ICT and Disaster Risk Reduction Division

Capacity development toolkit 7/2020

Adaptation and Resilience to Drought:

From know how to do how

A guidebook for the practitioners

[Based on the case studies from South East Asia]

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Preface

The Ready for the Dry Years publication series has been a part of joint efforts between ESCAP and ASEAN to support Member States to prepare for intensifying drought risk, by assessing patterns of drought hazard exposure and vulnerability, highlighting drought impacts, and assessing future drought risks in the decades ahead. The second edition of the Report was launched at the ASEAN Ministerial Meeting on Disaster Management, which was held virtually on 27th November 2020. This edition was designed to usher in a paradigm shift towards more proactive and adaptive drought management across South-East Asia. The Report provided the evidence base for these interventions, including the recently adopted ASEAN Declaration on the Strengthening of Adaptation to Drought. Further, the Report presented three policy tracks: i) reduce and prevent; ii) prepare and respond; and iii) restore and recover. The methodology presented in the second edition of the Report can be used for the implementation of the policies and interventions related to the adaptation and resilience to drought. It's in this context that 'Adaptation and resilience to drought: From know how to do how' – a guidebook for the practitioners has been developed that aims to operationalize the policy track to reduce and prevent the negative impacts of drought through cross-sectoral initiatives of addressing the water-food-energy nexus. ESCAP is a part of the Intergovernmental Working Group on Drought (IWG), established in September 2019 during UNCCD COP14. This guidebook contributes to the UNCCD Drought Toolbox that provides tools and methods to reduce drought risk, be better prepared and effectively respond to drought.

Acknowledgements

Adaptation and resilience to drought: From know how to do how is one of the deliverables of ESCAP's Asia-Pacific Disaster Resilience Network (APDRN) for enhancing the knowledge and building the capacity of Member States. Under the overall guidance of Tiziana Bonapace, Director, ICT and Disaster Risk Reduction Division, members of the core authors team led by Sanjay Srivastava, Chief, Disaster Risk Reduction Section, consisted of Prangya Paramita Gupta, Maria Bernadet Dewi, Kareff May Rafisura and Madhurima Sarkar-Swaisgood.

Valuable advice, reviews and inputs were received from Prof Mukund S Babel (AIT), Amin Shamseddini (APDIM), Caroline King, Xiaoxia Jia and Daniel Tsegai (UNCCD/IWG-Drought).

Anoushka Ali provided copy editing and proofreading. The graphic design and layout were created by Jeong Won Min. It was refined further by Sapna Dubey.

Chonlathon Piemwongjit and Natacha Pitaksereekul provided administrative assistance to the authors team.

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Acronyms

AAL	Average Annual Loss
ADPC	Asian Disaster Preparedness Center
APDRN	Asia-Pacific Disaster Resilience Network
ASEAN	Association of Southeast Asian Nations
ASMC	ASEAN Specialized Meteorological Centre
CCKP	Climate Change Knowledge Portal
BAU	Business-As-Usual
CGIAR	Consultative Group on International Agricultural Research
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station data
COP	Conference of the Parties
DHS	Demographic Health Surveys
ESCAP	Economic and Social Commission for Asia and the Pacific
GDP	Gross Domestic Product
IOD	Indian Ocean Dipole
NAP	National Adaptation Plan
NDA	National Drought Agreement
QGIS	Quantum GIS
RCLMS	Regional Land Cover Monitoring System
SDGs	Sustainable Development Goals
SHDI	Subnational Human Development Index
UNCCD	United Nations Convention to Combat Desertification
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WRI	World Resource Institute

Chapter 1. Overview

South-East Asia is frequently affected by drought and its impacts. During 2015 to 2020, the entire ASEAN region experienced at least six months of drought.[1] For a better understanding of current drought management practices in South-East Asia, ESCAP has advocated for a shift to a more pro-active drought management approach and introduced a three-track framework in their publication, *Ready for the Dry Years: Building resilience to drought in South-East Asia* (second edition). Considering future drought risks in this region, the framework demonstrates three parallel tracks for policy interventions for drought adaptation that need to be taken across different sectors and at various timescales. Track 1 focuses on reducing or preventing drought risk though managing food, water and energy using a nexus approach. Track 2 enables countries to be better prepared and respond to drought risks through risk assessment, monitoring and early warning using climate services, data and innovations. Track 3 emphasizes to build-back-better by adopting risk-informed financing and insurance strategies. For the effective implementation of this framework, it is essential to integrate these adaptation strategies into existing drought management plans and policies in both individual countries and in ASEAN as well.

Figure 1 Three parallel tracks for drought adaptation[2]

This guidebook aims to promote drought adaptation as the key to drought management processes and provides strategic and practical options to operationalize drought adaptation in South-East Asia. It includes the fundamental concept of integrating drought adaptation into existing drought management process and into regional or national drought management policies and their mainstreaming mechanism.

Furthermore, this guidebook describes various Track 1 strategies as well as provides technical support for the implementation of Track 2 strategies. Track 1 presents the lessons learnt from the best practices for drought adaptation in water, food and energy sectors across the South-East Asia region. To develop the Track 2 adaptation strategies, it is essential to understand the underlying causes of drought risks, including exposure to drought and specific vulnerability at the regional or sub-regional level. Different approaches (methods and data) have been adopted by various countries to identify drought risk, however, a common methodology can ensure the consistency and systemic replication of risk assessment across the region. This guidebook presents examples of geo-spatial-based drought risk assessment tools, at different spatial scales, using critically validated open source data and open source data analysis interface, which can be replicated across the region. It includes the identification of drought risk hotspots, exposure and vulnerability to drought as well as guidelines to estimate the economic impacts of drought in South-East Asia.

This guidebook targets multi-sector stakeholders, such as professionals from agriculture, water resources, energy, disaster and climate change, land management, planning and finance sectors, as well as administrators, government officials and policymakers who are working in relevant sectors. It is expected that this guidebook will become a useful tool in assisting such multi-sector stakeholders in addressing drought risk to develop more resilient communities in the future.

Chapter 2. Why drought adaptation?

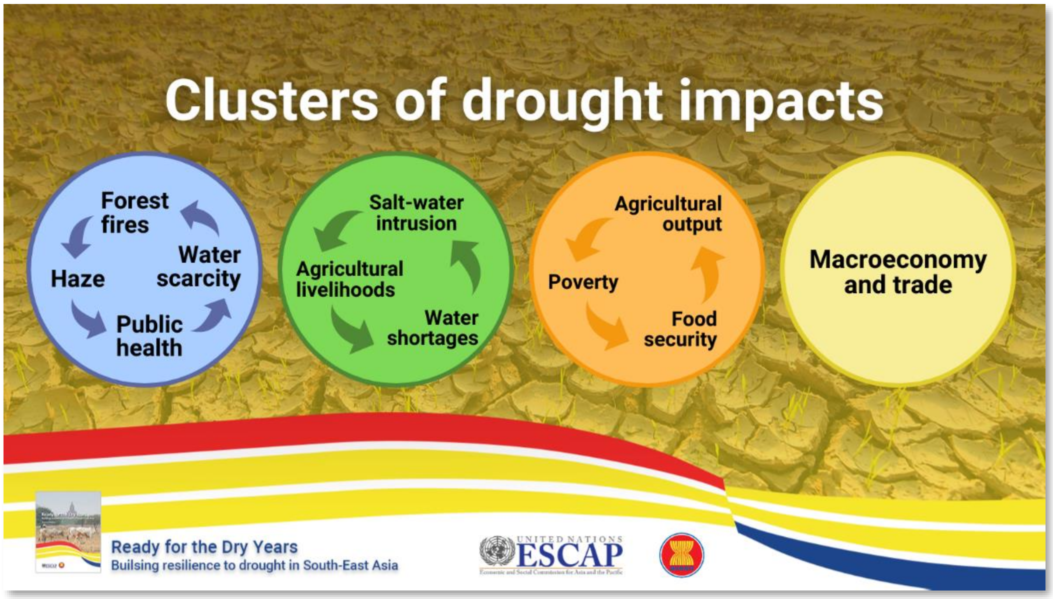
2.1 Drought in South-East Asia

Drought is a slow-onset natural hazard causing wide-reaching and prolonged impacts on the economy, people and environment. The creeping nature of drought makes it difficult to precisely determine its onset and ending. It directly impacts agriculture through declining crop yields, thereby increasing food insecurity. It disrupts the supply chain, impacts businesses and essential services, and enhances land degradation and the depletion of water resources. Furthermore, it may even widen social inequalities, create social conflicts and trigger migration.[3, 4]

Drought has intermittently covered large areas of South-East Asia throughout 1981-2020. Successive droughts, in this region, during 2015-2016 and 2018-2020 reflect its episodic nature. During this time more than 70 per cent of the land area, in this region, experienced moderate drought, however, the spatial extent varied.[5]

Drought in South-East Asia is primarily caused by a deficit of rainfall, which is driven by the interaction of multiple climate systems, at different spatio-temporal scales. El-Niño events which cause rainfall to shift further east of this region, often trigger the onset of drought. The anomalies in the sea surface temperature in the Indian Ocean (IOD) are another major driver of drought in the region. The strong and positive IOD contributes to deficient rainfall, in some parts of the region, and helps develop a drought situation. Moreover, on the decadal timescale, rainfall also shows variability, which is associated with changes in the sea surface temperature in the Pacific Ocean. Although rainfall is the primary driver of drought, high surface air temperature intensifies its impacts. Thus, drought in South-East Asia is also associated with above-average maximum temperature.[6]

Figure 2 Cluster of drought impacts[7]



Populations living in poor socioeconomic conditions have been more vulnerable to the impacts of drought. Drought magnifies already existing social inequalities, poverty and marginalization as crop failure, food shortage and drought-related diseases increase population vulnerability. Often, drought triggers environmental degradation, such as forest and peat land fire and air pollution, declining water quality and creating water scarcity. Droughts accelerate land degradation, especially in areas with over-exploited land and water resources, deforestation and unsuitable agricultural practices, which creates a huge economic burden. Moreover, drought has caused severe economic damage to countries primarily because of loss of agricultural production and its subsequent impact in the associated sectors.

The 'crisis management' approach is most common in addressing drought. However, it fails to build resilience of the society and provide long-term sustainability. On the contrary, adaptation seeks to reduce the harmful consequences of drought along with enhancing a society's capacity to anticipate, cope with, and respond to drought. Adaptation integrally addresses these socio-environmental consequences with assured economic benefits. As per the *Global Commission on Adaptation*, "the overall rate of return on investment in improved resilience is very high."[8] Moreover, adaptation builds resilience of the key system against the impacts of drought.

Therefore, for countries in South-East Asia, where a large proportion of the population is economically dependent on climate-sensitive sectors, such as agriculture, fisheries, forestry, water, energy and environment, adaptation is a key instrument to avoid and overcome the impacts of drought.

From this perspective, this guidebook aims to advise multisectoral, development professionals working in the water, energy, environment and agricultural sector, who support policy planners and decision makers through scientific evidence and technical expertise, on the strategic planning of drought adaptation and in the technical know-how of the available tools. The advice provided in this guidebook are based on the practical experiences of drought adaptation in South-East Asia.

2.2 Drought adaptation and its benefits

Drought adaptation can propel three dividends bringing about economic, social and environmental benefits.[9] Adaptation measures not only help avoid losses caused by drought, proving to be economically beneficial in the short-term, but enhanced resilience and future risk reduction are long-term benefits which are reflected in the social and environmental sectors. Figure 1 illustrates the benefits of adaptation action in three key dimensions of sustainable development.

