnerability reveals specific hotspots in which high levels of poverty, malnourishment and agricultural employment are converging with drought exposure.*
- *Impacts of drought in the past 5 years have cut across many sectors of society and are clustered around four key nexuses of policy areas.*
- *The convergence of the 2019-2020 drought event and the COVID-19 pandemic is eroding institutional capacity to respond to both disasters and exacerbating vulnerabilities of specific population groups.*

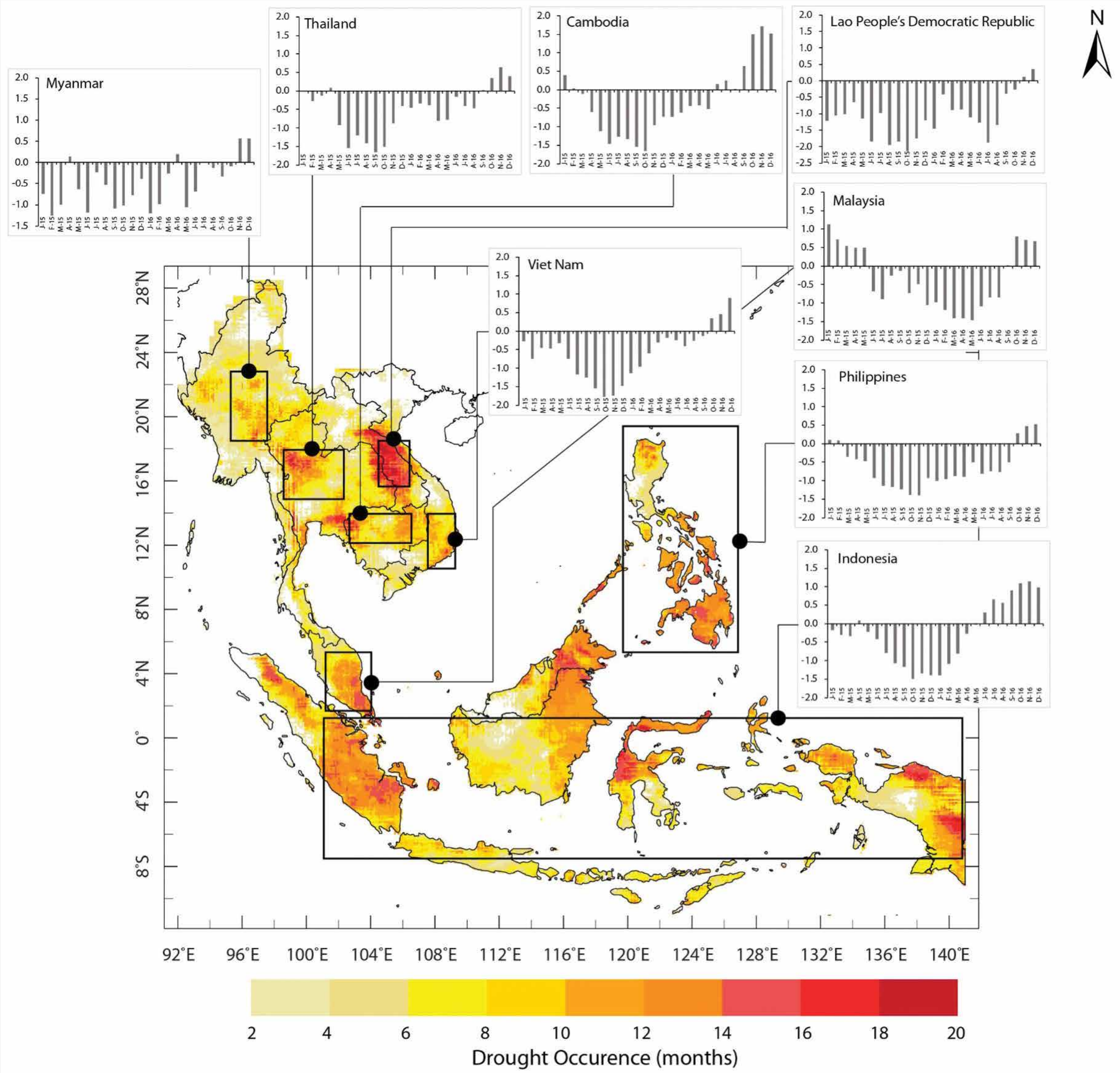
The previous chapter showed that there have been two periods of extensive drought in South-East Asia over the past 5 years, lasting from 2015-2016 and 2018-2020. This chapter explores what this means for people living within the region. It provides an overview of the reported drought events across the region, demonstrating that for all countries the severity and impacts of the drought events have been significant, and in some cases have not been experienced in the past two decades. The impacts cut across many sectors of society, interact with each other, and outlast the occurrence of drought itself, thereby threatening to undermine long-term development. In order to explore why the impacts have been so severe, the chapter begins by assessing how the return periods of drought, as well as the exposure and the vulnerability of populations, vary across the region. As a result, it identifies various hotspots of high drought risk, in which actions must be taken to strengthen resilience to drought. Key sectors are highlighted, in which these actions are more critical. Finally, the chapter explores how the impacts of the ongoing drought and COVID-19 pandemic are compounding each other. In doing so, it demonstrates the urgency of strengthening resilience to drought, so that institutions and populations have more capacity to cope with unprecedented disasters, such as the pandemic.

Drought events during 2015-2020

Major drought events have affected all South-East Asian countries during the past five years (2015-2020).

During the period 2015-2020, in South-East Asia as shown in Figure 2-1 and Figure 2-2, which provide time series calculations of the SPI6 in each country for which drought impacts were reported. As indicated in Figure 2-1, during 2015-2016 almost the entire land area experienced at least six months of moderate drought, and all countries contained areas where droughts lasted longer. However, the onset and duration of droughts varied considerably: the earliest and longest droughts were recorded in parts of the Lao People's Democratic Republic, Myanmar, Philippines and Viet Nam, whilst drought emerged a few months later in parts of Cambodia, Indonesia, Malaysia and Thailand.

Figure 2-1 — Occurrence of moderate drought in South-East Asia, January 2015 to December 2016



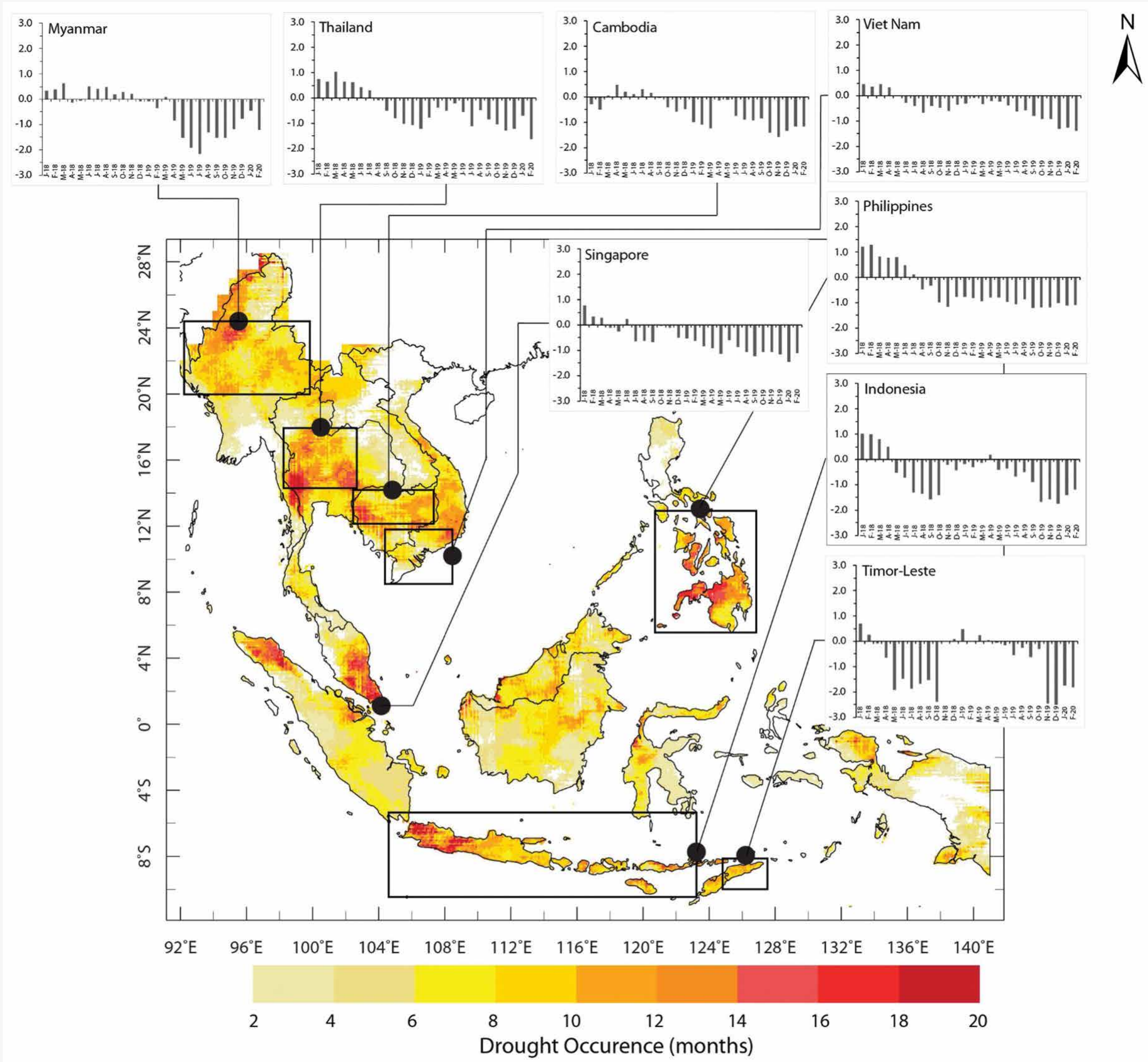
Source: ESCAP calculations, based on Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), January 2015 to December 2016.

Note: Shading indicates the number of months a given location experienced at least moderate drought (SPI6 is less than -0.8) between January 2015 and December 2016. Time series show the SPI6 across countries. A value of zero indicates average conditions while increasingly negative values are indicative of increasingly dry conditions.

Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2-2 shows that almost the entire land area experienced at least 6 months of moderate drought again during 2018-2020, with specific areas within many countries experiencing longer periods of drought. The time series data shows that the duration and onset varies between affected areas. For example, affected areas in Cambodia, Philippines, Singapore, Thailand and Viet Nam, have experienced drought consistently, since July 2018, whilst Indonesia and Timor-Leste have experienced two distinct episodes of drought in 2018, and then in late 2019, and Myanmar only experienced drought in 2019 and 2020.

Figure 2-2 — Occurrence of moderate drought in South-East Asia, January 2018 to February 2020



Source: ESCAP calculations, based on Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), January 2018 to February 2020.
Note: Shading indicates the number of months a given location experienced at least moderate drought (SPI6 is less than -0.8) between January 2018 and February 2020. Time series show the SPI6 across countries. A value of zero indicates average conditions while increasingly negative values are indicative of increasingly dry conditions.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

By comparing the findings in Figures 2-1 and 2-2, it is seen that the droughts during 2015-2020 had varying geographical distributions. For example, during 2018-2020, droughts were more likely to be within continental rather than maritime South-East Asia. Ultimately, these findings indicate that drought is an ASEAN wide issue. All countries have experienced drought, and will be exposed to future drought events. Every Government must therefore understand how drought risk will evolve in their context, in order to manage it effectively.

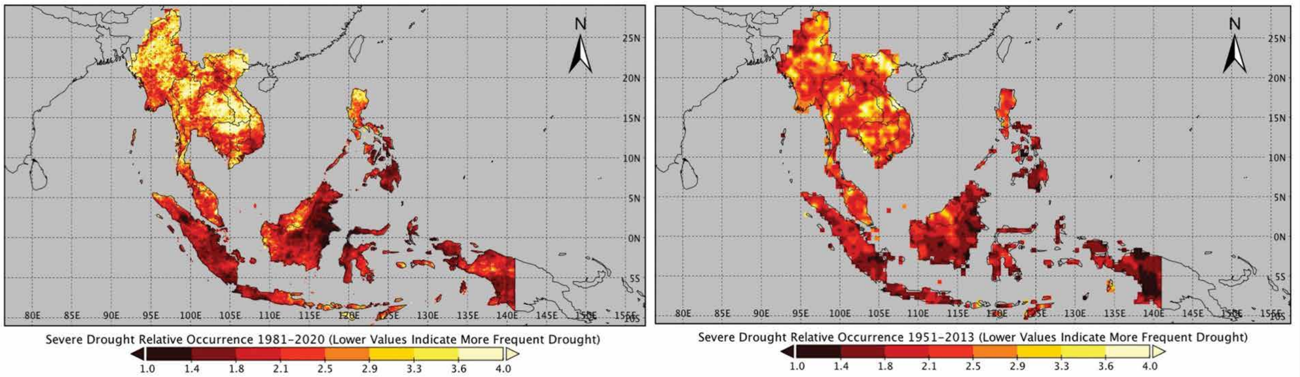
Hotspots of drought risk

Areas with high frequency of meteorological drought

While all regions of South-East Asia are prone to the episodic occurrence of drought, near-equatorial regions generally show shorter return periods (making drought conditions relatively more likely than other areas).

Assessing rainfall levels over the longer-term reveals numerous hotspots across South-East Asia in which the meteorological drought hazard recurs more often. Figure 2-3 demonstrates this using two datasets, displaying the relative return period for severe drought persisting for at least three months, based on SPI-6 data for 1981-2020 (left) and 1951-2013 (right), respectively. Plotted is the average return period at a given location compared to the shortest return period identified over the entire region. The darker shaded areas thus represent relatively lower return periods, and therefore more frequent severe drought recurrence. Overall, the two maps show that over the period 1951-2020, severe drought occured throughout the region, but more frequent drought was concentrated along the equator, and in hotspots across Indonesia, Malaysia and the Philippines, with more dispersed hotspots throughout continental South-East Asia. The results are most variable for southern Viet Nam, in which severe drought occurred more frequently during 1981-2020 than for the longer 1951-2013 period. Again, this demonstrates that drought may affect different areas of the region at different times, and all countries must be prepared.

Figure 2-3 — Relative frequency of severe drought, 1951-2013, and 1981-2020



Source: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), 1981-2020 (left) and Global Precipitation Climatology Centre (GPCC) data, 1951-2013 (right).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Hotspots of drought severity, exposure and vulnerability

The impacts of drought in South-East Asian countries are determined not only by the physical hazard itself, but also by the exposure and vulnerability of the population and key climate-sensitive sectors.

Identifying the geographical distribution of frequencies of meteorological drought is necessary, but not sufficient for fully understanding drought risk. Drought risk is also determined by how meteorological droughts are translated into hydrological and agricultural droughts. Furthermore, Box 2-1 shows that risk consists not only of the hazard, but also the exposure and underlying vulnerability of the population. For Governments, understanding the exposure and vulnerability provides an important entry point for reducing drought risk. Whilst the meteorological drought hazard may change as the climate warms, steps can be taken now to change the underlying socioeconomic conditions and thereby strengthen the resilience of vulnerable population groups and of society more broadly.

Box 2-1 – Risk consists of hazard, exposure, vulnerability

Hazard refers to the process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation.

Exposure refers to the degree to which people, infrastructure, housing, production capacities and other tangible human assets are located in hazard-prone areas. It can be measured as the number of people, the number of asset types, or value of stock, in an area.

Vulnerability refers to the conditions determined by physical, social, economic and environmental factors or processes which increase the susceptibility of an individual, a community, assets or systems to the impacts of hazards.

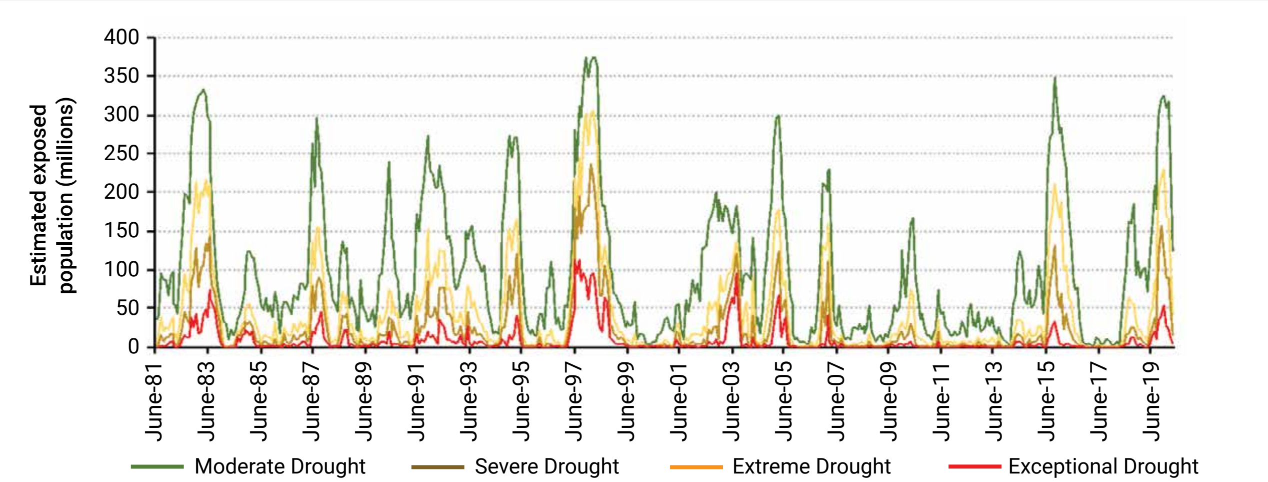
Risk is a composite measure, which can be quantified by combining measures of exposure, vulnerability and the magnitude of the hazard itself.[a]

[a] UNDRR (2020).

A substantial proportion of the population is episodically exposed to drought.

The wide geographic distribution of meteorological drought hazard means that a substantial proportion of the South-East Asian population is regularly exposed to drought. Figure 2-4 displays the number of people that were exposed to droughts of varying severity during the period 1981-2020. The greatest exposure was during the 1997-1998 El Niño, when over 225 million people were exposed to extreme drought, and 100 million to exceptional drought.

Figure 2-4 — Population exposed to drought, millions, June 1981-April 2020



Source: Population data from CIESIN; rainfall data from CHIRPS.
Note: Refers to drought of varying levels of severity, as based on SPI6.

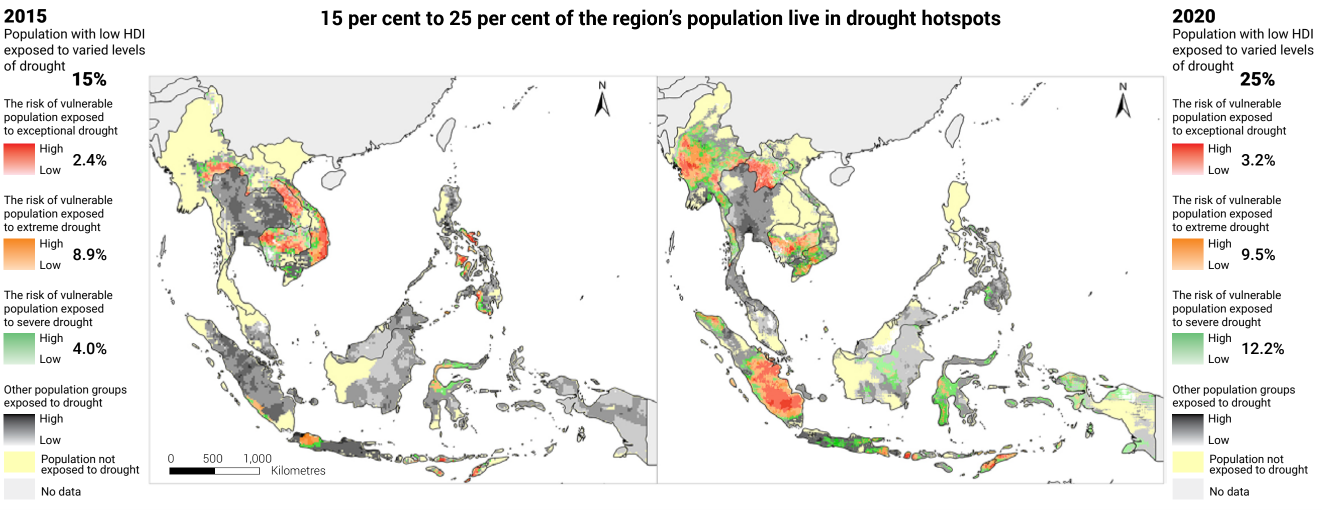
Subsequently, the greatest exposure occurred during the periods 2015-2016 and 2018-2020. In 2018-2020, more than 200 million were exposed to severe drought, and more than 150 million to extreme drought. For moderate drought, the numbers were even higher: 350 million in 2015-2016 and 325 million in 2018-2020.

When population exposure and vulnerability are considered along with the physical drought hazard, further hotspots of drought risk are identified.

This section presents the results of an analysis of drought risk, for the 2015-2016 and 2018-2020 drought events. It combines data on meteorological drought, the number of people exposed and information about the vulnerability of particular groups to identify likely drought hotspots. In this analysis, population exposure has been calculated for drought of varying severity levels using gridded population data and the SPI, on a monthly basis from 1981-2020. Comparing vulnerability at the regional level is more challenging. Vulnerability is a broad concept, tied up with the socioeconomic conditions, sensitivity of the population, and their adaptive capacities to cope with droughts. It is often measured differently within different countries, and each factor can vary greatly even at highly localised levels. For this analysis, the Human Development Index (HDI) is used as a proxy for vulnerability. It does not exhaustively capture all elements of vulnerability, but is selected because it is a statistic composite index of life expectancy, education, and per capita income, and therefore covers many of the key dimensions of vulnerability, and because the data is available for countries across the region, at the subnational level. This allows the analysis to uncover key vulnerabilities that are shared across South-East Asia.

The analysis revealed that throughout the past five years, the vulnerability of the exposed populations has varied. During 2015, 21 per cent of the population had both low HDI scores as well as exposure to drought, whereas in 2020, it was 48 per cent. This highlights the importance of accurately understanding where drought will strike, as it determines the underlying vulnerability of the exposed population and can therefore shape the impacts of the drought.

Figure 2-5 — Population vulnerability based on Human Development Index



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and February 2020; Sub-National Human Development Index (SHDI) Version 1, 2018 and Version 4.0, 2020; and UN WPP-Adjusted Population Density 2015 and 2020, v4.11.
Note: 1. The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years. 2. SHDI Version 1, 2018 in South-East Asia is classified as high, medium and low. SHDI Version 4.0, 2020 in South-East Asia is classified as medium and low.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Incorporating exposure and vulnerability into the analysis also changes the geographical distribution of drought risk. The previous section revealed hotspots of drought hazard over the past four decades (1981-2019), and during the past five years (2015-2020). However, as Figure 2-5 shows, when population exposure and vulnerability are considered along with the physical drought hazard, the hotspots of drought risk change.

Figure 2-5 shows that in October 2015, the highest overall drought risk was found within the western and central areas of Indonesia, central and southern areas of the Philippines, central and northern areas of Thailand, and central and southern areas of Viet Nam. In February 2020, the highest overall drought risk was found within the south-west and southern areas of Indonesia, central, northern and southern areas of Myanmar, southern areas of Philippines, central and northern areas of Thailand, all of Timor-Leste, and southern areas of Viet Nam.

Table 2-1 — Hotspots of drought risk for countries in South-East Asia

Countries	Areas with high frequency of severe meteorological drought (over period 1981-2019, based on SPI6)	Hotspots of drought severity, exposure and vulnerability in 2015, (based on SPI6, population density and HDI)	Hotspots of drought severity, exposure and vulnerability in 2020 (based on SPI6, population density and HDI)
Brunei Darussalam	All parts	None	None
Cambodia	Central parts	Central and northern parts	Central and southern parts
Indonesia	Western, north-central and eastern parts	Western and southern parts	South-west and southern parts
Lao People's Democratic Republic	Northern parts	Central parts	Northern parts
Malaysia	South-western and north western parts	South-western and north western parts	North-western parts
Myanmar	Northern and southern parts	Eastern parts	Central, northern and southern parts
Philippines	Southern parts	Central and southern parts	Southern parts
Singapore	All parts	Northern parts	None
Thailand	Central parts	Central and northern parts	Central and northern parts
Timor-Leste	All parts	Northern parts	Northern and central parts
Viet Nam	Central and southern parts	Central and southern parts	Southern parts

High   Medium   Low

Source: ESCAP calculations based on:
1) Ratio of recurrence time for severe drought persisting at least 3 months (based on SPI6) to the minimum recurrence time identified across all of South-East Asia for the period of 1981-2019.
2) Six-month Standardized Precipitation Index (SPI6) in October 2015 and February 2020; Sub-National Human Development Index (SHDI) Version 1, 2018 and Version 4.0, 2020; and UN WPP-Adjusted Population Density 2015 and 2020, v4.11.

Table 2-1 displays a risk matrix that compares the different identifications of hotspots of drought risk for each country in South-East Asia, categorised as high, medium and low risk, for comparison.

The severity of drought impacts, during 2015-2020, can be attributed to the exposure of vulnerable populations, who are the most likely to live in drought-affected areas.

Further analysis of this convergence reveals that more vulnerable populations are more likely to live in drought-affected areas. Of the total population exposed to drought in 2020, the largest proportion (48.2 per cent) are living in areas with low HDI scores. This pattern is consistent across drought severity, as larger proportions of the population with low HDI scores have been exposed to each severity of drought, than proportions of the population with medium HDI scores. For example, 6.9 per cent of the population with medium HDI are exposed to moderate drought, compared to 23.2 per cent of the population with low HDI. These results provide an explanation as to why drought impacts over the past 5 years have been so severe, as it is the most vulnerable populations that are exposed to the most severe drought.

A vulnerability analysis for four countries

Assessing subnational measures of vulnerability reveals specific hotspots in which poverty, malnourishment and high levels of agricultural employment are converging with drought.

As mentioned previously, HDI does not capture all dimensions of vulnerability. At the first administrative division level, four countries in the region have further data available. The analysis uses this data, on poverty, malnutrition and dependence on agriculture (Box 2-2), from the Demographic and Health Surveys (DHS) which are available for Cambodia, Myanmar, Philippines and Timor-Leste.

Based on this analysis, Table 2-2 presents first level administrative divisions that are hotspots in which high levels of poverty, malnutrition and agricultural vulnerability are exposed to drought. Areas highlighted in orange demonstrate recurrence during both drought peaks in 2015 and 2020, and for each measure of vulnerability.

Box 2-2 – Analysing vulnerabilities within countries

The analysis focuses on three variables that capture levels of poverty, health and agricultural employment. Poverty determines a person's capacity to cope with the impacts of drought, such as the potential loss of income, and fluctuations in food prices. It is measured by the wealth index, which is a composite measure of a household's cumulative living standard, calculated by using easy-to-collect data on a household's ownership of selected assets, such as televisions, bicycles and housing materials, and types of water access and sanitation facilities surveyed at the household level. Health is measured using a malnutrition index, which measures stunting or high deviation of height for age, for children under five years old. Finally, various measures relating to agriculture are included. These were selected based on data availability across all four countries, and include the percentage of men working in agriculture, the amount of land used for agriculture, and the percentage of farmers owning less than two hectares of land. These smallholder farmers have the least capacity to cope with disruptions to agricultural productivity.[a]

For the purpose of this regional analysis, a broad vulnerability framework is used. The limited scope is determined by the availability of comparable data at the subnational level, between countries. For individual provinces and communities, a full vulnerability analysis must be contextualized, by incorporating all factors that are relevant in that area. These may include, for example, gender, age, access to resources and land, societal and cultural norms, marginalization, and livelihood sensitivity.[b] Furthermore, it should be noted that many other types of livelihood are impacted by drought, including fisheries, those relying on water transport, etc.

[a] FAO (2019).
[b] Neville D. Crossman (2018).

Table 2-2 — Hotspots of drought vulnerability based on poverty, malnutrition, and agriculture, 2015 and 2020

Countries	Recurrent hotspots of drought and high poverty	Recurrent hotspots of drought and high malnutrition	Recurrent hotspots of drought and high proportion of men in agriculture	Recurrent hotspots of drought affecting a high proportion of agricultural land	Recurrent hotspots of drought and high proportion of farmland owned by smallholders
Cambodia	Battambang Province Pailin Province	Battambang Province Pailin Province	Battambang Province Pailin Province	Battambang Province Pailin Province	Battambang Province Pailin Province
				Kampong Cham Province	Kampong Cham Province
		Kampong Chhnang Province	Kampong Chhnang Province		Kampong Chhnang Province
		Kampong Thom Province	Kampong Thom Province		Kampong Thom Province
	Kratie Province	Kratie Province	Kratie Province	Kratie Province	Kratie Province
	Mondol Kiri Province	Mondol Kiri Province	Mondol Kiri Province	Mondol Kiri Province	
		Pursat Province	Pursat Province		Pursat Province
	Ratana Kiri Province	Ratana Kiri Province	Ratana Kiri Province	Ratana Kiri Province	
Myanmar					Chin State
					Kachin State
	Kayah State	Kayah State	Kayah State	Kayah State	*Kayah State in 2015
				Kayin State	
				Mon State	
		Nay Pyi Taw Union Territory	Nay Pyi Taw Union Territory		
		*Rakhine State in 2020	*Rakhine State in 2020		
					Sagaing Region
	Kayah State	Kayah State	Kayah State	Kayah State	*Shan State in 2015
Philippines	Zamboanga Peninsula Region	N/A	N/A	N/A	N/A
	Northern Mindanao Region				
	Caraga Region				
	Davao Region				
Timor-Leste	Bobonaro Municipality	Bobonaro Municipality	Bobonaro Municipality	Bobonaro Municipality	Bobonaro Municipality
	Ermera Municipality		Ermera Municipality	Ermera Municipality	Ermera Municipality
	Liquiçá Municipality	Liquiçá Municipality	Liquiçá Municipality	Liquiçá Municipality	Liquiçá Municipality
	Oecussi District	Oecussi District	Oecussi District	Oecussi District	Oecussi District

Recurrent hotspots for all variables (orange) Recurrent hotspots for certain variables (yellow)

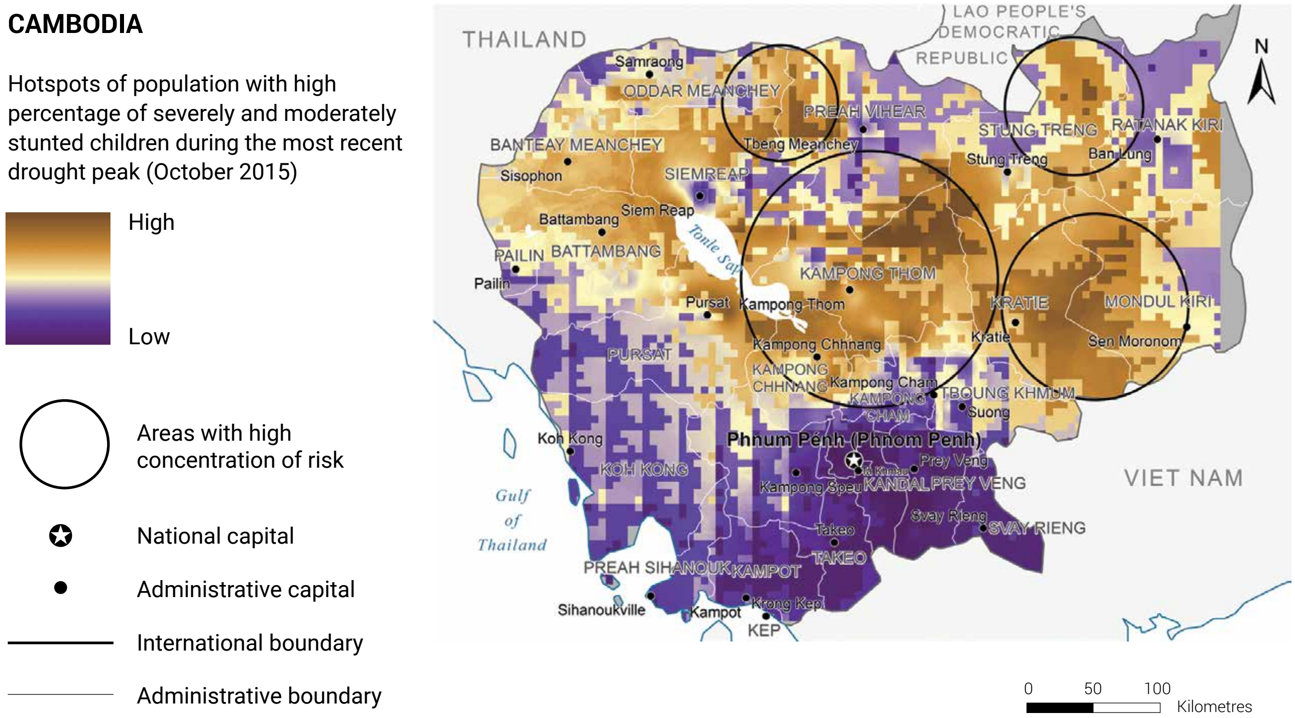
Sources: ESCAP calculations using GIS, based on the average value of six-month Standardized Precipitation Index (SPI6) in 2015 and 2020; and Demographic and Health Surveys (DHS) Programme for Cambodia 2014, Myanmar 2016, Philippines 2017 and Timor-Leste 2016.
Note: *These hotspots occurred only in the year shown, not in both 2015 and 2020.

Examining the four countries in more depth reveals the geographic distribution of vulnerability to drought.

Cambodia

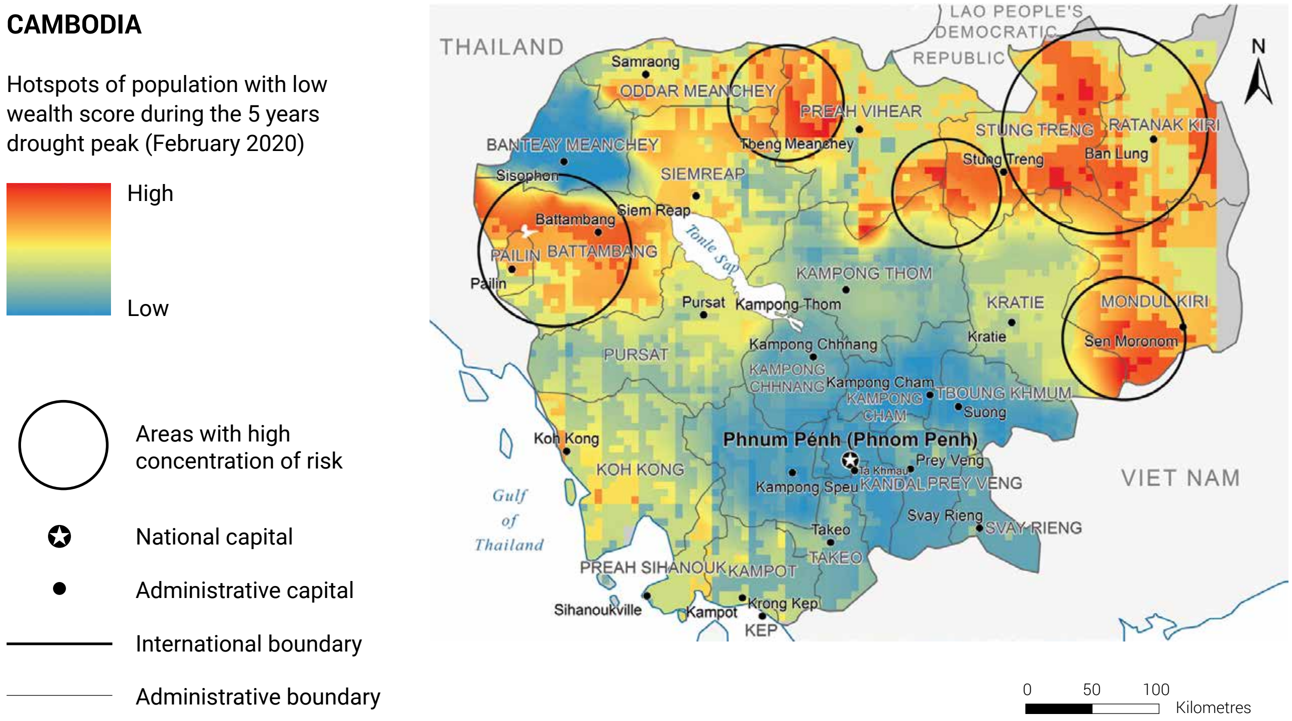
It has been found that 6 per cent of children in Cambodia are severely stunted and 27 per cent are severely and moderately stunted.[1, 2] Figure 2-6 shows those areas affected by drought during 2015 which also had high proportions of severely and moderately stunted children, and Figure 2-7 shows the areas affected by drought during 2015 that had high levels of poverty. These hotspots were located in Battambang, Pailin, Pursat, Kampong Chhnang, Kampong Thom, Kratie, and Mondol Kiri and Ratana Kiri provinces.