Figure 3 Triple dividends: Economic, social and environmental benefits of drought adaptation

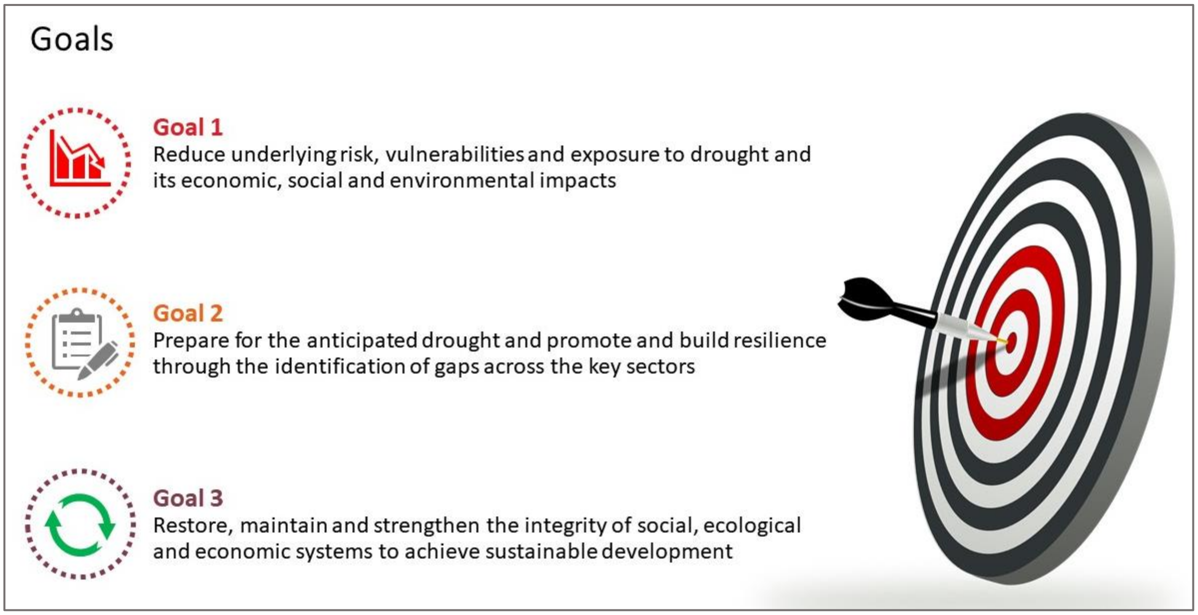
Adaptation measures often generate co-benefits. For example, in the long run, adaptation measures can reduce future vulnerabilities caused due to climate change and drought. Afforestation helps reduce land degradation and increases soil-water availability during drought, but also creates a carbon sink and helps mitigate global warming. The implementation of adaptation measures requires services, knowledge and resources and therefore, creates market opportunities for the providers. For example, the development of wastewater treatment infrastructure and transportation networks are required to facilitate the use of wastewater for agriculture during drought. By and large, the policies, measures and development activities taken toward drought adaptation can help achieve long-term sustainable development goals.

2.3 The aim of drought adaptation

Drought adaptation refers to the strategies which are developed or implemented to enhance a system's ability to adjust with the changing climate and related events (e.g., drought) by avoiding potential damages and losses, and taking advantage of the opportunities or coping with the consequences.

One such strategy is crop diversification, instead of monoculture, in drought-prone areas which can avoid potential economic loss due to drought.[10] For example, to encash the opportunities from drought-induced saltwater intrusion in the Mekong delta, farmers are practicing integrated rice-shrimp farming (which refers to shrimp farming in existing rice fields).[11] To cope with water shortages during drought, construction of water storage structures, such as ponds and tanks and rainwater harvesting, are recommended.[12, 13]

Figure 4 Goals of drought adaptation[14]



2.4 How to approach drought adaptation

- Learn and understand the extent and magnitude of the risk of drought to the society, environment and economy, through continuous communication with stakeholders and local communities, and through consultation with experts.[15]

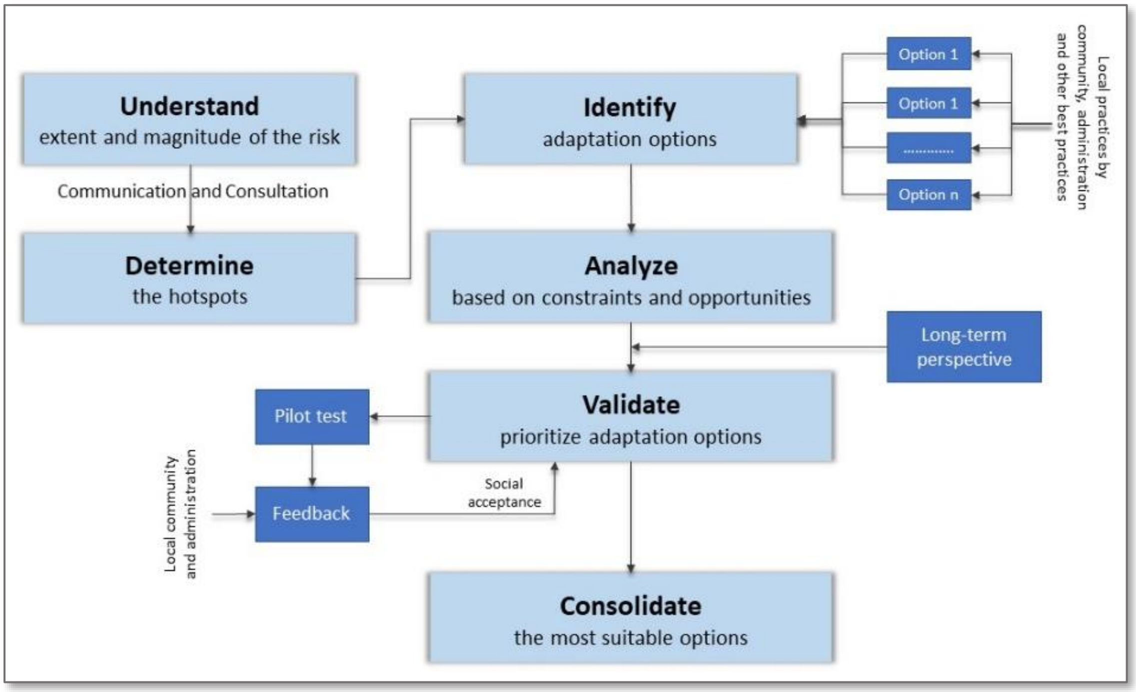
- Identify a range of potential adaptation options for different degrees of drought impact. Local adaptation practices, as well as the ongoing practices introduced by the different administrative units, also need to be considered.

- Analyse adaptation options based on their constraints, opportunities and factors, such as community awareness, economic development, government policies and initiatives, engagement of stakeholders, technical innovations etc.

- Validate the options based on the sociocultural, economic and ecological environment to understand what works and what options need to be prioritized. A small-scale field level trial and feedback from the community, as well as local administration and experts can help validate and prioritize the options.

- Consolidate the most suitable option in the form of guidance for drought adaptation.

Figure 5 Stages of drought adaptation



Box 1. Box 1: Case study: Helping address rural vulnerabilities and ecosystem stability (Cambodia HARVEST)

The Battambang province in Cambodia is a drought hotspot area with a high percentage of poor and food-insecure families. The main source of water is the Tonle Sap lake, which dries up every year during the dry season, with the reverse happening in the wet season. However, high temperatures prolong the dry season and low rainfall affects local agriculture and fishery.

To address the issue, the CGIAR initiated a five-year (2011-2015) project, named “Helping Address Rural Vulnerabilities and Ecosystem Stability (Cambodia HARVEST)”, to increase social resilience by increasing the incomes of rural households, developing income-generating activities for the ‘extremely poor’ households, diversifying the cropping system, increasing agricultural sales through promotions and strengthening the rice value chain and aquaculture systems.

As part of crop diversification, horticulture, including home gardens for dry season vegetable production on rice fields, was introduced in this area. Additionally, on the rice fields that had irrigation facilities, commercial horticulture farms were developed for cucumber, bitter gourd, cabbage, and other such vegetables. The interventions to increase adaptation measures boosted rain-fed lowland rice yields by up to 4 tons per ha with a gross annual margin of US$ 450 per ha, whereas the commercial horticulture (bitter gourd) provided a gross margin of $3,400 per ha per crop.

Source: R. Vernooy (2015).

Chapter 3. Drought adaptation – Know How

3.1 Structural changes in water-food-energy and drought

Major changes in the food system:

Between 1983 and 2017, agricultural land increased by nearly 70 per cent across South-East Asia, with a 290 per cent increase in Viet Nam, followed by Myanmar (134 per cent), Lao People’s Democratic Republic (65 per cent) and Malaysia (54 per cent).[16] This additional agricultural area has come from either utilizing fallow or waste lands, or clearing forest lands, or is compensated by increasing cropping intensity. Intensification, though required to address the increasing demand for food, has often caused land degradation and depletion of groundwater. Marginal and non-traditional lands are brought under cultivation of rubber and oil palm because of the high financial returns on investment that these crops provide.[17]

Major changes in the water system:

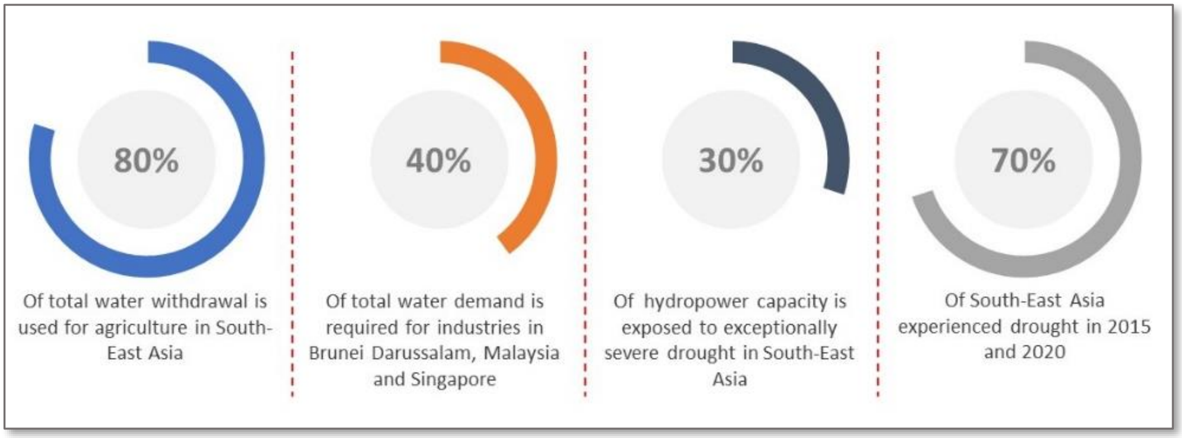
In South-East Asia, the total internal, renewable freshwater has been declining since the last two decades,[18] while the demand for water is expected to increase by 30 per cent by 2025. There has been a significant increase in the demand for freshwater resources in Cambodia, Lao People's Democratic Republic and Viet Nam for hydropower, industry and urbanization. However, the efficiency of water use, in the agricultural sector, has been one of the lowest in this region compared to the global scenario. Major growth in the service and tourism industries has added additional pressure on the region's freshwater resources.

Major changes in the energy system:

The development of hydropower as a renewable resource has been very promising in South-East Asia. Hydropower capacity in the region grew almost three-fold from 16 GW to 44 GW between 2000 and 2016.[19] Viet Nam has the highest installed capacity of hydropower among the ASEAN Member States.[20] However, drought exacerbates water shortages, which reduces the generation efficiency of hydropower plants. Furthermore, water shortages and occurrence of drought often coincides with a heavy demand for electricity.

These changes enhance the impact of drought, affecting long-term food, water and energy security of the region and increasing the social, environmental and economic vulnerability of the region.

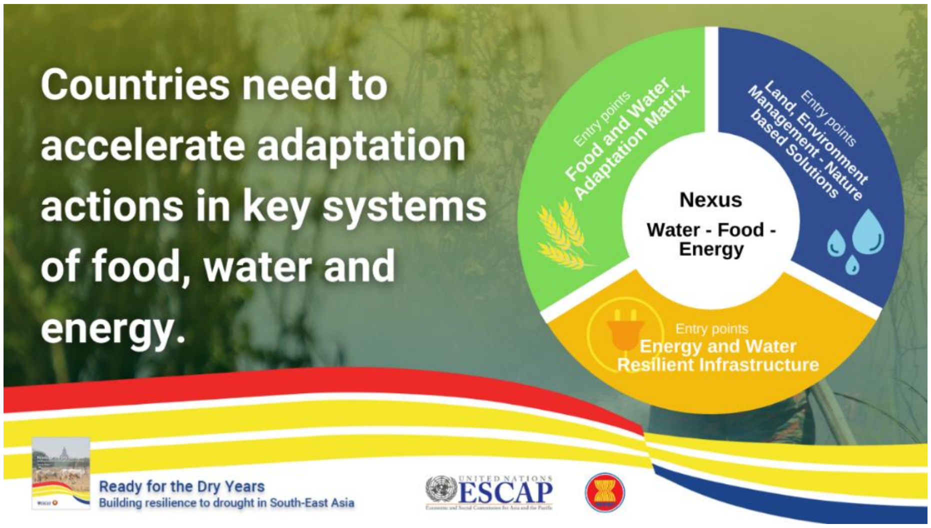
Figure 6 Key figures on water-food and energy domain in South-East Asia [21, 22]



3.2 Addressing water-food-energy nexus in drought adaptation

The impact of drought in South-East Asia is reflected across many sectors, however, it centres around the key nexus of water, food and energy due to their complex interactions and interdependencies. Although there has been growing interest in drought adaptation in recent years, the interventions have mostly been sectoral. In such cases, if a nexus approach is adopted, cross-sectoral adaptation options can build social, economic and environmental resilience of the all the systems across the nexus.

Figure 7 Water-food-energy nexus in drought perspective[23, 24]



Food-water system: Sustainable food production needs a sustainable supply of water. Hence, water scarcity or drought will have a profound impact on the food production system. On the other hand, agriculture affects the water sector through land degradation (affects the soil-water balance) and groundwater depletion through over-exploitation.

Water-energy system: Hydropower efficiency solely depends on water availability. Any disruption in the water supply, such as drought, hampers energy production and also the services to other essential sectors. On the other hand, energy is required for water purification, extraction and its transportation.

Energy-food system: Energy in agriculture is primarily required for irrigation and water supply. Thus, any disruption in energy supply impacts food production. Though the sustainable development goals encourage the increasing use of hydropower, however, any water scarce situation can affect food security by hampering irrigation and water supply to the farms.

The following are the key principals of addressing the nexus approach for drought adaptation:

- ✓ **Understand the interlinkages of the water-food-energy nexus as a ‘system’ to enhance the ‘system efficiency’, rather than focusing on the efficiency of any individual sector.**
- ✓ **Analyse the effect a change in one resource can have on other resources due to adaptation measures. Economic analysis should also involve nexus links.**
- ✓ **Capitalize on the understanding of the nexus in order to consider adaptation measures for potential “low-probability-high-impact” events in the near future.**
- ✓ **Identify integrated adaptation measures, which are mutually beneficial, and address the convergence among the sectors.**
- ✓ **Justify adaptation measures by interlinking the nexus with climate change in order to explain their sustainability across space and time.**
- ✓ **Ensure coordination among stakeholders of the sectors, while developing adaptation strategies in order to generate ancillary benefits for long-term sustainability.**

Box 2: Case study of nexus approach for drought

Drip irrigation has long been introduced in the South-East Asia region, and has produced varying levels of success. However, the acceptance and penetration of drip irrigation has been low for social, economic, ecological and institutional outlook. On a trial basis, drip irrigation was introduced to small-scale vegetable farmers in drought-prone provinces of Viet Nam (Binh Phouc), Cambodia (Prey Veng and Svay Reing), Philippines (Lantapan and Bukidnon) and Indonesia (Reing and Bogor, West Java; Rembang, East Java). As a result, water use efficiency and yield increased by 43 per cent and 15 per cent in Cambodia, respectively, whereas in Viet Nam the yield increased between 8 and 11 per cent, respectively. The average yield of vegetables increased by 15 per cent in the Philippines and the yield and quality of vegetable crops increased in Indonesia even during the dry season.

Nexus opportunity:

Drip irrigation increases water use efficiency and energy efficiency for agriculture by reducing the overall consumption of water and energy. Increased efficiency can lead to agricultural expansion, intensification, increased productivity and food security, as more crops could be produced per drop of water. Water efficiency in irrigation also reduces the demand for energy (for pumping water) for agriculture. By minimizing water requirements in agriculture, water can be re-allocated toward hydropower generation for the industrial and domestic sectors. Such effects help society to build resilience against drought and its impacts and help to restore environmental flows as a co-benefit.

Source: M. Palada and others (2011).

Box 3: Rice-shrimp farming - creating opportunity from threat

The Mekong delta region in Viet Nam is prone to drought. Climate change and hydropower infrastructure development, in the upstream region, affects water resources downstream with several associated impacts, an example of which is saline water intrusion. Low water discharge in the Mekong river and low rainfall in the dry season triggers backflow of saline water from sea into the river, which affects agriculture, aquaculture and the livelihood of the population in this region. In the case of drought, the impacts are more profound. In 2016, saltwater intrusion, in this region, led to a loss of 70 per cent of agricultural yield, 2000 ha of aquaculture produce and destroyed thousands of fruit trees. To address this problem, integrated rice-shrimp farming was adopted by the local farmers as an adaptive measure.

A study was conducted in An Bien (Kien Giang province) and Cau Ngang (Tra Vinh province) districts in Viet Nam, to understand the existing, collective adaptation process, as well as government initiatives which addressed the issue. These districts are exposed to saltwater intrusion due to drought, which is expected to worsen in the future. Primary data for the delta region suggested that the salt level had increased in both sides of the delta since 2002. As a result, in this rice-dominated area, the agricultural lands are decreasing due to the increasing level of saltwater and are now being replaced by shrimp farming. The potential of flourishing shrimp farming in saltwater was appropriately capitalized by the community. Moreover, the government land-use policy (Government's document No. 09/NQ-CP) and access to technical assistance (from the World Trade Organization) helped farmers to easily shift from rice farming to shrimp farming. Both extensive and intensive farming is underway in this area. In the An Bien district, integrated rice-shrimp farming (extensive) is dominant during the dry season and rice is grown in the wet season. In the Cau Ngang district, farming more diverse and intensive (both integrated farming and monoculture).

Collective actions also helped the local community to build resilience against the socioeconomic impacts of drought. The development of institutions, resource mobilization, coordination of activities, and information sharing also helped the communities, in this region, to overcome the problem in a collective way.

These initiatives helped farmers avoid economic loss during extreme events like drought, ensured their social well-being and, above all, build strong resilience against similar events that may likely occur in the future.

Source: V. H T. Pham, and others (2018)

Chapter 4: Drought adaptation – Do How

4.1 Integrating drought adaptation into the existing drought management process

To be most effective, drought adaption measures should be integrated into the existing drought management framework, plans and policies by Governments and other related organizations, rather than work as an independent system.

Developing perspective:

The needs of all major sectors, such as water, food, energy and the ecosystem, that address human development are affected by drought and the impacts are interconnected across these sectors. Adaptation measures in one sector must be consistent with the others. As Albert Einstein once said, “We cannot solve our problems with the same level of thinking that created them”. Hence, there is need to develop a new perspective in order to address drought. To develop this perspective, it is necessary to:

- **identify important or imminent sectors and communities who need urgent assistance.**
- **collect and analyse data on the key indicators to understand the interlinkages among sectors (a list of some of the key indicators are given in Annex I).**
- **integrate socioeconomic information in the analysis to understand the extent and direction of risk.**
- **identify the resources under threat, their correlations and competing interests, and probable potential criticalities which may arise due to drought.**
- **listen to the viewpoint of multiple stakeholders to understand the risk.**
- **learn about existing policies, plans and actions to identify the gaps.**

Identifying tools and skills:

The data on indicators vary in type, structure, volume, completeness, consistency and robustness. Thus, to analyse these data certain tools are necessary. For example, to understand changes in forest cover or expansion of agricultural area over a time period, spatial analysis tools are most suitable. Likewise, statistical software and policy analysis tools are necessary to analyse large volumes of socioeconomic data and policy instruments, respectively. Many of the tools are open source and thus easy to access. Examples of such tools and data sources are given in Annex I.

Furthermore, specific skill sets are also required to use the tools efficiently. Skills can be developed in professionals through different capacity development programmes. Technical analysis, planning and management and public outreach qualities are some of the skills that are critical for professionals.

Sharing knowledge and experience:

Sharing and learning from tangible measures are some of the important parts of drought adaptation. Fore replication and upscaling of best practices, communicating, sharing of experiences and knowledge and cross learning are very important. Public, private and government stakeholders should be consulted prior to decision-making. Recording and documenting traditional knowledges and practices also helps in building location specific adaptation strategies. Following are some of the tools for knowledge-sharing:

- Knowing adaptation best practices and case studies through online resources, such as the
  - Adaptation Knowledge Portal. Available at https://www4.unfccc.int/sites/nwpstaging/Pages/Home.aspxhttp://www.asiapacificadapt.net/adaptation-practices
  - PreventionWeb: The knowledge platform for disaster risk reduction. Available at https://www.preventionweb.net/english/professional/policies/
  - The UNCCD Drought Toolbox. Available at https://knowledge.unccd.int/drought-toolbox
- Information dissemination through workshops, webinars, conferences and capacity-building programmes.

Defining approach:

By knowing the risks and the various stakeholders involved, a strategic, flexible and structured approach should be undertaken to formulate adaptation actions. Flexibility in approach allows planning not only according to changes, but also to make changes in the approach when taking community perspectives or local circumstances into consideration. For example, adaptation is a long-term process and additional issues may develop along the adaptation journey. A flexible and responsive adaptation approach allows policymakers to address the changes embedded in the existing pathway.

Box 4: How to define the adaptation approach

The adaptation approach should:

- Be flexible, responsive and present a spectrum of potential actions that address sustainable adaptation.
- Be able to develop strategies which can follow changing circumstances.
- Serve as a menu for adaptation actions to guide decisions. Professionals should be able to select the most contextual option/options that provide benefits across sectors.
- Provide the team (professionals and stakeholders) a platform to discuss pertinent topics and issues.