Figure 2-6 — Drought and stunting vulnerability hotspots, Cambodia, 2015



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Cambodia 2014. Map source: UNmap 2020.
Note: 1. The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years. 2. Moderately stunted children are those with height-for-age score below minus 2 standard deviations, or below the mean on the WHO Child Growth Standards (hc70 < -200).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2-7 — Drought and poverty vulnerability hotspots, Cambodia, 2015



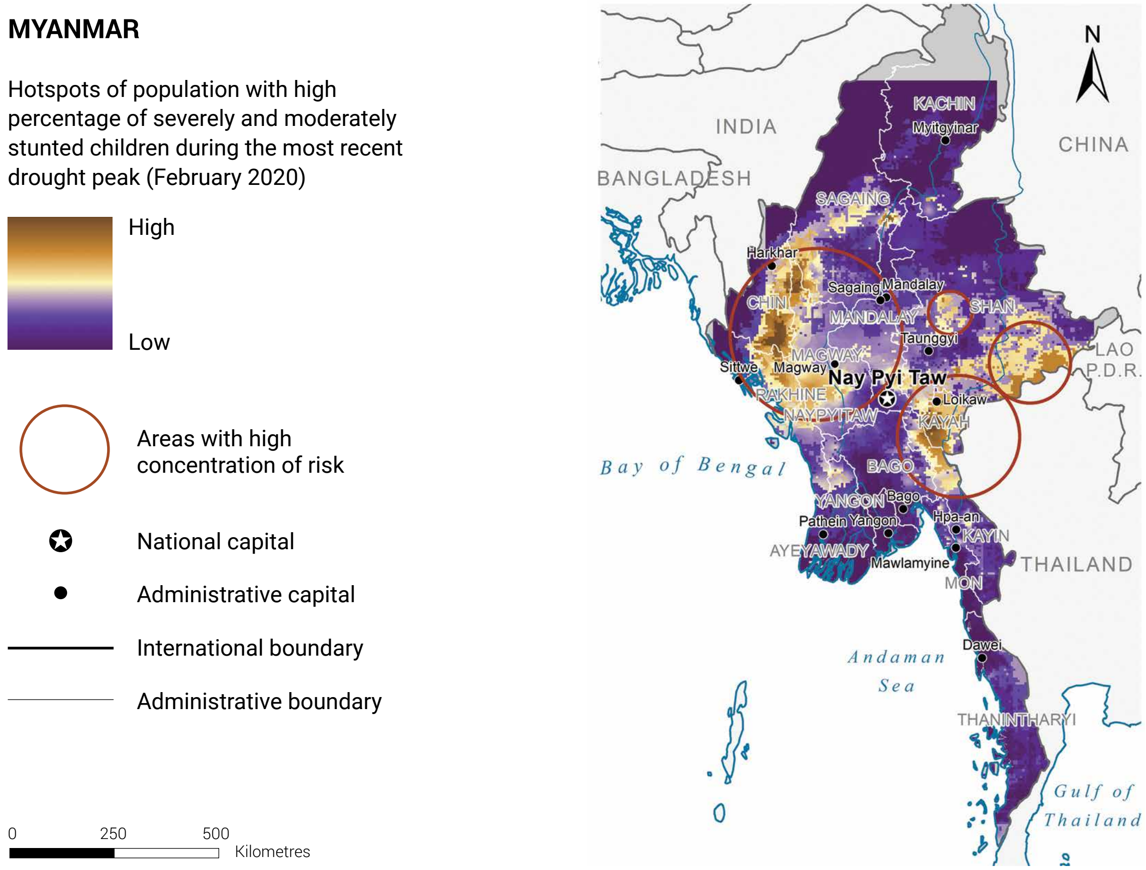
Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Cambodia 2014. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Around 45 per cent of men in Cambodia work in agriculture so their livelihoods are very exposed to drought. In 2015 and 2020, there were three hotspots where drought converged with areas of high levels of agricultural employment and high levels of poverty, covering the provinces of Battambang, Pailin, Kratie and Mondol Kiri.

Myanmar

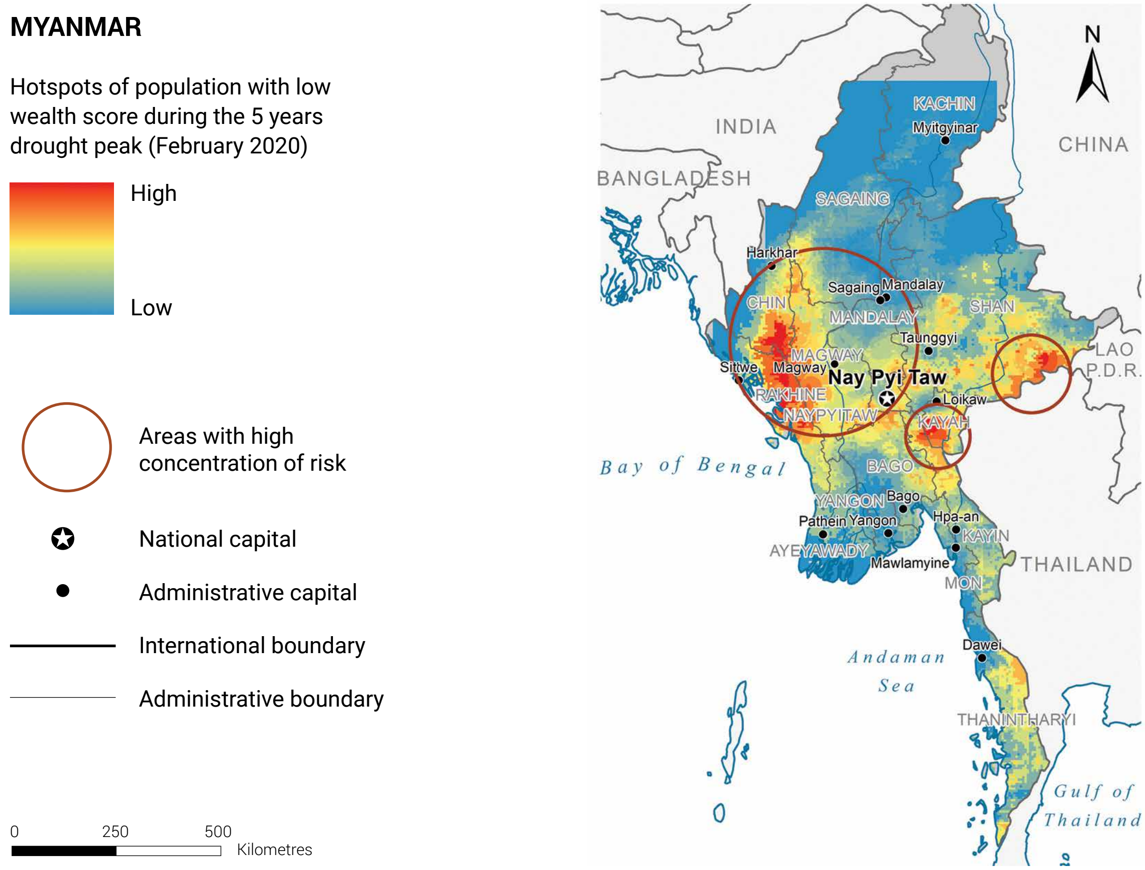
In Myanmar as a whole, 6 per cent of children are severely stunted and 24 per cent are moderately stunted. Figure 2-8 shows how in 2020 drought occurred in areas with high levels of child malnutrition, and Figure 2-9 shows how it occurred in areas with high levels of poverty. As with Cambodia, there were clear hotspots; notably within the Kayah, Shan, Chin, and Rakhine states, the Nay Pyi Taw Union Territory, and the Magway Region.

Figure 2-8 — Drought and stunting vulnerability hotspots, Myanmar, 2020



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) February 2020 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note: 1. The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years. 2. Moderately stunted children are those with height-for-age score below minus 2 standard deviations, or below the mean on the WHO Child Growth Standards (hc70 < -200).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

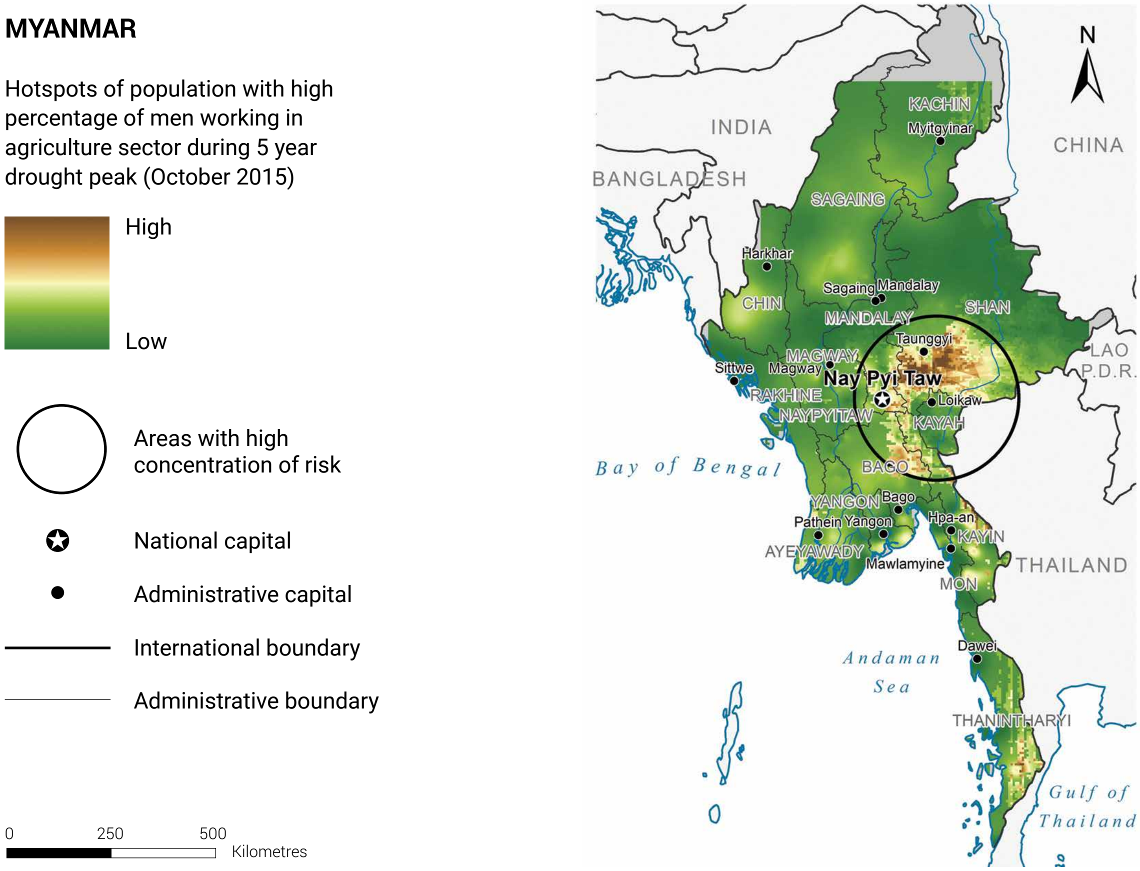
Figure 2-9 — Drought and poverty vulnerability hotspots, Myanmar, 2020



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) February 2020 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

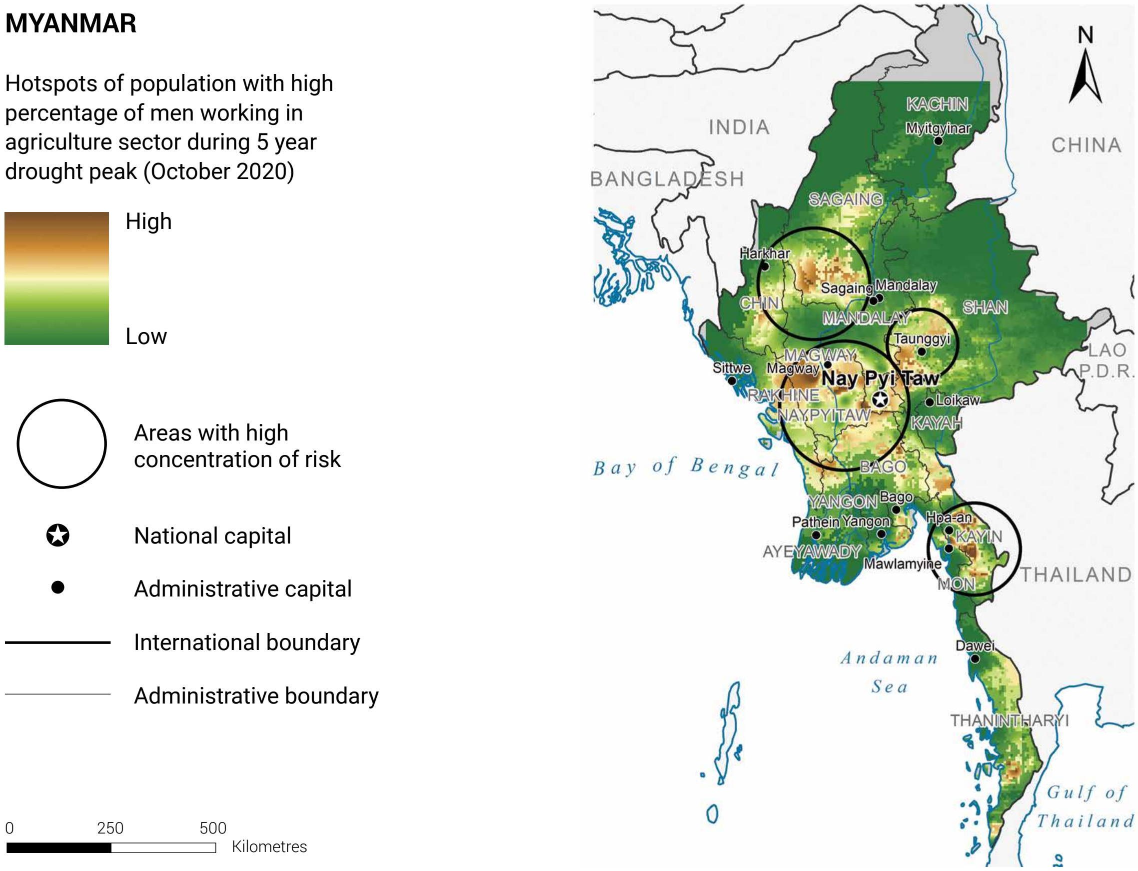
Many people in Myanmar depend on agriculture for their livelihoods. Around 27 per cent of men work in the sector. Figure 2-10 and Figure 2-11 show the areas affected by drought in 2015 and 2020, that had high agricultural employment. Particularly vulnerable were Kayah and Shan states which are also hotspots of high malnutrition and poverty. However, as these maps show, the impact was much greater in 2020; in addition to Kayah and Shan states there were hotspots across Chin, Kayin, Mon and Rakhine states, as well as Magway, Mandalay and Sagaing regions.

Figure 2-10 — Drought and agricultural employment vulnerability hotspots, Myanmar, 2015



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note : The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

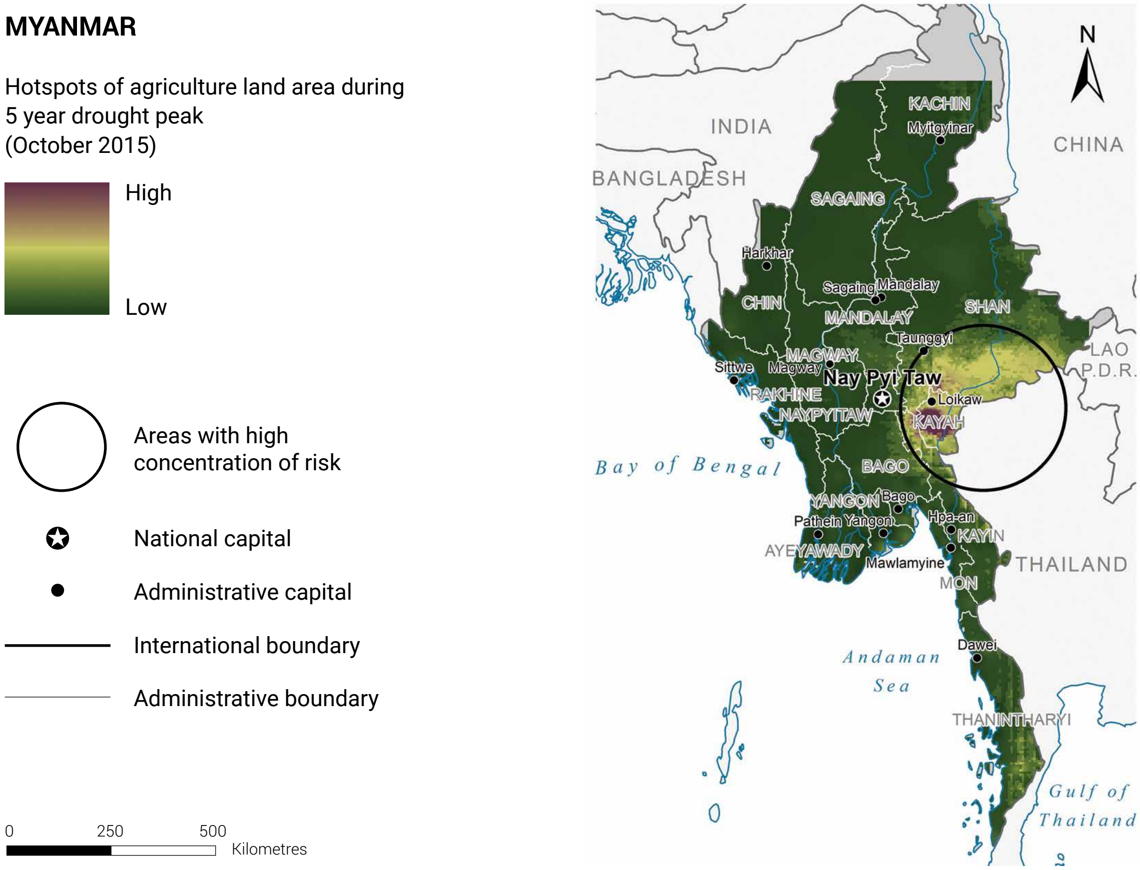
Figure 2-11 — Drought and agricultural employment vulnerability hotspots, Myanmar, 2020



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) February 2020 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

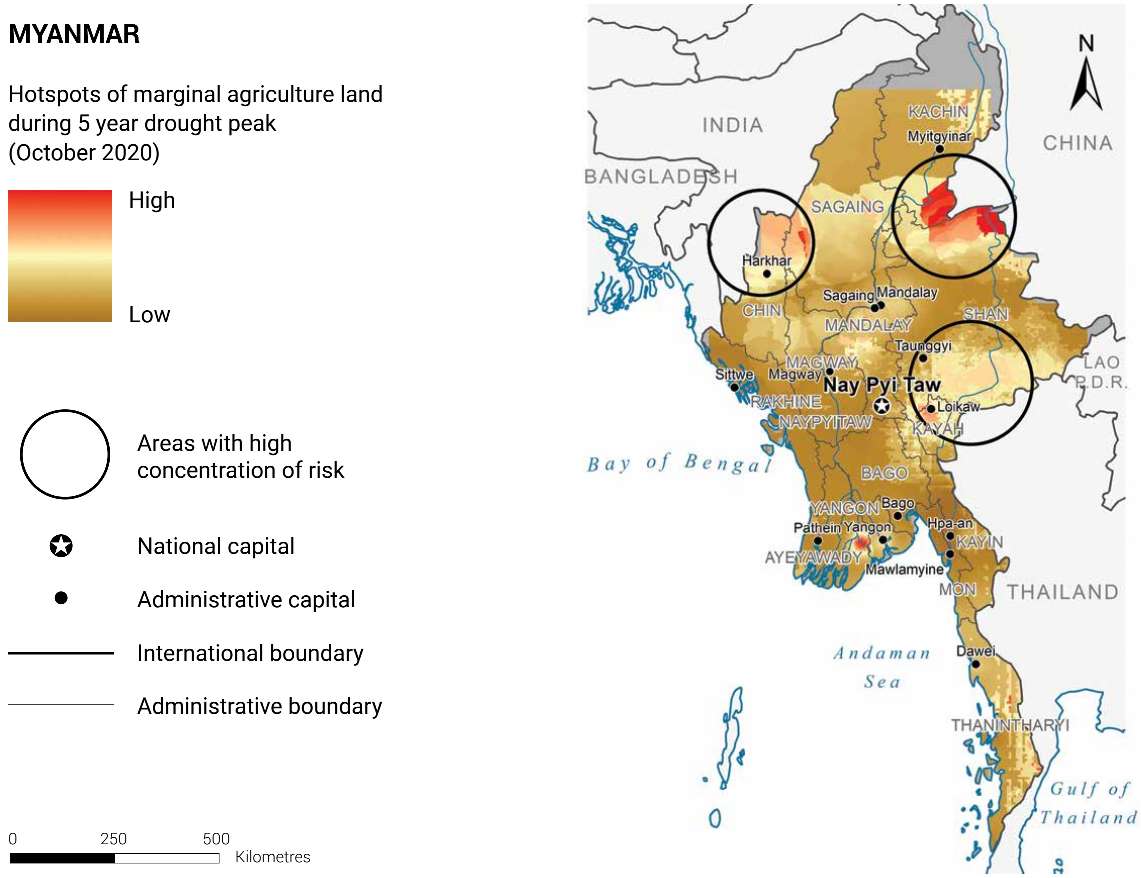
Other useful measures of exposure are the proportion of agricultural land affected by drought and the proportion of smallholder farmers. Figure 2-12 identifies hotspots for agricultural land exposed to drought in Nay Pyi Taw Union Territory, Kayah, Kayin, Mon, and Shan states, and Figure 2-13 identifies hotspots of smallholder farmer exposure in Chin, Kachin, and Shan states.

Figure 2-12 — Proportion of agricultural land area affected by drought, Myanmar, 2015



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2-13 — Drought and smallholder vulnerability hotspots, Myanmar, 2015



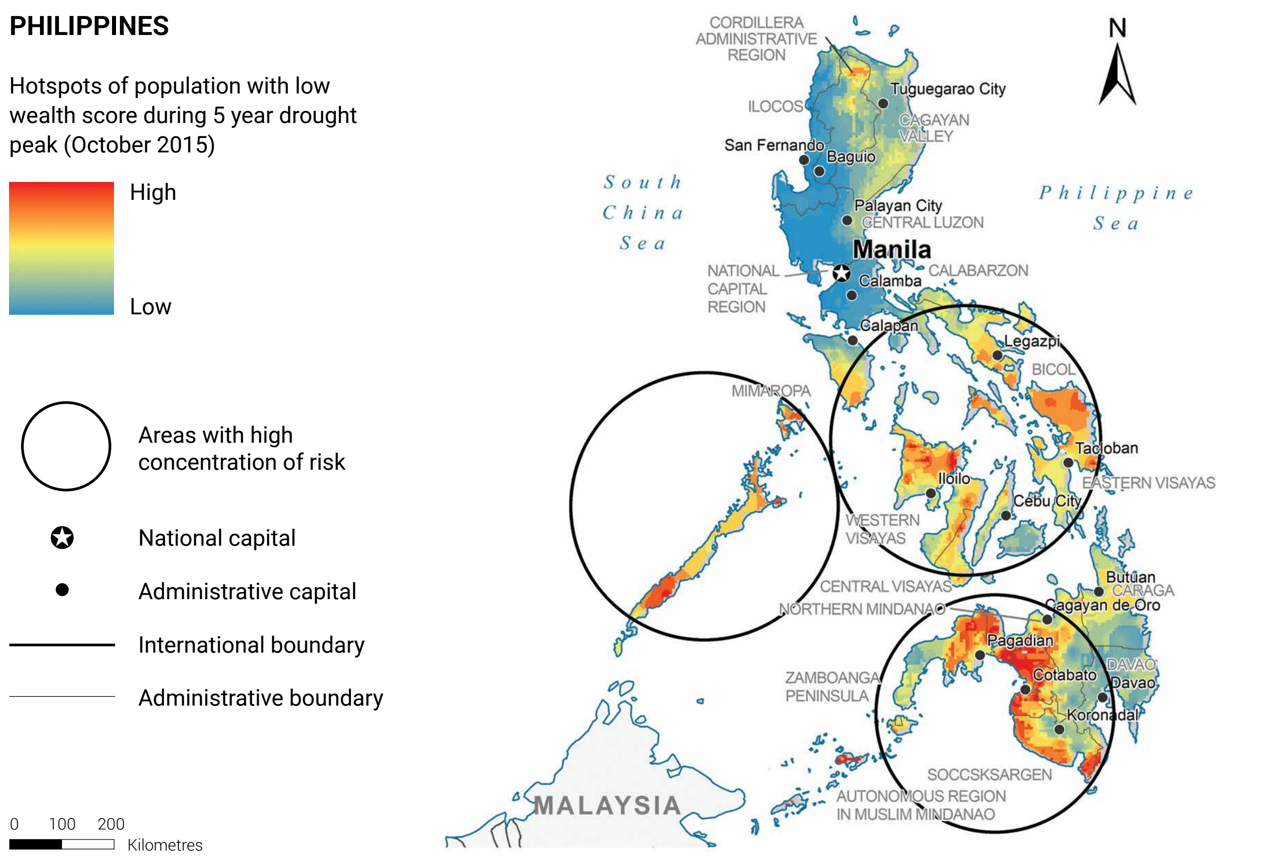
Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Myanmar 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

For recurring hotspots, as in the Shan state, it will be important to strengthen agricultural resilience whether supporting household or encouraging drought-resistant land use practices.

Philippines

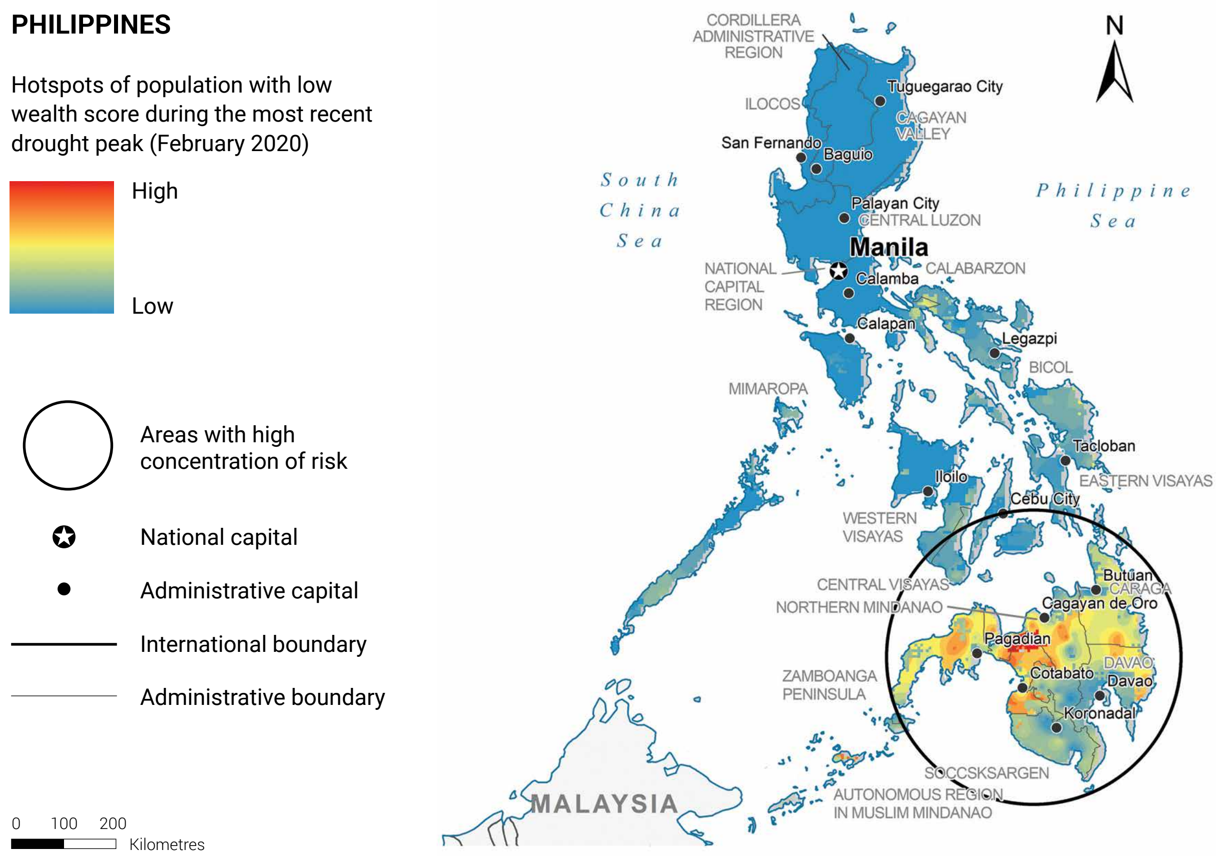
In the Philippines extensive subnational data on poverty make it possible to identify hotspots where poverty converges with drought. Figure 2-14 and Figure 2-15 show hotspots within Mimaropa, the western, central and eastern parts of Visayas, Bicol, Zamboanga Peninsula, northern Mindanao, central Mindanao (Socckssargen) and Caraga regions in 2015. In 2020, there were hotspots across the south of the country, including Zamboanga Peninsula, northern Mindanao, Caraga and Davao regions.

Figure 2-14 — Drought and poverty vulnerability hotspots, Philippines, 2015



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Philippines 2017. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2-15 — Drought and poverty vulnerability hotspots, Philippines, 2020

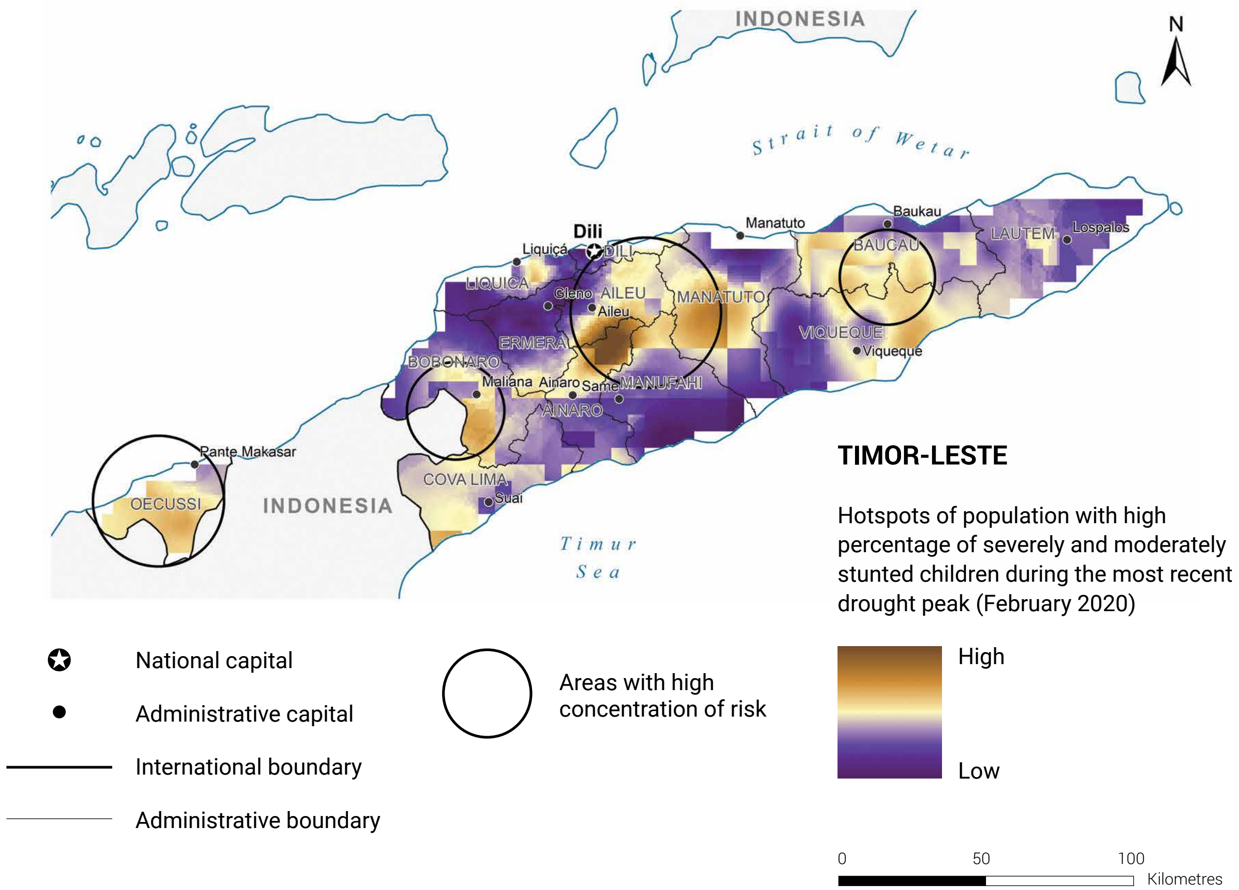


Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Philippines 2017. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Timor-Leste

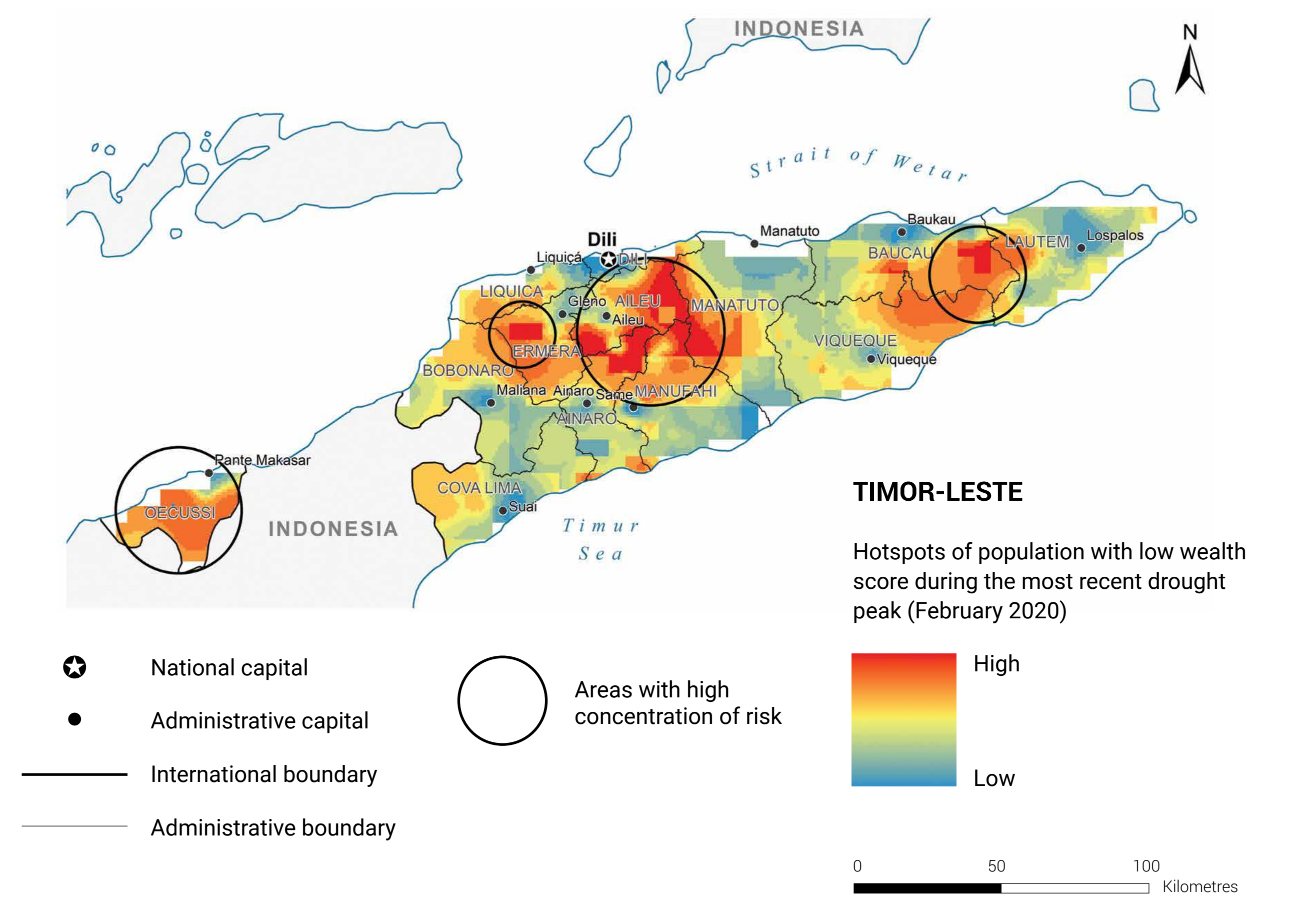
Of these four countries, Timor-Leste is the most vulnerable. Malnutrition is high with 17 per cent of children being severely stunted, and 37 per cent of children being severely or moderately stunted. Areas with high levels of malnutrition tend to correlate with areas with high levels of poverty. This is illustrated for 2020 in Figure 2-16 for malnutrition and in Figure 2-17 for poverty. All the hotspots were within Oecussi district, and Bobonaro and Liquiçá municipalities.

Figure 2-16 — Drought and stunting vulnerability hotspots, Timor-Leste, 2020



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) February 2020 and Demographic and Health Surveys (DHS) Programme for Timor-Leste 2016. Map source: UNmap 2020.
Note: 1. The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years. 2. Moderately stunted children are those with height-for-age score below minus 2 standard deviations, or below the mean on the WHO Child Growth Standards (hc70 < -200).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

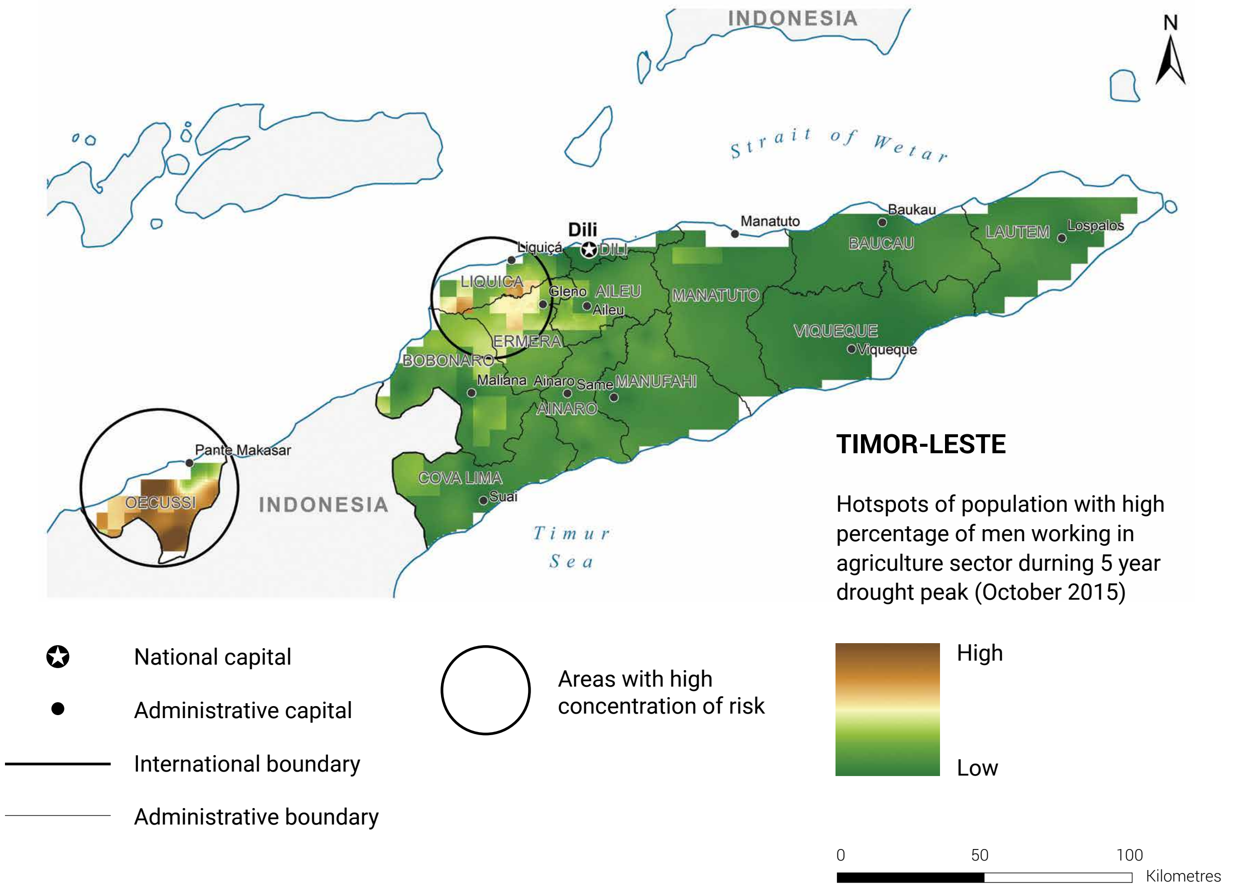
Figure 2-17 — Drought and poverty vulnerability hotspots, Timor-Leste, 2020



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) February 2020 and Demographic and Health Surveys (DHS) Programme for Timor-Leste 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

In Timor-Leste agricultural land is not as fertile as elsewhere in South-East Asia. The country has few rivers, and the soil consists mostly of limestone and marine clays. Irrigation schemes are difficult to maintain. Furthermore, the climate is generally very dry and some areas of the country have only one viable cropping season. As a result, recurring droughts have a significant impact on agricultural output.[3] Around 37 per cent of men work in agriculture and 40 per cent of these farmers own less than two hectares of agricultural land. Smallholders have little financial capacity to cope with droughts. Figure 2-18 identifies Liquiçá municipality as a hotspot, in 2015, for high levels of agricultural employment.

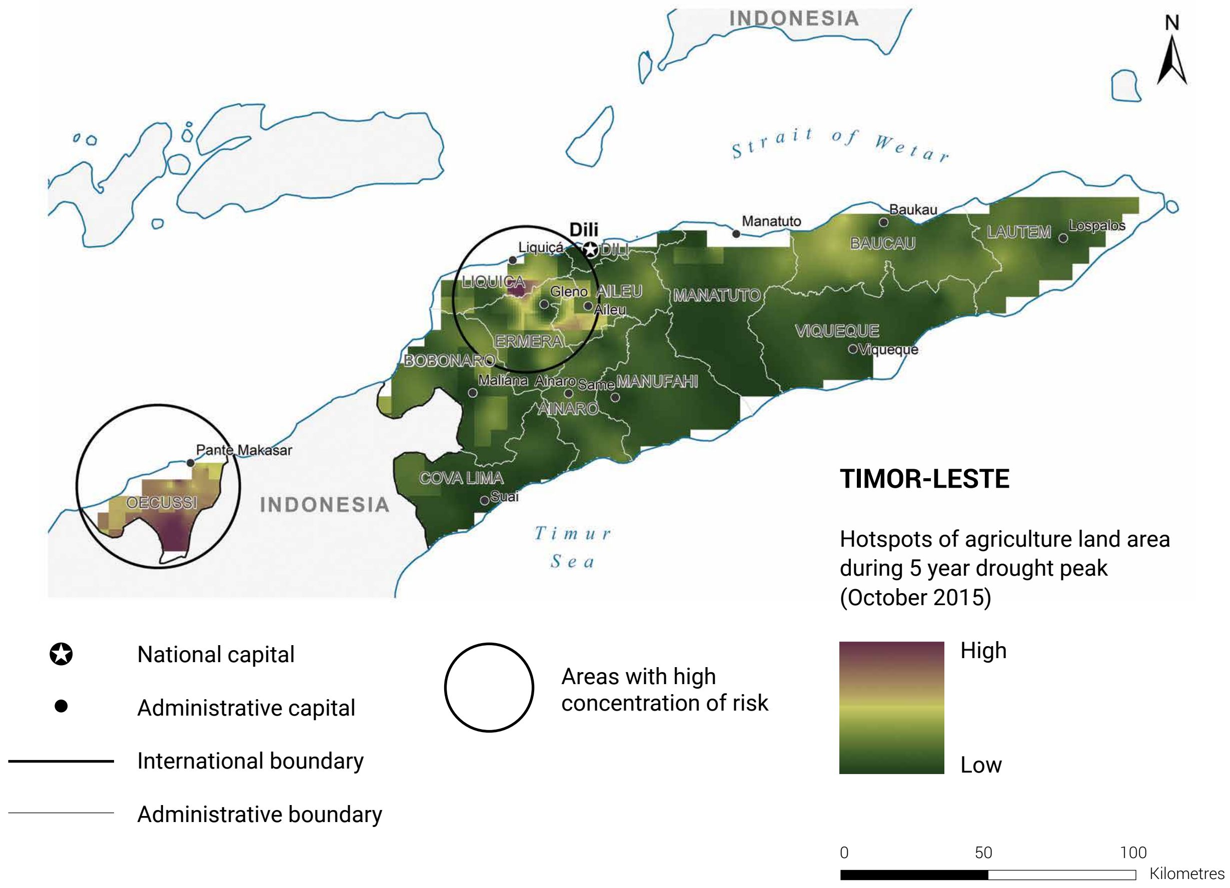
Figure 2-18 — Drought and high levels of agricultural employment, Timor-Leste, 2015



Sources: ESCAP calculations on based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Timor-Leste 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

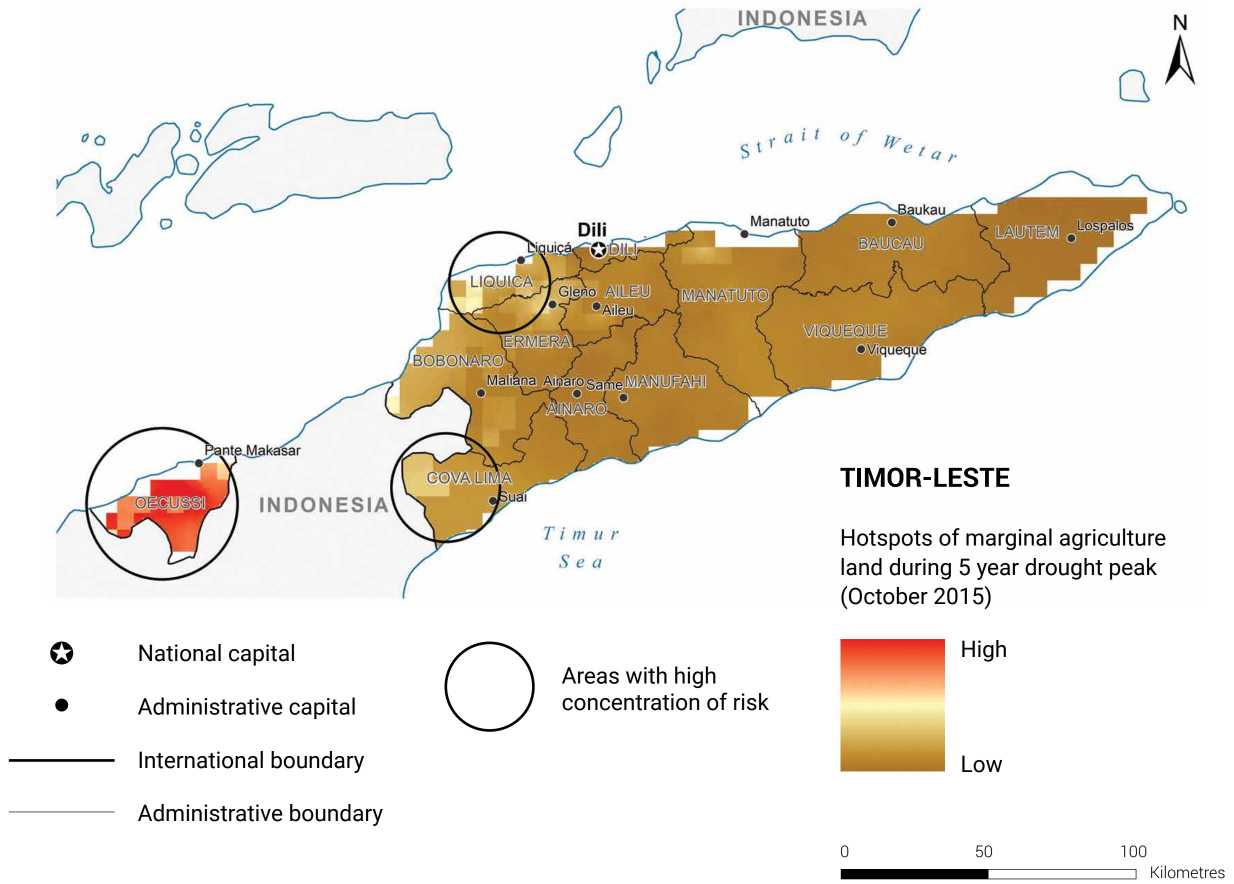
Vulnerability in Timor-Leste also arises through the high proportion of land used for agriculture. Figure 2-19 identifies hotspots during the 2015 peak, including Ermera and Liquiçá municipalities and the Oecussi district. Finally, the analysis highlights the exposure of marginal agricultural land, run by smallholder farmers. Figure 2-20 identifies two hotspots in Oecussi, Ermera and Liquiçá, as well as in Cova-Lima municipality, in which marginal agricultural land was exposed to drought in 2015.

Figure 2-19 — Agricultural land exposed to the drought peak, Timor-Leste, 2015



Sources: ESCAP calculations on based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Timor-Leste 2016. Map source: UNmap 2020.
Note: The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years.
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Figure 2-20 — Marginal smallholder land exposed to the drought peak, Timor-Leste, 2015



Sources: ESCAP calculations based on six-month Standardized Precipitation Index (SPI6) October 2015 and Demographic and Health Surveys (DHS) Programme for Timor-Leste 2016. Map source: UNmap 2020.
Note: 1. The SPI6 value is categorized into moderate, severe, extreme and exceptional drought using CHIRPS rainfall data within the past 5 years. 2. The marginal agricultural land class is defined as agricultural land area below 2 hectares (FAO, 2014).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Even for the selective vulnerability framework used, it is clear from this subnational analysis that drought exposure and vulnerability across South-East Asia is complex. Many factors must therefore be taken into consideration when identifying priority areas for targeted drought risk management. The findings also illustrate why the impacts of drought can be so varied across different areas, and for different population groups. The next section explores how these impacts have developed over 2015-2020.

Impacts of drought during 2015-2020

Collating standard regional information on drought impacts is difficult because definitions of drought vary from country to country and reporting is inconsistent. Moreover, the impacts can long outlast the drought event itself. This section nevertheless uses humanitarian assessments and news reports as a basis for summarizing drought impacts during the period 2015-2020.[4] Even this preliminary analysis reveal patterns which show that some sectors, such as agriculture, are affected repeatedly.

Table 2-3 — Reported drought events and selected impacts, 2015-2016, and 2018-2020

2015-2016	2018-2020
Cambodia	
2014-July 2016 *Almost every province declared drought.* Worst drought in 50 years, in almost every province. Water security: water levels in rivers fell to between 50 per cent and 70 per cent of the inter-annual average.[5] 2.5 million people experienced water shortages. 260,000 affected families required water deliveries.[6] Livelihoods: disrupted by massive depletion of fish stocks and livestock.[7] Food security: Farming households still struggling with food security in December 2016.[8]	*2019-2020* *16 provinces around the Tonle Sap region and southern provinces.* By March 2019, 16 provinces reported water shortages. By January 2020, dry conditions reached provinces surrounding Tonle Sap lake basin, and in the south of the country.[9] Agriculture: planting season disrupted, as temperatures peaked during April and May 2019.[10] Water security: Mekong river levels declined at Kampong Cham from five metres to three metres, and at Phnom Penh, from four to below three metres. This placed the river at the lowest levels it has been in these areas, during this period, over the past 40 years.[11]
Indonesia	
2015 -2016 *102 districts of 16 provinces reported drought, mostly in Central Java, West Java, East Java, Lampung, South Sumatra and Bali.* 102 districts of 16 provinces reported drought, with central Java, west Java, east Java, Lampung, south Sumatra and Bali as the hardest hit. 578,589 households and approximately 111,000 hectares of agriculture fields affected. Food security: disruption to the planting and growing season left over 1.2 million people in need of food assistance.[12] Secondary hazards: peatland fires and haze, which extended across Sumatra and Kalimantan, as well as reaching Malaysia and Singapore.[13]	*Late 2018-2020* *92 per cent of the country affected. Emergencies declared in Banten, Central Java, West Java, East Java, Yogyakarta, West Nusa Tenggara and East Nusa Tenggara.* By October 2019, 92 per cent of the country, and 48.5 million people affected.[14] Emergencies declared in Banten, Central Java, West Java, East Java, Yogyakarta, West Nusa Tenggara and East Nusa Tenggara.[15] Secondary hazards: forest and peat land fires, poor air quality causing disruption to education and damage to human health.[16, 17]
Lao People's Democratic Republic	
December 2014-late 2016 *Drought impacts recorded in Champasak, Luang Prabang, Savannakhet, and Vientiane provinces.* Agriculture: over 1,000 hectares of upland crop areas were affected, 420 hectares seriously damaged.[18] Over 104,000 hectares of freshly planted rice seedlings were affected, and 48,000 ha of rice growing land lost (5-10 per cent of the national rice area).[19]	*2018-2019* *Drought reported in central and northern areas, namely Vientiane, Xaysomboun, Xayaburi and Luang Prabang.* Meteorological drought compounded by significant reduction in the water released from dams, at half of 2018 levels. Agriculture: farmers were able to plant rice on approximately 40 per cent of the country's 850,000 cultivable hectares. As a result, 2019's rice production was more than 17,500 tons short of the 2018 total.[20] Water security: widespread shortages. Over 100 families in the Nam Tha 1 Dam hydropower resettlement village, in Luang Namtha province, had to be relocated as no water was available.[21]

Continued ▶

Malaysia	
March 2016 *Drought reported across Sabah and northern Sarawak districts.* Sabah and northern Sarawak districts affected. Secondary hazards: forest fires destroyed several hundred hectares of crops. Reports of water pollution and water scarcity.[22]	*2019* *Agriculture: damage to 54.6 hectares of rice crops in Machang District, Kelantan.*[23] Secondary hazards: haze reported across Peninsular Malaysia and southern Sarawak, due to forest fires in Kalimantan and Sumatra, Indonesia.[24]
Myanmar	
May 2015– September 2016 *Severe drought reported in Sagaing, Magway, and Ayeyarwady regions.* 15 million people, mainly farmers, affected in Sagaing, Magway, and Ayeyarwady regions. Agriculture: 3 large water reservoirs dried up in Sagaing Region, leaving 40,000 hectares of farmland uncultivable. Led to delayed planting season.[25] Water security: 1,700 villages and 5.4 million hectares of farmland experienced water shortages.	*August-September 2018* *Central Myanmar (Mandalay, Magway and Saigang) reported water shortages.* Agriculture: farmers in central Myanmar (Mandalay, Magway and Sagaing regions) struggled to grow and cultivate monsoon paddy due to water shortages caused by drought.[26, 27]
Philippines	
December 2015-September 2016 *Drought reported across 40 per cent of the country, including provinces in Luzon, the Visayas and Mindanao.* Around 40 per cent of the country affected, including provinces in Luzon, the Visayas and Mindanao.[28] 676,465 people affected in Cotabato, south Cotabato, and Sultan Kudarat in Soccsksargen Region, and Maguindanao in the Autonomous Region in Muslim Mindanao (ARMM).[29] Water security: shortages reported across Mindanao. In Zamboanga City 160,000 people were rationed access to water to seven to eight hours a day. Drop in the Tumaga River reservoir left 16,300 people without adequate access to potable water.	*January 2019-2020* *Most of the country affected, 17 local government units in Cotabato province, 2 in Sultan Kudarat, 3 in Sarangani and 2 in South Cotabato declared a state of calamity.* 17 local government units in Cotabato province, two in Sultan Kudarat, threee in Sarangani and 2 in South Cotabato have declared a state of calamity. Agriculture: 19,430 farmers affected by May 2019 (9,247 in Cotabato province, 4,077 in South Cotabato, 3,645 in Sarangani, and 2,461 in Sultan Kudarat).[30] Water security: shortage across parts of Metro Manila since March 2019.[31] Health: increased incidence of pulmonary diseases due to poorer air quality caused by forest fires and haze, and increases in tropical diseases and food-borne diseases due to drier and warmer conditions.[32]
Singapore	
	July - August 2019 *Recorded first dry spell in over 5 years, from 31 July to 16 August 2019.* Significantly below average rainfall and high temperatures resulted in the first dry spell (15 or more consecutive days with less than 1mm rainfall) in over five years, from 31 July to 16 August.[33]
Thailand	
2015 – 2016 *55 districts, 290 counties, 2,666 villages, and 14 provinces affected.* Over 50 per cent of the area of the Mekong watershed in north-eastern Thailand at critical drought status. Economy: Losses of $1.7 billion across 13 provinces with insufficient water for agriculture.[34]	*2019-2020* *25 provinces declared drought disaster areas, covering 6,846 villages in 146 districts.* Meteorological Department declared the worst drought in 40 years, Government declared a drought emergency.[35, 36] By April 2020, 25 provinces declared drought disaster areas, covering 6,846 villages in 146 districts.[37] Salt intrusion reported water shortages and disruption to agriculture and industry. Secondary hazards: exacerbated forest fires in Chiang Mai during March-April 2020. During March 2020, 5,810 hotspots were recorded across the country.[38] Six people have been killed whilst fighting the fires.[39] Air pollution: fires increased level of PM2.5 particulates, which reached 1,000 mg/m3 (WHO threshold is 25 mg/m3),[40] and the air quality index reached 296, which was the highest recording globally.[41]

Continued ▶

Timor-Leste	
Late 2015 to 2017 *Drought reported in at least 6 municipalities, Baucau, Bobonaro, Cova Lima, Lautém, Viqueque and Oecusse District.* 350,000 people affected – one-third of the population. Agriculture: households affected by loss of livestock and disruption to harvests used negative coping measures such as reducing meal portion sizes and using households' savings.[42]	*December 2019-2020* *13 municipalities affected.* Almost one million people in 13 municipalities experienced more than 30 days without rainfall. Approximately 50 per cent of these experienced more than 60 days without rainfall, categorized as extreme drought.[43] Agriculture: 36 per cent of cropland (210,000 hectares) under severe to extreme drought by December 2019.[44]
Viet Nam	
2014-2016 *52 out of 63 provinces affected, in central Highlands, southern central and Mekong Delta regions.* 18 provinces declared states of emergencies. Environmental: saltwater intrusion up to 90km inland, Water security: February to May 2016, 2 million people (520,000 children and 1 million women) experienced acute water shortages and required humanitarian assistance.[45, 46] Nutrition: 39,000 women and 27,500 children became malnourished from water scarcity and food shortages.[47] Economic damage: $675 million.[48]	*2019 – 2020* *13 provinces affected, five in state of emergency.* Secondary hazard: saltwater intrusion exceeding conditions during 2015-2016.[49] Water security: 82,000 households experiencing water shortages. Agriculture: 29,700 hectares of agricultural land damaged or lost. Expected to affect 332,000 hectares of winter-spring rice and 136,000 hectares of fruit trees by May 2020.[50]

Source: Range of news articles and humanitarian assessment reports, refer to endnotes and reference list of Chapter 2.

Drought impacts are reported across almost all countries in South-East Asia, but vary between countries of different income levels.

The summary in Table 2-3 shows that certain impacts of drought, such as agricultural disruption and water shortages, are found consistently across all countries in South-East Asia, whilst others are experienced predominantly by countries of specific income levels or geography. For example, Thailand and Viet Nam reported devastating salt intrusion, whilst Indonesia, Malaysia, Philippines and Thailand were affected by forest fires and haze. There were also differences between countries at different income levels, which reflects the underlying vulnerabilities uncovered in the analysis. Cambodia, Myanmar, Philippines and Timor-Leste, which have high levels of poverty, malnutrition and agricultural vulnerability, as well as the Lao People's Democratic Republic and Viet Nam, recorded impacts on agriculture, food insecurity, nutrition, and the need for humanitarian assistance. In contrast, upper middle-income country of Malaysia and high-income country of Singapore reported impacts on public health and water shortages.

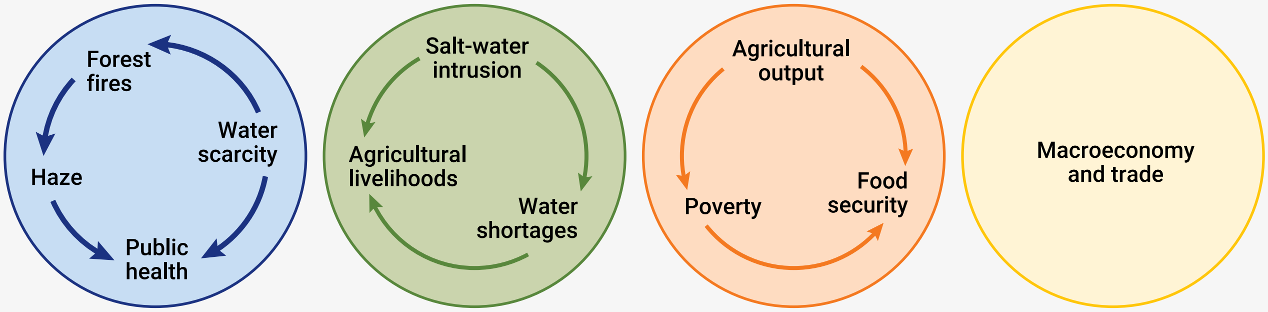
Impacts are concentrated in the identified hotspots of high drought hazard, population exposure and vulnerability.

The impacts reported in Table 2-3 also match the hotspots of drought risk. For example, the reports for 2015-2016 correspond to those areas with high population vulnerability and moderate drought exposure during the drought peak in 2015, which include western and central areas of Indonesia, central and southern areas of the Philippines, central and northern areas of Thailand, and central and southern areas of Viet Nam. There are also correlations between the hotspots identified in Table 2-3 with high drought exposure and vulnerability. For example, in the Philippines, two of the identified hotspots where populations living in poverty are exposed to drought, namely Zamboanga Peninsula and Northern Mindanao, recorded significant drought impacts across 2015-2020.

Impacts outlast the occurrence of drought itself, cumulating over time to erode livelihoods.

It is also notable that drought can affect livelihoods long after the event has passed. In Cambodia in 2015 and 2016, for example, droughts led to massive depletion of fish stocks and livestock.[51] Even though the rains improved from July 2016, farming households with little resilience and low agricultural productivity were still struggling in December 2016.[52]

Figure 2-21 — Clusters of drought impacts



Impacts of drought in the past five years have cut across many sectors of society and are clustered around four key nexuses of policy areas.

For countries in South-East Asia, droughts disrupt many aspects of national life; social, economic and environmental. This section identifies four nexuses where impacts are converging and reinforcing each other (Figure 2-21). It is within these nexuses that policy interventions will be most critical.

Forest fires, water scarcity, haze and public health

The nexus between forest fires, water scarcity and public health is well established across South-East Asia. Whilst drought is one contributory factor to exacerbating forest fires along with poor land management practices, the link is well established. Drought can exacerbate forest fires for numerous reasons, such as through physical changes to the landscape that increase their likelihood and magnitude, and through creating water shortages that constrain efforts to prevent and stop fires from spreading.

These interlinkages were reported numerous times during 2015-2020. For example, during the Cambodian drought event from 2014 to 2016, there were hundreds of fires across the north-eastern mountain region and the north-western Lake Tonle Sap region. Water shortages constrained efforts to combat the fires, which ultimately destroyed an estimated 250,000 hectares of the Lake region. This not only affected agricultural livelihoods, but also fishery livelihoods, as it reduced the production of key migratory fish species in the Mekong river.[53] Forest, as well as peatland, fires have been consistently reported across Indonesia during drought events. For example, in August 2015 the rainfall was low enough for forest fires to spread underground into drained, degraded peat swamps, where they were able to burn for longer. As a result, more than 2.6 million hectares of forest, peat, and other land burned, which was the worst on record since 1997 and substantially disrupted agricultural output.[54]

Ultimately, drought and forest fires pose a significant threat to public health across the region. For example, they contribute to the production of haze, where enough smoke particulates are emitted so as to obscure the clarity of the sky. Since the late 1990s, forest fires and haze occur during the most severe periods of dry weather, resulting in transboundary haze almost every year, during the monsoon season in the south-west (between June and September). Haze has been consistently reported across Indonesia during the drought events of the past five years. 19 deaths in the country were directly attributed to the smoke emissions from the 2015 fires.[55] Other sectors, such as education, are impacted by public health measures taken to limit the impacts of haze. During the 2018-2020 drought event, the forest and peat land fires in Kalimantan and Sumatra led to thousands of school closures to protect the undeveloped immune systems of nearly 10 million children under the age of five.[56] Public health was also threatened by water shortages, as an outbreak of Hepatitis A, that infected more than 1,000 people in east Java, was attributed to water scarcity caused by the drought.[57]

In South-East Asia, the nexus between drought, haze and public health means that drought must be recognised as a transboundary hazard. For example, the Indonesian forest fires, in 2015, produced a haze that not only covered most of the country, but caused a transboundary haze crisis.[58] The haze also covered large parts of Malaysia and Singapore, as the smoke particles were transported by prevailing winds. This was recreated in 2019 as well. For example, in Singapore, reports about haze resulting from fires across neighbouring countries emerged by mid-September. As a result, the Pollutant Standards Index (PSI) levels exceeded the 100 mark, which was the highest in three consecutive years, and fell in the 'unhealthy' range according to Singapore's standards.[59]

There has been some progress in tackling the issue in recent years. In 2015, all ASEAN Member States ratified the ASEAN Agreement on Transboundary Haze Pollution, with various country strategies. Nevertheless, countries in South-East Asia continue to be among the worst affected by such hazes and the number of premature deaths, attributed to air pollution, has been increasing each year.[60]

Salt-water intrusion, water shortages and agricultural livelihoods

Many parts of the region regularly suffer from salt-water intrusion; where saline water moves into freshwater aquifers, degrading supplies of the groundwater needed for irrigation and drinking water. Salt intrusion is caused by excessive groundwater extraction, which increases during times of drought when other water supplies are reduced, and water consumption needs are higher.

Salt-water intrusion has had a devastating impact in Viet Nam. During 2014-2016, saline water reached up to 90 kilometres inland, thereby leaving river water too salty for human or animal consumption, or to be used to irrigate crops or farm fish. By June 2016, 477,113 hectares of agricultural land had been damaged, disrupting production of rice, maize, vegetables, fruits and other perennial and annual crops. Rice crops are particularly sensitive to salt stress in the early growth stages and between 2015 and 2016 the rice harvest fell by 4 per cent.[61] The worst-affected households lost 30 to 70 per cent of their annual paddy yields and, in a few provinces, the number was up to 90 per cent. There was also a substantial loss of livestock, where more than 3,810 animals died, and many others had to migrate inland. More than 81,000 hectares of shrimp breeding areas were disrupted, especially across the Mekong Delta.[62]

In 2019-2020, the intrusion was even more severe, starting earlier and reaching a further 20 kilometres inland than reported in 2016.[63, 64] This affected the livelihoods of 680,000 people.[65] Again there was severe crop damage and disruption to fishing and animal husbandry.[66] Nevertheless, the disruption to agriculture was less severe than in 2015-2016, as authorities and farmers had taken precautions: planting rice early, building embankments to store irrigation water, upgrading irrigation systems and installing new water pipes.[67]

Food security and poverty

Across South-East Asia, 31.8 million people, or 4.8 per cent of the total population, were severely food insecure in 2019. When moderate food insecurity is included, the numbers are significantly higher, with 122.8 million people moderately or severely food insecure, or 18.6 per cent of the population.[68] The overall trend is that this has worsened in recent years, with the number of severely food insecure people increasing from 27.4 million, that is, 4.4 per cent of the total population, in 2014.[69] However, the extent of food insecurity varies between individual countries; for example, in 2016, the severe food insecurity in the population among females aged 15 was recorded as only 0.6 per cent in Singapore and 2.3 per cent in Viet Nam, compared to 11.2 per cent in Philippines and 14.4 per cent in Cambodia.[70]

Climate changes and extreme weather events have a negative impact on food security in the region.[71] Projected changes in drought risk threaten to further exacerbate food insecurity by damaging agricultural land, planted crops, and livestock health, and delaying planting seasons. These challenges are particularly disruptive for small-scale farmers, who have less capacity to cope with even small economic shocks, compared to large-scale commercial farming. Furthermore, for these small-scale farmers, reduced water availability due to drought will increase the time burden on farmers for collecting water, thus reducing time available for productive activities.

This reduces the physical availability of food, which in turn raises food prices, and disrupts agricultural livelihoods. Both are likely to reduce food affordability. From 2018/2019 to 2019/2020, rice paddy production across the region decreased by 8.38 million tons or 4.36 per cent, as drought damaged 605,000 hectares of agricultural land, and maize production decreased by 0.16 million tonnes, or 0.36 per cent, as drought damaged 17,590 hectares of land, and sugarcane production decreased by 18.42 million tons, or 8.48 per cent.[72] Additionally, loss of crops and livestock disrupt agricultural livelihoods, reducing incomes needed to purchase food and again reducing food affordability.

These issues of food insecurity were evident during 2015-2020. Table 2-3 demonstrates that every country, except Singapore, recorded adverse impacts on agricultural output, food security or both, over 2015-2020. In the Philippines, for example, the worst affected island, Mindanao, suffered damage to 5,730 hectares of rice and 15,416 hectares of corn, with losses exceeding $6.73 million.[73] Worst affected were the poorest farmers, who had little savings to cope due to their exposure to repeated armed conflict and natural hazard.[74] In some provinces, over 70 per cent of farmers reported damage to crops and shortages of food, with over 60 per cent of households resorting to selling productive assets.[75]

In Indonesia, food security declined in August 2015, as water shortages caused 40 per cent of primary rice growers, in eight regencies in the four different provinces of Jawa Timur, Nusa Tenggara Barat, Nusa Tenggara Timur, Papua, to lose more than half of their last harvest. The late arrival of the rains then disrupted the October-January planting and growing season. The resultant increase of rice prices meant that household budgets, in 2016, were 12 per cent higher than in the previous year. By March 2016, over 1.2 million people required food assistance.[76]

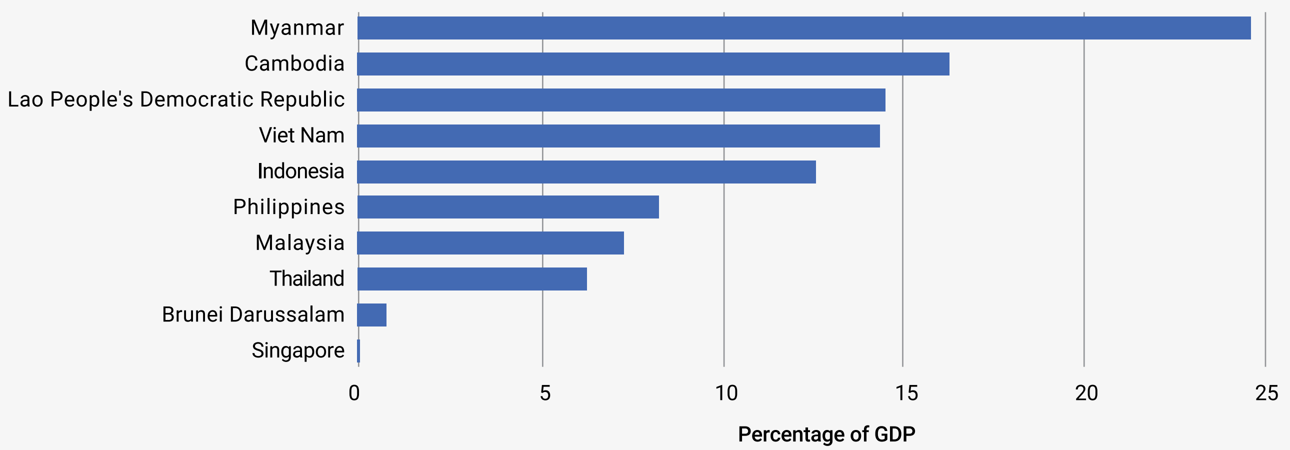
The 2015 to 2017 drought event in Timor-Leste demonstrates how reductions in agricultural productivity can force households to use negative coping strategies. During the drought, harvests were below average and 70,000 livestock were lost. As a result, households resorted to either reduced meals and dietary diversity, or use of household savings. By March 2016, at least 100,000 people were estimated to be food insecure. These impacts were compounded when the subsequent rainy season, from November 2016 to May 2017, was then insufficient and erratic. Even in June 2017, two-thirds of households in the six affected municipalities were continuing to implement the negative coping measures.[77]

Macroeconomy and trade

Drought not only damages human health and livelihoods, but also poses a substantial threat to national economies since for many countries in South-East Asia agriculture contributes a significant proportion of GDP (Figure 2-22). Previous ESCAP calculations estimate that average annual losses (AAL) due to disasters in South-East Asia are around $87 billion. Of these 60 per cent are due to drought (Figure 2-23). These involve direct and indirect losses across multiple sectors making drought a systemic risk to national economies.

For some countries, these losses represent a significant proportion of GDP. The extent of the risk can be represented in terms of AAL as a proportion of GDP.

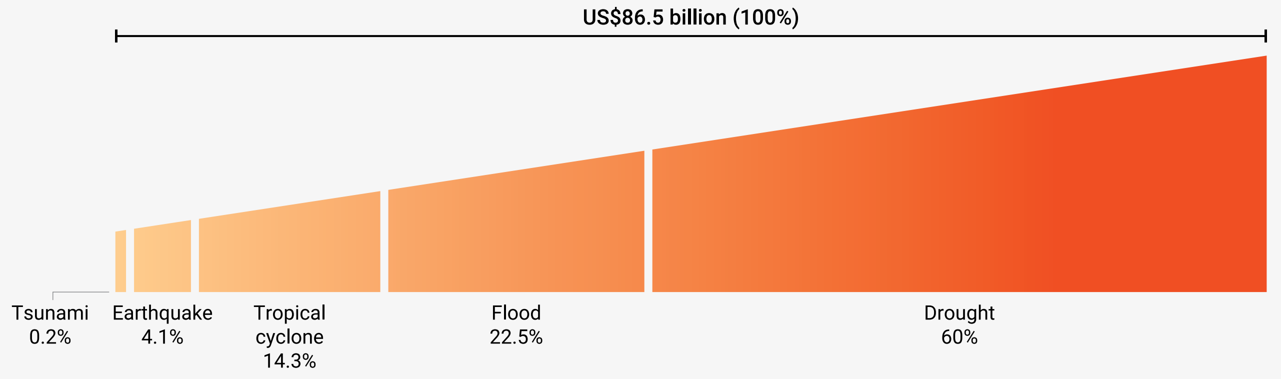
Figure 2-22 — Agricultural contribution to Gross Domestic Product, 2018



Source: ASEAN (2019).