The adaptation approach should not:

- Be rigid with set guidelines and recommendations to avoid dependency on any specific method.
- Express preferences for the use of any of the options.

Monitoring and evaluation (M&E):

As the implementation and mainstreaming of adaptation need investments, it is essential to ensure effectiveness, efficiency and equity of the interventions. A successful adaptation process for all sectors should be supported by an adequate reporting mechanism to identify the most feasible options, in order to ultimately preserve livelihoods and ensure that the sectors contribute effectively to the economy.

- Monitoring is done through continuous collection of information on the progress of the interventions.
- Evaluation is done through systematic collection and analysis of the information to understand the extent of progress with respect to the set objectives.

M&E involves the implementation authorities (governments, administrations and institutions) who are responsible for coordinating the process and reporting the results, the boundary teams (local administration, NGO's etc.,) who translate the policies into ground practices and the beneficiaries (local communities) who actually implement the adaptation measures. Some examples of the M&E tools are:

- Audit in different time-scales using data on the development indicators.
- Focus groups/ in-depth interviews, direct observation and participatory assessments.

Box 5: Thailand's initiatives in M&E

Thailand has begun establishing a national M&E system for the water and agriculture sectors. These sectors are planning to integrate the M&E of adaptation measures in line with the country's National Adaptation Plan (NAP), which lies within the overall information governance framework. The requirement of M&E has been highlighted in the UNFCCC Paris Agreement, the Sustainable Development Goals (SDGs), and the Sendai Framework for Disaster Risk Reduction 2015-2030. The establishment of a national level M&E system will facilitate the reporting of Thailand's achievements towards the goals set out in these agreements.

In the agriculture and water sectors, adaptation interventions, such as organic agriculture, piloting drought-resistant crop varieties and soil and water conservation, are already functioning to achieve resilience to drought. In both sectors, adaptation interventions often have their own M&E system or framework at the project level. However, with a national level M&E system, it will be easy to assess whether these adaptation actions, policies and plans can achieve the desired results across a broader scale (contribute to the country's Nationally Determined Contribution) as well. The M&E of water management, including adaptation actions, will be anchored as a vital part of integrated and climate-sensitive river basin planning (River Basin Master Plans).

Source: UNDP (2019a) and German Cooperation (2019).

4.2 Integrating drought adaptation into national/regional climate change policy

While the understanding of drought and its potential impacts have become much clearer over time, policy guidance on the adaptation processes have been out of pace. Drought and climate are interlinked, as climate change amplifies drought risk. Hence, through drought adaptation, the impacts of climate change can also be minimized or alleviated. For this purpose, integrating drought adaptation into existing national or regional climate change policies, with a clear roadmap is essential. Generally, public agencies working in relevant fields, such as environment, water, energy and land provide policy inputs. However, professionals in multisectoral development have an equally important role to play in the following steps to bring about desired effects or changes.

Agenda setting:

Through agenda setting, the policy and its related problems are acknowledged to be of public interest. Individuals or groups identify problems, propose their solutions, as well as influence the government to intervene. In such cases professionals can assist through following actions:

- Support policymakers through sharing of information on potential drought risks.
- Highlight the relation between climate change and drought occurrence and emphasize the need of inclusive policy.

- Explain the linkages between drought adaptation and sustainable development goals to emphasize the broader perspectives of drought adaptation.

- Inform policymakers about international best practices on the impacts of drought and provide examples of adaptation to strengthen the rationale for inclusive policy.

Policy formulation:

During this stage, various policy options are analysed to provide possible solutions for a particular problem. The policy statement must clearly mention who is going to implement the policy, how it will be implemented and what resources will be used for that purpose. In this stage, experts can contribute in the following ways:

- Identify and promote policy options that will be most effective in the anticipated future. Experts can support policy formulation by analysing current and future risks and interlink these with climate change adaptation priorities.

- Use supporting briefs, statistics and analyses to strengthen, and make well-informed and evidence-based policies.

- Promote those options and potential approaches which advocate future resilience.

- Promote policies which address drought adaptation in a coherent and integrated way across principal sectors. Uncoordinated and fragmented policy frameworks can result in high costs of investment in the implementation of adaptation measures.

- Act as the bridge between stakeholders and policymakers to highlight the priorities in policy formulation, for example, for local water services, water infrastructure or ecosystem restoration.

Policy adoption:

In this stage, policy decisions are made based on the alternatives, arguments and evidence provided during the formulation phase. Experts can assist decision makers through advocating for a specific policy decision.

Policy implementation:

In this stage, the policy implementation parameters are established. The factors which decide effectiveness of the policy are (a) type and complexity of the problem, (b) magnitude of the expected change and the target groups, (c) volume of human and financial resources attributed for implementation and (d) the administrative structure and regulations to implement the law.[25] Experts can assist those involved in the policy network to understand these parameters for effective implementation by:

- Describing the type and complexity of drought through risk information, with a crucial understanding of the interaction between different sectors.

- Assessing the magnitude of the expected change through an evaluation of risks and impacts. Information about the extent and intensity of drought will help the implementation authority assess the magnitude of the interventions required. Likewise, knowledge about the socioeconomic, cultural and political structure of the target groups will help to decide the effectiveness of the adaptation measures.

- Gathering information on the volume of human and financial resources needed for implementation, by identifying the government's budget and other available resources.

- Bridging the gap between the administration and target group through capacity development programmes, where the exchange of information and resources are undertaken. Building a relationship between administrations and target groups, together with the nature of the regulations (e.g., lenient or stringent), ensures the success of a law. In general, well-accepted laws by the target group are often successful.

Policy evaluation:

Policy evaluation is necessary to verify whether the policy goals are attained after implementation. Evaluation can also help incorporate new technologies, lessons learned from recent drought events and changes in vulnerability into policies. Experts can assist in policy review by cross-checking the adaptation components of the policy and highlighting the achievements through answering questions such as:

- Does the policy align with current climate change adaptation plans?
- Does the policy promote and is in line with sustainable development?
- Does the policy enhance community resilience against drought?
- Does the policy reduce exposure of the community to drought?
- Does the policy reduce vulnerability of the community to drought?
- Does the policy have a multisectoral approach?
- Do the policy measures bring about triple dividends, in terms of social, environmental and economic benefits to the society?

Box 6: Development of Australia's National Drought Policy

Australia is a dry continent characterized by varied rainfall and frequent drought. Prior to 1989, drought was considered a natural disaster. Drought management focused on financial assistance to state governments in the form of relief and recovery payment and infrastructure restoration. After identifying the gaps in this approach, the National Drought Policy was announced, in 1992, to:

- Encourage primary producers and other sections of rural Australia to adopt self-reliant approaches to manage climate variability.
- Facilitate the maintenance and protection of Australia's agricultural and environmental resources base during periods of climatic stress.
- Facilitate the early recovery of agricultural and rural industries, in order to be consistent with long-term sustainable levels.

Until 2008, drought was termed as an exceptional circumstances event and addressed with a crisis management approach. In 2008, the review of the drought policy indicated the need for policy reform with a consideration of variable climate, as well as the social impact of drought on farm families and rural communities and recommended the restructuring of policy to help farmers prepare for drought, rather than wait for drought occurrence.

In 2013, based on a pilot of drought reform measures in parts of Western Australia, the Intergovernmental Agreement on National Drought Program Reform (IGA) outlined the roles and responsibilities for implementing a new approach focused on drought preparedness.

In 2015, the Australian Government released a roadmap of practical actions to develop the agriculture sector under drought conditions. This was aimed to help farmers prepare for drought, not only from a business perspective, but through better social and community support. Improved seasonal forecasting, tax measures, farm insurance advice and risk assessment grants was announced in the roadmap.

On 12 December 2018, the Council of Australian Governments agreed and signed a new National Drought Agreement (NDA). The NDA focusses on a joint approach to drought preparedness, responses and recovery, with an attention to accountability and transparency. Climate change and variability was recognized during the framing of action plans and the measures covered all aspects of risk management practices, thereby enhancing long-term preparedness and resilience.

Source: Australian Government, Department of Agriculture, Water and the Environment (2020).

4.3 Mainstreaming drought adaptation into national/regional drought management strategies

Mainstreaming drought adaptation refers to the process of systematically integrating adaptation considerations into the decision-making and planning process for drought management, rather than implementing them as stand-alone measures. This can take place at different geographical scales (regional, national or sub-national), and at different stages of decision-making (policymaking, planning, budgeting or implementation).

Supporting with information:

Understanding drought risk in the local context, where drought management measures will be implemented, will help to address them specifically. Experts can support the planning process by providing site-specific data on risk, vulnerability and exposure.

Defining entry points:

For comprehensive mainstreaming, thorough analysis is required to locate exactly where changes need to be made and who will be making them. Identifying the important economic sectors most vulnerable to drought will be an advantage. Local perception of the risk, existing adaptation mechanism, existing drought management programs, plans, policies across different administrative levels can serve as a baseline for decision-making on the adaptation options. Figure 8 highlights some of the potential entry points.

Figure 8 Possible entry points for mainstreaming drought adaptation

Identifying stakeholders:

In order the decide who should participate in mainstreaming activities, stakeholder identification is required. An exhaustive list of organizations, institutions, groups or individuals involved in drought adaptation or management activities or in policies and programmes can be used to design an appropriate institutional set-up that promotes the mainstreaming objective.

Capacity-building and awareness:

Apart from institutionalization, the capacity of the target group in the mainstreaming process must be enhanced so that they can include appropriate adaptation measures in their decision-making process.

4.4 Potential outcomes of integrating drought adaptation into the drought management process

- **Transition from crisis management to a systematic risk management approach**

The integration of drought adaptation into the drought management process will help to develop a systematic approach in the process of drought risk reduction. The drought management process, which will be supported by scientific evidence, will thereby become more robust and focused. It will significantly change the way governments prepare for and respond to drought, by placing greater emphasis on risk management, rather than crisis management.

- **No-regret development and resilience-based approach**

The integration of adaptation will make developments (for example, in human resources, social and infrastructure) more drought resilient across all sectors. Drought adaptation is a precautionary measure that will promote no-regret development, which will increase the system's ability to deal with impacts of drought. It will enhance the resilience of society, the environment and infrastructure and enable sustainable growth.

- **Cost-effective investment with risk-informed development for long-term sustainability**

Adaptation leads to long-term sustainability of resources, even with the uncertain future climate change scenario. It will reduce the driving forces that cause social, environmental and economical vulnerability due to drought, in a cost-effective way. As adaptation has an economic advantage over recovery and rebuilding, it will help in making cost-effective investment for building resilience against drought.

Chapter 5: Quantifying the potential economic , social and environmental costs of drought

5.1 UNCCD drought toolbox

As requested by the Conference of the Parties (COP), at its thirteenth meeting (COP13), the drought initiative was conceived by the United Nations Convention to Combat Desertification (UNCCD) with the aim of enhancing resilience of communities and the ecosystem to drought and strengthening drought adaptation through national action plans. The new initiatives focused on:

- Drought preparedness systems
- Regional efforts to reduce drought vulnerability and risk
- A toolbox to boost the resilience of people and ecosystems to drought

The drought toolbox is a repository of tools, case studies and other resources which can support the framing of the National Drought Policy Plan. The drought toolbox consists of three modules; (1) Drought Monitoring and Early Warning; (2) Drought Vulnerability and Risk Assessment; and (3) Drought Risk Mitigation Measures.[26]

5.2 Add-on module in the UNCCD Drought toolbox: analysis of socioeconomic drought indicators

The socioeconomic structure of a population defines their vulnerability or the adaptive capacity to drought and water stress. Household income, employment, social life, access to information, health and nutritional status, education, physical infrastructure, demographic factors, economic well-being and inequality etc., reflect a society's capacity to anticipate, cope with and respond to drought. Poor socioeconomic conditions, and drought and water stress have a cumulative impact on a population and can even cause social conflicts and migrations. Hence, prior knowledge on these indicators gives an edge to policymakers so they can develop drought adaptation and mitigation strategies.