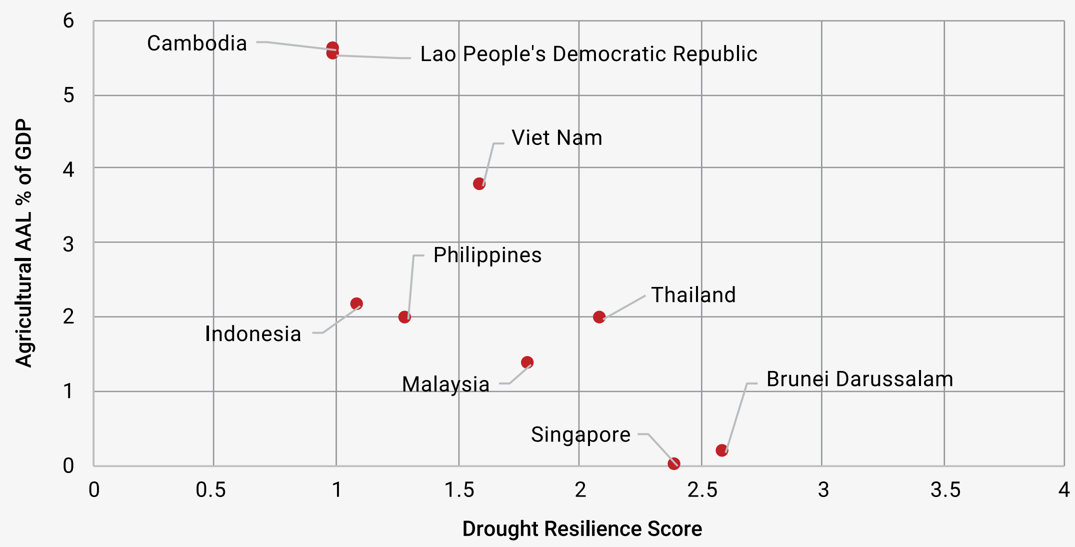
A higher score indicates that a large number of poor and vulnerable people are at risk. Another measure of exposure is the ADB drought resilience score. This is calculated based on a country's exposure, vulnerability and adaptive capacity.[78] Figure 2-24 compares these two measures, to demonstrate that there is a correlation between countries with low drought resilience, and those with high agricultural AAL/per capita GDP.

Figure 2-23 — Average annual losses, by hazard



Source: ESCAP (2020), based on a probabilistic risk assessment.

Figure 2-24 — Drought resilience score and annualized average losses as a percentage of GDP



Source: Drought resilience score from ADB (2016) and Agricultural AAL as a percentage of GDP from ESCAP (2020).
Note: Singapore agricultural AAL is not displayed as the value is less than 0.5 per cent. Data are not available for Myanmar.

During the drought events of 2015-2020, many economic impacts of drought were recorded. For example, in Thailand in 2015-2016, drought damaged crops and land in 13 provinces and caused rice production to fall by 27 million tonnes to the lowest level since 2000-2001.[79] Drought has also reduced productivity so that sugar cane output in 2020 is likely to fall by 30 per cent, potentially the worst season in five years. Combined with damage to rice and rubber production, this is expected to cost the country $1.5 billion, which is 0.3 per cent of GDP.[80]

Drought can also disrupt economies by reducing the output of hydropower. In South-East Asia, around 8 per cent of hydro-power plants that contribute to 30 per cent of the total capacity are exposed to exceptionally severe drought. The hydropower plants then operate less efficiently, which reduces electricity output, requiring a switch to the use of fossil fuels, which then boosts carbon emissions and exacerbates drought.

In the Lao People's Democratic Republic, during the 2018-2020 droughts, reservoirs were only half full, and there have been concerns that electricity generation will not be sufficient to supply the whole country at peak hours. As a result, the Ministry of Energy and Mines has requested the public to reduce electricity usage.[81]

It will be important therefore to protect hydropower systems. This will require revisiting existing hydropower facilities to ensure that they abide by standards for climate change adaptation by, for example, designing upstream and downstream storage in existing dams in order to retain rainwater for use during droughts.

The COVID-19 pandemic converges with the 2018-2020 drought

The double burden

Governments in South-East Asia are currently facing a double burden, as the impacts of ongoing drought are compounded by the socioeconomic impacts of the COVID-19 pandemic.

Prior to the emergence of the pandemic, Governments in South-East Asia were already facing the challenge of the economic impacts of a severe drought. Now the economic loss and damages from agricultural disruption, salt intrusion and forest fires, are being compounded by the unprecedented economic shock caused by the shutdown of entire sections of the national economies. As a result, economic growth projections for 2020 have fallen from 4.4 per cent to 1 per cent.[82]

Every economy in South-East Asia has been affected, but the greatest contractions have been in the countries already hit by drought. In Thailand, for example, the ongoing drought significantly reduced the yield of major crops in 2019, namely rice, rubber, and sugar. Combined with impacts of US-China trade wars, this meant that annual growth was already constrained in 2019, falling from 4 per cent in 2017 and 4.1 per cent in 2018, to 2.4 per cent in 2019. Then in 2020, the COVID-19 outbreak damaged trade and tourism, disrupting supply chains, and weakening domestic consumption. As a result, in April 2020, the World Bank projected growth in 2020 to be 3.0 per cent.[83] There have been significant impacts on employment as well. So far, drought-induced reductions in agricultural productivity have left 370,000 seasonally unemployed workers, the highest in seven years for the sector, whilst 2.1 million of the remaining farmers had insufficient water and were unable to engage in agricultural activities. This is now being compounded by the expected losses of 8.4 million jobs across the tourism, industrial and service sectors due to the COVID-19 pandemic. In total, due to the drought and the pandemic, job losses are expected to be around 14.4 million in the second and third quarters of 2020.[84] In 2020, GDP is expected to fall by between 4.8 per cent and 6.7 per cent.[85]

Timor-Leste has also been hard-hit, mostly due to its high dependency on oil, trade and import of food staples. The pandemic has led to a simultaneous decrease in global oil prices and increase in the prices of food imports. Ultimately this meant that the Timorese economy is likely to shrink by approximately 3.7 per cent in 2020.[86] This is compounded, as the dependence on importing food staples means that there are limited employment opportunities in the agriculture sector which could otherwise have provided a safety net for unemployed people.[87]

The disruption to the national economy has also reduced the potential for government expenditure.[88] These disruptions to national economies put pressure on government budgets which must fund the public health response and implement social protection measures within already stretched allocations.[89]

Sectors that are being hardest hit by the ongoing drought and COVID-19 pandemic include those identified as key nexuses for drought intervention.

Agriculture and food security

Food security across South-East Asia is threatened both by the ongoing drought and the COVID-19 pandemic.[90] The two disasters are converging at a critical time in agricultural crop calendars, during the harvesting and planting seasons; for rice in the Lao People's Democratic Republic, Myanmar, Thailand and Viet Nam; for rice and corn in Cambodia, Philippines, and Timor-Leste; and for rice, corn and soybeans in Indonesia.[91] Productivity will be threatened by shortages of labour when farmers become infected or are forced to self-isolate. Border closures, travel blockages and quarantines will restrict the access of farmers to markets and processing plants, to implement measures of social distancing.[92]

Many countries are reporting problems with rice security, as the impacts of drought and COVID-19 mean that global rice prices have reached a seven-year high.[93] For example, in Thailand, despite rising prices, the value of rice exports in the first quarter of 2020 was around 9 per cent less than in the first quarter of 2019.[94] This issue has required regional cooperation; as several countries, including Cambodia and Viet Nam, temporarily implemented export bans and/or quotas on rice to maintain national stocks during the early stages of the pandemic in March 2020.[95]

During the 1997-1998 financial crisis, agriculture served as a buffer, providing jobs for unemployed urban workers. But, agriculture now contributes a smaller share of GDP, and provides less buffering capacity. Thus, in this double crisis, it is more important than ever to scale-up social protection and provide a safety net for those who have lost agricultural livelihoods.[96] In April 2020, the ASEAN Ministers of Agriculture and Forestry issued a Joint statement in April reaffirming their commitment to ensure food security, food safety and nutrition in the region during this outbreak.

Water availability

At the same time, dwindling supplies of water are also threatening the COVID-19 response. In Thailand, the dams are only 49 per cent full.[97] Water availability also varies significantly between regions. For example, the water management authorities are working to allocate water from the supply network to fill the Nong Pla Lai and Khlong Yai reservoirs which are facing shortages. If successful, this effort will help ensure water availability in the Rayong Province and the Eastern Economic Corridor.[98]

Intersecting vulnerabilities to drought and COVID-19

The impacts of drought and other hazards are exacerbating vulnerabilities to the COVID-19 pandemic.

Across the region, hazards such as the ongoing drought, combined with socioeconomic vulnerabilities and a lack of social protection, are all contributing to increasing the many societal impacts of the COVID-19 pandemic.

Vulnerabilities to the COVID-19 pandemic can be considered in four categories:[99]

Epidemiological – This includes fatalities based on underlying conditions and age. By exacerbating food insecurity and malnourishment, drought could compromise the immune system response to the virus.

Transmission – The transmission rates will be higher where drought-induced water shortages restrict access to sanitation and the ability to practice safe hygiene.[100] This has been reported in Rakhine state, Myanmar, where acute water shortages due to the ongoing drought and lack of soap in the local markets are constraining efforts to follow hygiene guidelines for COVID-19 prevention.[101]

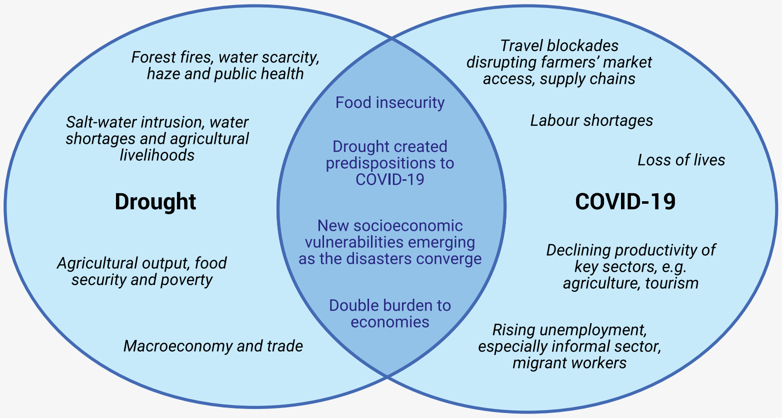
Health System – This includes the availability of intensive care. There are concerns in Cambodia, for example, that drought could lead to reduced hydropower generation, thereby leading to power cuts, reducing the health system's capacity to provide sufficient services to people with COVID-19 and to the wider community.[102]

Pandemic control – Public health measures implemented to slow the transmission of COVID-19 can prevent people earning their incomes. For example, in south-central Viet Nam in Viet Bane Van Lam 3 village, after more than 12 months without noticeable rainfall, the soil was too arid for farming so villagers were relying on temporary jobs outside the village. However, after two returning residents tested positive for COVID-19, the village was placed into lockdown leaving people unable to earn their livelihoods.[103] There are also gender impacts since the combination of drought and the increased need for better hygiene practices are expected to increase the unpaid care work burden of women, who are primarily responsible for the collection of water for household use.[104]

Households relying on incomes from migrant workers face a double exposure to loss of livelihoods.

In many countries in South-East Asia, during the dry season (November-April), many rural workers migrate to urban areas to work in the informal sector, such as in construction, and send remittances back to their families. At the same time, they and urban workers migrate overseas as well. However, both national and international migration have been hampered by COVID-19 travel restrictions.[105] Most migrants are in the informal sector with little or no social protection, thereby failing to qualify for social protection schemes because, for example, they have not made sufficient contributions, or because many schemes in the region are targeted and conditional rather than universal in nature.[106] These and other conditions should be waived to protect migrant workers and their dependent households from food insecurity and poverty.[107]

Figure 2-25 — Convergence of drought and the COVID-19 pandemic



Building back better from double disasters

Assessing the impacts of the ongoing drought event reveals how effective drought risk management can strengthen societal resilience.

The convergence of the COVID-19 pandemic with existing socioeconomic vulnerabilities and exposures to hazards has created cascading risks that threaten all parts of society throughout the world.[108] In South-East Asia, it is particularly important to understanding the interaction between the pandemic and the ongoing drought event, to design government interventions that can be taken now to limit the immediate impacts on the national economies, key sectors, and vulnerable groups. This is especially important for the four key nexuses identified in this chapter. Moving forward, understanding the interactions between the two disasters will also be essential for identifying the vulnerabilities that need to be addressed in order for the recovery strategies to be robust.

For example, Governments must be prepared to enhance social protection programmes to unprecedented scales, to help people cope with temporary income losses during the past couple of months. However, there is also an opportunity to use these programmes to address the conditions that make people vulnerable to recurring disasters and pandemics. For example, ASEAN Member States could leverage the ASEAN Guidelines on Disaster-Responsive Social Protection to Increase Resilience, and may wish to examine how the current guidelines perform in light of the current pandemic.

The interactions between the two disasters also highlight the importance of pro-active drought risk management. Drought can be predicted, and its onset can be slow; Governments can therefore take risk-informed measures to strengthen societal resilience so that if another disaster like the COVID-19 pandemic occurs, key institutions, sectors and populations have the capacity to cope. The remainder of this Report explores how this can be achieved. Chapter 3 begins by presenting how drought risk is projected to change in the near future. Chapter 4 highlights where existing drought policies will need to be improved and proposes specific actions that should be taken at the national level, and Chapter 5 argues that this must be underpinned by strengthened regional cooperation.

Endnotes

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[2] The analysis uses Demographic Health Survey data, from USAID, to compare across countries. This is based on household samples and may therefore differ from national statistics.
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[31] Matt Blomberg (2019).
[32] Rodrigo S. Victoria (2019).
[33] The Straits Times (2019).
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[35] NASA Earth Observatory (2020).
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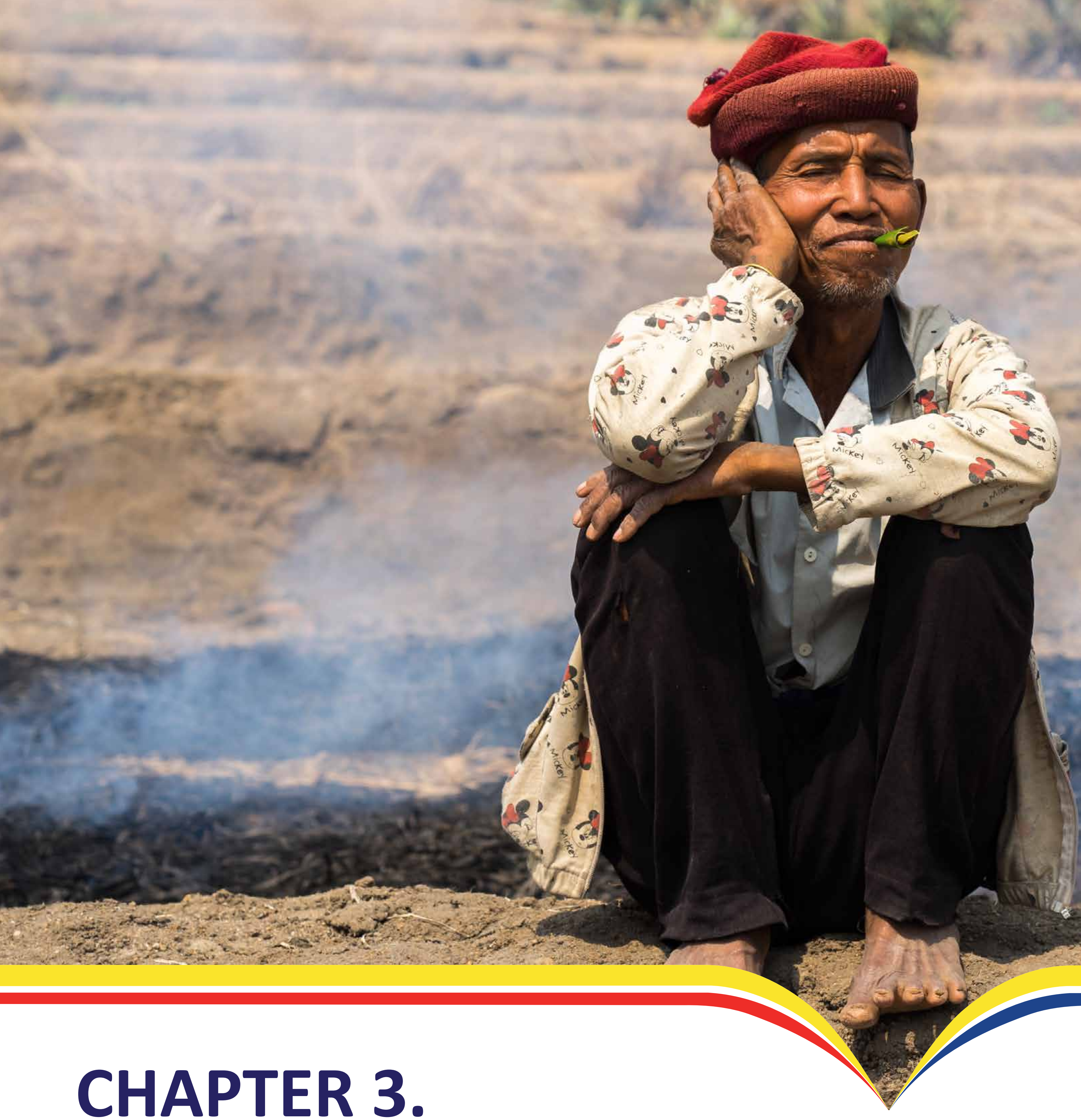


CHAPTER 3.

Warmer droughts: projections for a changing climate

Repeated drought events in Gia Lai, central highland of Viet Nam are degrading the land.

Chapter 3.
Warmer droughts: projections for a changing climate

Key Messages

- *Analysis of temperature data from across South-East Asia reveals that there has been a statistically significant positive trend, since 1981. This trend is projected to continue across climate models. Future droughts are projected to generally be warmer as a result.*

- *The projected change in annual rainfall across South-East Asia, based on the average output from 31 climate models using both the RCP4.5 and RCP8.5 greenhouse gas concentration scenarios, indicates slightly wetter conditions by mid-century (2040-2060) although there are important seasonal variations contributing to the annual trend.*

- *The average projected change in surface evaporation across models and greenhouse gas scenarios shows an increase, which could at least partially offset the projected increase in rainfall.*

A fundamental concern for drought management and planning is how anthropogenic climate change will alter future drought conditions. From a hydro-meteorological perspective, changes in drought are fundamentally linked to changes in the amount of rainfall received, but are also tied to such factors as increasing surface air temperature. Higher air temperatures can exacerbate existing drought conditions while also increasing the atmospheric demand for water, thereby potentially increasing evaporation from the land surface. The complexity is enhanced as it is not only the amount of future rainfall that influences drought, but also its intensity and frequency of occurrence, as these will influence soil moisture conditions by potentially altering how much rainfall runs off from the land surface rather than being absorbed into the soil. This chapter explores the projected climate changes across South-East Asia, to provide a drought outlook for the coming years.

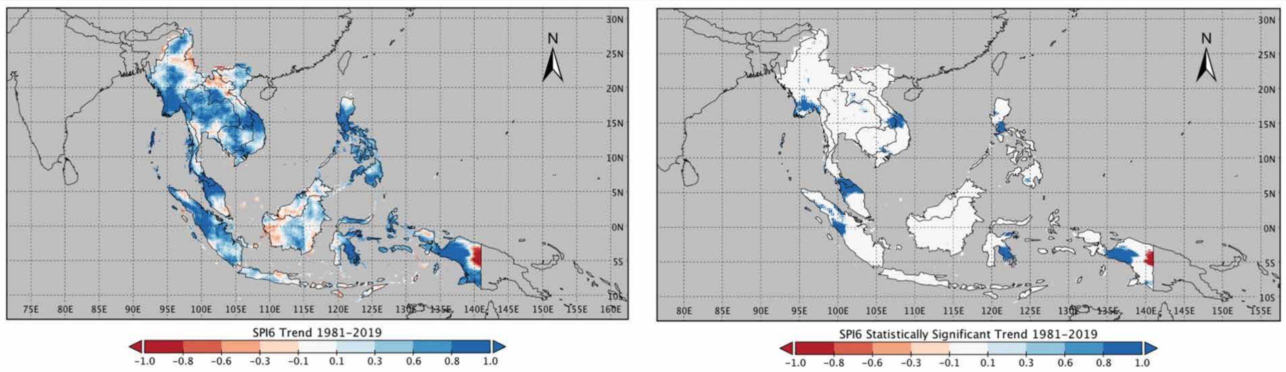
Drought trends since 1981

Rainfall

Local trends in the six-month SPI for 1981-2019 have generally been positive across South-East Asia, indicating a general tendency towards wetter conditions.

Over the past four decades, it appears that climatic conditions have been getting wetter. Rainfall data covering the period 1981-2019 have been analysed based on the standardized precipitation index (SPI6). Figure 3-1 generally indicates an overall positive trend in SPI6 for this period. The map on the left of the figure shows that a few locations have negative SPI6 trends, indicating a tendency towards drier conditions, but these areas are quite small in size. The map on the right of the figure clarifies the picture a little more, showing where the trend of positive SPI6 values is statistically significant. It should be noted that some of the historical SPI6 trends over this period will include the influence of the Pacific Decadal Oscillation. Based on the Pacific Decadal Oscillation alone, the recent increase in rainfall is not expected to continue over the coming decades.

Figure 3-1 — Trend in SPI6 1981-2019, and locations with a statistically significant trend



Source: ESCAP calculations, based on Standardized Precipitation Index (SPI) of Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), 1981-2019.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Assuming the historical trends continue, the future will be wetter, although there is no clear spatial pattern. It should also be noted that the SPI6 is based only on rainfall and it does not include the effects of temperature changes on drought conditions, which will also affect soil moisture.

Rising temperatures

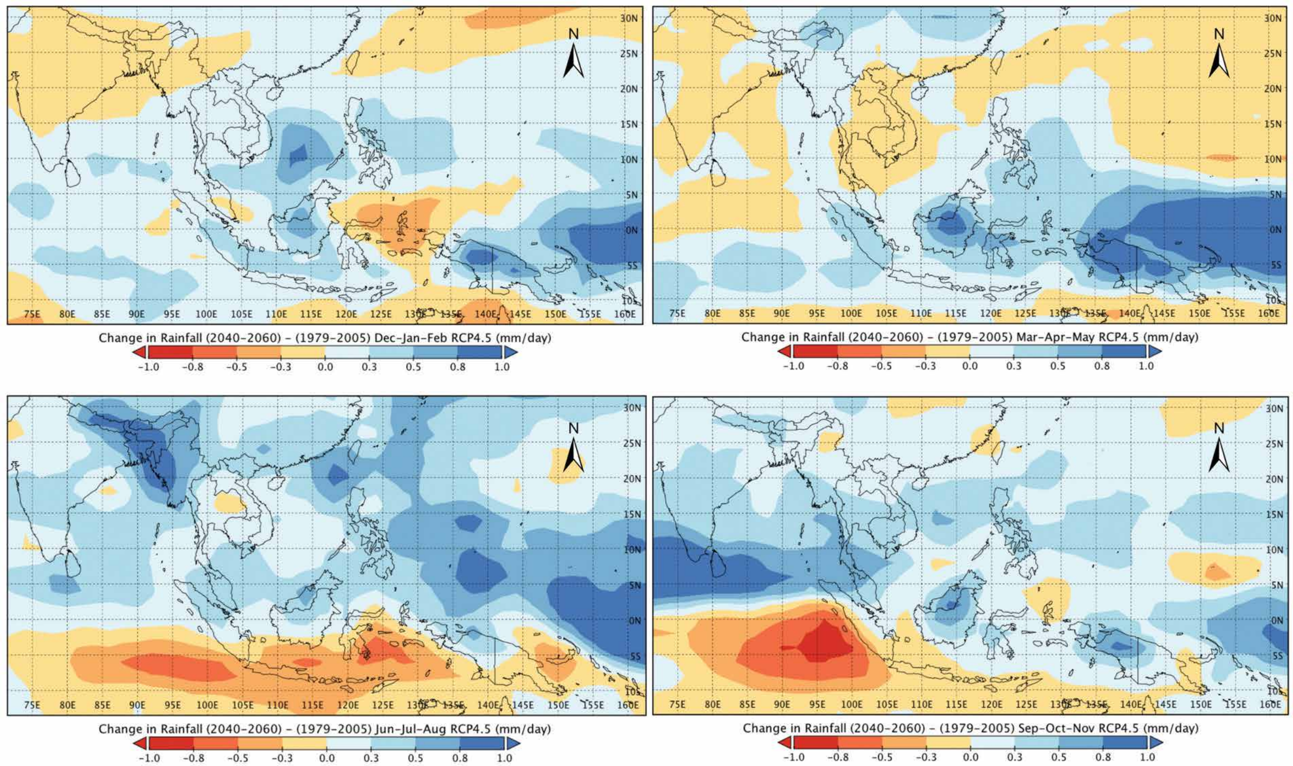
Over the 1981-2020 period, there is an observed upward trend in surface air temperature across much of South-East Asia. Droughts are thus occurring in an increasingly warmer climate.

As indicated in Chapter 1, over the 1981-2019 period, there has been an increase in surface air temperatures. Droughts are occurring in an increasingly warmer climate. The effects of both rainfall and temperature can be modelled, for example, using the Palmer drought severity index (PDSI). Recent studies have examined PDSI trends for the period 1950-2008.[1] These do not indicate a significant trend towards drier conditions. Nevertheless, the region has over this period suffered major droughts – most recently in 2015-2016 and 2018-2019. While there is no overall drying trend, in the future, droughts may also result from changes in the variability of rainfall (such changes were not examined explicitly in this Report). Thus, policymakers need to prepare for periodic episodes of severe drought, given variations in the current climate, which may possibly be influenced by anthropogenic climate change.

The influence of climate change

The patterns for rainfall and temperature indicated above are based on historical trends. The Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report

Figure 3-2 — Projected change in seasonal rainfall (mm/day) for the period 2040-2060 compared with 1979-2005, for the moderate greenhouse gas scenario (RCP4.5)



Source: ESCAP calculations based on Coupled Model Intercomparison Project Phase 5 (CIMP5).
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

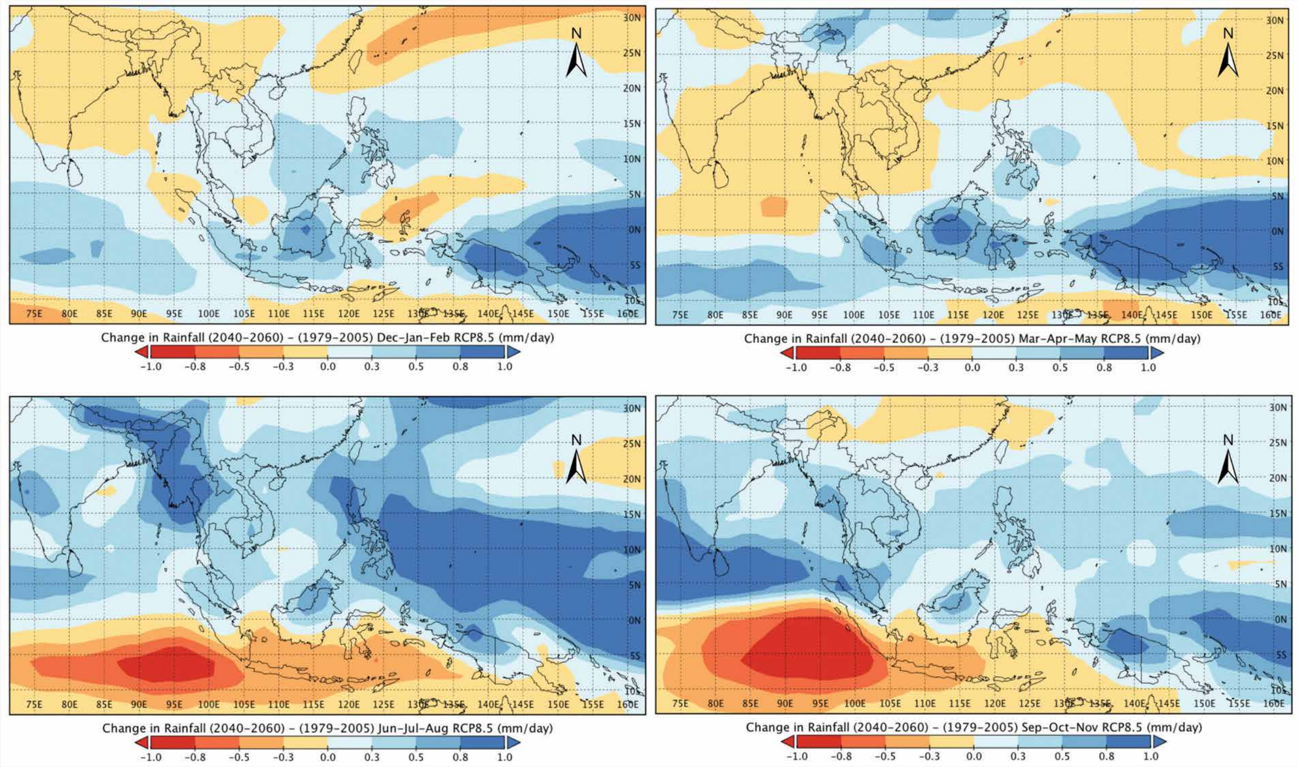
(AR5) includes climate projections based on several climate models. Output from many of these models is considered here.

Rainfall

By mid-century, the projected change in annual rainfall is found to be generally positive (though modest) across South-East Asia. This is case for both medium and high greenhouse gas concentration scenarios. However, there are some important seasonal variations to this overall trend.

As a starting point, Figure 3-2 and Figure 3-3 show the projected change in mid- twenty-first century rainfall by season, computed as the difference between average seasonal values for the years 2040-2060 and those for the period 1979-2005. These projections are based on output from 31 climate models used in the IPCC Fifth Assessment Report (AR5) that incorporate a middle-of-the-road greenhouse gas concentration scenario and a high concentration scenario. In the language of AR5, these two greenhouse gas scenarios are members of a set of Representative Concentration Pathway scenarios referred to as RCP4.5 (moderate) and RCP8.5 (high), respectively. For the RCP8.5 scenario, data for all 31 models was available, while for RCP4.5 output from only 23 of the 31 models was available.

Figure 3-3 — Projected change in seasonal rainfall (mm/day) for the period 2040-2060 compared with 1979-2005, for the high greenhouse gas scenario (RCP8.5)



Source: ESCAP calculations based on Coupled Model Intercomparison Project Phase 5 (CIMP5).
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Across all seasons, the figures suggest an increase in rainfall for the year as a whole; an increase which is somewhat greater if the concentration of greenhouse gases is higher. However, there are seasonal variations in this change. Most notable, is the projected decrease in rainfall across central Indonesia and Timor-Leste during June-August. While this is typically the dry season in these areas, the projected decrease could serve to exacerbate dry soil conditions prior to the start of the subsequent rainy season. As pointed out in AR5, the magnitude of these rainfall changes is fairly modest in comparison with natural variations in 21-year average rainfall, as modelled for the recent, observed climate.[2] As such, the overall projected increase in rainfall is not a particularly robust result, but it nonetheless represents the central tendency across climate models. In some locations, such as Cambodia, the Lao People's Democratic Republic, and northern Thailand, the projected rainfall change is particularly modest.

As climate models have fairly coarse resolution, attempts have been made to "downscale" their output to finer spatial scales using regional climate models. A recent study has downscaled rainfall projections from 15 global climate models for parts of South-East Asia. The results show that rainfall is generally projected to increase in the lower Mekong Basin, but some locations may still suffer severe drought.[3]

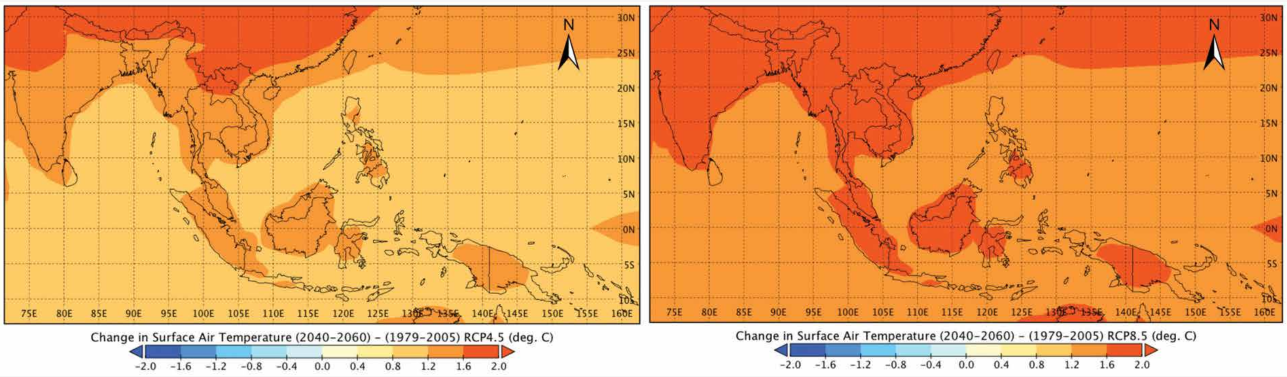
Another study used ten global climate models as input to five different regional models for South-East Asia. The results indicate drying trends for some areas within the region if global climate has warmed by 2°C above current values. These changes are, however, modest: changes in annual rainfall are of a few per cent and are evident mostly across Indonesia and the southern parts of Cambodia and Viet Nam. It should also be noted that not all of the regional models agree on whether annual rainfall is going to increase or decrease, so greater spatial resolution does not necessarily provide greater confidence in the results. Overall, by mid-century current results indicate modest changes in rainfall and drought conditions. But if greenhouse gases continue to increase, changes in both rainfall and temperature are generally expected to be greater.

Temperature

The multi-model mean projected change in surface air temperature is positive across all of the region. Future droughts are projected to be occurring within a warmer climate.

Climate change will affect future temperatures. The average temperature projections across climate models is indicated in Figure 3-4. For both greenhouse gas scenarios, there is a clear increase in temperature across South-East Asia and, as expected, with a greater increase for the higher greenhouse gas scenario. The oceans can hold more heat energy than the land so they warm more slowly. These projected temperature changes are consistent with the observed upward trend in surface air temperature indicated in Chapter 1.

Figure 3-4 — Multi-model average, projected increases in annual air surface temperature for the period 2040-2060 compared with 1979-2005



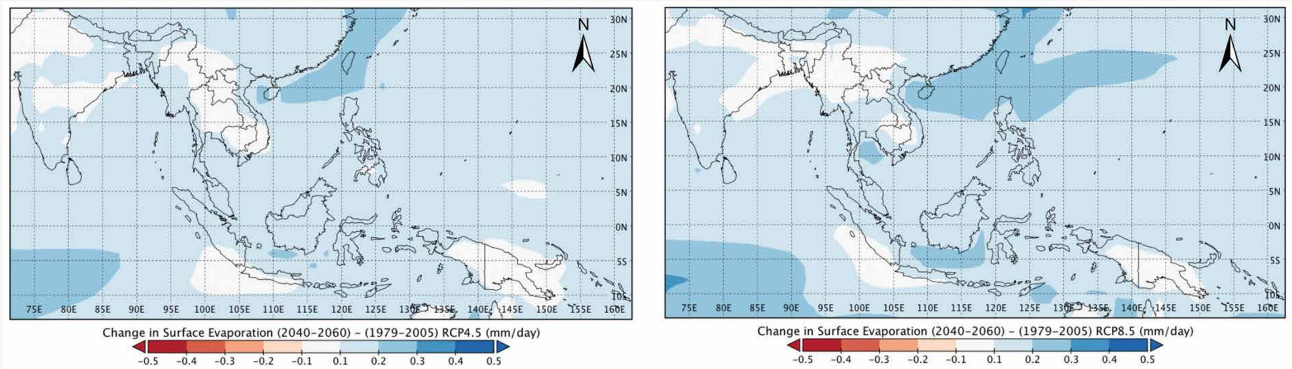
Source: ESCAP calculations based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive, 1979-2005.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Surface evaporation

The multi-model mean also shows a projected increase in surface evaporation under both greenhouse gas scenarios, suggesting a possible offset to an overall projected increase in rainfall.

Higher temperatures could increase rates of surface evaporation. However, evaporation also depends on wind speed, levels of humidity and solar radiation. Modelling these physical factors, however, does generally confirm projected increases in evaporation across South-East Asia. Again, the change is greater at higher concentrations of greenhouse gases. Such an increase is projected to partially offset any increase in rainfall.[5]

Figure 3-5 — Multi-model average, projected increases in annual air surface evaporation (mm/day) for the period 2040-2060 compared with 1979-2005



Source: ESCAP calculations based on the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive, 1979-2005.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Local climates

An important caveat to keep in mind when considering projections is that climate models have fairly coarse spatial resolution compared to spatial variations in topography across South-East Asia.

Local climates can vary considerably on scales much smaller than the resolution of current climate models. Indonesia, for example, is the largest archipelagic state in the world, with substantial variations in elevation. More research is needed to examine these smaller scale changes in climate across the region. By mid-century, however, a summary statement is that current results indicate that the projected changes in rainfall and drought are generally modest.

Consecutive dry days

Based on observed rainfall data, a robust increase in the number of consecutive dry days has yet to emerge across South-East Asia. However, climate models generally show an increase in the number of consecutive dry days between rainfall events with implications for soil moisture conditions.

Soil moisture variations depend in part on the distribution of rainfall from day to day. One useful indicator of such rainfall variability is 'consecutive dry days' (CDDs), which is typically the number of consecutive days having less than 1 mm of rainfall. Using observations, one study has examined trends in CDDs in South-East Asia from the 1950s to early 2000s.[6] This study suggested that in several locations the CDDs have been increasing, though in some places they decreased. Trends in CDDs can also depend on the season considered.[7] In 2014, Singapore had its longest dry spell on record.[8] This event could not be attributed directly to climate change, but both global and regional climate models project an increase in the number and length of CDDs in the future.[9, 10]

While the length of dry spells is generally projected to increase, as the climate warms there may also be more heavy rainfall events, which can also influence conditions, such as soil moisture.[11] Another measure of the character of the rainfall relevant to drought is a delay in the onset of rainy seasons, projected to occur in several locations.[12] However, a recent study based on rainfall observations at multiple stations finds little evidence for such delays in South-East Asia.[13] Taken together, changes in future rainfall relevant to drought include more than just changes in seasonal or annual mean amounts. Changes in the character of rainfall, such as its frequency and intensity are also important, as are the number of consecutive dry days between rainfall events and the timing of the onset of rainy seasons. While observations do not show consistent changes in these differing characteristics, many climate models project an increase in consecutive dry days and an increase in the intensity of rainfall events.

Potential changes in the climatic drivers of drought

Given the observed relationship of drought to El Niño and the Indian Ocean Dipole (IOD), changes in the behaviour of these climate phenomena will also have an impact on future droughts in South-East Asia.

Changes in the future behaviour of El Niño in response to increasing greenhouse gases are uncertain. In addition to affecting drought, one study suggests that as the climate warms, temperatures could become more extreme in association with El Niño events.[14] Many global climate models show increases in rainfall and temperatures in the eastern equatorial Pacific in a manner that is somewhat reminiscent of El Niño conditions. At the same time, however, recent sea surface temperature trends in climate models in this part of the ocean have generally been larger than those subsequently observed.[15]

Climate change may also change the behaviour of the Indian Ocean Dipole (IOD). A recent study, for example, concludes that there will be an increase in extreme IOD events.[16] Since positive IOD events are associated with drought, this implies that these episodic droughts will become more severe in the future. One important caveat here is that climate models also have a tendency towards generating IOD events that are too strong.[17] The projected increase in the intensity of IOD events, however, is a concern, and Indonesia appears to be particularly sensitive to such changes.

What is more certain is that future droughts will be occurring in a warmer climate, which is likely to exacerbate the impact of drought. Overall, countries in the region could let current climate variations and future changes creep up on them, or they could take a more pro-active approach to reducing drought risk. The opportunities for doing so are explored in the next chapter.

Endnotes

[1] Justin Sheffield, Eric Wood, and Michael L. Roderick (2012); Dai (2011).
[2] Collins and others (2013).
[3] Madusanka Thilakarathne and Venkataramana Sridhar (2017).
[4] For more information, see Dai (2011).
[5] Flavio Lehner and others (2017); Lin, L. A and others (2016).
[6] Nobuhiko Endo, Jun Matsumoto and Tun Lwin (2009).
[7] For more information, see Deni and others (2010).
[8] J. McBride and others (2015).
[9] For more information, see Figure 12.26c in Collins and others (2013).
[10] For more information, see Fredolin Tangang and others (2018).
[11] For more information, see Figure 12.26b in Collins and others (2013).
[12] For more information, see Anji Seth and others (2011).
[13] Gerald van der Schrier Marjuki and others (2016).
[14] For more information, see Fasullo, B. L. Otto-Bliesner and S. Stevenson (2018).
[15] For more information, see Martin Hoerling, Jon Eischeid and Judith Perlwitz (2010).
[16] Wenju Cai and others (2014).
[17] Wenju Cai and Tim Cowan (2013); E. Weller and W. Cai (2013).

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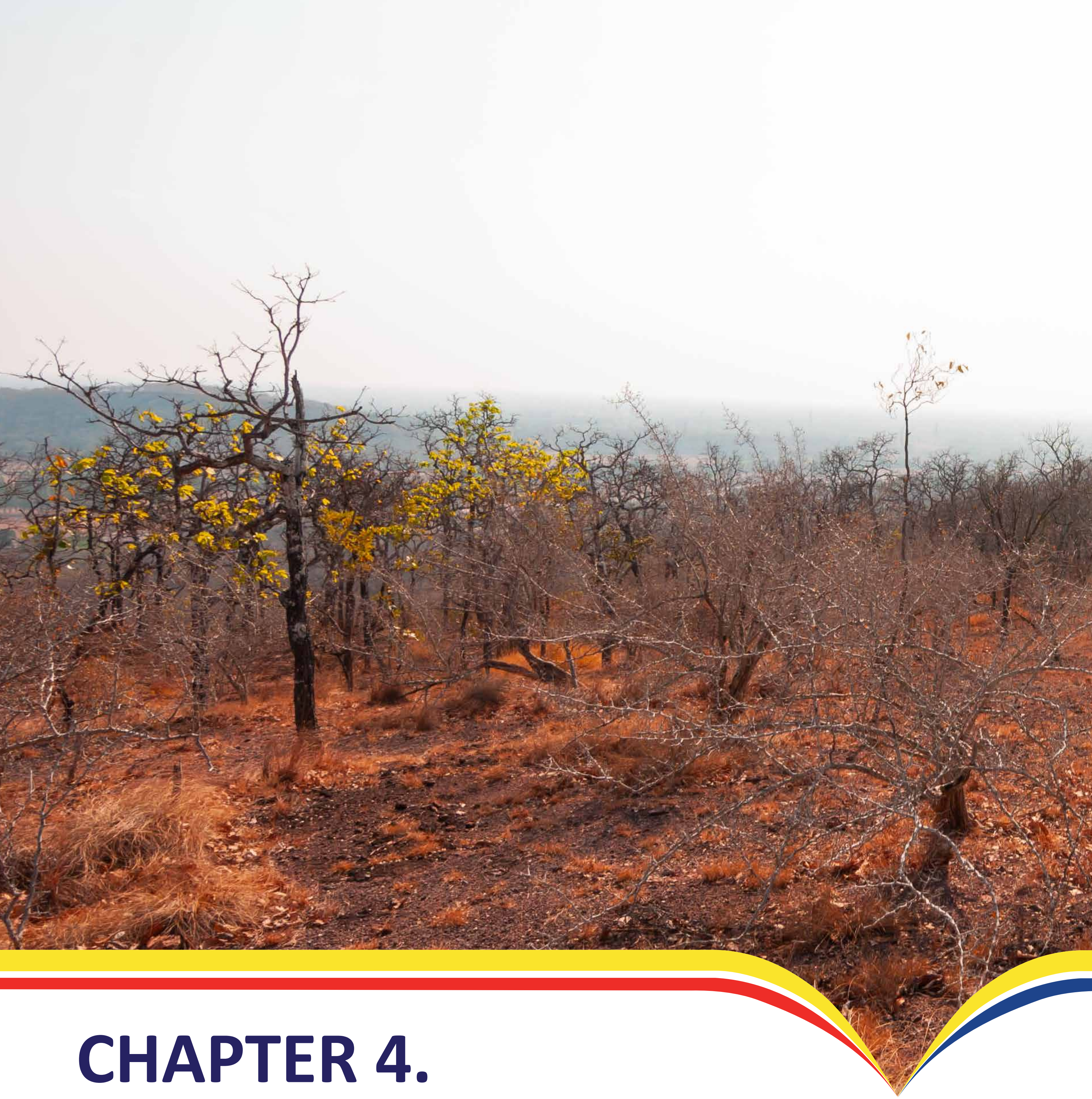


CHAPTER 4.

Shifting from drought response to drought adaptation: policy tracks for transformation

Recurring droughts degrade agricultural land and natural systems.

Chapter 4.
Shifting from drought response to drought adaptation: policy tracks for transformation

Key Messages

- *Reviewing the existing national policies relating to drought reveals that they remain fragmented and mostly reactive, rather than adaptive. This is no longer sufficient; efforts need to be accelerated to prepare societies and institutions as drought risk is intensifying under the changing climate.*

- *While many countries in South-East Asia are implementing some adaptive practices in land, water, food and energy systems, large-scale operationalization through enabling policies, investment and technologies, is critical in all countries.*

- *The ability of state-of-the-art climate models to forecast rainfall characteristics over many locations in South-East Asia, coupled with more and better satellite-derived drought indices and advances in data integration can be leveraged for improving the development of drought early warning across the region.*

- *Financing drought risk management and adaptation can take advantage of a wide range of innovative solutions and new adaptation funding sources, but persistent roadblocks that hinder large scale adoption need to be addressed.*

- *COVID-19 stimulus packages present a strategic opportunity to address the root causes of vulnerability to future pandemics and droughts.*

Chapter 3 demonstrated that future droughts will be occurring in a warmer climate, likely exacerbating drought impacts. In this context, it is essential to review whether national drought policies are fit for purpose in dealing with future droughts in South-East Asia. Most national policies on drought typically focus on emergency response and recovery. This chapter suggests a more pro-active approach that will allow countries to adapt to the risk of future droughts, along three tracks: reduce and prevent, prepare and respond, and restore and recover.

Drought risk management in countries in South-East Asia is currently governed by multiple, overlapping plans.

Reviewing the existing policies relating to drought reveals several critical gaps that must be urgently addressed. Whilst many countries have incorporated drought management, to varying extents, within national strategies for adapting to climate change, managing disaster risk, and improving agriculture, thus far only the Philippines has developed a specific National Drought Plan.[1] In other countries, drought management is guided by a combination of national disaster risk management (DRM) strategies, National Adaptation Plans (NAPs), and even national development plans. Specific elements of drought are also covered by plans for individual sectors, such as for agriculture, water resource and haze management. Table 4-1 displays an overview of all of the national policies in each country, that address elements of drought management.

Table 4-1 — National plans that incorporate elements of drought management

	Disaster Risk Management	Climate Change	National Development Plan	Agriculture	Water Resource Management	Haze	Land Degradation	Forest Fires
Brunei Darussalam	×					×		
Cambodia	×	×	×		×			
Indonesia	×							×
Lao PDR	×	×		×				
Malaysia		×	×	×				
Myanmar	×	×		×		×*		×*
Philippines	×	×	×	×			×	
Thailand	×	×		×	×	×		
Singapore		×						
Timor-Leste	×	×					×	
Viet Nam	×	×	×	×	×			

Source: See Appendix 4 for a full list of references.
Note: * Under development as of June 2020.

Reviewing these policies reveals that countries are currently taking diverse approaches. Countries such as Cambodia, Myanmar, Thailand and Viet Nam recognise that drought affects many sectors and is a critical issue shaping long-term development, and as a result have incorporated it into many national plans for development, as well as for individual sectors such as agriculture, water resource, haze and fire management. Overall, it is encouraging that many of the sectors most exposed to drought have been considered.

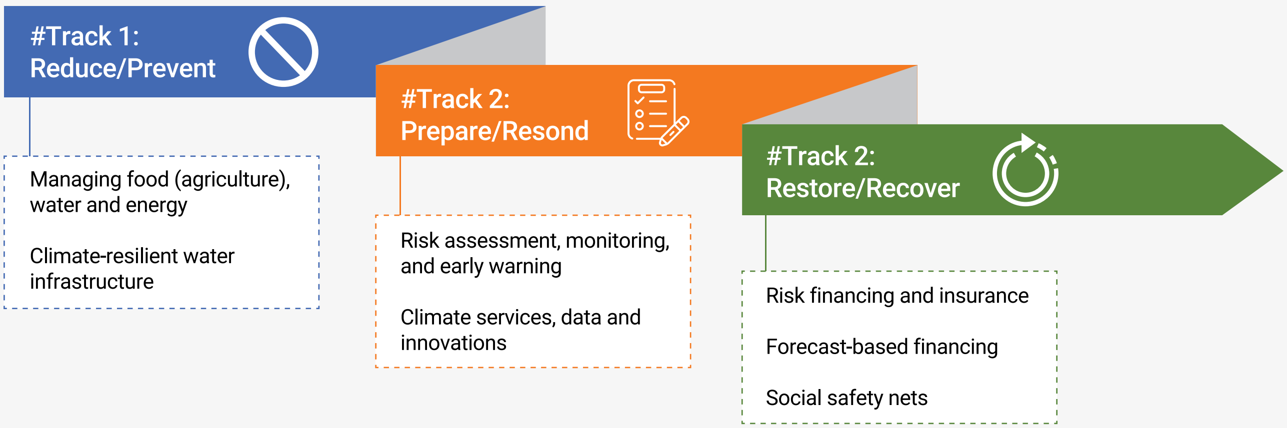
A strategic approach to drought risk management must be a coherent effort across the whole of society, and must include long term, pro-active measures that incorporates climate change projections to mitigate intensifying drought risk.

It is evident from the variety of sectoral plans in Table 4-1, that Governments in South-East Asia recognise the need to mainstream drought risk management across many different ministries. However, many of the sector plans contain overlapping tasks and responsibilities. It is therefore clear that there is significant scope for building on existing plans to improve drought risk governance across South-East Asia. Moving forward, every Government must ensure that a broader range of sectors including environment, food security and agriculture, transport, health, tourism, energy and education learn from the DRM sector, and incorporate drought risk into their long-term plans.[2]

It is also concerning that the policies in Table 4-1 mostly include reactive measures, such as the provision of humanitarian assistance, or short-term preparedness measures taken just before drought onset, such as issuing early warnings, with less emphasis on mitigating drought severity or reducing vulnerability to drought.[3] All of these measures are essential, but alone they are insufficient to manage the intensifying future drought risk. A focus on reactive measures fails to meaningfully address underlying vulnerabilities. Even where vulnerabilities are addressed in the existing plans pertaining to disaster risk management and climate change, only certain dimensions of vulnerability, such as poverty are considered.

The reactive approach to drought risk management in South-East Asia is in line with traditional approaches to drought management in other parts of the world, which are based upon analyses of current risk variability. However, the United Nations 2030 Agenda for Sustainable Development, the Sendai Framework for Disaster Risk Reduction and Paris Agreement all promote adaptation to the adverse impacts of climate change as key to reducing disaster risk and societal climate resilience.[4] Fortunately, the slow-onset nature of drought means that there is a significant opportunity to take steps now, that can reduce the impacts of droughts later. Accordingly, this Report advocates for a shift towards more pro-active drought management. A three-track framework is introduced to integrate the measures that need to be taken across the various timescales of drought management, including future drought risks.

Figure 4-1 —Three parallel tracks for drought adaptation



Source: Modified from the Global Commission on Adaptation Report 2019.

National drought management plans can be an effective instrument to ensure policy coherence.

For Governments, the implementation of long-term, adaptive drought management approaches with contributions from numerous sectors will require a strategic overview of all possible measures, as well as coherence across different policy domains. This can be achieved through developing national drought plans, which identify all of the necessary actions to manage drought, assign responsibilities for implementing them, and set out indicators for measuring their effectiveness.

Organising existing plans into one coherent plan prevents different sectors from implementing a series of fragmented and uncoordinated actions and investments across agriculture, land use etc., ensuring instead that actions are synergized so as to reduce drought risk most effectively, and at the least cost.[5] Otherwise, incoherent policies may undermine each other. For example, an agricultural ministry may seek to strengthen productivity by providing incentives to intensify frequency of cropping seasons. However, if this policy does not consider the crop exposure, it will lead to more economic damages during drought.[6] Instead, agricultural measures must be informed by a national drought plan and will need to consider broader food security issues.

Policy coherence will also ensure more efficient use of finances. Traditional models of drought financing are donor-based, whilst new approaches are emerging such as forecast-based financing. Designing one coherent drought plan will allow Governments to leverage these sources, and integrate them with budgeting across multiple sectors, for maximum cost benefit. Furthermore, the planning process itself will strengthen coordination across different government ministries, facilitating better collaboration during emergency drought response. The need for drought policy coherence will be reinforced as the future changes in drought conditions, outlined in this chapter, interact with societal mega-trends, most notably changes in land and water use, economic structural transformations, demographic trends, and technological change.

The good news is that a lot of the initial work has already been done; the existing sectoral plans contain important measures that must now be integrated into single, authoritative national drought plans that assess all aspects of drought. Furthermore, NDMAs have developed knowledge on population vulnerability. This must now be combined with the knowledge of sectoral capacities from their individual ministries, to capture the full complexity of drought risk. NDMAs must therefore play a key role in designing national drought plans, that build upon and integrate closely with the multi-sectoral plans.

One example is the National Drought Plan of the Philippines 2019, which establishes actions required for monitoring, forecasting and impact assessment; risk and vulnerability assessment; drought mitigation and preparedness; as well as drought communication and response actions. These address all three pillars of the three-track framework, and are drawn from existing plans aimed to enhance water security, reduce disaster risk, increase climate resilience, and conserve natural resources. The plan was developed through consultations with many stakeholders and sectors, with subsequent consultations and regular revisions expected, so that it can be adapted as drought risk changes in the future.

Track 1: Reduce and prevent

Adaptation to drought must be a key priority for South-East Asia where a large proportion of a country's population is economically dependent on climate-sensitive sectors, such as agriculture, fisheries, forestry, water, energy and environment. Land is the principal resource for agriculture and food production and water is fundamental for life. Further, hydroelectric-power uses water as fuel, and thus addressing the inter-linkage of food, water and energy is the key to target adaptive actions. Chapters 1 and 2 illustrated that adaptation to drought that addresses the nexus could follow three parallel tracks of the policy interventions (Figure 4-1):

Food, water and energy systems are undergoing structural transformations.

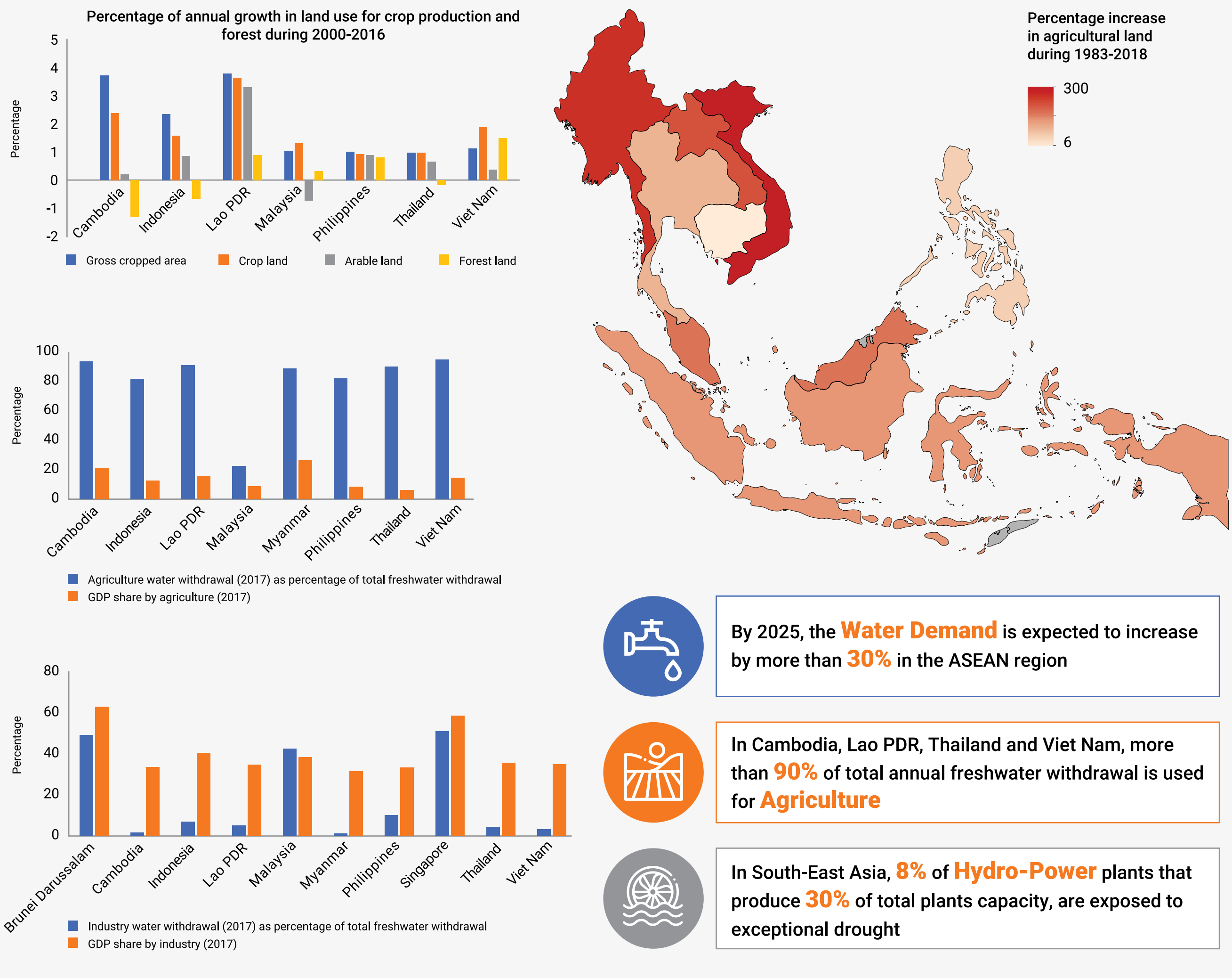
From a food security perspective, agriculture is a predominant sector with respect to utilization of land and water resources. Between 1983 and 2017, agricultural land has increased by nearly 70 per cent across South-East Asia, with 290 per cent in Viet Nam, followed by Myanmar (134 per cent), Lao People's Democratic Republic (65 percent) and Malaysia (54 per cent).[7] The additional area for agriculture has come from utilizing fallow or waste lands; clearing forest lands; or compensated by increasing cropping intensity. Moreover, rubber and oil palm cultivation are on the rise in South-East Asia because of high financial returns on investment.[8] Large-scale intensive monoculture of oil palm cultivation has negative impacts on soil, water and biodiversity.[9, 10]

Agriculture accounts for 80 per cent of total water withdrawals in several countries in South-East Asia and is more than 90 per cent in Cambodia, Lao People's Democratic Republic, Thailand and Viet Nam.[11] Expansion of agricultural land, intensive cropping and production of more water intensive food (e.g. meat and dairy products), due to changes in dietary patterns, will require more and more water in the coming days. Moreover, since economies in South-East Asia are some of the fastest growing economies in the world, water consumption and demand are also increasing as part of industrialization and urbanization. Inefficient water management is threatening the freshwater availability in the South-East Asia region. Over the last couple of decades, the amount of total renewable fresh water per capita is declining, while its demand is gradually increasing in this region.[12]

The generation of hydro-electric power depends on the availability of water. Drought exacerbates water shortages, which reduces the power generation efficiency of hydropower plants. Often water shortages or occurrence of drought coincides with the time of heavy demand of electricity. In South-East Asia, around 8 per cent of hydro-power plants, that contribute 30 per cent of the total capacity, are exposed to drought of exceptional severity. Based on this empirical evidence, Figure 4-2 highlights a nexus between food, water and energy and summarizes the key trends.

A fire fighter tackles a bush fire during the dry season in Sabah, Malaysia.

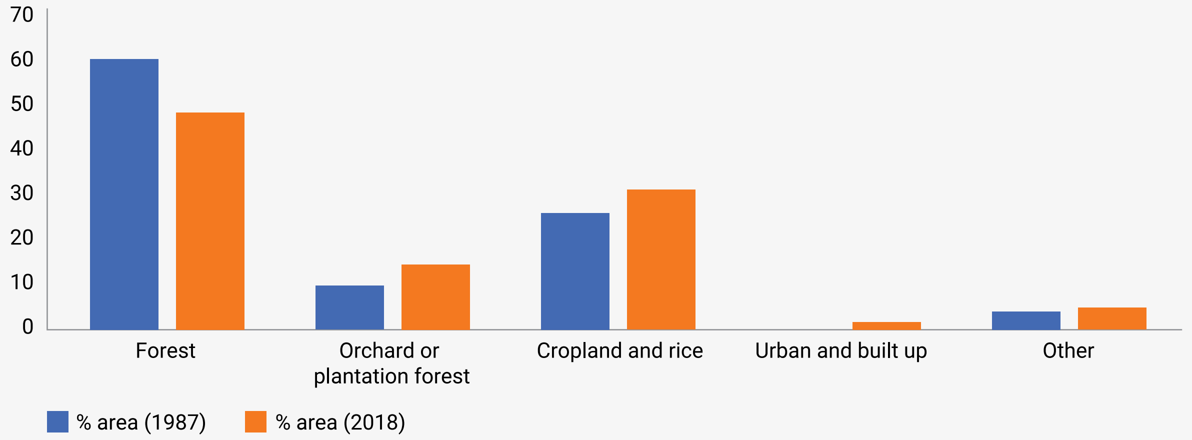
Figure 4-2 — Drought risk in South-East Asia is systemic in nature, and closely linked with food, water and energy systems



Source: ASEAN Food Security Information System; Birthal and others, 2019; Food and Agriculture Organization Corporate Statistical Database (FAOSTAT) and ASEAN Statistical Yearbook, 2018.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

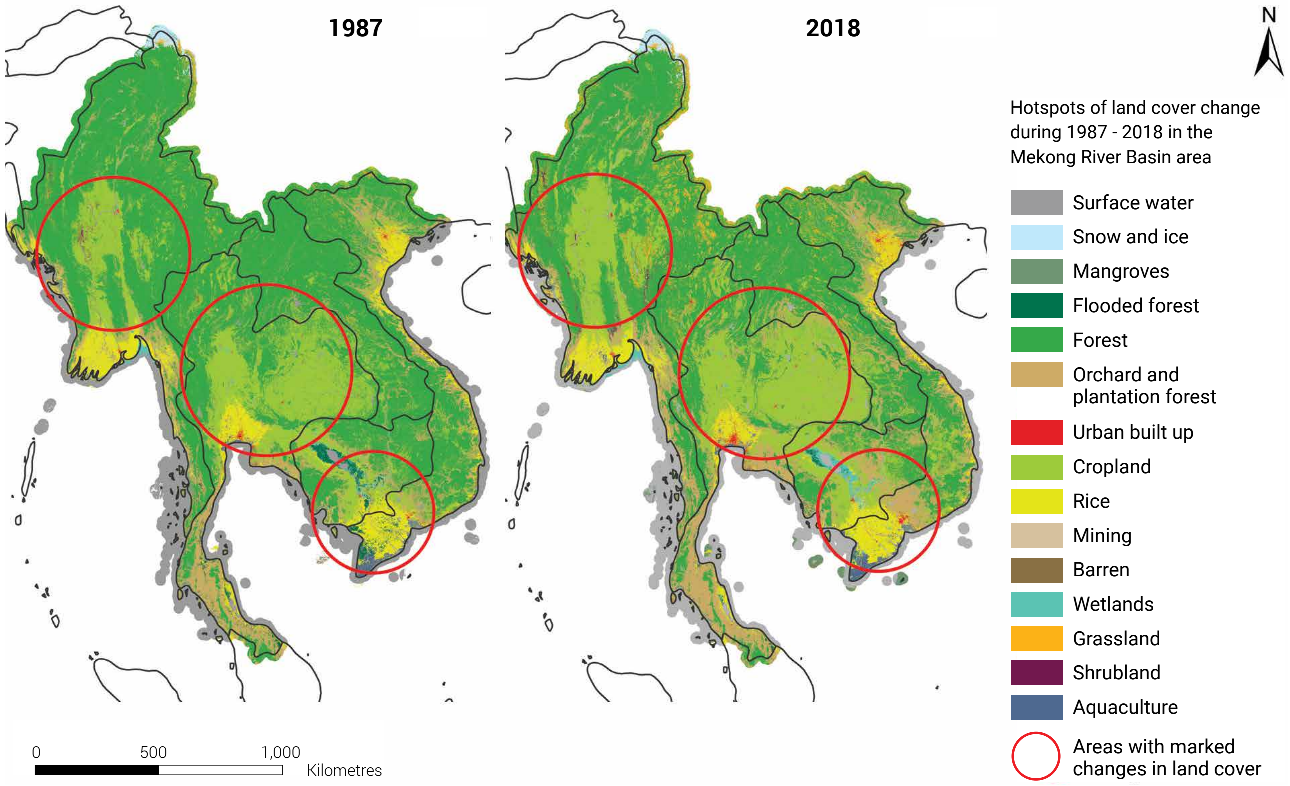
Land degradation and drought are interlinked as drought amplifies land degradation. Land degradation can also impact the water holding capacity of soil, intensify water scarcity and increase drought vulnerability in a vicious cycle. Land degradation is often triggered by poor land use and land cover management. Unplanned land cover change accelerates land degradation. Changes in land cover could have negative impacts on the environment, which is reflected through the water, food, and energy nexus. A land use and land cover analysis of the Mekong river basin area over the last three decades provides clear evidence of agricultural expansion at the cost of forest lands.[13] During this period, the subregion has lost more than 10 per cent of its total forest cover, concentrated mostly in northern and central Thailand, eastern and central Myanmar, central Cambodia and southern Viet Nam. The land cover share of urban and built-up area has almost doubled in the last three decades (Figures 4-3 and 4-4).

Figure 4-3 — Change in area under major land cover categories in the Mekong River Basin area



Source: ESCAP based on Regional Land Cover Monitoring System (RLCMS), ADPC SERVIR, Mekong.

Figure 4-4 — Land cover change in Mekong River Basin area during 1987 and 2018



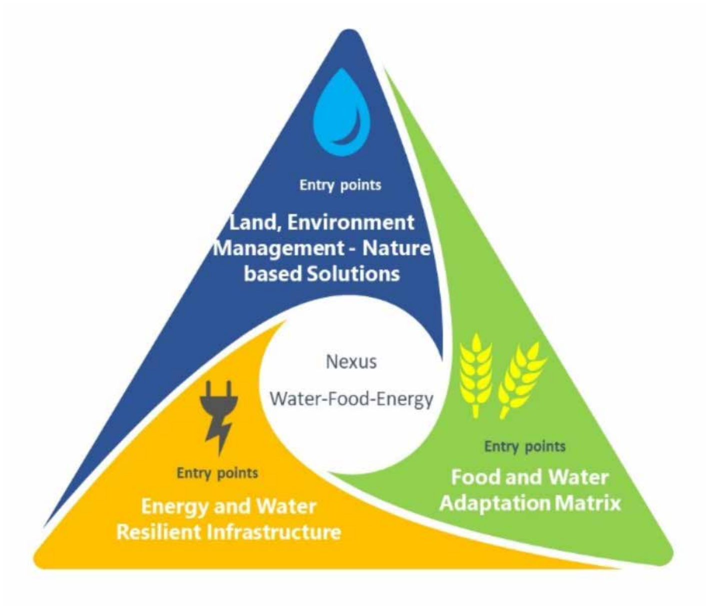
Source: ESCAP based on Regional Land Cover Monitoring System (RLCMS), ADPC, SERVIR, Mekong.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

A predictive analysis of land cover change based on the historical time-series data also indicated high probabilities of change for the forest, plantations and agricultural lands to other generic land use across this region.[14] Comparing the spatial extent of drought occurrence during last five years (see Chapter 1, Figure 1-4a) with the land use and land cover change reveals that areas with maximum land cover change were affected by more severe drought either in 2015 or in 2020. The shorter return period of severe drought (see Chapter 1) in those areas establishes the impacts of poor land cover management. In many of these areas the population is exposed to moderate to exceptional drought among which the poor and marginal populations are the most vulnerable.

Adaptation actions need to be accelerated in key systems.

For reducing and preventing drought, countries need to follow a more systemic approach to conserving and using food, water and energy. The entry points for these form an adaptation matrix, requiring innovative practices in (i) food security and water management, (ii) land management, environment and nature-based solutions, and (iii) energy systems and resilient water infrastructure (Figure 4-5).

Figure 4-5 — Accelerating adaptation actions in key systems of food, water and energy



Food security and water management systems

Countries in South-East Asia have already been adapting their food systems in many ways, including crop diversification, upland cropping, rice intensification systems, integrated farming, planting short-maturing and stress-tolerant varieties, integrated pest management, soil conservation, and crop watches for early warning (Table 4 2). Countries have also strengthened their water systems. Measures include integrated water resources management, water accounting, managed aquifer recharge, alternative wet and dry irrigation technology, reuse of wastewater, rainwater harvesting, traditional water management and early warning systems (Table 4-2). Countries in South-East Asia have implemented pilot practices (Box 4-1) but they now need to scale them up with the necessary policies, investment and technologies.

Table 4-2 — Adaptation for food security in South-East Asia

Adaptation Measures	Interventions	Location	Outcome
Crop diversification	Intercropping of rice with groundnut, pigeon pea, green gram, sesame, sorghum. Plantation of medicinal trees (e.g. Thanakar tree) and fruit trees.[15]	The central dry zone of Myanmar.	Enhanced drought resilience and food security.
Upland cropping	Restructuring the rice farms with upland crops like maize, soybean, groundnut and sesame. Expansion of sesame cultivation in Thoi Lai District-Can Tho City.[16]	Mekong delta region Viet Nam.	Increased profitability of farm and economic resilience of the society.
System Rice Intensification technique	Plantation of direct seeding rice and anaerobic rice.[17, 18]	Thailand, Malaysia and Viet Nam.	Sustainable crop production during drought and improved water efficiency.
Integrated farming	Agroforestry.[19] Integrated crop-livestock farming.[12] Rice-Shrimp farming.[20, 21]	Viet Nam, Indonesia, Philippines, Myanmar, Lao People's Democratic Republic and Thailand.	Enhanced drought resilience and food security. Increased profitability of farm.
Planting short maturing and stress tolerant variety	Recommended in 'National multi-stakeholder policy dialogue: Early actions to mitigate drought and saline intrusion in the South of Viet Nam'.[22] Site specific adjustment of crop calendar with stress tolerant and short maturing rice.[14] Release of drought-tolerant rice varieties Sahbhagi Dhan in India, Sahod Ulan in the Philippines and the Sookha (Sukkha) Dhan varieties in Nepal.[23]	Mekong delta region, Philippines, India, Nepal.	Increase annual productivity and yield and enhanced economic security of the farmers.
Integrated pest management (IPM)	National policies on IPM.[24] Pest smart intervention such as ecological engineering.[25]	Cambodia.	Reduced pest attack in the rice crops and reduced pesticide application.
Introducing Drought Resistance Agriculture Techniques (DRAT)	Integrated training materials in adapting to drier years, including techniques for home gardening, such as composting, soil improvement and seedling preparation; chicken-raising, including feed production and vaccinations; and water-saving techniques such as drip irrigation.	Cambodia.	Integrated learning modules on drought and weather systems, which allows farmers and leaders to predict and plan for upcoming seasons – a skill which has only existed previously using limited conventional methods.
Soil conservation	Mulching to retain soil moisture. Conservation tillage to reduce soil water stress and retain soil nutrients.		
Crop watch based early warning system	Adjust crop calendar, use climate resilient variety and adopt appropriate farm management measures based on weather forecast.[26, 27]	Thailand, Indonesia.	Sustainable crop production during drought and improved water efficiency.

Table 4-3 — Emerging trends in South-East Asia on water management

Adaptation Measures	Interventions	Location	Outcome
Integrated water resources management (IWRM)	Construction of a reservoir and a levee. Installation of piped water supply network connecting all the households in the village. Strengthening local knowledge on climate change, agricultural resilience techniques. Improved tree planting techniques. Diversifying livelihood options through rearing livestock.[28] Developing a platform of hydrological solutions that store and display data from the various hydrometeorological stations in the country.	Cambodia.	Sustainable water supply to the community during dry period. Improved socioeconomic condition and enhanced climate resilience. Real time monitoring for drought forecasting and early warning system.
Water accounting	Implementation of Water Account Plus (WA+) framework to estimate the inflow and outflow of water.[29]	Cambodia.	Enhanced knowledge about water stock of the region to facilitate equitable water allocation during dry season.
Managed aquifer recharge	Construction of a groundwater recharge pond along the Managa River.[30]	Philippines.	Enhanced water supply to Cebu city and surroundings during dry period.
Alternative wet and dry (AWD) irrigation technology	Mainstreaming of AWD through different programmes for 3.2 million ha of rice cultivation areas of Viet Nam by 2020.[31] Implementation of AWD in intensive rice production system in the Mekong Delta region.[32]	Mekong Delta Region.	Reduced irrigation water requirement and improved farm profitability.
Reuse of wastewater	Using treated domestic effluents for washing the streets and watering urban green areas. Using treated industrial effluents multiple secondary purposes within the industrial estate area.[33]	Thailand.	Increase availability of water during dry season.
Rainwater harvesting	Community wells and rainwater collection ponds. Maintenance of the water ways to rainwater collection ponds.[34]	Myanmar.	Increase availability of water for domestic purpose during dry season.
Traditional water management systems	Subak system for efficient water allocation.[35]	Indonesia.	Enhanced water availability and equitable allocation during dry seasons.
Using early warning system	Preparation of drought risk maps through analysis of climate change scenario coupled with water accounting. Development of new water infrastructures, such as dams, reservoirs, head waters and check dams. Community-based water management practices, such as adjustment of water allocation, increasing water usage efficiency and changes in cropping patterns.[36]	Thailand.	Increased water availability and reduced rick of drought.

Box 4-1 — High water use efficiency in Malaysia

From 1990 to 2016, Malaysia improved its water use efficiency by 119 per cent , which is one of the highest increases in the world.[a] It has done so by adopting appropriate technologies, and management systems and practices for water resources. Malaysia has also continually invested in research and development in the water sector. The following measures have enabled Malaysia to achieve high water use efficiency:

- Water demand management through recycling and reuse of water.
- Rational development of the water sector through uniform and innovative policies and legislation, with legal and financial instruments that enabled equitable allocation of water across all sectors.
- Institutions built around the river basins with integrated management of land and water for sound management of catchment and river basins using comprehensive database and decision support systems.
- Active community participation for basin-wise planning and management of water resources.
- Affordable water pricing policies with support from the private sector to extend safe and quality water to every household.
- Efficient water pollution control through green technologies for agriculture and industries.
- Improvement and strong enforcement of waste and wastewater management systems.
- Efficient water management in agriculture using high-yielding and bio-safe crop varieties.
- Disaster management systems, such as early warning systems and rescue measures to reduce the exposure and vulnerability to hydro-meteorological disasters.

Malaysia's water management policies provide an example for accelerating adaptation in food and water systems.[b]

[a] A. Rossi, R. Biancalani, and L. Chocholata (2019).
[b] Information for this box has been taken from FAO/ESCAP (2001).