The add-on module is intended to assist policymakers with an analytical interpretation of the socioeconomic impacts of drought. This module will be interlinked with the Asia-Pacific Disaster Resilience Network (APDRN) data portal, which is currently under development, to facilitate all the base data required for the analysis.

5.2.1 Estimating Population Exposure

Population exposure to water stress can be estimated through integrating water stress data and gridded population data. The methodology is described below.

Key question

- What number of people are exposed to different levels of water stress in the current and future scenario?

Data sources

- The water stress projection data developed by World Resource Institute (WRI).

Available at https://www.wri.org/resources/data-sets/aqueduct-water-stress-projections-data.

- Gridded population data by WorldPop.

Available at https://www.worldpop.org/geodata/listing?id=17

1. **Extracting water stress data for the South-East Asia region**
    - Add the "aqueduct_projections" shape file in QGIS window using "Add Vector Layer" button.
    - Add the boundary of South-East Asia region from APDRN in the existing QGIS window
    - Click Vector > Geoprocessing tool > Clip.
    - Add "aqueduct_projections" as input layer, boundary of South-East Asia as overlay layer. Name the output feature class as "Aqueduct_SEA", mention the location to save the data and click on "Run".
    - Add "Aqueduct_SEA" in QGIS window > Open attribute table of "Aqueduct_SEA" to view water stress data for different climate change scenarios and socio-economic pathways which are presented in each column.
    - The description of data can be found in "aqueduct_projections_schematic_20140615.xls" downloaded along with the data.

2. **Creating scenario wise raster file**
    - Add "Aqueduct_SEA" in QGIS window > right click > Export > Save Features As
    - Add the following details:
      File Name - as "ws2028tl" and save it in the same location.
      Select field to export and their export options - Select BasinID, dwnBasinID, Area_km^2, Shape_lenght and ws2028tl and click "OK".
    - Repeat the process for scenario ws3028tl and ws4028tl.

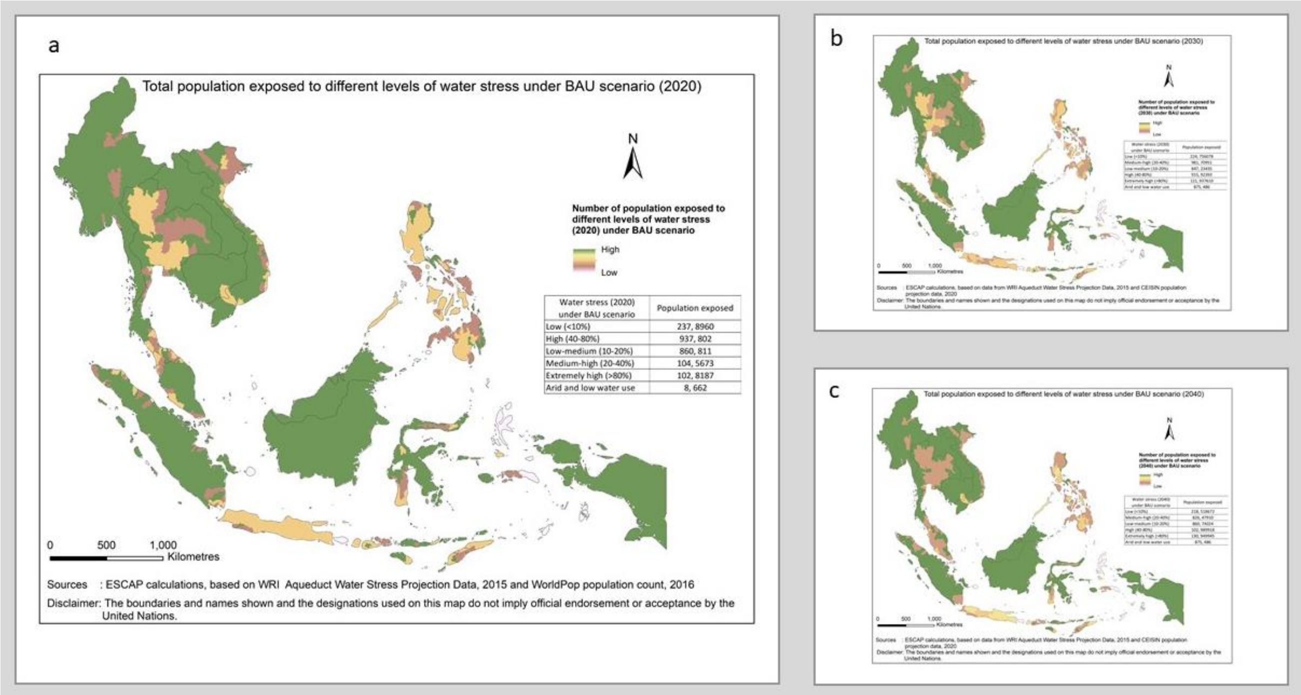
3. **Extracting population data for the South-East Asia region**
    - Add "Asia_PPP_2020_adj_v2.tif" in the QGIS window using "Add Raster Layer" button.
    - Click on Raster > Extraction > Clip raster by mask layer.
    - Put "Asia_PPP_2020_adj_v2.tif" as input layer and boundary of South-East Asia region as Mask layer. Under Clipped (mask), name the output raster as "worldpop_SEA" and save in the same location as earlier.

4. **Calculating population distribution in different water stress zones**
    - Click on Processing Toolbox > search for Zonal Statistics.
    - Add “worldpop_SEA” as raster layer.
    - Add “ws2028tl” as vector layer containing zones.
    - Choose “SUM” as statistics to calculate and click “Run”.
    - Open attribute table of “ws2028tl”. A new column with the statistics is added in the attribute table. From that column the number of populations in each water stress category can be calculated.
    - The thematic map can be prepared by using properties > symbology> categorize

    Save the data using export > Save Feature As “pop_WS2028tl”.

Likewise, population distribution in future water stress scenario (such as ws3028 and ws4028) can be done using water stress data and population projection data. For different socioeconomic pathways, the population projection data can be downloaded from https://sedac.ciesin.columbia.edu/data/set/popdynamics-1-km-downscaled-pop-base-year-projection-ssp-2000-2100-rev01/data-download.

Figure 9 Population exposed to different levels of water stress under a business-as-usual (BAU) scenario in South-East Asia in (a) 2020, (b) 2030 and (c) 2040



5.2.2 Estimating exposure of agricultural lands to drought

Agriculture is one of the sectors most impacted by drought. Exposure of agricultural lands to different levels of drought can be estimated using landuse/land cover data and drought occurrence data generated by ESCAP. The methodology is described below:

Key question

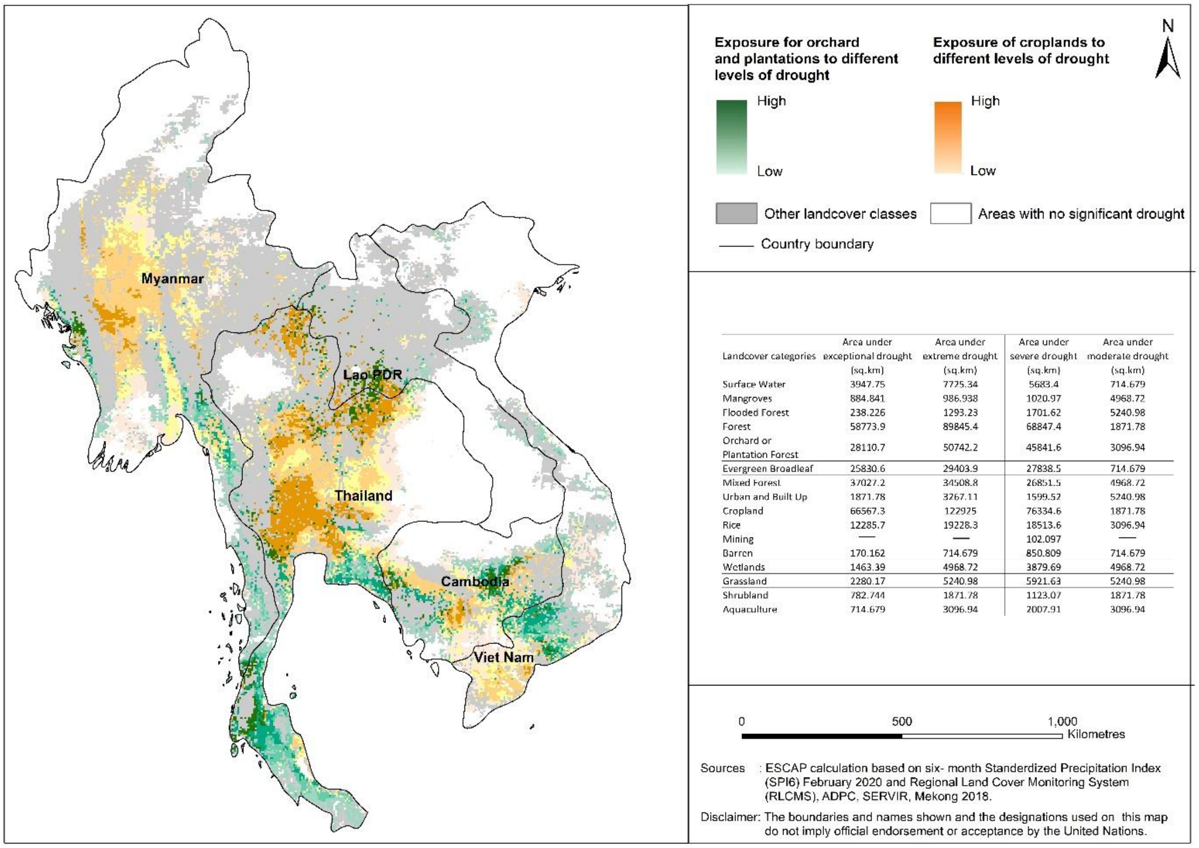
- How much agricultural land is exposed to different levels of drought?

Data sources

- Regional Land Cover Monitoring System (RCLMS) developed by SERVIR-Mekong programme. Available at https://landcovermapping.org/en/landcover/
- Drought occurrence data from ESCAP's APDRN web portal.
- Mekong river basin boundary from ESCAP's APDRN web portal.

1. **Projecting land cover data**
   - Download the RCLMS raster data and add in the in QGIS.
   - Click Raster > Projection > Wrap (Reproject). Use Asia_South_Albers_Equal_Area_Conic as the Target CRS. Name the output data and save in desired location. Then "Run"
2. **Extracting drought data for Mekong river basin area**
   - Add individual drought data in the QGIS window using "Add Raster Layer" button.
   - Click on Raster > Extraction > Clip raster by mask layer.
   - Put drought data as input layer and Mekong river basin boundary provided in APDRN web portal as Mask layer.
3. **Calculating exposure of agricultural lands to different drought levels**
   - To find out the exposure of agricultural lands to different levels of drought multiply individual drought data with the landcover data using Processing Toolbox > Raster calculator.
   - Open Processing Toolbox. Type Raster layer zonal statistics. Add (drought*landcover) data as input layer and zones layer. Save it in desired location and click "Run".
   - This will produce a table with area under different landcover categories exposed to drought. Agriculture data can be extracted from the table.
   - Repeat the process for each (drought*landcover) files.