Land management systems

***Sustainable land management is a key to drought adaptation as it delivers multiple environmental and social benefits*.**

Addressing water, agriculture and climate change issues in an integrated way requires following the principles of sustainable land management (SLM).[37] The United Nations defines sustainable land management (SLM) as "the use of land resources, including soils, water, animals and plants, for the production of goods to meet changing human needs, while simultaneously ensuring the long-term productive potential of these resources and the maintenance of their environmental functions".

An extension of the SLM is the drought-smart land management (D-SLM) which works to improve the terrestrial ecosystem services that are affected by changes in precipitation and soil moisture. D-SLM can be implemented especially in those areas of unsustainable land cover change. D-SLM has already proved effective in building drought resilience by improving the hydrological balance in soil and enhancing plant water efficiency in particular,[38] and strengthening the resilience of natural systems, in general.

D-SLM can include changes in tillage practices. In the Philippines, for example, through *tipid saka* (zero tillage) principles, corn cultivation was undertaken in paddy fields with stubble from the last paddy season. The intervention increased soil moisture and soil fertility, reduced soil erosion, and increased crop yields and farm income.[39]

In some places, soil erosion can be tackled by planting stylo grass, which is a drought-tolerant leguminous shrub used in pastures and as fodder. In Cambodia, for example, one of the worst drought-affected areas is Kampong Chhnang. The soil in this area is acidic with low fertility and deforestation has led to soil erosion. Here, stylo grass was incorporated under and between mango trees. This provided readily available fodder which enabled the farmer to raise more livestock. Additionally, the permanent undergrowth reduced soil erosion and run-off.[40]

D-SLM should also include sustainable forest management to improve the water cycle and conservation in the forest ecosystem, making it more resistant to drought and reducing the probability of forest fires. Agro-forestry and agro-pastoralism, for example, increase soil fertility and the retention capacity of soil water. This generally requires reducing deforestation and increasing reforestation and afforestation. Integrated watershed management reduces soil erosion and run off, enhances ecosystem functioning, and reduces social and economic vulnerability of drought at the watershed scale.

San Miguel, a municipality on the island of Bohol in central Philippines, was suffering from deforestation, and the removal of natural vegetation. With support from the Department of Environment and Natural Resources, land users employed SLM technologies. This included a fire line constructed along the boundaries by clearing vegetation and planting *kakawate* (a leguminous tropical tree) and root crops. The interventions helped increase fodder production, reduce surface run-off, increase ecosystem diversity and reduce the risk of fires.[41]

Natural environment and nature-based solutions

A healthy natural environment with robust ecosystems act as a buffer against natural hazards while requiring small capital investments and maintenance costs.

Communities can better protect themselves against natural hazards by promoting robust ecosystems that require very little capital or maintenance. This can take the form of ecosystem-based adaptation (EbA) which promotes nature-based solutions for building resilience by focusing on human-ecosystem integrity.[42, 43] EbA measures are being widely applied around the world because they generally require small capital investment, have low maintenance costs and rely more on self-motivated communities who know that they will benefit from better ecosystem services.

The Government of Thailand, for example, has launched EbA measures to address flood, soil erosion, sedimentation, water scarcity and drought in three river basins: the Huai Sai Bat basin, Tha Di basin, and the Lam PaChi river basin. The Department of Water Resources, the Royal Irrigation Department, existing river basin committees along with local stakeholders joined hands to improve the ecosystems by combining both grey and green measures. Grey measures refer to technological and engineering solutions, while green measures take the ecosystem approach. These have included creating micro-dams, modifying river channels, constructing wetlands, developing riparian zones to reduce land erosion, constructing sediment ponds, developing flood plains and better water resources management to ensure water supplies.[44]

Community-based solutions have also been adopted in Cambodia. One of the most drought-prone provinces of Cambodia is Kampong Speu. Here, in order to address food security and protect the livelihoods of farmers, farm water user groups have worked on water conservation structures to increase water availability, as well as raise rice productivity, even during the dry season. The groups also manage and maintain irrigation structures, and there is a village seed credit system to maintain supplies even during extreme events. At the same time capacity development programmes have increased the community's understanding of climate change and sustainable farming practices.[45]

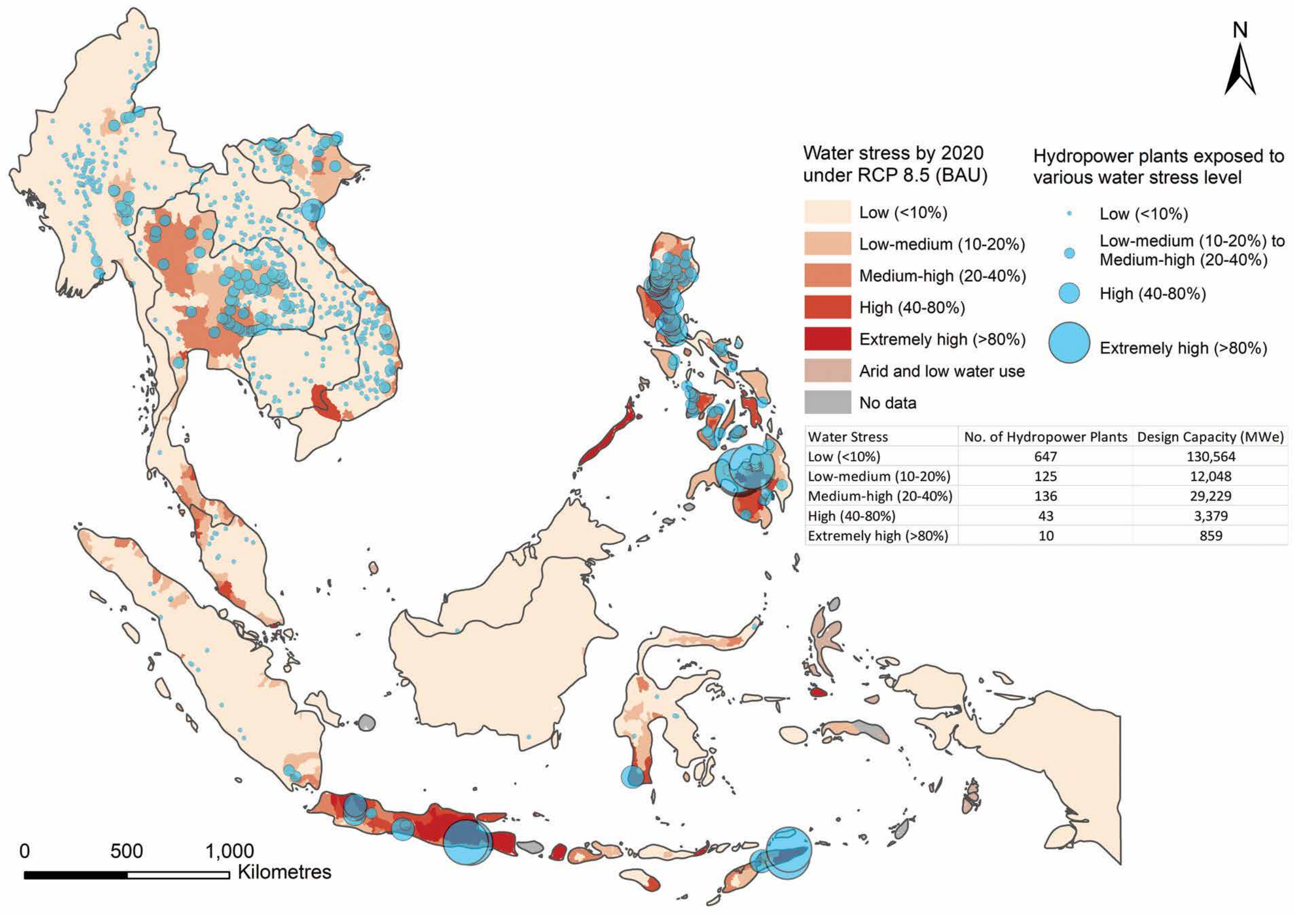
Energy systems

Addressing the high levels of risk exposure of energy systems is needed.

South-East Asia gets nearly 1.5 per cent of its total energy supplies from hydropower, a proportion that is likely to increase in the near future.[46] Hydropower generation is, however, vulnerable to drought and future climate change. As highlighted in Figure 4-6, many of the hydropower plants are located in highly water-stressed areas.

Currently, 53 hydropower plants are exposed to extremely high water stress, and by 2040, the number is projected to rise to 82. Almost all are in Indonesia, Philippines and Timor-Leste, among which, 15 are large hydropower projects with a total design capacity of 3,433 MWe.

Figure 4-6 — Exposure of hydropower plants to water stress



Water Stress	No. of Hydropower Plants	Design Capacity (MWe)
Low (<10%)	647	130,564
Low-medium (10-20%)	125	12,048
Medium-high (20-40%)	136	29,229
High (40-80%)	43	3,379
Extremely high (>80%)	10	859

Source: ESCAP calculations, based on data from WRI Aqueduct Water Stress Projection Data (2015), and Asia-Pacific Energy Portal (2018).
Disclaimer: The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Box 4-2 — Risk-informed hydropower development in Tajikistan

Tajikistan gets 98 per cent of its electricity from hydropower. As part of climate preparedness, the Qairokkum hydropower project in Tajikistan developed internationally recognized best practice to address climate change in the hydropower sector by embedding climate change risk in investment design.

Key interventions:

- Developed a future climate change scenario for the region and forecasted water inflow to the reservoir under different climate change scenarios using hydrological models.
- Modelled electricity generation under forecasted water inflow scenarios.
- Based on the forecasted scenarios, the project identified and implemented structural rehabilitation options to increase the plant's generation capacity with best economic performances across climate scenarios.

The project is also intended to increase dam safety and efficiency, while securing reliable electricity supplies through various climate change scenarios.[a]

[a] Information for this box has been taken from Sustainable Energy Initiative. "Case Study Qairokkum Hydropower: Planning ahead for a changing climate". European Bank.

Governments in South-East Asia have started using strategic planning to create and finance more climate-resilient infrastructure systems for a range of climate scenarios. This planning should provide flexibility over time and reflect the different priorities of communities (Box 4-2).

The ASEAN Connectivity through Trade and Investment project has developed a framework and risk assessment tool for screening hydropower facilities for climate change risk. This tool can help investors and managers identify risks for individual plants and guide structural, policy and planning measures accordingly. The framework has been applied, for example, to the Tudaya 2 hydropower plant on the Sibulan River, in the Philippines.[47]

Action points for accelerating adaptation in key systems

South-East Asia has many adaptation bright spots where innovation efforts have begun. These now need to be scaled up in the following key systems:

Food – Countries need to plan for future food security. This will mean scaling up climate-resilient production for a large number of vulnerable small-scale farming households. This should include crop diversification, using rice intensification techniques, integrated crop-livestock farming, stress tolerant varieties, integrated pest management and conservation tillage.

Water – Successful adaptation will require scaled-up investments in healthy watersheds and water infrastructure, dramatic improvements in efficiency of water use, and the integration of new climate risks. Countries in South-East Asia need to make water management a top national priority, backed up by major governance changes and investments. This should include integrated water resources management, water accounting, managed aquifer recharge, alternative wet and dry technologies, direct dry seeding rice, reuse of wastewater, rainwater harvesting, and traditional water management systems.

Energy – Owners need to climate-proof existing hydro-electric and renewable infrastructure, and investors should plan new energy infrastructures, including the use of wind and solar energy, that are more drought resilient. This will provide many economic advantages, as on average, the benefits outweigh the costs by 4:1. Building resilience to drought will require blended public-private approaches that share the costs and benefits.

Land – Land use and investment decisions on public and private resources should aim to safeguard nature and also better support communities. Many of these solutions are also beneficial for drought mitigation and can also help achieve the objective of the United Nations 2030 Agenda for Sustainable Development to keep global warming below 2°C. This should include integrated approaches for spatial land-use planning, and drought-smart land management.

Natural environment – Nature-based solutions regulate water flows, protect shorelines, cool cities, and complement built infrastructure. Meeting existing political commitments will mean large-scale protection and restoration of nature, and community-driven adaptation approaches.

Track 2: Prepare and respond

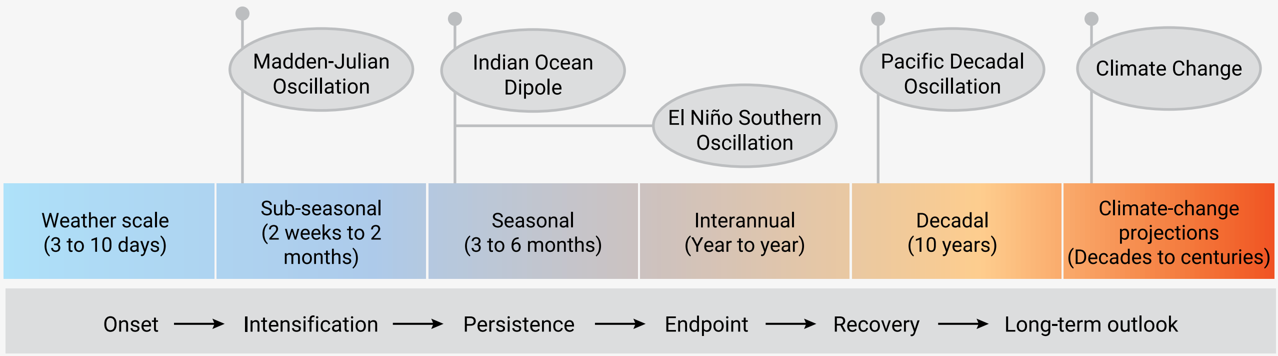
Adaptation to drought requires services for prediction, monitoring and early warning. Though there have been many policy and technical discussions on science-based interventions, in practice, the uptake of solutions has been slow.[48] This section showcases proven science-based solutions in three broad areas: improved capability to predict rainfall patterns; more and better satellite-derived drought indices; and automated data integration techniques. These would fall into the remit of national meteorological and hydrological services (NHMSs). However, these agencies also need to work closely with the custodians of climate-sensitive sectors, including agriculture and food security, disaster management, water, health, energy, and with communities.

User-oriented services

Aligning with users should be the starting point.

A drought early warning system aims to "track, assess and deliver relevant information concerning climatic, hydrologic and water supply conditions and trends."[49] At the minimum, the system should provide timely information ahead of drought.[50] It should also predict their intensification, persistence, endpoint/decay, and recovery.[51] Ideally, it should also provide long-term outlooks to inform decisions on infrastructure and economic planning whose implications could last for centuries (Figure 4-7).

Figure 4-7 — Drought early warning information across timescales



Science-based solutions will only be effective if they make sense to users. Early warning services should deliver the "right information to the right people at the right time".[52] But what is the right information for managing and adapting to drought? The best drought indicator is the one that most closely corresponds with the specific interests of decision makers and policymakers and communities who are the first to bear the brunt of drought impacts. These should include data on precipitation, temperature, streamflow, groundwater and reservoir levels, and soil moisture.[53]

***Pre-agreed plans and procedures on how the information should be used are needed to effectively prepare and respond to drought*.**

All the indicators and derived indices need to be linked with drought/disaster contingency plans, drought policies, and adaptation plans. There should be pre-agreed plans and procedures on how the information will be used, what will happen once certain thresholds are crossed, and where the required funds will come from.

The Drought Manual of India (2016), for example, has quantitative criteria consisting of rainfall, vegetation, water and crop indices. When pre-established thresholds are breached, a drought is declared, which in turn triggers a whole range of actions from federal, state and district-level governments, including the release of financial resources and implementation of water saving measures.[54] In the Philippines and Viet Nam (see Table 4-4), the Governments have implemented pilot schemes using forecast-based indicators, tested by FAO, to see how they can be used to trigger early action, with corresponding financial mechanisms.[55]

Seamless rainfall prediction across timescales

Mainly due to its connection to anomalous sea surface temperature patterns (e.g., El Niño), drought across many parts of South-East Asia is potentially predictable on the seasonal timescale.

Droughts that occur across many parts of South-East Asia are often connected to anomalous sea surface temperature patterns, such as El Niño, whose behaviour can be used to make seasonal climate predictions (Appendix 5). This can provide forecasts on rainfall three to six months ahead.[56] Interestingly, the highest correlations between El Niño and rainfall are in some of the region's drought hotspots.

Studies in Cambodia, for example, demonstrate the usefulness of an ENSO-based index to predict drought.[57] In 2019, the Philippines formally adopted an alert and warning system based on the oceanic Niño index to provide guidance for sectoral contingency plans.[58, 59] But not all droughts are so predictable, and many result from sub-seasonal events.[60] In South-East Asia, droughts start and end at different times in the year as they are not consistently related to the onset of the rainy season. Moreover, droughts are an issue not just of total rainfall, but also on how it is distributed through the season.

Recent scientific research shows that for hazards, such as dry spells and heatwaves, it might be possible to provide sub-seasonal (S2S) predictions, from up to two weeks to one month ahead. These advances provide an opportunity to bridge the gap between the longer lead times of seasonal predictions and the greater precision of weather forecasts. Interestingly, the South-

East Asia region is one of the most likely to benefit from S2S predictions because it has some of the greatest skills at this timescale.[61] The confidence levels of these predictions may vary, but seamlessly combining predictions for different timescales can enable decision makers to assess risks more dynamically. While seasonal climate forecast triggers early preparation, S2S offers the opportunity for mid-course corrections.

National meteorological and hydrological services are already providing seasonal climate forecasts and predictions. These are three-monthly, and for at least two variables; rainfall and temperature. NHMSs also have products for specific sectors, such as streamflow forecasts and agro-meteorological advisories/monitoring bulletins.

An important resource for countries looking for climate products and services is the South-East Asia Regional Climate Centre (RCC) network. Each member or 'node' in the network performs one or more of the RCC functions and its related functions; climate monitoring (PAGASA, Philippines); long-range forecasting (MSS Singapore)); and operational data services (BMKG, Indonesia). The ASEAN Specialised Meteorological Centre (ASMC) also provides monthly updates and convenes a bi-annual ASEAN Climate Outlook Forum (ASEANCOF). The ASMC and the RCC network have recently explored S2S products as part of their suite on an experimental basis (See Table 4-4).

Table 4-4 — Examples of forecast-based early actions

Country	Physical indicators	Threshold	Action	Remarks
Viet Nam	Standard Precipitation Index.	Severe or extreme drought.	Warn potentially at-risk communities (Nov-Jan). Promote early crop sowing. Rainwater harvesting (Oct-Nov). Designate fodder reserve for livestock (Aug-Sept).	Pilot scheme implemented by FAO, UN Women, Save the Children with communities and local authorities in Ca Mau (in the Mekong River Delta) and Gia Lai (in Central Highlands). Physical indicators considered alongside socioeconomic and market indicators.
		60 per cent chance of severe or extreme drought.	Distribution of water tank (Nov-Dec). Destock livestock based on pasture carrying capacity; maintain storage capacities; support market to facilitate selling of livestock (Jan-Feb).	
Philippines	Observed sea surface temperature anomaly (SSTA): 1 month 0.5°C or greater. Observed Oceanic Nino Index (ONI): between <0.5°C and >0.5°C or neutral. Forecast from CPC NOAA and other GPCs: Probability of El Niño development is 55 per cent or higher.	PAGASA issues a "Watch".		PAGASA official ENSO Alert and Warning System; input to formulation of guidance for El Niño contingency planning.
	SSTA: 5 consecutive months of 0.5°C or higher. ONI: 3 consecutive ONI of +0.5°C or higher. Forecast from CPC NOAA and other GPCs: Probability of El Niño development is 70 per cent or higher.	PAGASA issues an "alert" and recommends early action to sectors.		
	SSTA: 7 consecutive months of 0.5°C or higher. ONI: 5 consecutive ONI of +0.5°C or higher. Forecast from CPC NOAA and other GPCs: El Niño is already observed and expected to continue.	PAGASA issues an "advisory" and recommends sectors to take action.		

Philippines	Combined scores from: Seasonal and monthly rainfall and temperature forecast, NDVI, Vegetation Condition Index, length of dry spell, watershed rainfall forecast, ENSO forecast.	Phase 1: Monitoring: If the combined score is between 35-40 per cent.	Monitor and update stakeholders.	Pilot scheme implemented by FAO in Maguindanao and North Cotabato.
		Phase 2: Assessment: Between 40 to 60 per cent.	Send out field assessment teams, focus on food security and nutrition.	
		Phase 3: Action: More than 60 per cent.	Implement early action activities.	

Source: For Viet Nam, see FAO Viet Nam (2020). For Philippines, see PAGASA (2019) and FAO Philippines (2020).

Table 4-5 — Drought-relevant regional-scale experimental S2S and seasonal forecast information available from either ASMC or the SEA-RCC network

Hazard	Forecast product	Forecast lead times	Regional/Global sources	Skill level** (high, medium, low)
Drought/dry spell	Duration of dry spells and consecutive dry events.	2 - 4 weeks.	SEA-RCC (planned).	Medium at 2 weeks, low at 3 - 4 weeks.
	Weekly rainfall updates (drier than average).	2 weeks.	ASMC Sub-seasonal Weather Outlook.	High
	Probability of below normal (bottom third) and way below (bottom fifth) rainfall.	1 month to 1 season.	SEA-RCC.	Low to high depending on location and season.
Heatwave	Consecutive high temperature days, with temperatures above location specific thresholds.	2 - 4 weeks.	SEA-RCC (planned).	Medium at 2 weeks, low at 3 - 4 weeks.
	Weekly temperature updates (warmer than average).	2 weeks.	ASMC Sub-seasonal Weather Outlook.	High
	Probability of above normal (upper third) and way above (upper fifth) temperature.	1 month to 1 season.	SEA-RCC.	Medium to high depending on location and season.
Haze	Potential hotspot activity based on assessment of weekly rainfall and temperature outlook.	2 weeks.	ASMC Haze outlook.	Medium
	Potential hotspot activity based on seasonal outlook.	Season.	ASMC Seasonal Outlook.	Medium

Source: ESCAP, ASMC, RIMES (2019).
Note: **Based on initial assessment of model skill with some variation based on season and location. Usefulness of products requires end-user assessment and further assessment of model skill.

Satellite-derived indices

Greater and improved satellite-derived indices hold significant promise in improving drought monitoring and damage verification but local verification is needed.

Drought monitoring could make better use of data from satellites, both for monitoring droughts and its associated impacts, such as haze, and for verifying damage. For example, CHIRPS can be used for monitoring rainfall; the normalized difference vegetation index can be used for vegetation; the soil moisture active passive index can be used for monitoring soil moisture; and the normalized difference water index for water.[62] In some countries, such as Myanmar and Indonesia, these indices have become part of the routine drought monitoring products issued by their respective NHMSs. Myanmar, for instance, has been using monthly NDVI data for monitoring drought conditions in the dry zone. Higher resolution satellite data have expanded the possibilities for drought monitoring and damage verification and also enabled long-term monitoring of forest cover, agricultural land expansion, groundwater, and many other aspects of land and water use. A forthcoming publication by ESCAP entitled, *Geospatial Information for Sustainable Development: Perspectives from Asia-Pacific*, features examples from across Asia and the Pacific.[63]

Satellite data and the derived indices are only useful, however, if countries have the capacity to use them. There have been several initiatives to facilitate access and build national capacity to customize them. Through the ESCAP Regional Drought Mechanism, for example, satellite data and expertise from China, India and Thailand have been deployed to selected countries in South-East Asia, to provide them with tools, web-based portals, and capacity development. Thailand's space agency drought monitoring portal, GISTDA, offers at least ten indices.[64] SERVIR-Mekong, a joint initiative between the Asian Disaster Preparedness Center (ADPC) and NASA, is an integrated web-based information system, which provides access to current and forecast data for a range of energy balance, soil and water balance indicators and for at least eight drought indices.[65]

Satellite-derived indices are traditionally used solely for monitoring drought, but the recent generation of satellites offer a potential to predict how the impacts could cascade onward from water to vegetation. For example, NASA's Gravity Recovery and Climate Experiment (GRACE) satellites enable scientists to measure water below the Earth's surface with unprecedented precision. These data have been used to develop a new drought severity index (GRACE-DSI) that captures changes in deep water storage that affect soil moisture recharge and drought recovery.[66] In the United States, they have been used to forecast water availability with a three-month lead time.[67] Scientists have also been able to combine GRACE's data surface water with top-soil data from other satellites to predict impacts on vegetation and bushfire risk in Australia, as much as five months in advance.[68] GRACE satellites now provide data for weekly global maps of soil moisture and groundwater wetness conditions. These have recently been made available globally although operational applications have yet to be demonstrated.

Satellite-based indices are particularly useful in locations where traditional drought monitoring methods are limited by sparse ground observations. This permits 'convergence of evidence'. For example, a study in Cambodia revealed that a couple of satellite-based and composite indices may be predisposed to over-estimating rainfall over a particular area.[69] If decision makers are to have confidence in these data, they need therefore to be validated and customized (Box 4-3).

Box 4-3 — Localizing drought indicators in Cambodia based on regional data

A study conducted by the United Nations Development Programme (UNDP) in Cambodia verified the relevance of satellite-based global and regional products vis-à-vis ground observation data. The results of the study reinforce the need to verify and calibrate regional products before applying them locally. The validation and calibration of global data was instrumental in developing localized drought indicators. This emphasizes the importance of data from the observation (meteorological and hydrological) stations.

The study concludes that an effective and locally-appropriate drought early warning system for the country would need to be based on a combination of the following indicators: (i) the SPI between mid-May to mid-November for meteorological drought; (ii) the normalized difference vegetation index between October-November for agricultural drought; and (iii) the surface water drought index in December-January for hydrological drought.

El Niño has a strong influence on droughts in Cambodia; it is not a one-to-one relationship but certainly co-occurrence. In 2004, for example, a weak ENSO year, Cambodia experienced one of its most severe droughts in recent history. ENSO forecasts can nevertheless offer forecasts with longer lead times. The study also notes the potential for complementing ground observations with the global precipitation measure.[a]

[a] The information for this box has been taken from UNDP (2019a).

Automated data integration

Creating products from the ever-increasing stream of data from diverse sources can be enabled by advances in automated data integration techniques.

Analysts and policymakers are now faced with a constant stream of data from diverse sources. These include local measurements of temperature, precipitation, wind; remote sensing from satellite, aircraft, and unmanned aerial vehicles; and predictions from climate models.[70] The rainfall datasets used in Chapter 1, for example, merge data from observation stations and satellites with outputs from climate models.

In order to best combine these to support decision-making, there are now many data integration techniques, ranging from the more common geographic information systems (GIS) to more complex processes offered by artificial intelligence and its sub-branches. These are particularly promising for issues, such as drought that require multi-disciplinary solutions. Analysts can combine environmental datasets with social, economic, and demographic variables to discover relationships between them, or to model future changes in global, regional or local environments.[71]

GIS-based analysis can integrate geospatial datasets of different types and spatial scales, and present the results of the analysis in a geospatial format. The World Food Programme for example, has developed the Platform for Real Time Impact and Situation Monitoring (PRISM) for Indonesia and other countries to monitor climate hazards and produce risk analytics by combining satellite imagery and on the ground data.[72]

Another promising area of research is data mining. This uses techniques from machine learning, pattern recognition, statistics and visualization to extract information from large databases.[73] For drought, the main application so far is the vegetation drought response index (VegDri).[74] This provides a one-kilometre-resolution map of drought-induced vegetation stress, which is more precise than traditional drought indicators.[75] VegDri can integrate data, from many sources; from climate monitoring, such as the standardized precipitation index; from satellites, using the Palmer drought severity index; and biophysical data on land cover, such as the percentage of irrigated agriculture, available water capacity for the soil, and type of ecosystem.

Automated data integration requires a geospatial data architecture and technological solutions in data storage and processing, such as cloud computing. In Cambodia, for example, the ESCAP Regional Drought Mechanism has introduced a data cube tool to establish a water accounting and balance system.

A national roadmap for improving drought early warning

Scientific and technological advances can improve the way we gather, store, process, visualize, and convey data and information. Countries can then use these to inform decision making. This will require convergence in five areas:

Producer-user convergence – Decision-making is enhanced if there is an established link between the scientific output and policy documents, plans and operations, and a prior arrangement on when and how they will be provided and received. Each agency needs therefore to identify the decisions, and the essential indicators and indices that are required to make them risk-informed. These may be articulated in drought policies or in the specific contingency plans of agencies, or in National Adaptation Plans. It may not be possible to identify all the information requirements at once, but many arise from routine decisions, such as the declaration of a drought emergency and periodic government exercises, such as the development of multi-year economic and investment plans.

Institutional convergence – To meet drought information requirements, countries need an inter-agency operational plan. This could be drawn up from a working group which can consider how all government agencies might gather the required information on a sustainable basis, how this might be delivered, and the mechanisms for receiving user feedback and evaluation. The working group should be inter-sectoral, with the NHMS as the technical lead. Solutions need to be scalable and updated and adapted as new technologies emerge.

Data convergence – Technical experts and senior policymakers frequently lament the lack of data sharing and exchange. There are a number of technological solutions for addressing this, such as cloud computing and inter-operable web-based processing services. For this purpose, Governments may opt to build a centralized data architecture for all risk-related data. This can be made available to users through a web-based portal, such as the one recently built by Myanmar (Box 4-4).[76] On the other hand, Governments may adopt a decentralized and distributed, but inter-operable, data architecture. This would require common data formats, data-sharing protocols and data management principles aligned with internationally-accepted standards. Whatever the solution, it needs to be geospatially-enabled to allow scalability and facilitate sharing, integration, and better visualization.

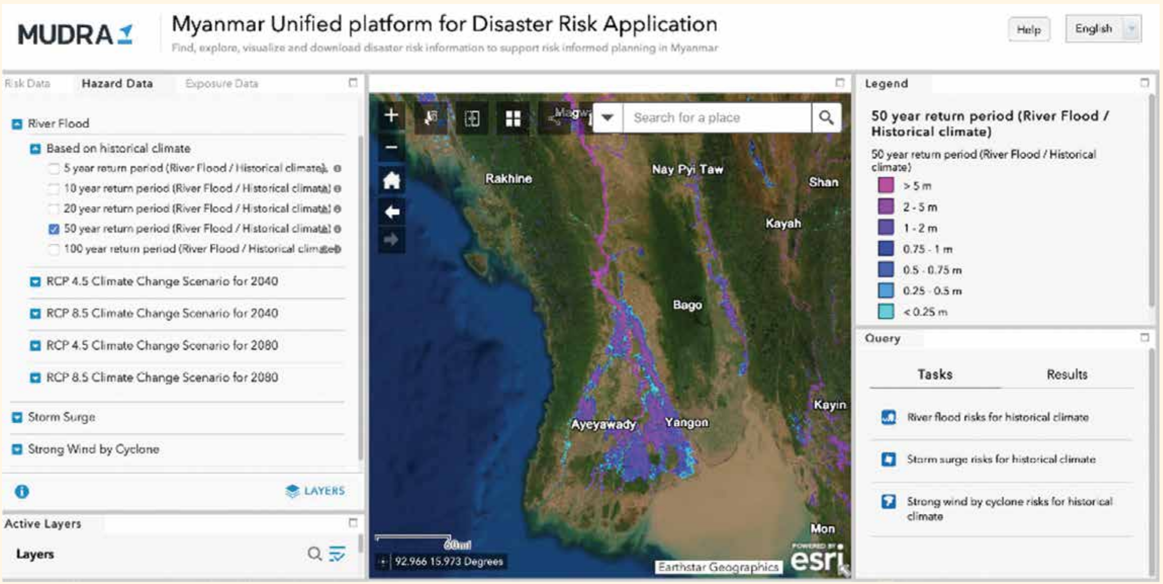
Scientific-economic convergence – Producers and users of data need to know the economic benefits of informed management of risk and opportunities with regard to the climate. Expressing these estimates in economic terms can help producers of data and information to demonstrate, to the finance and planning ministries, that there is a good return on investment, and thus facilitate the integration of climate services into national development strategies. This will require better documentation of the damage from drought and of the actual use and value of using data information to inform decision-making.[77]

Information and demand-investment convergence – Governments will need to invest sufficiently in people and systems to match the current and emerging demand for information and decision support tools. This will mean investing in capacity-building and technical staff as well as in ground observation systems and equipment. Each agency should make provisions for these investments under its regular budget. NHMSs and other producers of information should receive a fair share of global adaptation funding, commensurate with the increased expectation for their services.

The scientific understanding of climate and biophysical systems can thus enable access to more and better data. But individual advances are unlikely to make a real difference unless they are integrated within a drought early warning framework. ASEAN Member States should build on existing global and regional initiatives and mechanisms to adopt these scientific solutions at the necessary scale (see Chapter 5).

Box 4-4 — Myanmar Unified Platform for Disaster Risk Application

To enable access to risk information and promote risk-informed development planning in Myanmar, the Department of Disaster Management (DDM), of the Ministry of Social Welfare, Relief and Resettlement, spearheaded the development of the Myanmar Unified platform for Disaster Risk Application (MUDRA) in collaboration with the Department of Meteorology and Hydrology and Environment Conservation Department.



MUDRA is an online GIS-based interactive portal that provides disaster risk information for strategic planning at various spatial and time scales. The current portal includes hazard and risk information for priority hazards, riverine floods, coastal floods (storm surges) and cyclone winds for the current climate as well as for risks associated with future climate changes (2040 and 2080), particularly with an intent to cover other major hazards. The portal includes 60 sets of exposure data including demographic, social, economic and critical infrastructure from 20 sector departments that can be overlaid to assess the exposure to hazards, as well as enable modelling for other hazards by providing access to relevant data.[a]

The portal has been designed to serve as a common platform across agencies for developing, collaborating and sharing disaster risk information in order to promote risk-informed development. It is aligned with the Government's broader OneMap Myanmar programme to decentralize access to data, information and knowledge and to enable the Government and citizens to make more sustainable and evidence-based decisions on land management and broader development planning.[b] The risk indicators are aligned with the global targets, thereby contributing to the objectives of the Sendai Framework for Disaster Risk Reduction, the Paris Agreement and the Sustainable Development Goals.

With the operationalization of the MUDRA portal, DDM is working with OneMap Myanmar project and the departments on protocols for data management to align their work with the OneMap data sharing policy which is under finalization.[c]

[a] MUDRA webpage.
[b] Bastide and others (2017).
[c] Information for this box was contributed by Department of Disaster Mitigation, Myanmar.

Track 3: Restore and recover

Governments in South-East Asia typically retain most of their country's disaster risk, largely financing their disaster response from current contingency budgets.[78] Middle-income countries can usually meet these humanitarian needs quite easily, but the low-income South-East Asian countries regularly struggle to secure adequate and timely funding for early recovery.[79]

Drought risk is thus a hidden public debt that becomes a realized fiscal liability when disasters occur. Governments therefore need to consider drought risk needs in their balance sheets as, otherwise, they can generate important macroeconomic and microeconomic imbalances.

An important element, at the national level, is disaster risk financing and insurance (DRFI). For Governments, DRFI instruments will include contingent facilities, such as the World Bank's loan with catastrophe deferred drawdown option. At the business and household level, there should also be property catastrophe insurance for homeowners. For farmers and herders, there has been some agricultural insurance which can take the form of weather index insurance. Forecast-based financing, for example, can be particularly effective and has created opportunities for other more efficient insurance programmes.

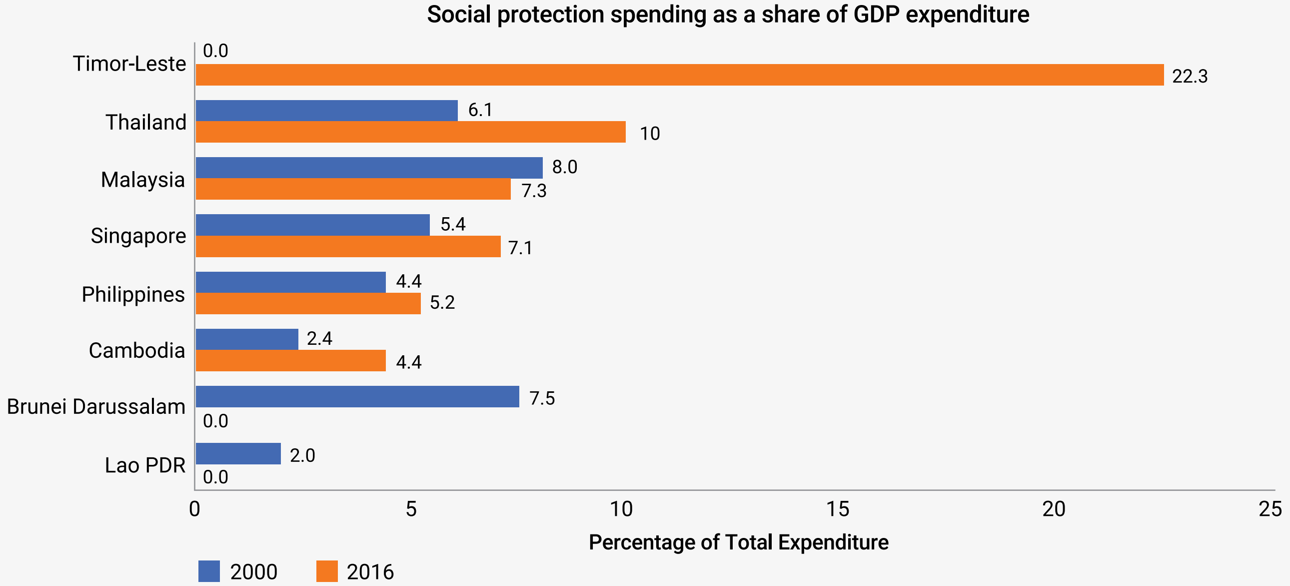
At present, however, in most countries in South-East Asia, private disaster risk insurance markets are still underdeveloped. Indeed, Governments may have not considered drought in the development of their risk model, primarily due to the complexities in determining drought-related pricing strategies.[80] DRFI will inevitably therefore be covered by a combination of public funds and private markets.

Financing drought risk management

Ex-ante financial measures must include large-scale losses from drought to develop effective resilience measures, such as social protection.

Most countries recognize the importance of social protection and have adopted disaster-responsive social protection guidelines. Indeed, over the past two decades, countries in South-East Asia have increased social protection investments. Nonetheless, the countries in the region still spend below the world global average of 11 per cent (Figure 4-8).[81]

Figure 4-8 — Government expenditure on social protection, 2000 and 2016



Source: ADB Key Indicator Database. Available at https://kidb.adb.org/kidb/.
Note: 0.0 means that data was not available for 2000.

The additional expenditure needed is considerable. Nevertheless, the annual investments needed are still less than the losses from drought. Investing in risk-sensitive social protection in the Philippines is projected to lift 4.1 million people out of extreme poverty.[82] Furthermore, additional investments in sectors like infrastructure and social protection that help prevent drought are also much lower than the projected drought losses, as in Cambodia, Lao People's Democratic Republic, Viet Nam, Thailand, and Timor-Leste (Figure 4-9).

Social protection spending must not only be scaled-up, but designed to absorb the impacts of disasters, and to protect the most vulnerable populations. Shock-responsive social protection has been introduced for rapid-onset disasters, and now it needs to be extended for drought. For example, in the Philippines, a pilot drought early warning and early action programme has been introduced in the provinces of Maguindanao and North Cotabato. Here, cash-for-work programmes are implemented based on climate forecasts, to support vulnerable farming households.[83]

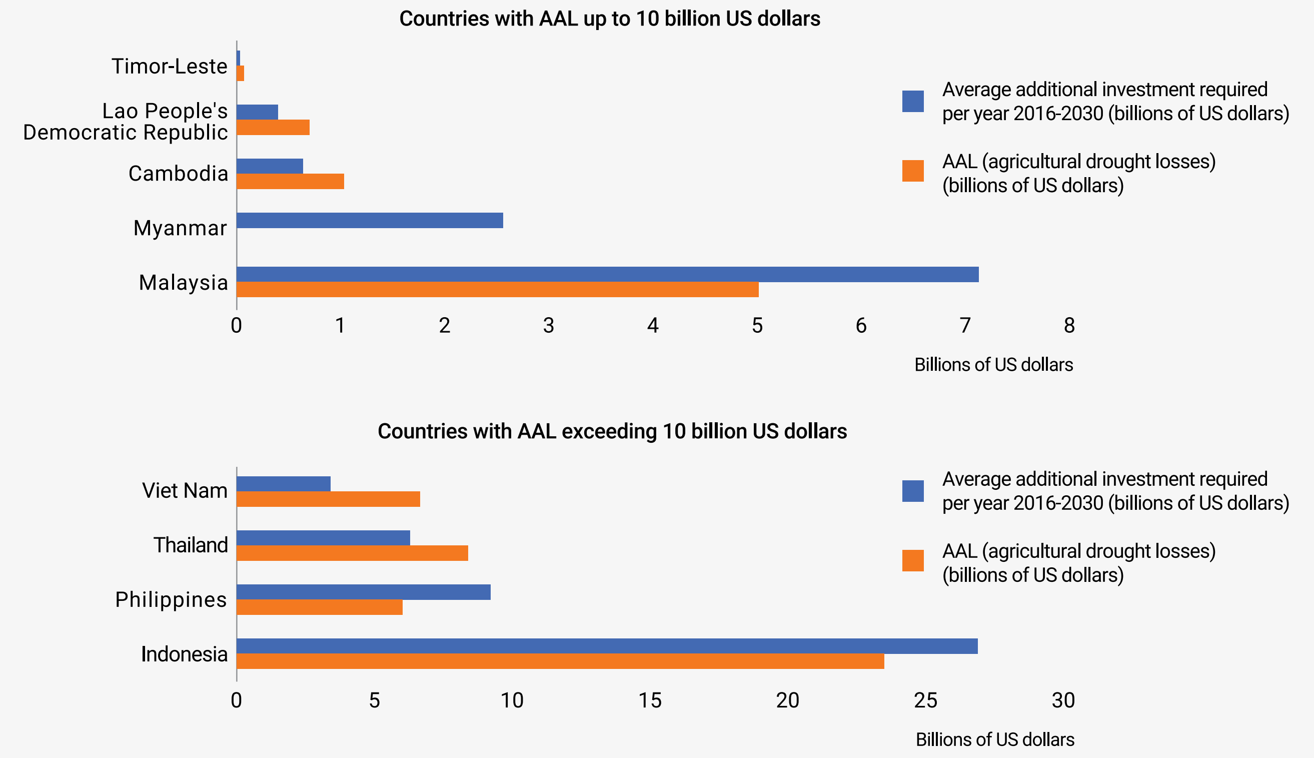
At present, however, financing for social protection and investments often comes from government funds. A 2019 study estimated that over the last six years countries in the Asia-Pacific region allocated around $5 billion for disaster risk financing. These included contingency funds, reserves, and other instruments, such as national budgetary allocations and re-allocations. These contingency funds, however, are not generally used to access insurance solutions and do not have a risk layer for drought.[84]

Future losses from drought could put government budgets under increasing stress. Furthermore, following the COVID-19 pandemic, social protection systems in many countries in South-East Asia, will be further strained to cover vulnerable populations. At the same time, international aid is shrinking. In Thailand, for example, the confluence of COVID-19 with droughts and forest fires are creating a perfect storm of challenges for the Government.[85]

Governments do have options for creating the necessary fiscal space to increase social investment.[86] They can reallocate public expenditures, increase tax revenues, expand social security coverage and contributory revenues, and adopt a more accommodative macroeconomic framework. They can also lobby for aid, increased borrowing or restructuring existing debt.

But they should also seek innovative financing measures to reallocate risk, including increasing the role of private finance and insurance. Scaling these options up will require more accurate and efficient assessment of drought risk.

Figure 4-9 — Additional investments needed in key areas including social protection compared to drought losses, billions of US dollars



Source: ESCAP (2020).

Quantifying risk

Improving risk assessment and risk databases is the foundation of drought risk financing. This section will explore a range of innovative approaches that must now be implemented across the region.

Innovations in drought risk assessments can lead to risk-sensitive economic investments.

A series of innovations in the past few decades have revolutionized the accuracy of risk modelling and the cost-effectiveness of disaster risk financing mechanisms. Innovations, such as catastrophe risk modelling, the creation of parametric insurance instruments for risk transfer, and the convergence of traditional reinsurance markets and broader global financial markets have made it possible to transfer larger volumes of natural hazard risk to global markets more cheaply and effectively. Using these innovations, Governments are scaling up social safety nets and supporting short- and medium-term response to disasters.[87]

Forecast-based financing

Forecast-based financing solutions for early actions supports ex-ante risk management.

Forecast-based financing which relies on parametric or index-based solutions, like weather or yield index, is being increasingly used to overcome these challenges. These insurance solutions use an index, such as rainfall, to determine payouts which can be made more quickly and with less risk than products that are based on indemnity. Faster payouts mean that farmers do not have to sell their assets to survive and that the need for emergency food aid is reduced. All these advantages should make weather index-based insurance attractive to low-income farmers.

However, one of the main challenges in forecast-based financing is a high basis risk, in which the index formula may not exactly reflect the real world losses of farmers; index measurements from weather stations, satellites, and other sources may not be precise enough to reflect a farmer's losses; or conditions on a particular farm may be caused by something that wasn't covered by the insurance.[88] Any index-based approach, be it at macro level, meso-level or micro level, whether for direct insurance or to support social protection programme scalability, requires an index that reasonably proxies the impacts of the drought on the target population. Many potential drought indexing tools are available for testing and have been used for risk profiling, but only a few have been used as a basis for drought risk financing.[89] Here, approaches to drought risk assessments, using new modelling techniques and innovative technologies, are ensuring that basis risk can be minimized and the products be scaled up.

Advances in modelling and geospatial techniques provide more accurate drought indicators for indexed weather-based insurance.

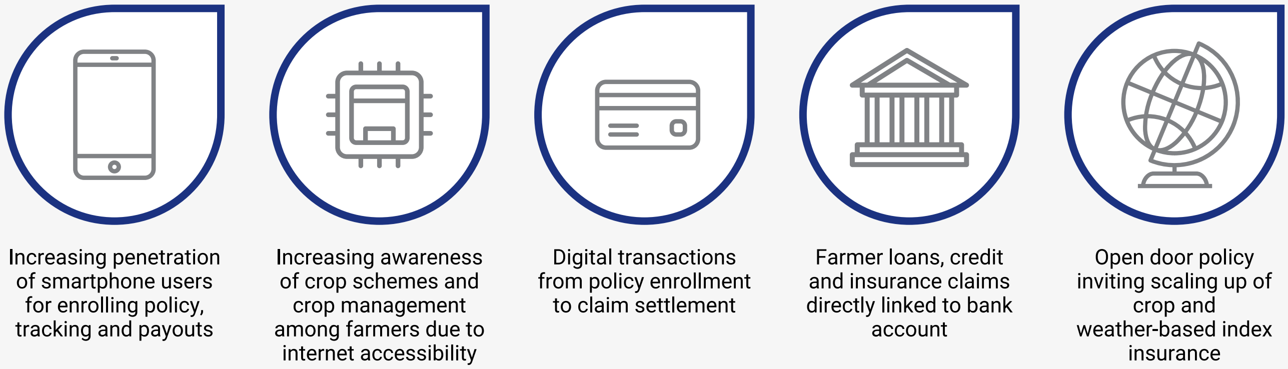
Remote sensing, and climate models are particularly valuable in data-scarce regions. For these places, local data can be supplemented with gridded weather datasets to evaluate climate impacts.[90] Improved statistics for geospatial classifications are now also providing information about current drought situations and drought trends to assist long-term decision-making about water resource management.[91]

ICT technologies and digital innovations

ICT technologies and digital innovations are making weather-based payouts more efficient.

Farming communities can benefit directly and indirectly from information and communications technology (ICT), which improves their access to financial services, allows them to make payments, and secure savings and affordable insurance (Figure 4-10).[92] Recent developments which have benefited agriculture and allied fields include the increase in the use of mobile-broadband access devices, the internet of things (IoT), drones, smart networks, the capacity for big data analytics, blockchain technologies and artificial intelligence. Farmers could also benefit from lower basis risk by using agro-climate ICT tools to monitor and register losses.[93]

Figure 4-10 — Digital agriculture for financial resilience



Source: Adapted from Munich RE (2019).

There are several successful examples of mobile-based technologies that offer relevant insurance products and increase the accuracy of payouts.

Mobile-based payouts (Kenya) – Kilimo Salama (safe farming) is a crop insurance scheme which collects insurance premiums using a mobile app. Local agents register a policy using their phone camera to scan bar codes and send farmers a text message confirming the policy. Farmers are registered at their nearest weather station, which transmits data over a mobile network. When weather conditions deteriorate, a panel of experts use an index-based system to determine crop viability. Payouts are made directly to farmer's mobiles using Safaricom's M-Pesa mobile money service. The scheme is self-financing and produces better outcomes for under-served farmers.[94]

Picture-based insurance (India) – A pilot project implemented in India's rice-wheat belt is using smartphone pictures to verify losses and detect damage at the plot level. This reduces the risk for insurers and is making crop insurance more attractive and accessible to small farmers. Nearly two-thirds of trained farmers took at least four pictures, at roughly one per growth stage, which was considered sufficient for loss assessment. Severe damage was visible from smartphone pictures in 71 per cent of affected sites, which was a significant improvement over index-based products, which identified severe damage in at most 34 per cent of affected sites.[95]

Another innovation that is helping streamline the management of insurance is blockchain technology, through which data on contracts are held in an open, distributed ledger that records transactions efficiently and in a verifiable and permanent basis. In India, for example, the IBISA platform uses a decentralized mutuality-based system that harnesses blockchain technology with satellite Earth observation data and index-based risk modelling. This enables the sharing of farmer-to-farmer risks in a transparent and cost-efficient way. IBISA acts as a market-place for mutual risk sharing between farmers worldwide through smart contracts and virtual currencies. In case of calamity, experts worldwide assess the damage using actionable Earth observation data where the indemnity is fully transparent.[96] Agricultural insurance of this type, built on blockchains drafted on a smart contract, facilitates immediate payout in the case of a drought or flooding in the field.[97]

In the future, crop health and soil conditions can also be monitored precisely and accurately using autonomous drones and sensors that cover large agricultural areas. Drones fitted with infrared, multispectral and hyperspectral sensors can collect data for the normalized difference vegetation index, and other indices, such as the crop-water stress index and the canopy-chlorophyll content index. These agricultural mapping tools can provide valuable insights into crop health before and during drought. Smart sensors can monitor plant health, analyse crop damage, monitor parameters of crop growth precisely, and measure soil moisture, air temperature and humidity levels.[98]

Used together, index insurance and climate-smart tools and technologies can produce long-term benefits for farmers and help them and national economies become more financially resilient to drought and the impacts of climate change.

Probabilistic risk assessment

Assessment of drought disaster risk also requires probabilistic-based solutions for loss assessments which can be used to generate accurate economic risk metrics for sectoral planners.

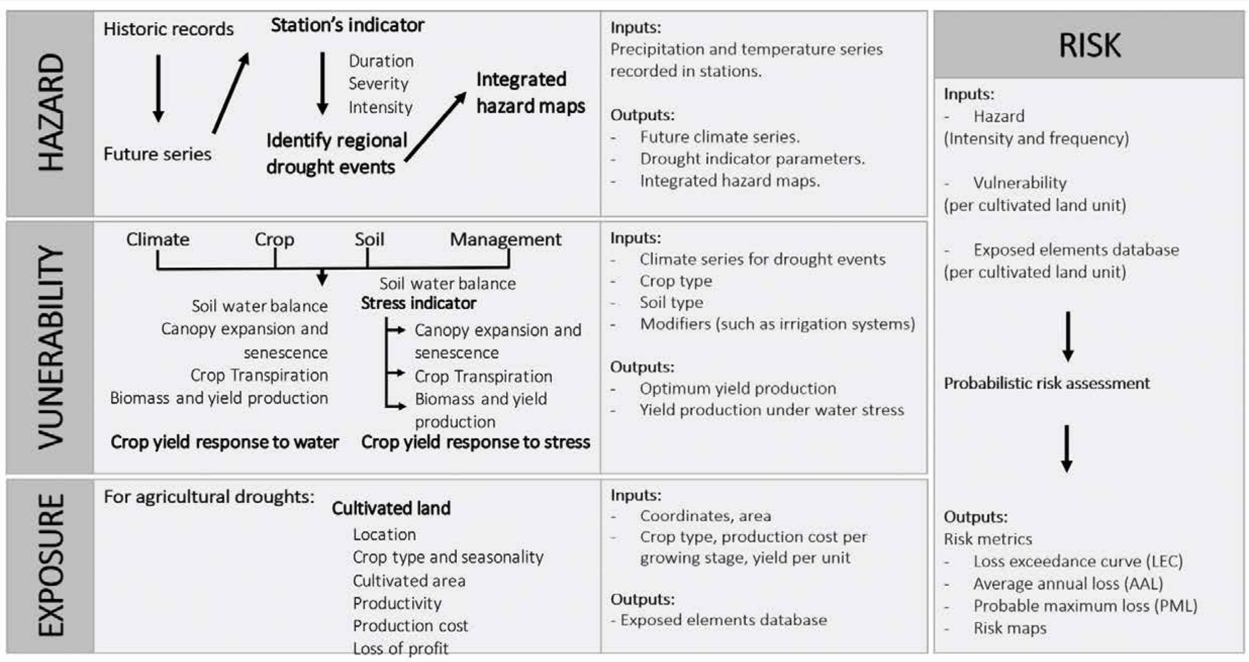
Probabilistic risk assessments use scientific evidence to simulate future disasters. This offers a more complete picture of the spectrum of risks than is possible with historical data. The models 'complete' historical records by reproducing the physics of the phenomena and recreating events. These assessments can be standardized across countries and administrative levels enabling policymakers to prioritize investments.

A probabilistic drought risk model for the region has yet to be developed. Instead, a proxy for each country can be the ratio of the agricultural GDP to total GDP. Based on probabilistic assessments of drought risk in other contexts, it is then possible to estimate the future risk in the region over a long-time frame.

This is expressed through annual average loss (AAL). The AAL will be the sum of the resources needed across all sectors, including expenditure on social protection, education, health, agriculture, infrastructure, and disaster risk reduction. This can then be expressed as a proportion of GDP. In South-East Asia, this proportion is highest in the Lao People's Democratic Republic, at 8.7 per cent, and in Cambodia, at 8 per cent. ESCAP has, for example, been piloting a probabilistic agriculture drought risk AAL model in Kazakhstan.

Figure 4-11 shows a summary of the proposed methodology divided into its main components: hazard, vulnerability, exposure, and risk.[99]

Figure 4-11 — A probabilistic drought risk assessment summary



Source: Adapted from Maskrey and others (2019).

A fully probabilistic model for drought hazard and risk assessment can also be used for traditional insurance and to validate index-based financial protection systems. Together with increasing the quality of existing insurance, it can also be used to design new forms, for example, collective insurance schemes.

Financing for long term adaptation and resilience

While short- and medium-term disaster risk management strategies are a quick-fix, there is an urgent need to spur far-term investments into climate adaptation and resilience, in both the public and private sectors.

Adaptation to climate change is a human, environmental, and economic imperative. It is also cost effective.[100] *The Global Commission on Adaptation Report 2019 – Adapt now: A Global Call for Leadership on Climate Resilience* estimates that the overall rate of return on investments in improved resilience is very high, with benefit-cost ratios ranging from 2:1 to 10:1.

Countries in South-East Asia also need long-term investments into climate adaptation and resilience, in both the public and private sectors. For this purpose, they can draw on global experience and resources. The United Nations Framework Convention on Climate Change (UNFCCC), for example, along with its associated implementation network, offers technical and financial resources to support developed and developing countries in their efforts to address the oncoming impacts of climate change.

Governments should also look to the private sector, especially for larger infrastructure projects.[101] To make projects more attractive for the private sector, they can support initial market studies and technology demonstrations. They can also incorporate climate risk assessment requirements in public-private partnership (PPP) infrastructure contracts.

At the same time, to increase the supply of climate adaptation products, Governments can improve public data by supporting local catastrophe risk models, and providing technical and financial assistance to suppliers of adaptation products and services. Local utilities can also raise funds by issuing resilient infrastructure bonds. There may also be opportunities to participate in regional catastrophe risk insurance pools.[102]

At the global level, there are several financing mechanisms for long-term climate adaptation. The largest is the Green Climate Fund which uses public investment to stimulate private finance. National and sub-national organizations can also receive funding directly, rather than through international intermediaries only.[103] Most funds usually go to single countries, but there should also be opportunities for regional and sub-regional risk pooling, for example, in transboundary areas, such as the Mekong River Basin.

Under the umbrella of UNFCCC, the funds available for drought and slow-onset disasters include the Adaptation Fund, the Special Climate Change Fund (SCCF) and the Least Developed Countries Fund (LDCF). The Adaptation Fund was established to finance adaptation projects and programmes in developing countries that are particularly vulnerable to the adverse effects of climate change.[104] The SCCF was established to finance projects relating to adaptation in sectors, such as energy, transport, industry, agriculture, forestry and waste management, as well as technology transfer and capacity-building with priority given to the most vulnerable countries in Asia, Africa and the Pacific Small Island Developing States.[105] In conjunction, the LDCF was established to meet the adaption needs of the least developed countries.[106]

Another unique financing mechanism is the Climate Risk and Early Warning Systems (CREWS) initiative which works directly with countries to increase availability and access to early warning systems. It supports country portfolios and promotes a favourable environment for leveraging additional financing.[107]

Box 4-5 — Forecast-based financing in Viet Nam

Since 2017, FAO, together with UN Women and Save the Children, local communities and local and national authorities introduced forecast-based financing or the early warning early action approach in building drought resilience in Viet Nam.

	Indicators	Indices	Actions	
Climate	Drought forecast	Standard Precipitation Index: Severe or Extreme Drought	Deploy early warning system November - January	Designate reserve fodders for livestock August - September
			Harvest/store rainwater October - November	Sow early crops; encourage use of short duration seeds
		Standard Precipitation Index: 60% of Severe or Extreme Drought	Distribute water tanks November - December	Maintain storage facilities January - February
			Destock livestock January - February	Enable animal sales market January - February
Livelihood	Agricultural Damages and Losses	50% (70%) hectares of damaged paddy crops	Distribute cash grants March - April	Provide agricultural inputs April - May
	Daily Labor Rates and Opportunities	30% decrease of daily labor rates or opportunities	Expand social assistance Ongoing	Distribute cash grant for food March - April
	Household Expenditure Patterns and Coping Strategies	50% of poor or near-poor households taking loans or purchasing food on credit	Expand social assistance Ongoing	Multi-purpose cash grant for food purchase March - February
Market	Price of Basic Commodities	30% increase in price of basic commodities	In-kind food assistance March - April	Distribute cash grant for food March - April
	Water Price	30% increase in price of a water bottle	Introduce low-cost water treatment techniques February - April	Promote best hygiene practices and truck water February - April

This involves downscaling drought forecast to the provincial level, using available data at global, regional and national levels, combined with community-level risk assessment and analysis of past drought impacts on food security, water and sanitation to anticipate the probability, severity and potential impacts of an anticipated drought. This impact-based forecast helps identify thresholds for improved drought early warning and triggers early actions, specific to the province and district as shown in the Table.

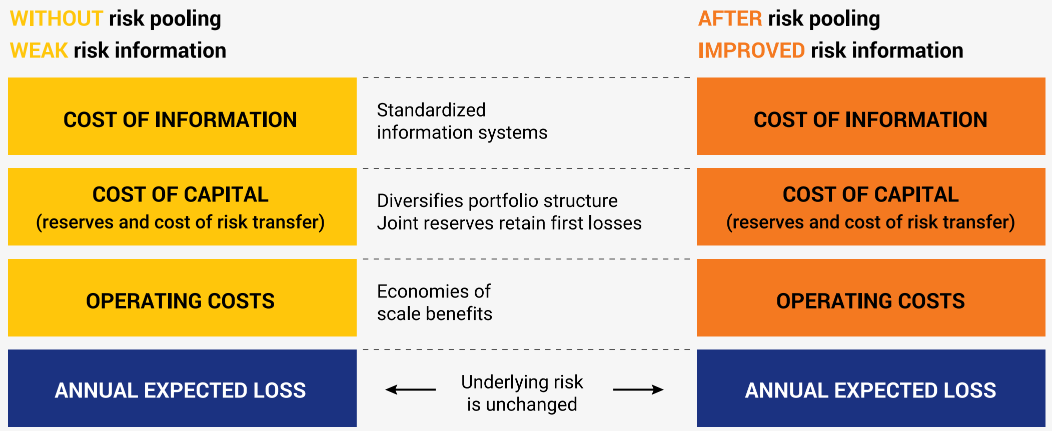
Source: FAO (2020).

Regional risk pooling

Incorporating drought risks in regional and sub-regional risk pooling supports long-term adaptation for disaster resilience.

Risk pooling refers to the spreading of financial risks evenly among countries. Pools can make risk transfer more cost-effective by helping to: (i) diversify risk across multiple countries; (ii) establish joint reserves to self-insure a part of the risk managed by the pool; (iii) facilitate access to international reinsurance and capital markets; (iv) share operational costs, such as programme development and day-to-day back office operations; and (v) build up a better foundation of risk information (Figure 4-12).

Figure 4-12 — Financial benefits of risk pooling



Source: Adapted from ESCAP (2018a).

The ASEAN/World Bank study on disaster risk financing and insurance notes that the development of disaster risk financing and insurance needs to be strengthened via regional and sub-regional cooperation. In particular, the study points out areas where countries can share resources and costs for trans-boundary hazards, like drought. These include regional risk information, assessment, and modelling systems, and regional knowledge advisory services and capacity-building programmes. There should also be a regional vehicle to leverage international reinsurance and capital markets, potentially generating significant economies of scale by pooling risk and reducing operating costs, thereby making risk transfer products more affordable both for governments and private individuals.[108]

Existing collaborative programmes to mitigate climate risks include the South-East Asia Disaster Risk Insurance Facility (SEADRIF) and the ASEAN Disaster Risk Finance and Insurance Programme (ADRFI).[109]

By helping countries develop standard products based on their respective needs, and structuring a portfolio of diversified country risks, risk pools offer larger and more attractive transaction sizes. In addition, risk pools can cut premiums by reducing the cost of capital, operating costs, and the cost of risk information. Risk pooling has helped increase insurance literacy, institutional capacity, and disaster risk data and modelling capacity.

Risk pools can be linked to pre-agreed post-disaster programmes. For example, payouts could support existing national safety net programmes to poor and vulnerable households in the event of a disaster. An example is the Pacific Risk Information System, which is a platform that covers four million assets. Its associated catastrophe risk model has been used by domestic insurers and brokers to inform their underwriting and pricing decisions. In Fiji, the model was used to inform the provision of catastrophe risk insurance for hotels and resorts. The model has also been used to explore the feasibility of crop insurance in some Pacific islands.[110]

The Pacific Catastrophe Risk Insurance Company, set up as a multi-national sovereign risk pool in 2012, has been instrumental in the recovery process following tropical cyclone Pam. The risk pool provided immediate relief to Vanuatu with a payout of $1.9 million, and helped the country with a rapid liquidity injection in the immediate aftermath of the disaster.

Setting up risk pools and expanding the use of risk transfer mechanisms in Asia and the Pacific requires strong commitments and coordination among countries. While pools cannot reduce a country's underlying climate and disaster risks, they can create incentives for risk reduction measures by putting a price on risk.

COVID-19 stimulus packages

COVID-19 stimulus packages can be used to address overlapping vulnerabilities for long-term climate adaptation.

Overlaid on drought risk, is now the COVID-19 pandemic which threatens the recovery of economies and livelihoods. The risk transmission pathways of COVID-19 and extreme climate events are different, but they typically affect the same people. Communities that are the most vulnerable to slow-onset disasters have also emerged as those with high vulnerability to the socioeconomic impacts of COVID-19.

ASEAN Governments have quickly mobilized financial support to back businesses and expand welfare benefits in response to the COVID-19 pandemic by increasing emergency fiscal measures, supporting small businesses, expanding unemployment benefits, providing additional social assistance, supporting vulnerable households with cash transfers,[111] and establishing the COVD-19 ASEAN Response Fund. These investments can be expanded into much-needed investments on climate action and adaptation, and thus can support vulnerable populations that are exposed both to pandemics and slow-onset disasters. This underlines the importance of shifting from the siloed approach which considers natural hazards and health disasters separately.

While it is important to respond to disasters, it is better to prepare for them and if possible prevent them. The COVID-19 pandemic has revealed that both biological disasters and droughts have social and economic impacts. So fiscal and investment responses to COVID-19 could simultaneously accelerate and support climate change adaption efforts.

In the era of overlapping disasters from the COVID-19 pandemic and drought, and their cascading impacts on vulnerable populations, there are opportunities now to capitalize on regional cooperation for risk transfer and risk pooling and integrate strategies for climate-related disasters strategies and biological hazards. These have been laid out in the Bangkok Principles adopted by the Asia-Pacific countries in 2017.[112] Integrated risk assessment products will hold the key to building infrastructure that is resilient to all hazards be it biological or natural, and support communities in critical times.

The three tracks covered in this chapter have primarily considered national action. But there are also major opportunities for cooperation at the regional level. These are considered in the next chapter.

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CHAPTER 5.

Ready for the dry years: a regional drought agenda

Students partake in celebrations of the 46th anniversary of the establishment of ASEAN.

Chapter 5.
Ready for the dry years: a regional drought agenda

Key Messages

- *The recent droughts reinforce the importance of drought as a regional issue, and indicate that efforts being taken to develop an ASEAN-wide response are timely.*

- *While national actions are most critical in translating the recommendations of this study into actions on drought, regional cooperation can provide the much-needed boost to ensure that countries succeed in their efforts.*

- *Regional efforts need to be scaled up and upgraded to produce a coherent ASEAN-wide response that matches the complexity of drought risk in a changing climate.*

- *Based on the evidence presented in this Report on the past trends and future drought outlook, three priority regional actions are presented for consideration by ASEAN Member States. These include: adopting a declaration to mandate a whole-of-ASEAN approach; supporting cross-sectoral approaches in adaptive land and water management, drought early warning services and coordinated disaster risk financing; and addressing human and ecosystem vulnerabilities in drought hotspots.*

- *The stimulus packages being rolled out by Governments to revive their economies amid the COVID-19 fall-out offer an excellent opportunity to address persistent systematic vulnerabilities that will strengthen the capacity of ASEAN populations to better manage the risk and cope with the impacts of the pandemic and future droughts.*

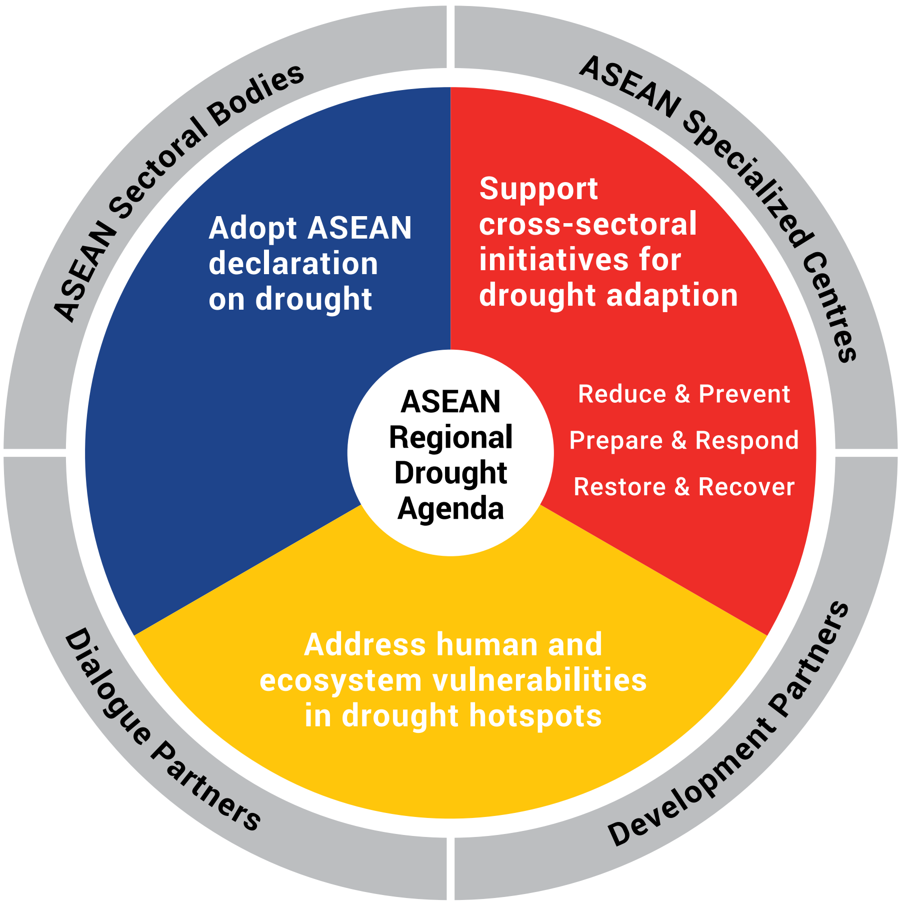
With the notable exception of the COVID-19 pandemic, drought is perhaps the only issue that has simultaneously affected all countries in South-East Asia on a massive scale. The primary responsibility for dealing with drought lies with national Governments. But, drought poses many complex problems that are best tackled through regional cooperation, thereby enabling all countries to benefit from the wealth of scientific and development expertise across the region and beyond.

Over the past five years, successive drought events affected most of South-East Asia; 70 per cent of the region's land area and nearly 60 per cent of the population. Drought is thus a systemic problem that demands a systemic response and proactive solutions. The most direct response needs to be undertaken at the local and national levels, but countries will increase their chances of success if they cooperate.

Such cooperation is already underway. In May 2016, at the informal ASEAN Ministerial Meeting on Disaster Management, ASEAN Ministers resolved to build the region's capacity to address drought. This was followed up by a meeting of the ASEAN Senior Officials on the Environment. And between 2019 and 2020, the focal points of the ASEAN Committee on Disaster Management convened national drought policy dialogues.

This chapter proposes three further priority actions that could be taken at the ASEAN level. The aim is to establish a regional drought agenda for adapting to risk in a changing climate (Figure 5-1).

Figure 5-1 — Priority actions and actors for an ASEAN regional drought agenda



Priority 1 – An ASEAN drought agenda

There are already various regional discussions on disasters that include drought, but the policy landscape is overlapping and disjointed. Drought is addressed directly or indirectly, for example, in several ASEAN frameworks and agreements. These include: *the ASEAN Vision 2025 on Disaster Management; the ASEAN Agreement on Disaster Management and Emergency Response; the ASEAN Climate Change Initiative, the ASEAN Action Plan on Joint Response to Climate Change,* and the *ASEAN Declaration on Environmental Sustainability.*

ASEAN Member States are also signatories to relevant international conventions and agreements. These include *the United Nations Convention to Combat Desertification, the United Nations Convention on Climate Change, the Sendai Framework on Disaster Risk Reduction,* and the *United Nations 2030 Agenda for Sustainable Development.*

These agreements represent commendable progress, but the result is rather fragmented. The time has come for a coordinated ASEAN response that aligns with existing commitments but also ensures coherence across the various plans and initiatives, and across ASEAN's three pillars. This could be achieved through a legal instrument, such as a declaration, that would mandate cross-sectoral collaboration and initiatives.

Priority 2 – Cross-sectoral initiatives

The previous chapter presented three tracks for policy intervention. Most of the related actions need to be taken by national authorities. But these should also be able to rely on regional cooperation that offers support, expertise and resources along with opportunities for peer learning within and across countries. For this purpose, Member States can harness the collective resources and expertise of the ASEAN bodies and technical working groups.

Track 1 – Reduce and prevent

There are already several mechanisms for collaboration on the environment, and on food, agriculture and climate change. These include the *ASEAN Strategic Plan on Environment and the ASEAN Vision and Strategic Plan for Cooperation in Food, Agriculture and Forestry 2016-2025*. In addition, ASEAN has a Working Group on Climate Change which is responsible for implementing cooperative activities under the ASEAN Climate Change Initiative. These mechanisms and initiatives need to be re-examined to ensure that they are still adequate for addressing the complexity of future drought risks.

One example of a cross-sectoral approach is the *ASEAN Multi-Sectoral Framework on Climate Change: Agriculture, Fisheries and Forestry towards Food Security*. Following this model, two immediate areas of action are recommended:

- ***Science, modelling and impact-based forecasting*** – ASEAN sectoral bodies should harness more of the advances in science, modelling and impact-based forecasting innovations. The ASEAN Working Group on Water Management, in particular, would benefit from such advances for planning and investments in integrated water management and for building resilient water infrastructure.

- ***Sustainable land management*** – The ASEAN Senior Officials Meeting on Agriculture and Forestry should promote sustainable land management, including drought-smart land management and nature-based solutions.

Track 2 – Prepare and respond

ASEAN Member States could use the existing global and regional initiatives and mechanisms to scale up efforts to improve drought early warning services. The three areas of cooperation proposed are:

1. ***A regional technical resource facility***. To support drought management, there are already a number of global and regional products. But, countries may need support in customizing these and in assembling the various components into comprehensive early warning frameworks. This requires expertise to validate and localize the products, for example, and set up the data architecture. ASEAN Member States may therefore consider designating an existing centre to provide technical and advisory support. Alternatively, the function could be performed on a task-sharing basis by a consortium of existing centres/programmes. This consortium could include: the AHA Centre, the ASEAN Specialised Meteorological Centre (Singapore); the ASEAN Hydro-Informatics Centre (Thailand); the ASEAN Research and Training for Space Technology and Applications (Thailand), the ESCAP Regional Drought Mechanism, and the Regional Integrated Multi-hazard Early Warning System for Asia and Africa. The consortium should, however, report to the appropriate ASEAN sectoral working group to ensure the synergy of various institutions and that technical assistance is driven by the requirements of user.

2. ***A drought-focused regional programme for the Global Framework for Climate Services***. Countries adopted the *Global Framework for Climate Services (GFCS)* with a vision "to enable society to better manage the risks and opportunities arising from climate variability and change, through the development and incorporation of science-based climate information and prediction into planning, policy and practice." The framework calls for countries to adopt national frameworks for climate services.[1] The idea of adopting a regional strategy to implement the GFCS was raised at the Joint Workshop on Strengthening Multi-Hazard Early Warning Systems and Early Actions in South-East Asia, held in February 2020.[2]

   Member States, working through the Committee on Science and Technology and the ASEAN Working Group on Climate Change, could launch a comprehensive regional programme to help countries implement their national frameworks on drought.This would cover the five pillars of GFCS namely: (i) observations; (ii) climate research, modelling and prediction; (iii) a climate services information system (CSIS); (iv) a climate user interface programme; and (v) capacity-building/development.

   The ASEAN bodies that could help them integrate climate and satellite data in operational early warning systems are the ASEAN Committee on Science and Technology, which has subgroups on meteorology and space applications and the ASEAN Working Group on Climate Change, whose task is to enhance regional cooperation on climate change and promote collaboration between sectoral bodies. The regional programme may tap into existing partnerships, such as ESCAP and WMO, and the ESCAP-facilitated Asia-Pacific Disaster Resilience Network.