Figure 10 Exposure of orchards, plantation and agricultural lands in South-East Asia to different levels of drought



Landcover categories	Area under exceptional drought (sq.km)	Area under extreme drought (sq.km)	Area under severe drought (sq.km)	Area under moderate drought (sq.km)
Surface Water	3947.75	7725.34	5683.4	714.679
Mangroves	884.841	986.938	1020.97	4968.72
Flooded Forest	238.226	1293.23	1701.62	5240.98
Forest	58773.9	89845.4	68847.4	1871.78
Orchard or Plantation Forest	28110.7	50742.2	45841.6	3096.94
Evergreen Broadleaf	25830.6	29403.9	27838.5	714.679
Mixed Forest	37027.2	34508.8	26851.5	4968.72
Urban and Built Up	1871.78	3267.11	1599.52	5240.98
Cropland	66567.3	122925	76334.6	1871.78
Rice	12285.7	19228.3	18513.6	3096.94
Mining	—	—	102.097	—
Barren	170.162	714.679	850.809	714.679
Wetlands	1463.39	4968.72	3879.69	4968.72
Grassland	2280.17	5240.98	5921.63	5240.98
Shrubland	782.744	1871.78	1123.07	1871.78
Aquaculture	714.679	3096.94	2007.91	3096.94

Sources : ESCAP calculation based on six- month Standerdized Precipitation Index (SPI6) February 2020 and Regional Land Cover Monitoring System (RLCMS), ADPC, SERVIR, Mekong 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.

5.2.3 Estimating population vulnerability

Population vulnerability due to water stress and drought can be estimated using the sub-national Human Development Index and the WRI water stress data and drought occurrence data generated by ESCAP, respectively. The methodology is described below:

Key question

- What is the population vulnerability distribution due to water stress in the current and future scenario?

Vulnerability indicator

- Sub-national Human Development Index (SHDI)

Data sources

- The water stress projection data developed by World Resource Institute (WRI). Available at https://www.wri.org/resources/data-sets/aqueduct-water-stress-projections-data.
- SHDI (SHDI Complete 4.0 (1).csv and SHDI-4.0-Vardescription (1).csv). Available at https://globaldatalab.org/shdi/download_files/
- Sub-national administrative boundary downloadable from ESCAP's APDRN web portal.

1. **Joining SHDI data with the subnational administrative boundary**
   - Download SHDI data. Extract the data for South-East Asian countries in Microsoft Excel and save as "SHDI_SEA2018.csv".
   - Add Sub-national administrative boundary "GDL_SEA.shp" and "SHDI_SEA2018.csv" in QGIS
   - Right click on "GDL_SEA" > properties > Joins…
   - Click on "+" at the bottom of the window.
   - Add the following details
     Join layer: "SHDI_SEA2018"
     Join field: GDLCODE
     Target field: GDLCode
     and click "OK"
   - Right click on "GDL_SEA.shp" > Export > Save Feature As> give the file name as "GDL_SHDI_SEA.shp" and click "OK".

2. **Creating scenario wise raster file**
   - Open Processing tool > search for Rasterize.
   - Give "GDL__SHDI_SEA.shp" as Input layer, shdi as Field to use for a burn-in value, Horizontal and vertical resolution as 0.0833.
   - Under Rasterize click on Save to a File and give name as "GDL_SHDI_SEA.tiff", and click "Run".

Population vulnerability depends on the SHDI. The higher the SHDI values, the lower the vulnerability. To estimate the vulnerability, the SDHI values are categorized as:

Category	SHDI
very high	0.8 – 1
high	0.7 - 0.799
medium	0.550 - 0.699
low	0 - 0.549

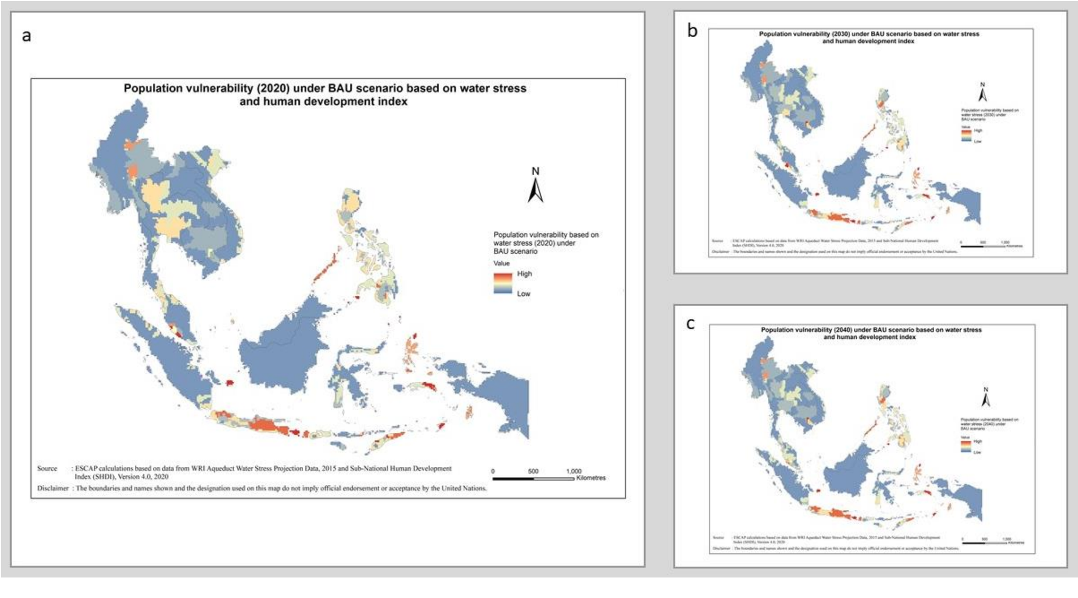
- Add “GDL_SHDI_SEA.tiff” in QGIS window.
- Open Processing Toolbox > search for Raster Calculator to create raster files for different categories of vulnerability from “GDL_SHDI_SEA.tiff” using the following expressions:
  very high (vul_veryhigh): "GDL_SHDI_SEA" <= 0.549
  high (vul_high): ("GDL_SHDI_SEA" >= 0.550) & ("GDL_SHDI_SEA" <= 0.699)
  medium (vul_medium): ("GDL_SHDI_SEA" >= 0.7) & ("GDL_SHDI_SEA" <= 0.799)
  low (vul_low): "GDL_SHDI_SEA" >= 0.8

3. Calculating population vulnerability in different water stress zones

- To identify population vulnerability in different water stress zones, multiply WS2028tl and vul_low, vul_medium, vul_high and vul_veryhigh in Raster calculator using the following expressions:
  "WS2028tl" * "vul_low"
  "WS2028tl" * "vul_ medium "
  "WS2028tl" * "vul_high"
  "WS2028tl" * "vul_veryhigh"

A similar procedure can be followed to estimate population vulnerability under future water stress conditions using ws3028tl and ws4028tl.

Figure 11 Population vulnerability under business-as-usual (BAU) scenario based on water stress and human development index in South-East Asia in (a)2020, (b) 2030 and (c) 2040



5.2.4 Identifying risk hotspots

A) Identifying hotspots of high level of malnutrition and drought occurrence in Myanmar

Sub-national Demographic and Health Survey (DHS) cluster level data provides information on different variables of population and health, and on the nutrition status of population, which can be used to identify the population that is vulnerable due to drought.

Key question

- Where are the highest percentages of severely and moderately stunted children, who are vulnerable due to drought, located in Myanmar?

Vulnerability indicator

- Demographic and Health indicator (stunting)

Data sources

- Demographic and Health Surveys (DHS) data and its geographic location data. Available at https://dhsprogram.com/data/
- Drought occurrence data from ESCAP's APDRN web portal

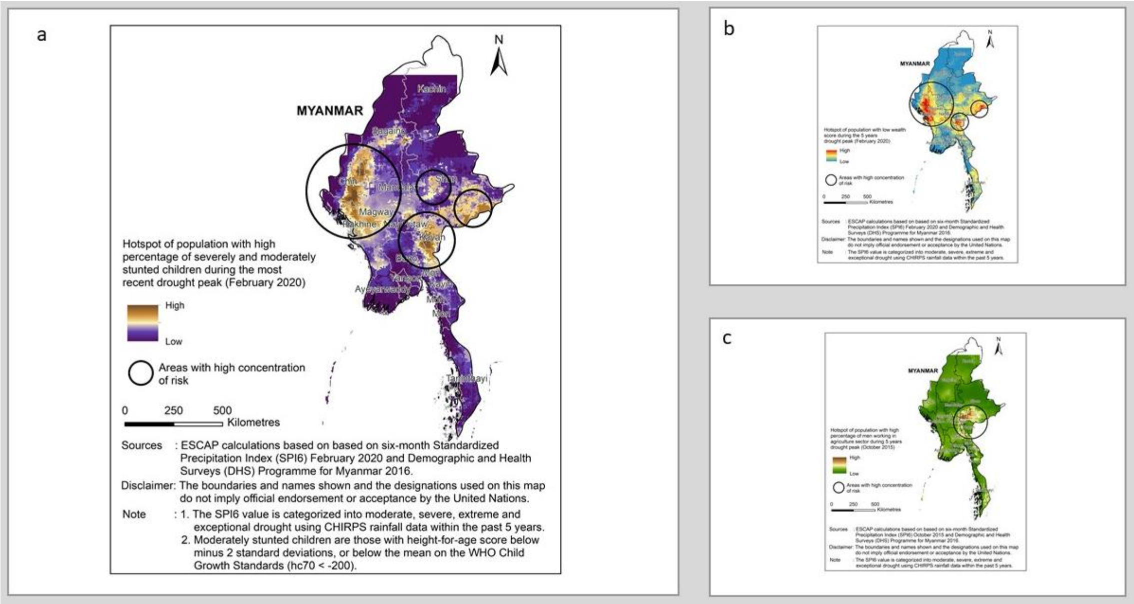
1. **Joining DHS data with the geographic location data**
   - Extract the malnutrition data for Myanmar using SPSS or any other statistical analysis platforms, and save as MM_malnutrition locate.csv.
   - Add "Myanmar.shp" and "MM_malnutrition locate.csv" in QGIS.
   - Right click on "Myanmar.shp" > Properties > Joins.
   - Click on "+" at the bottom of the window.
   - Choose "Cluster" for Join field and Target field and click "OK".
   - Right click on "Myanmar.shp" > Export > Save Feature As> give the file name as "Myanmar_malnutrition.shp" and click "OK".

2. **Interpolating the point data**
   - Add "Myanmar_malnutrition.shp" in QGIS window.
   - Open Processing Toolbox > Search for Ordinary kriging.
   - Add the following details
     Points = "Myanmar_malnutrition.shp"
     Attribute = "STUNT_MOD"
     Type of Quality Measure = Standard deviation
     Output extent = same as the point layer
     Cell Size = 0.08333 and "Run"
   - Add "MM_stunt_moderate_krig" as the output file name and save in the desired location.
   - The exposure/vulnerability data have to be weighted similarly, or equal (or 1) through normalization.