3. ***University collaboration***. Efforts to improve drought early warning services can benefit from the wealth of multi-disciplinary knowledge and expertise available in universities across ASEAN and beyond. This regional effort can use the existing ASEAN University Network to link the research agenda of universities with the region's major gaps and needs. These could include regional climate downscaling, data integration, and the influence of ENSO on seasonal rainfall fluctuations and drought in individual ASEAN countries.

   One example of a multi-component project undertaken by universities on a task-sharing basis is South-East Asia Regional Climate Downscaling (SEACLID)/CORDEX, though its outputs need to be better linked with adaptation decision making.[3]

   Knowledge and expertise should be applied to real-world early warning operations. Opportunities for doing this include the regular SEACOFs and the meetings of relevant working groups, such as the Working Group on Risk Awareness and Assessment of the ASEAN Committee on Disaster Management (ACDM).

Track 3 – Restore and recover

Funding for disasters in Asia has mostly been for emergency response, reconstruction and repair. To finance these activities countries have had to reallocate budgets, issue debt, or rely on foreign aid.[4] Instead, the region should be looking further ahead by investing in long-term solutions that would make communities more resilient and reduce the need for humanitarian interventions. The most appropriate body for this would be the ASEAN Cross Sectoral Coordinating Committee on Disaster Risk Financing and Insurance (ACSCC) which brings together finance ministers and central banks, insurance regulators and the national disaster management organisations.[5]

The ACSCC could examine the lessons learned from ASEAN Disaster Risk Financing and Insurance and build capacities to scale up good practices, and develop other options for disaster risk financing, such as catastrophe bonds and regional sovereign risk pools. The ASEAN Business Council could take steps to strengthen public-private engagement on disaster risk financing across the region.

Priority 3 – Address drought hotspots

The region has many hotspots where high drought exposure overlaps with human vulnerability and land degradation. If ASEAN countries are to ensure human well-being and build capabilities in these hotspots, they need to build awareness and closely collaborate with communities to address the underlying factors that make people vulnerable to climate-related disasters. This would be consistent with the United Nations 2030 Agenda for Sustainable Development which declares that no one should be left behind, and also with the commitments made at the informal 2016 ASEAN Ministerial Meeting on Disaster Management, which aimed for prevention, protection and assistance for all, especially the most vulnerable.

There will be an opportunity to carry this agenda forward through the *ASEAN Framework Action Plan on Rural Development and Poverty Eradication* which expired in 2020.[6] The next iteration of the plan should address drought risk hotspots and include an integrated package of actions for adaptation. This would not only reduce drought risk but also bring many other economic, social and environmental benefits.

The stimulus packages being rolled out by Governments to revive their economies amid the COVID-19 fall-out will also offer opportunities for investment in drought preparedness. These packages should also be designed to build resilience of ASEAN peoples to future disaster risk, including drought.

Ready for the dry years – one ASEAN, one response

2020 saw an extraordinary display of energy and cooperation across ASEAN to deal with the COVID-19 pandemic and its socioeconomic impacts. ASEAN Member States undertook large-scale collaboration by establishing the COVID-19 regional response fund. The same spirit of cooperation to meet a shared threat now needs to be extended to drought.

The region has taken a major step forward with the landmark *ASEAN Agreement on Disaster Management and Emergency Response*. The regional initiatives described in this chapter should now serve as the basis for a renewed determination to protect the most vulnerable against drought: a united effort, a one ASEAN, one response.

Endnotes

[1] Govindarajalu Srinivasan and others (2015).

[2] WMO and others (2020).

[3] SEACLID/CORDEX Southeast Asia (2020).

[4] Jacqueline Loh (2019).

[5] Ibid.

[6] ASEAN (2017).

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Appendices

Appendix 1 – Selection of a Meteorological Drought Index

There is a long history of the development and use of drought indicators,[1] and multiple indicators have been used in the study of drought and its impacts across South-East Asia.[2] While frequently referred to as "drought" indicators, most of these indices typically measure both, unusually dry (drought) as well as unusually wet conditions. Here, two criteria were used to select a drought index: 1) the acceptance and use of the index within the South-East Asia region and around the world, and 2) the relative simplicity of the index, allowing for it to be computed from a limited set of inputs, making it amenable for adoption to drought early warning efforts across the region. With these criteria in mind, it was decided to use the Standardized Precipitation Index (SPI).[3] The use of the SPI has been endorsed by the World Meteorological Organization,[4] and it was recommended for use by national meteorological and hydrological services around the world to characterize meteorological drought by the Lincoln Declaration on Drought Indices.[5,6]

Another advantage of using the SPI is that it is a "standardized" index, meaning it can be used to compare drought conditions across locations with differing climatological precipitation,[7] as in South-East Asia. The index compares accumulated rainfall over a given period, for example, the past 6 months, with the amount of rainfall that was received historically, for that period, under average conditions. Index values typically range between -3 and +3, where a value of zero indicates average conditions and increasingly negative values are indicative of increasingly dry conditions.

For the purposes of this Report, a six-month time period was primarily used to compute the SPI, which will be referred to as SPI6. The SPI6 was chosen as it allows for spatial variations in the seasonality of monsoon rainfall across South-East Asia (see Figure 1-1) to be captured by the index. Thresholds of drought severity were selected based on those used in operational drought monitoring, as described by M. Svoboda and others (2002). The four severity categories used and their associated SPI6 values are: *moderate drought* (< -0.8), *severe drought* (< -1.3), extreme drought (< -1.6) and *exceptional drought* (< -2.0).

Endnotes

[1] John Keyantash and John Dracup (2002).

[2] Nyda, Chhinh and Andrew Millington (2015); B. Lyon and S. J. Camargo (2009); B. Lyon and A. G. Barnston (2005); R. Boer and A. R. Subbiah (2005); N. Van Viet, and V. K. Boken (2005); B. Lyon (2004).

[3] Thomas B. Mckee, Nolan Doesken and John Kleist (1993); N. B. Guttman (1999).

[4] WMO (2006).

[5] Michael Hayes and others (2011).

[6] WMO and GWP (2016).

[7] WMO (2012).

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Appendix 2 – Climate data sources

The study utilizes several datasets, including analyses of observed meteorological and oceanic variables, gridded population estimates and output from climate models. A general description of each dataset is provided below by data category. The source of the data is also listed.

Meteorological Data

Gridded analyses of monthly average precipitation from the Global Precipitation Climatology Centre (GPCC) are utilized. These global data are based on station observations that are gridded to a 0.5° latitude/longitude spatial resolution and cover the period 1901-2013.[1] To examine changes in the seasonal and sub-seasonal character of precipitation, daily rainfall data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS v2.0) are employed. These data are based on a combination of satellite and station observations and are gridded daily analyses covering 50°S-50°N for the period 1981 to near-present. The version of the data to be used are gridded to a 0.25° latitude/longitude spatial resolution and the full dataset is described in a recent report by Funk.[2] Finally, gridded temperature analyses (1981-2019) for the globe from Berkeley Earth have been utilized.[3] These data are based on station observations of daily maximum and minimum temperature that have been gridded to a 1.0° latitude/longitude spatial resolution, with monthly average values being used.

Ocean Data

Gridded analyses of monthly average sea surface temperatures for the globe from the ERSST v5 dataset were employed. These data are at a 2.0° latitude/longitude spatial resolution and cover the period 1895-present.[4] Also used is the IOSST v2 monthly average sea surface temperature data, which are gridded analyses at 0.25° latitude/longitude and cover the globe for the period 1981-present.[5]

Climate Model Data

Coupled model hindcasts of monthly average precipitation and temperature from the NOAA Coupled Model Forecast System version 2 (CFSv2) for the period 1980-2010 are utilized.[6] These forecasts are at a 1.0° latitude/longitude resolution and have forecast lead times from 1 month to 9 months.

Precipitation, surface temperature and other atmospheric variables are available for 31 models contained in the Coupled Model Intercomparison Project Phase 5 (CMIP5) archive.[7] These data are available for the Representative Concentration Pathway 4.5 and 8.5 greenhouse gas scenarios (RCP4.5 and RCP 8.5).

The World Climate Research Programme's Working Group on Coupled Modelling is acknowledged, which is responsible for CMIP, and we thank the climate modelling groups for producing and making available their model output. For CMIP5 the U.S. Department of Energy's Program for Climate Model Diagnosis and Inter-comparison provides coordinating support and led the development of the software infrastructure, in partnership with the Global Organization for Earth System Science Portals.

The meteorological and ocean data used in this study was obtained from the International Research Institute's Climate Data Library, which is available at http://iridl.ldeo.columbia.edu/.

Population Data

Gridded population estimates for 2020 were obtained from the Gridded Population of the World version 4 dataset (UN WPP-Adjusted Population Count, GPWv4).[8] The population data are gridded to roughly a 4km spatial resolution (0.04° latitude/longitude) and obtained from CIESIN at Columbia University.

Endnotes

[1] This has been described by Udo Schneider and others (2008).

[2] Chris C. Funk and others (2014).

[3] Robert Rohde and others (2013).

[4] Boyin Huang and others (2017).

[5] Richard Reynolds and others (2007).

[6] Suranjana Saha and others (2014).

[7] Karl Taylor, Ronald Stouffer and Gerald Meehl (2012).

[8] Erin Doxsey-Whitfield and others (2015).

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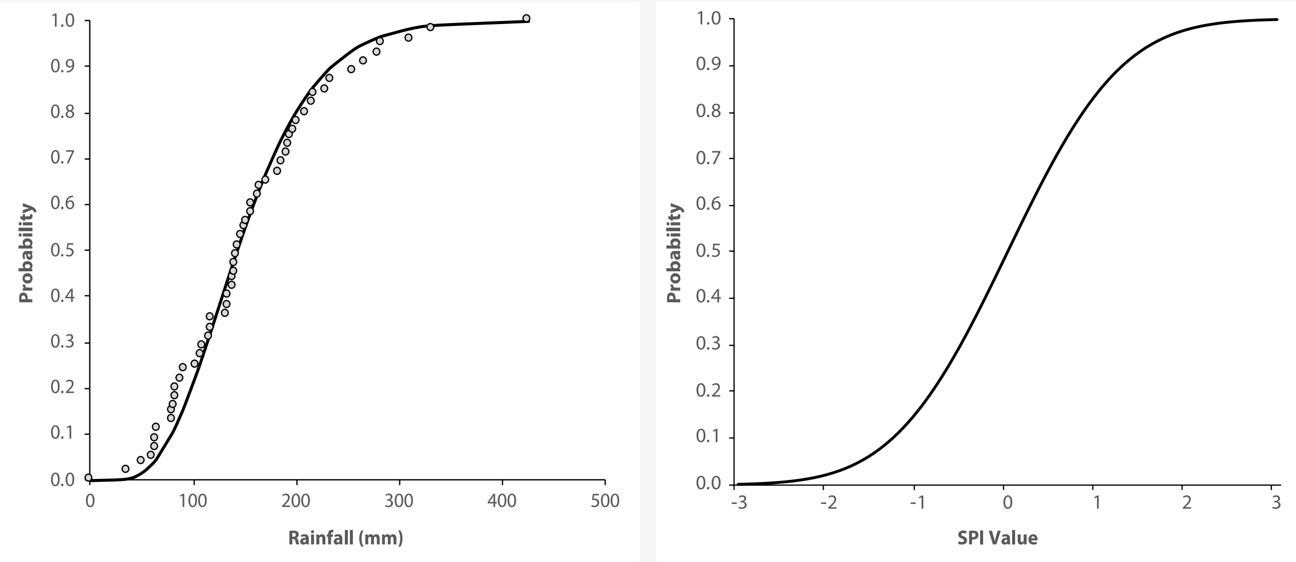
Appendix 3 – Methodologies

Computing the Standardized Precipitation Index (SPI)

The calculation of the SPI follows the methodology suggested by N.B. Guttman. Although the SPI can be used to assess drought on multiple timescales, the procedure to compute the index is the same regardless of timescale considered. For a given "accumulation" period (e.g., precipitation accumulated over 1, 3, 6 or 12-months) and location (observing station or grid point), the first step is to generate a cumulative distribution of historical precipitation for the specified period. For example, if considering the 3-month SPI (SPI3) for the months of January-March, then the historical accumulated precipitation over those three months is ranked from lowest to highest and expressed as a relative frequency (or probability) ranging from 0 to 1. The second step is to fit a smoothed distribution to the observed probabilities. The 3-parameteer Pearson Type III distribution (also known as a 3-parameter gamma distribution) was used for this purpose. The smoothed, cumulative probabilities are then mapped onto the associated probabilities of a standard normal distribution to obtain the SPI. A schematic of how this is done is shown in Figure A.

Figure A — Schematic showing the calculation of the SPI for a location in Bicol in the Philippines



Source: Vicente-Serrano (2004).
Note: Example of computing the SPI drought index based on observed rainfall from Bicol in the Philippines for the March to May season (left) along with a gamma distribution fit to the data. Right side is just the cumulative probability distribution for a normal distribution, which is the SPI.

SPI values typically range between -3 and +3, where a value of zero indicates average conditions and increasingly negative values are indicative of increasingly dry conditions (drought). For the purposes of this Report, six-month and three-month time periods were used to compute the SPI, which are referred to as SPI6 and SPI3. The SPI6 was chosen for most computations as it allows for spatial variations in the seasonality of monsoon rainfall across South-East Asia (Figure 1-1) to be captured by the index. Thresholds of drought severity were selected based on those used in operational drought monitoring, as described by M. Svoboda and others (2002). The four severity categories used and their associated SPI6 or SPI3 values are: *moderate drought* (< -0.8), *severe drought* (< -1.3), *extreme drought* (< -1.6) and *exceptional drought* (< -2.0).

Assessing the Spatial Extent of Drought

Time series of the spatial extent of drought across South-East Asia were generated by first counting the number of land area grid points in a given month, where the SPI6 index fell below various drought severity thresholds. This count was then divided by the total number of land area grid points across the South-East Asia domain and multiplied by 100 to express the spatial extent as a percentage of total land area in the study region.

Evaluation of Trends and their Statistical Significance

Temporal trends in temperature, rainfall and the SPI data were identified based on a least-squares linear regression fit to the data, either for a particular location, or for data averaged across South-East Asia. Statistical significance of these trends (that is, the confidence that the identified trends did not occur by chance) was evaluated by converting the explained variance associated with the trend to a t-statistic. The t-statistic was then used in a two-tailed t-test to identify trends that exceeded the 90 per cent (or 95 per cent) confidence level. That is, there was only a 10 per cent (or 5 per cent) chance that the trends arose by chance.

Quantification of number of exposed and vulnerable people to drought

To determine the risk of population exposed to drought, a combination of precipitation and exposure datasets are used from various sources.

Precipitation datasets are based on ESCAP calculations of Climate Hazards Group InfraRed Precipitation with Station (CHRIPS) data. This dataset consists of October 2015 and February 2020 Standardized Precipitation Index (SPI6) which have particularly been the periods of maximum drought extent in the past five years. Within the -3 to 3 scale of SPI6, drought levels are categorized into: *moderate drought* (< -0.8), *severe drought* (< -1.3), *extreme drought* (< -1.6) and *exceptional drought* (< -2.0).

Exposure dataset comprises gridded population data and Subnational Human Development Index (SHDI). Human Development Index (HDI) is a composite of multidimensional variables in life expectancy, education and GNI indices.[1] The SHDI as a spatial data of HDI is available at the global level. The 2018 and 2020 SHDI are used in this analysis.[2] The HDI in South-East Asia, in both datasets, are within the range of high (0.70 – 0.79), medium (0.55 - 0.69) and low (0.37 – 0.54) HDI. The gridded population data is taken from The Gridded Population of the World, Version 4 (GPWv4) for 2015 and 2020 population estimates.[3]

After normalization of selected variables, the risks hotspots and exposure of vulnerable population were calculated by using multiplication of precipitation and exposure datasets.

Generating the ENSO Index

An index of the El Niño-Southern Oscillation (ENSO) was generated based on monthly sea surface temperature departures from a 1981-2010 average from the ERSSTv5 dataset. These data were averaged across the east-central equatorial Pacific (120°W-170°W, 5°S-5°N), which is frequently referred to by climate scientists as the Niño3.4 region.

NOAA CFSv2 Seasonal Forecasts

The skill of the CFSv2 seasonal rainfall forecasts (1982-2010) was assessed by computing the linear correlation coefficient between these seasonal forecasts and observed seasonal rainfall. The forecasts consist of 24 ensemble members, or separate runs of the model made using slightly different so-called initial conditions, with the results averaged across all 24 runs to minimize the influence of random weather events on the forecast. The model seasonal forecasts used here were for one season ahead. For example, at the start of January in a given year, the model was run 24 times to generate a seasonal forecast of rainfall for the months of January, February and March. Near the start of each February, a seasonal forecast was generated for February, March and April, etc.

Interpolation of drought and poverty, malnutrition and agriculture in Cambodia, Myanmar, Philippines and Timor-Leste

In this analysis, merged socioeconomic data from the Demographic Health Surveys (DHS) with ESCAP drought data to examine the spatial distribution of drought-affected areas with high poverty, malnutrition, agricultural occupation, and agriculture land to quantify number of drought-vulnerable populations.

The exposure datasets are obtained from the Demographic and Health Survey (DHS), which provides the Global Positioning System (GPS) data of survey clusters. For

South-East Asia, the DHS datasets are available for Cambodia, Myanmar, Philippines and Timor-Leste.[4] The DHS variables used are as follows:

1. Wealth (proxy for poverty): The variable is classified into 5 categories, from 1 (poor) to 5 (rich).

2. Malnutrition: The variable is the percentage of stunted children in each cluster. Moderately stunted children are those with height-for-age score below minus 2 standard deviations, or below the mean on the WHO Child Growth Standards (hc<200), and severely stunted category is for below minus 3 standard deviations, or below the mean on the WHO Child Growth Standards (hc<300).[5]

3. Agriculture exposure: The index comprises of: (a) number of men working in agricultural sector compared to other occupation, (b) total area of agriculture land in each cluster, and (c) number of agriculture land less than 2 hectares,[6] as a proxy of most vulnerable farmers.

Each of the variables is interpolated by using empirical Bayesian Kriging (EBS). The EBS interpolation is implemented in ArcGIS to account for the error variance by estimating multiple semivariogram models from the data instead of a standalone semivariogram.[7] K-Bessel model of EBK is selected because of its high interpolation accuracy.[8]

After interpolation, the hotspots exposure was calculated by overlaying each variable with the drought exposure data. The drought exposure dataset used is the SPI6 during the periods of maximum drought extent in the past five years.

Administrative divisions included in each hotspot, in Table 2-1: Hotspots of drought risk for countries in South-East Asia

Countries	Areas with high frequency of severe meteorological drought (over period 1981-2019, based on SPI6)	Hotspots of drought severity, exposure and vulnerability in 2015, (based on SPI6, population density and HDI)	List of provinces	Hotspots of drought severity, exposure and vulnerability in 2020 (based on SPI6, population density and HDI)	List of provinces
Brunei Darussalam	All parts	None	None	None	None
Cambodia	Central parts	Central and northern parts	Banteay Meanchey, Battambang, Kampong Chhnang, Kampong Thom, Kampot, Kratie, Oddar Meanchey, Pailin, Prey Veng, Siemreap, Takeo and Tboung Khmum.	Central and southern parts	Battambang, Kampong Cham, Kampong Chhnang, Kampong Thom, Kampot, Kandal, Kratie, Pailin, Pnom Penh, Prey Veng, Pursat, Svay Rieng, Takeo and Tboung Khmum.
Indonesia	Western, north-central and eastern parts	Western and southern parts	Aceh, Bali, Bangka Belitung, Banten, Bengkulu, Gorontalo, Special Capital Region of Jakarta, Jambi, Jawa Barat, Jawa Tengah, Jawa Timur, Kalimantan Selatan, Nusa Tenggara Barat, Papua, Riau, Sulawesi Barat, Sulawesi Selatan, Sulawesi Tengah, Sumatera Barat, Sumatera Selatan, Sumatera Utara and Special Region of Yogyakarta.	South-west and southern parts	Aceh, Bali, Banten, Bengkulu, Gorontalo, Special Capital Region of Jakarta, Jambi, Jawa Barat, Jawa Tengah, Jawa Timur, Kalimantan Selatan, Kalimantan Timur, Lampung, Nusa Tenggara Barat, Nusa Tenggara Timur, Papua Barat, Papua, Riau, Sulawesi Barat, Sulawesi Selatan, Sulawesi Tenggara, Sulawesi Utara, Sumatera Barat, Sumatera Selatan, Sumatera Utara and Special Region of Yogyakarta.

Lao People's Democratic Republic	Northern parts	Central parts	Bokeo, Champasak, Khammouan, Salavanh, Savanhnakhet, Vientiane, Xayyabouly and Xiengkhouang.	Northern parts	Bokeo, Louangnamtha, Luangprabang, Udomxay, Vientiane, Xayyabouly, Xaysomboun and Xiengkhouang.
Malaysia	South-western and north-western parts	South-western and north-western parts	Johor, Melaka, Pahang, Perak, Sabah and Selangor.	North-western parts	Johor, Kedah, Kelantan, Melaka, Negeri Sembilan, Pahang, Perak, Perlis, Sabah and Terengganu.
Myanmar	Northern and southern parts	Eastern parts	Bago, Kayah, Kayin, Mandalay, Naypyitaw and Shan.	Central, northern and southern parts	Ayeyawady, Bago, Kayah, Kayin, Magway, Mandalay, Mon, Naypyitaw, Rakhine, Sagaing, Shan and Yangon.
Philippines	Southern parts	Central and southern parts	Autonomous Region in Muslim Mindanao, Bicol, Cagayan, Calabarzon, Caraga, Central Luzon, Central Visayas, Mimaropa, National Capital Region, Northern Mindanao, Soccsksargen, Western Visayas and Zamboanga Peninsula.	Southern parts	Autonomous Region in Muslim Mindanao, Bicol, Caraga, Central Visayas, Davao, Northern Mindanao, Soccsksargen and Zamboanga Peninsula.
Singapore	All parts	Northern parts	Northern parts	None	None
Thailand	Central parts	Central and northern parts	Bangkok Metropolitan Region, Chiang Mai, Mukdahan, Nong Khai, Nonthaburi, Pathum Thani, Samut Prakan and Samut Sakhon.	Central and northern parts	Bangkok Metropolistan Region, Chon Buri, Nong Khai, Nonthaburi, Pathum Thani, Phra Nakhon Si Ayuthayya, Samut Prakan and Samut Sakhon.
Timor-Leste	All parts	Northern parts	Ermera and Oecussi.	Northern and central parts	Aileu, Baucau, Bobonaro, Cova Lima, Dili and Ermera. Some parts of Ainaro, Lautem, Manatuto, Manufahi and Viqueque.
Viet Nam	Central and southern parts	Central and southern parts	An Giang, Ba Ria, Bac Lieu, Ben Tre, Binh Dinh, Binh Duong, Binh Phuoc, Binh Thuan, Ca Mau, Can Tho, Da Nang, Dak Lak, Dak Nong, Dong Nai, Dong Thap, Gia Lai, Ha Tinh, Hau Giang, Ho Chi Minh, Khanh Hoa, Kien Giang, Kon Tum, Lam Dong, Long An, Nghe An, Ninh Thuan, Phu Yen, Quang Binh, Quang Nam, Quang Ngai, Quang Tri, Soc Trang, Tay Ninh, Thua Thien Hue, Tien Giang, Tra Vinh and Vinh Long.	Southern parts	An Giang, Ba Ria, Bac Lieu, Ben Tre, Binh Dinh, Binh Duong, Binh Phuoc, Binh Thuan, Ca Mau, Can Tho, Dak Lak, Dak Nong, Dong Nai, Dong Thap, Gia Lai, Hai Duong, Hai Phong, Ha Noi, Hau Giang, Ho Chi Minh, Hoa Binh, Khanh Hoa, Kien Giang, Kon Tum, Lam Dong, Long An, Nam Dinh, Ninh Thuan, Quang Binh, Quang Nam, Quang Ngai, Quang Tri, Soc Trang, Son La, Tay Ninh, Thai Binh, Thanh Hoa, Thua Thien Hue, Tien Giang, Tra Vinh and Vinh Long.

High Medium Low

Endnotes

[1] UNDP (2020).

[2] Global Data Lab (2018) and (2020).

[3] CIESIN (2018).

[4] USAID (2014), (2016a), (2016b) and (2017).

[5] UNICEF (2019).

[6] FAO (2019).

[7] Konstantin Krivoruchko (2012).

[8] ESRI (2020).

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Appendix 4 - National plans that incorporate elements of drought management

1. Brunei Darussalam
National Haze Action Plan of Brunei Darussalam
Strategic National Action Plan for Disaster Risk Reduction 2012-2025

2. Cambodia
Climate Change Action Plan (2016-2018) – Ministry of Environment
Climate Change Strategic Plan 2014-2023
Climate Change Strategic Plan for Water Resources and Meteorology 2013-2017
National Action Plan for DRR 2019-2023
National Framework for DRR 2019-2030
National Strategic Development Plan 2014-2018
Plan for Action for DRR in Agriculture (2014-2018)

3. Indonesia
Disaster Management Strategic Policy 2015- 2019
Grand Design for the Prevention of Forest, Plantation and Land Fires 2017 - 2019

4. Lao People's Democratic Republic
Action Plan on Climate Change (2013–2020)
Eighth National Economic and Social Development Plan 2016-2020
National Adaptation Programme of Action to Climate Change 2009
National Disaster Management Action Plan
National Strategy on Climate Change (NSCC) Lao 2010
Plan of Action for Disaster Risk Reduction and Management in Agriculture (2014-2016)

5. Malaysia
Eleventh Malaysia Plan 2016-2020
National Climate Change Policy
Standard Operating Procedure SOP for Drought Response
Twelfth Malaysia Plan 2021-2025

6. Myanmar
Climate Smart Agriculture Strategy 2015
(Draft) Framework of Integrated National Strategic Action Plan on Fire Management in Myanmar
Myanmar Action Plan on Disaster Risk Reduction 2017
National Climate Change Strategy 2016-2030
Action plan on transboundary pollution - under development

7. Philippines
Agriculture and Fisheries Management Plan 2018-2023
Aligned Philippines National Action Plan to combat Desertification, Land Degradation, and Drought 2015-2025
National Climate Change Action Plan 2011-2028
National Disaster Risk Reduction and Management Plan 2011-2028
National Drought Plan for the Philippines 2019
Philippine Development Plan 2017-2022

8. Thailand
Agriculture Strategic Plan on Climate Change 2017-2021
Climate Change Master Plan
National Disaster Risk Management Plan 2015
National Haze Action Plans
20 Year Water Management Master Plan

9. Singapore
National Climate Change Strategy 2012
Whole-of-Government Integrated Risk Management Policy Framework

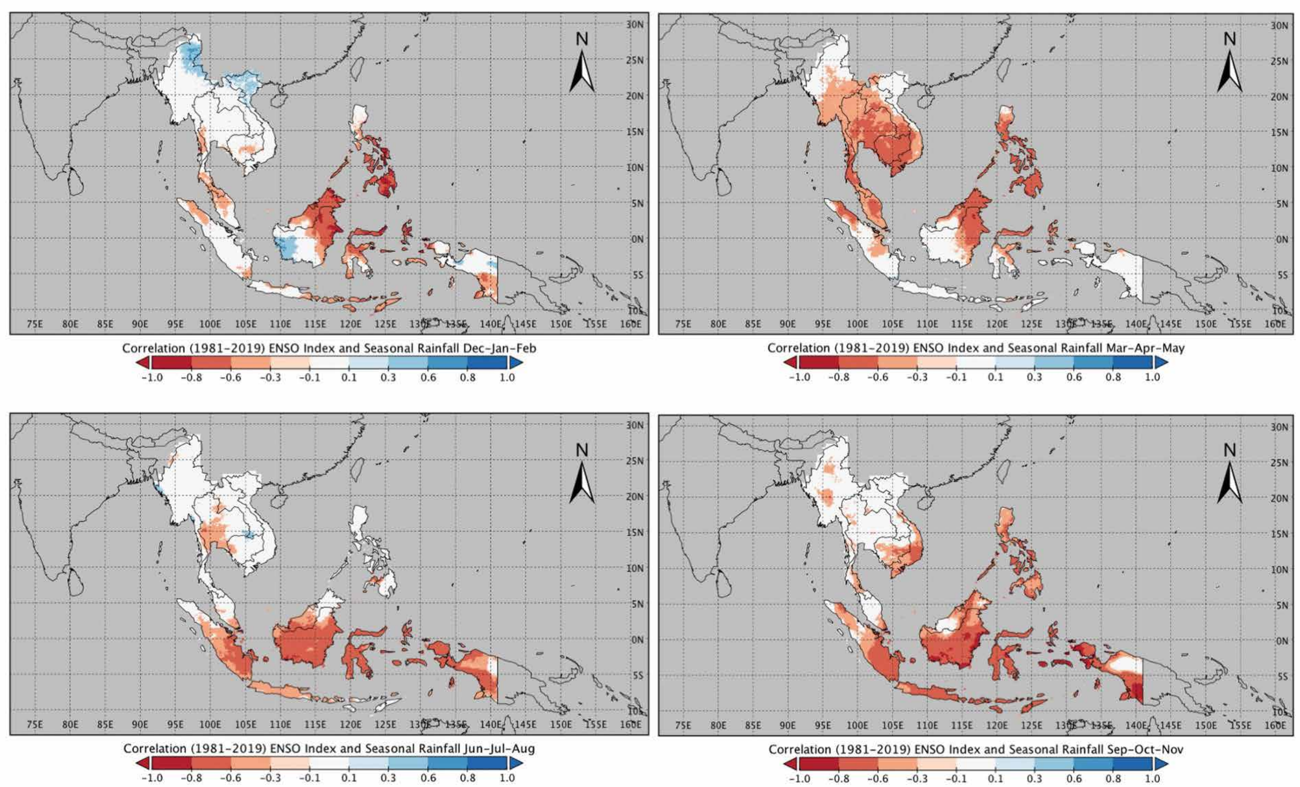
10. Timor-Leste
National Action Plan to Combat Land Degradation
National Adaptation Program of Action for Climate Change 2010
National Disaster Risk Management Policy 2008

11. Viet Nam
National Strategy for Disaster Prevention, Response and Mitigation to 2020
National Strategy for Natural Disaster Prevention, Response and Mitigation to 2020
National Strategy on Climate Change 2011
The Five-Year Socio-Economic Development Plan of Viet Nam 2016- 2020

Appendix 5 – Is rainfall predictable?

Drought early warning requires the ability to predict rainfall. Regions with potential drought predictability were assessed based on the relationship between seasonal rainfall and ENSO conditions in the east-central tropical Pacific Ocean. ENSO is the dominant driver of drought in South-East Asia. A seasonal ENSO index was generated based on sea surface temperature departures from average in the east-central Pacific using data from NOAA (see Appendix 3), and this was correlated with CHIRPS seasonal precipitation for the December-February, March-May, June-August and September-November seasons over the period 1981-2020. El Niño events are associated with positive values of the ENSO index during which rainfall is generally expected to be below average. As such, it is generally expected that the correlation between ENSO and seasonal rainfall will be negative. The correlation results are shown in Figure A, which only shows the correlation values that are statistically significant (at the 90 per cent confidence level). Statistically significant correlations indicate seasonal rainfall is potentially predictable.[1]

Figure A — Correlation (1981-2019) between the ENSO climate index and seasonal rainfall, showing only statistically significant results

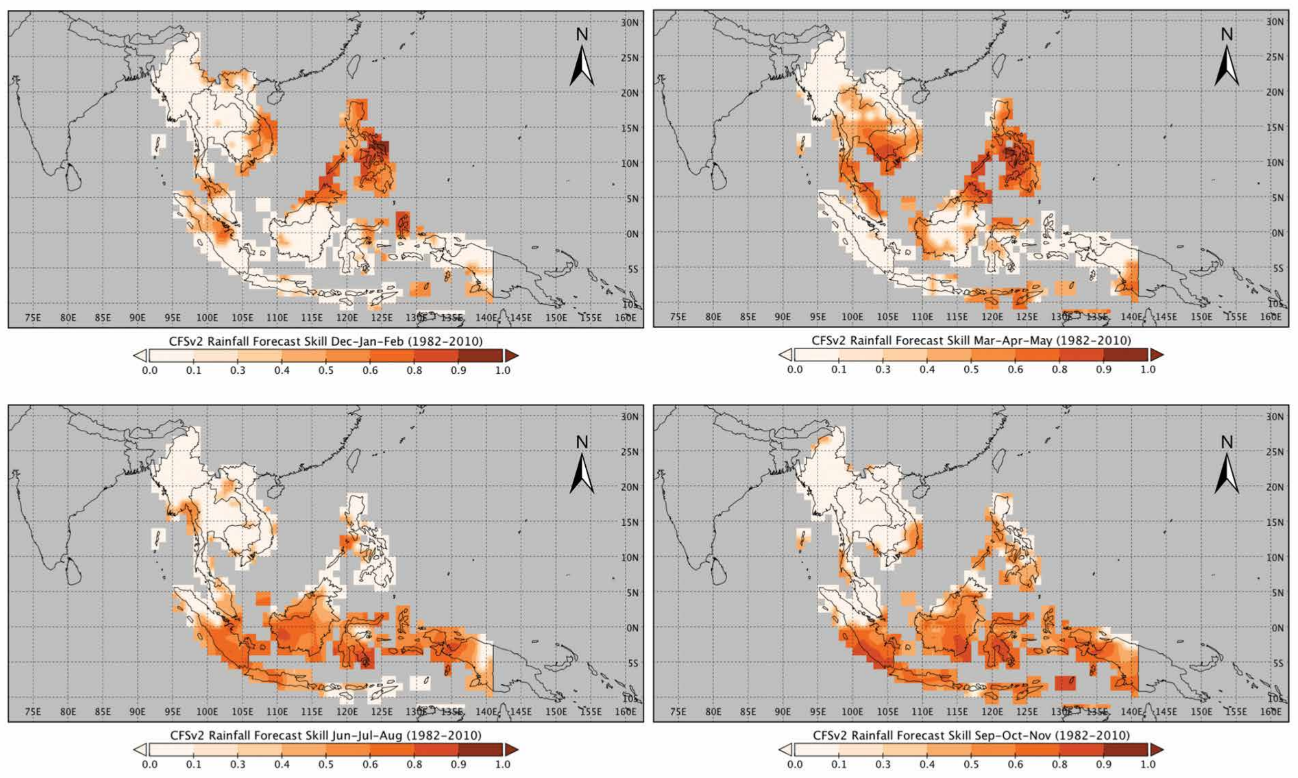


Source: Rainfall data is from CHIRPS with the ENSO index based on sea surface temperatures are from NOAA, 1981-2019.
Note: 1. Negative correlations indicate El Niño conditions are associated with drier than average conditions. 2. The upper-left map is for the period December-February, the upper-right map is for the period March-May, the lower-left map is for the period June-August, and the lower-right map is for the period September-November.
Disclaimer:The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

To gain a better sense of the actual predictability of seasonal rainfall, Figure B shows the correlation between predicted seasonal rainfall from a state-of-the-art climate model from NOAA (CFSv2) and observed rainfall for the period 1982-2010. Forecasts were made one season in advance (see Appendix 3). Correlation values that are statistically significant are plotted with darker shading, indicting locations where the model exhibits forecast skill. Studies have shown that much of this predictability comes from ENSO[2] although oceanic conditions in other basins may also play a role.[3] The IOD is an important example of the latter (e.g., Figure 1-9) and climate models are developed as a mathematical representation of climate physics, so they can respond to other sea surface temperature variations as well. In addition, climate models are improving in their ability to capture other climate phenomena that influence rainfall in South-East Asia on the sub-seasonal timescale, such as the Madden-Julian Oscillation (MJO).[4] As such, the models are at least theoretically capable of generating skilful forecasts even in the absence of ENSO events

Figure B shows that seasonal predictive skill varies both with the season considered and geographically, but there are many locations where the climate model is skilful. That a large part of the region shows skilful seasonal rainfall predictions is encouraging from a drought management perspective. In addition, statistically significant forecast skill is identified in many of the relative drought hotspots.

Figure B — Correlation (1982-2010) between predicted and observed seasonal rainfall, with darker shading showing statistically significant results



Source: Predicted rainfall is from NOAA climate model CFSv2, with observed rainfall data from GPCC, 1982-2010.
Note: The upper-left map is for the period December-February, the upper-right map is for the period March-May, the lower-left map is for the period June-August, and the lower-right map is for the period September-November.
Disclaimer: The boundaries and names shown, and the designations used on this map do not imply official endorsement or acceptance by the United Nations.

Endnotes

[1] For more information, see Nyda Chhinh and Andrew Millington (2015); B. Lyon and others (2012).

[2] K. C. Mo and B. Lyon (2015).

[3] For more information, see W. Bejranonda and M. Koch (2010).

[4] L. C. Hirons and others (2013); Waliser and others (2009).

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South-East Asia has long experienced droughts. However, the two drought events during 2015-2016 and 2018-2020 exceed anything recorded in the past two decades. This second edition of *Ready for the Dry Years* looks at their severity and impacts, as well as their climatic drivers and their socioeconomic consequences. It also combines data on rainfall with other socioeconomic indicators to reveal the hotspots where the populations are most vulnerable to drought.

Compared with other disasters, droughts are fairly predictable, yet policy responses still tend to be largely reactive. This Report argues instead for a more proactive approach along three clear tracks: reduce and prevent; prepare and respond; and restore and recover. Many institutions in South-East Asia have extensive expertise in the relevant scientific disciplines which countries can capitalize on through greater regional cooperation.

This Report comes at a critical time, as ASEAN Member States face the double burden of drought and the COVID-19 pandemic. Governments have responded rapidly with stimulus plans, which could be expanded to accommodate measures for drought resilience.

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