3. **Identify the risk hotspot**
   - Add "MM_stunt_moderate_krig" and drought data in QGIS window.
   - Multiply the data using Processing tools > Raster Calculator to find out the risk hotspots.

A similar method should be followed to identify the population vulnerability hotspots based on poverty and employment under agriculture.

Figure 12 Hotspots of population during the 5 years of drought peak (October 2015) in Myanmar based on (a) high percentage of severely and moderately stunted children, (b) low wealth score and (c) high percentage of men working in the agricultural sector[27]



B) Identifying hotspots of high level of agricultural employment and drought occurrence in Viet Nam

Agriculture is directly impacted by drought, and so is the population employed in the agricultural sector. Therefore, the data on employment in agriculture can be integrated with drought occurrence data to identify the hotspots.

Key question

- Where are the highest percentages of population employed in agriculture, who are vulnerable due to drought, located in Myanmar?

Vulnerability indicator

- Employment in agriculture

Data sources

- The sub-national data on employment under agriculture (.csv/ .xlsx) can be downloaded from http://www5.worldbank.org/mapvietnam/ .
- Drought occurrence data from ESCAP's APDRN web portal

1. **Joining demographic data with the geographic location data (.shp file)**
    - A unique id should be generated in vietnam.shp by adding a field in the attribute table and manually entering data based on the unique id of districts in the agriculture employment database prior to joining them.
    - Add “vietnam.shp” and “emp_agri.csv” in QGIS window.
    - Right click on “vietnam.shp” > Properties > Joins.
    - Click on “+” at the bottom of the window.
    - Choose “unq_id” for Join field and Target field and click “OK”.
    - Right click on “vietnam.shp” > Export > Save Feature As> give the file name as “vietnam_agri.shp” and click “OK”.

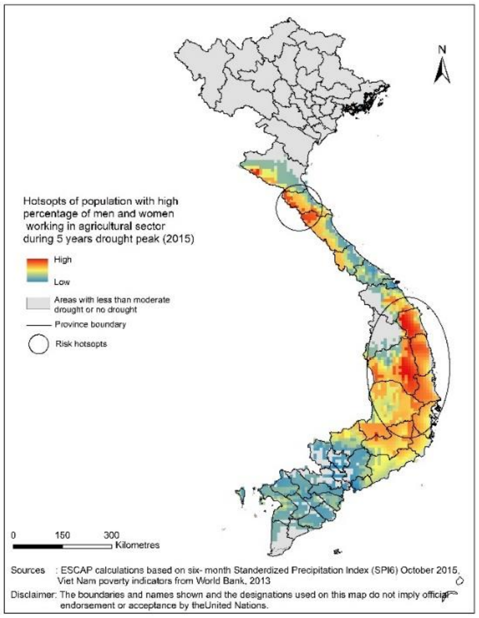
2. Interpolating the point data

- Add “vietnam_agri.shp” using in QGIS window.
- Open Processing Toolbox > Search for Ordinary Kriging.
- Add the following details
Points = “vietnam_agri.shp”
Attribute = “emp_agri_perc”
Type of Quality Measure = Standard deviation
Output extent same as the point layer
Cell Size = 0.08333 and “Run”
- Add “vet_agri_krig” as the output file name and save in the desired location.
- Normalize the output and give output file name as “vet_agri_krig_norm”.

3. Identify the risk hotspot

- Multiply “vet_agri_bessel_norm” with the drought data using Processing tools > Raster Calculator to find out the risk hotspots.

Figure 13 Hotspots of population with high percentage of men and women working in the agricultural sector during the 5 years of drought peak (2015) in Viet Nam



5.2.5 Estimating economic loss due to drought

Economic losses due to disasters is estimated through probabilistic risk models and expressed as the Average Annual Loss (AAL). It is the expected overall loss per year due to disasters, averaged over many years.[28] ESCAP has estimated the AAL for drought for South-East Asia,[29] as well as developed different drought scenarios for this region. Both data can be used to calculate the spatial distribution of losses for drought with different intensities.

Key question

- What is the spatial distribution of AAL due to drought?

Data sources

- AAL and drought occurrence data from ESCAP's APDRN web portal

Assumption:

1. AAL has been used to calculate the economic loss due to drought.
2. If the drought in 2020 continues for 7 months, it will cost 0.34 per cent of GDP,[a] which is equivalent to 45 per cent of AAL.
    - For exceptional drought, the loss is 45 per cent of AAL.
    - For extreme drought, the loss is 35 per cent.
    - For severe drought, the loss is 25 per cent.
    - For moderate drought, the loss is 15 per cent of AAL.

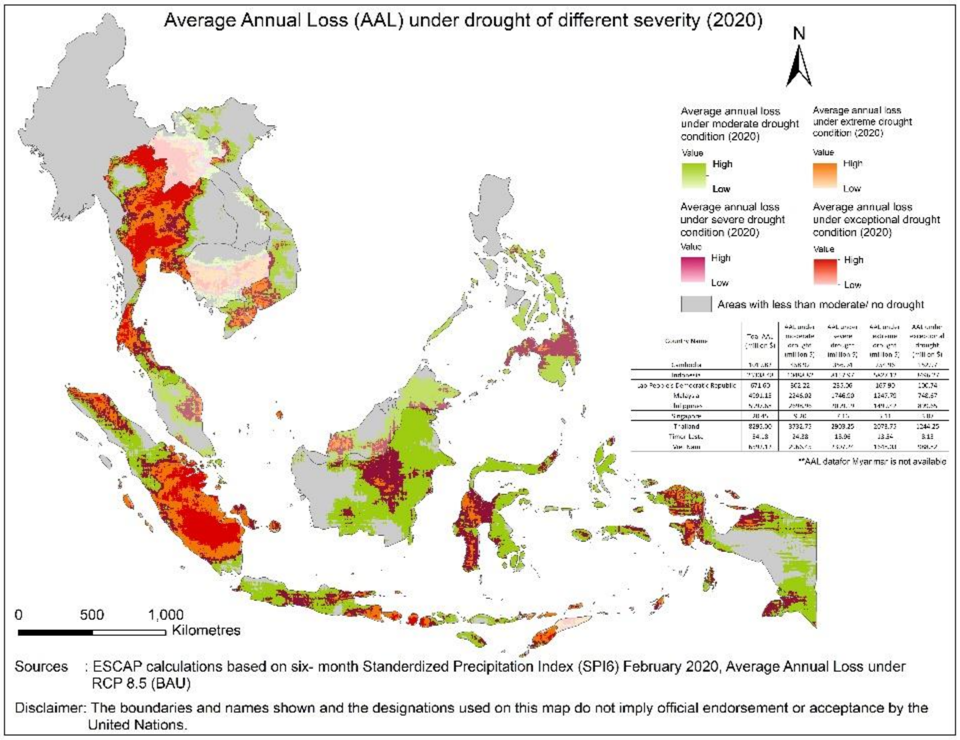
[a] Chalwat Sowcharoensuk and Chamadanai Marknual (2020).

1. **Calculating AAL for different categories of drought**
- Add "SEA_BND" in ArcMap and populate the AAL for drought data for each country in the attribute table.
- Add 4 fields in the attribute table (mod_loss, sev_loss, extr_loss, expc_loss) following the same procedure mentioned above.
- Calcuate each categories of loss using the following formulae:
  mod_loss = [Loss_m_USD] *15/100
  sev_loss = [Loss_m_USD] *25/100
  extr_loss = [Loss_m_USD] *35/100
  expc_loss = [Loss_m_USD] *45/100

2. **Creating raster files for different drought - AAL category**
- Open Processing tool > search for Rasterize.
- Input layer is "SEA_BND", Field to use for burn-in value = mod_loss.
- Give Horizontal and Vertical resolution as 0.0833.
- Under Rasterize click on Save to a File and give name as "mod_loss", and click "Run".
- Similarly create raster files for "sev_loss", "extr_loss" and "expc_loss".

3. **Calculating AAL for each categories of drought in South-East Asia**
    - Add SPI6_Feb_2020_exceptional, SPI6_Feb_2020_extreme, SPI6_Feb_2020_severe, SPI6_Feb_2020_moderate obtained from APDRN in QGIS window
    - Open Processing tools > Raster Calculator and multiply the drought data with the AAL data using following formulae:
      "SPI6_Feb_2020_exceptional" * "exp_loss"
      "SPI6_Feb_2020_extreme" * "extr_loss"
      "SPI6_Feb_2020_severe" * "sev_loss"
      "SPI6_Feb_2020_moderate" * "mod_loss"
    - Export the table in Microsoft Excel for further analysis.

Figure 14 Average Annual Loss (AAL) under droughts of different severity (2020)



This information can add value to drought management planning. Integration of more socioeconomic indicators can further enrich the tool to help make evidence-based policy decisions and management plans.

5.3 Adaptation techniques

Countries in South-East Asia have already put in place a set of drought adaptation practices that help food, water, land and ecosystem to accelerate adaptation actions. Country specific examples are already listed in the ESCAP publication entitled *Ready for the Dry Years*: Building resilience to drought in South-East Asia. Some of the examples are as follows:

Food system:

In a rainfed agricultural system, such as South-East Asia, several crop diversification measures are undertaken to cushion the crop loss due to drought events. Shifting from monoculture to a multi-cropping system, both upland cropping and integrated farming are important strategies to enhance the economic and ecological sustainability of the agricultural system. For efficient resource utilization, the System Rice Intensification (SRI) technique is undertaken, which can improve the growth of the crop together with its productivity and resilience. The stress-tolerant and short-maturing varieties of crops have been experimented successfully, in some drought prone areas, which could avoid crop loss during drought. To save crops from pest infestation due to prolonged drought conditions, Integrated Pest Management is another important adaptation tool. All these tools contribute toward building environmental resilience, developing economic resilience, ensuring nutrition security of the community, as well as promoting resource conservation.

Water system:

Integrated water resources management (IWRM) is a widely implemented mechanism which ensures a sustainable water supply to a community during the dry period, improves the socioeconomic condition of the community through alternative livelihood and enhanced climate resilience. Water accounting underpins evidence-based monitoring and early warning, builds stronger water governance, and helps in the sustainable allocation of available water. Groundwater recharge through Managed Aquifer Recharge (MAR), can overcome spatio-temporal variability of groundwater during drought conditions. Alternative Wet and Dry (AWD) and Direct Dry Seeding Rice (DDSR) technologies are effective water conservation techniques to improve the efficiency of irrigation water use without affecting the yield. Safely treated wastewater and rainwater can be the sources of multi-purpose usage of water that will help to cope with water scarcity during the dry season and strengthen drought preparedness.

Energy system:

For the energy infrastructures, Governments in South-East Asia have started to develop robust plans for risk-informed investment and climate resilient infrastructure keeping the future climate scenario in mind. Risk assessment is a critical part of this plan which will identify the critical assets and prioritize investments.

Land system:

Sustainable land-based management practices (SLM), that are identified by UNCCD, are effective for drought management and mitigation. Many South-East Asian countries have incorporated SLM in their national adaptation plans. Drought-Smart Land Management (D-SLM) is a unique framework which centres around the land-drought nexus and promotes sustainable land-based interventions as part of drought management. Spatial land-use planning can be used to monitor long-term changes in land use and land cover. Sustainable forest management is another important adaptation tool for water and soil conservation and for increasing drought resilience.

Ecosystem:

Nature-based solutions are gaining importance as drought management strategies as they enhance an ecosystem's capacity to protect the society from the impacts of drought. Ecosystem-based adaptation measures are sustainable adaptation tools for future uncertain climate conditions, have low maintenance costs and require voluntary community participation.

5.4 Dynamic drought risk assessment

Drought risk and its impacts depend on the severity and probability of the drought occurrence, the exposed assets and/or the population and its vulnerability. The variables contributing to drought risk can be of two types based on their frequency of change. Variables, such as climate, land use soil properties and socioeconomic factors exhibit significant changes in a longer time frame, generally annual to decadal, whereas other variables, such as weather, crop status and water resources require a shorter time frame, months or a season, to show detectable changes. For long-term policy planning, decision-making and investments, understanding the variables, such as the future climate change scenario or the nature of socioeconomic changes is essential, information on the drought indicators, such as weather and crop status are also important for monitoring and immediate response. Many tools are available online which can provide useful and timely information on such variables, and can guide in drought adaptation planning. Following are some examples of such online platforms of weather/climate information for different spatio-temporal scales.

5.4.1 ASEAN Specialized Meteorological Centre (ASMC)

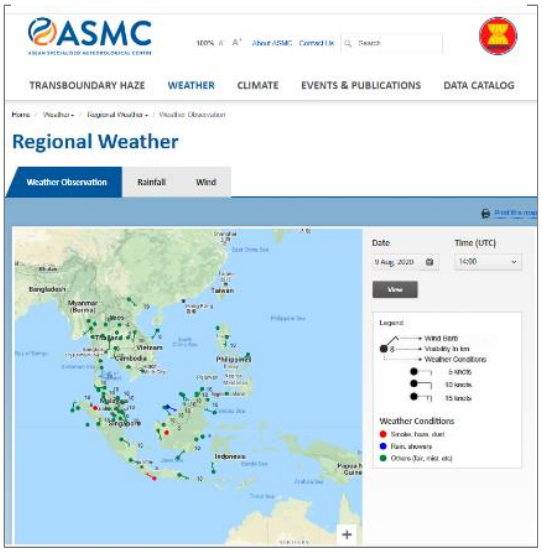
The ASMC undertakes research and development to improve scientific understanding and the prediction of significant weather and climate systems in the South-East Asia region. It has a web-based weather information system which provides:

- 12 to 72 hours forecast of surface winds
- Monthly rainfall data across South-East Asia
- Information on weather conditions, such as smoke, haze, dust, rain, showers etc.

The application can be accessed through http://asmc.asean.org/home/.

Monthly, seasonal and sub-seasonal climate outlook on precipitation and temperature for the entire South-East Asia region is published in this portal. The El Niño Southern Oscillation (ENSO) conditions are also monitored monthly and published in the website.

Figure 15 ASMC regional weather forecasting web portal

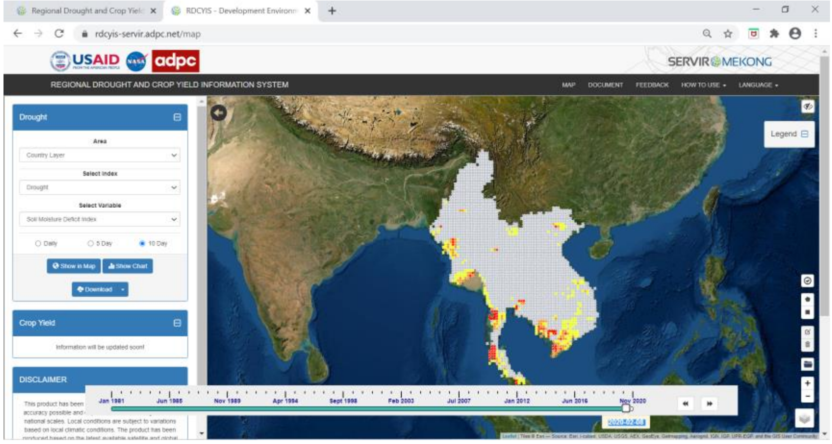


5.4.2 Regional Drought and Crop Yield Information System (RDCYIS)

The RDCYIS is an integrated web-based information system to facilitate drought monitoring, analysis and forecasting. It provides current status and seasonal forecast of drought indices in the Mekong river basin area to implement short and long-term drought adaptation and mitigation measures. The application provides information on the following drought indices:

- Standardized Precipitation Index for (1 month, 3 months, 6 months and 1 year with 1 – 10 days interval).
- Soil moisture deficit index (with 1 – 10 days interval).
- Dry spell events (with 1 – 10 days interval).
- Standardized run-off index (1 month, 3 months, 6 months and 1 year with 1 – 10 days interval).

Figure 16 Regional drought and crop yield information system by SERVIR and ADPC

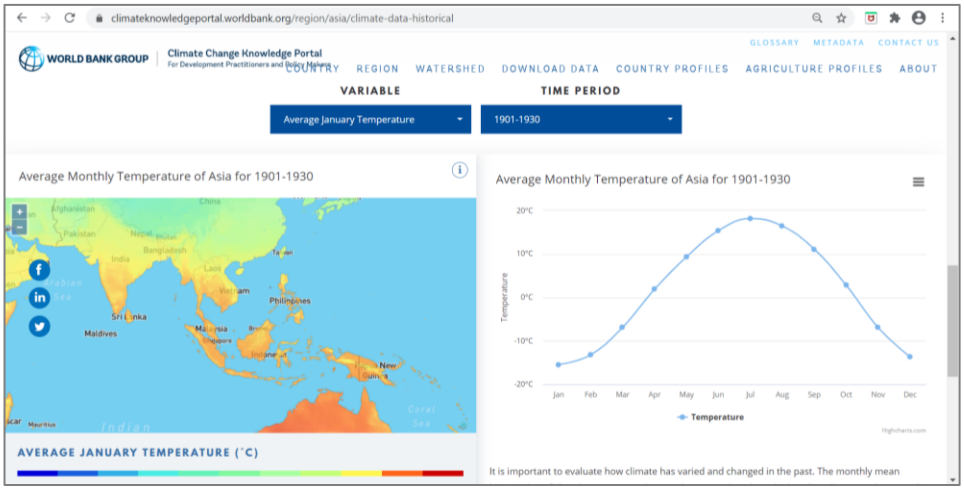


These spatial data can be downloaded in both Raster and Vector format and the attribute data can be downloaded in ".csv" or ".xlsx" format for further analysis. Interactive graphs and charts can also be generated online using the data. The application can be accessed through https://rdcyis-servir.adpc.net/map

5.4.3 Climate Change Knowledge Portal (CCKP)

The CCKP provides global data on historical and future climate variables, such as temperature and precipitation. The historical data is available from 1901 to 2016, while the future projection data is available till 2099. The data can be visualized online through maps and/or as an annual cycle chart for three different geographical extents, namely watershed, country and region. This information can be analysed at various spatio-temporal levels. The application can be access through https://climateknowledgeportal.worldbank.org/

Figure 17 Climate Change Knowledge Portal



The historical data on temperature and precipitation are presented as monthly average and annual average (annual total in case of precipitation). The future projections are expressed though several other indices of temperature and precipitation. For example, Maximum Daily Rainfall (10 - 25-yr RL), Days with Rainfall > 50mm, Summer Days (Tmax >25°C) and Hot Day (Tmax >35°C). CCKP also provides several agriculture indicators (Projected Change in Growing Season Length, Days of Consecutive Dry Spell, Days of Consecutive Wet Spell and Rainfall Seasonality) and drought indicators (Mean Drought Index, Severe Drought Likelihood, Monthly Rainfall Range and Annual Rainfall Range). These data can also be downloaded in ".xlsx" or ".csv" formats for further analysis and planning purposes.

Chapter 6: Conclusions

- **It is important to include water-food-energy nexus into the drought adaptation and planning process**

Drought impedes the overall development of a society through its long-lasting impacts on key sectors, such as water, food and energy and their associated sectors. The impacts of drought are compounded due to the complex interlinkages between water, food and energy. Therefore, drought adaptation should include a consideration of this nexus into policy planning to increase resilience against climate change and drought impacts and reduce vulnerability.

- **Multisectoral development professionals in the water, energy, environment and agriculture sector play a very important role in developing policy decisions on drought adaptation**

Policy decisions on drought adaptation should be risk-informed and evidence-based. Such decisions should also connect with the nation's climate change policy and sustainable development goals. The practical and first-hand experience of development professionals, together with their skills to identify risk and knowledge about several tools and technologies, should be utilized to develop robust adaptation guidelines and policy planning.

- **The Add-on tool is a key instrument in developing evidence on the social and economic impacts of drought in order to drive policy decisions**

Although the UNCCD drought toolbox has an extensive application in monitoring drought indicators, identifying risks and vulnerabilities and propose mitigation or adaptation measures, the add-on tools on the socioeconomic aspects of drought can enhance its analytical output and bring about socioeconomic resilience to the communities. This tool, if utilized efficiently on a case to case basis, can be instrumental in reducing the impacts of drought.

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Annexure I

Sector	Driver to develop adaptation strategy	Tools/ Data
Agriculture (Food)	Type of critical/ commercial food crops	Land cover map
	Value of critical/ commercial food crops	Land cover map
	Harvest cycle critical/ commercial food crops	
	Crop Health of critical/ commercial food crops	Vegetation indices (NDVI, VHI etc.)
	Yield and production of critical/ commercial food crops	
	Input (fertilizer/ pesticides) of critical/ commercial food crops	Statistical data on consumption
	Irrigation infrastructure	Statistical data
	Livestock (Number, type, value, fodder)	Statistical data
	Aquaculture (Number, type, value, location)	Statistical data
Water	Total renewable freshwater available	Statistical data
	Groundwater availability	Statistical data/ Groundwater map
	Seasonal variability of groundwater	Statistical data/ Groundwater map
	Water levels at rivers and reservoirs	Statistical data
	Salinity	Statistical data/ salinity map
	Water stress and scarcity	Water stress index
	Water demand and consumption – all sectors	Statistical data
	Water-use efficiency	Statistical data
	Wastewater generation and treatment capacity	Water recycling capacity
Energy	Water levels at rivers and reservoirs	Statistical data
	Location of hydropower	Statistical data and map
	Consumption and production of hydropower	Statistical data
Land	Soil type	Soil maps
	Soil moisture and variability	Soil moisture index
	Soil salinity	Soil maps
	Topography	Digital Elevation Model/Digital Terrain Model/ Slope
	Land Use/ Land Cover	Land Use/ Land Cover dynamics
	Degraded land	Land Use/ Land Cover map
Socioeconomic	Population and demography	Statistical data

	HDI indicators	Statistical data
	Employment in agriculture/ unemployment	Statistical data
	Income (inequality), farmer	Statistical data
	Agri land holdings for insurance and cash transfer	Statistical data
	Farming Households	Statistical data
	Health (undernourishment – stunting, wasting)	Statistical data
	Farmer's access to mobile phone, internet and broadband	Statistical data
	Alternative livelihood	Statistical data
Weather	Temperature	Temperature anomaly
	Precipitation (seasonal variability)	Precipitation indices (Standardized Precipitation-Evapotranspiration Index, Standardized Precipitation Index) Rainfall anomaly, rainfall in relation to stage of crop,
	Evaporation	Evaporation indices
	Pre-existing rainfall and soil moisture condition	Statistical data/ map

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