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Changing Disaster Risk Landscape due to Climate Change in ASEAN

ASEAN Socio-Cultural Community Trend Report

The ASEAN Secretariat
Jakarta

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Executive Summary

- The report seeks to provide a better understanding of the hydro-meteorological disaster trends in Southeast Asia by assessing the past hazards in Southeast Asia for both rapid (tropical cyclones/storms, floods, and extreme temperatures) and slow onset (drought and sea level rise) disasters. It assesses the data from several sources (ASEAN Disaster Information Network, the Internal Displacement Monitoring Centre, and The Emergency Events Database) to capture the pattern and trend of a particular disaster and its impact on the human and economic sector through a descriptive statistics method. This report then aims to capture the emerging trends caused by changing risk landscape on a number of displaced communities, level of food security, and affected critical infrastructures.
- In the past half a century, Southeast Asia has experienced frequent and more intense storms and heavy rainfall which caused flooding . Since 1900, at least 1,575 hydro- meteorological disasters have occurred in the region. Floods and storms were the most frequent disasters and both have shown significant increase in the past 30 years. With regard to slow onset disasters, while droughts have historically taken place every five years, some recent droughts have affected the region severely, such as in 1997-1998, 2015, and 2019. In addition, based on the World Meteorological Organization's (WMO) report, Southeast Asia is also under the threat of sea-level rise where in the period of 1993-2021 the Indochina Peninsula and the Maritime Continent experienced 3.59 mm/year and around 3.94 mm/year of area-averaged sea-level change, respectively.
- With the frequent occurrence of hydro-meteorological disaster,, ASEAN's human and economic sectors are also severely impacted. At least 202.393 casualties were recorded in the span of 32 years due to disasters, majority of which were caused by storms. Myanmar has the highest number of casualties among the ASEAN Member States (AMS) due to Cyclone Nargis in 2008, where it caused around 138,266 casualties. On the other hand, flooding is caused the most injuries in Southeast Asia. The Trenggalek floods in 1992 in Indonesia caused the highest number of people injured based on the Emergency Events Database (EM-DAT) record, followed by Typhoon Haiyan in 2013 the Philippines, and Cyclone Nargis in 2008 in Myanmar. In terms of economic impact, floods caused a total l of USD49,705,047 worth of economic damages in Thailand alone, this is the highest amount of economic damage caused by a disaster. Ranking second, the total economic losses attributed to Typhoon Haiyan/Yolanda in 2013 amounted to USD14.390.037.
- These conditions have caused several emerging trends of risks, including the risk of displacement and forced migration, risk of rapid food production loss which triggers food insecurity, and the risk of damaged critical infrastructures and disrupted operation. Therefore, it is very critical for ASEAN across sectors to accelerate action against the changing climate risk landscape by establishing robust evidence of climate change and disaster data systems, and innovating the integration of climate and disaster risk assessment. Furthermore, ASEAN also needs to accelerate the disaster risk reduction - climate change adaptation (DRR-CCA) financing, reduce the risk of investment by integrating risk information in decision making, improve political traction and commitment to DRR by strengthening communication and public advocacy, and integrate climate agenda within the DRR agenda.
- Recommendation to support the implementation of possible actions include: integrate DRR and CCA approaches or mechanisms to determine at-risk communities before a disaster occurs and deliver required assistance in a timely manner to mobilizing necessary resources and appropriate measures to address climate-disaster impacts

TREND REPORT

Trend Report on Changing Disaster Risk Landscape due to Climate Change in ASEAN

Resilient Development Initiative

1. Introduction

1.1 Background, Objectives, and Methodology

Climate-driven disasters are now threatening human systems[1] as the global warming temperature is projected to rise beyond 1.5 °C above the pre-industrial level. Hydro- meteorological disasters have increased over the past 50 years. Of 22,326 disasters in the span of 1970-2019, about half of them were caused by climatic, weather, and water hazards. They contributed to three-quarters of all reported financial losses and nearly half of all reported fatalities globally (WMO, 2021b). The Intergovernmental Panel on Climate Change (IPCC) Working Group II, in its Sixth Assessment Report, stated with high confidence that climate extreme events have escalated in frequency and severity, including heavy precipitation events, drought, and fire weather (Pörtner et al., 2022).

1 The report refer human systems to the IPCC definition: "Any system in which human organizations and institutions play a major role. Often, but not always, the term is synonymous with society or social system. Systems such as agricultural systems, urban systems, political systems, technological systems and economic systems are all human systems in the sense applied in this report. See: https://www.ipcc.ch/sr15/chapter/glossary/ (accessed on 24 July 2022)

Southeast Asia is a region prone to climate change impacts. The ten ASEAN Member States (AMS) share similar threats, vulnerability characteristics, and risk profiles. Their economies and population continue to grow significantly. To support social and economic activities, most of them gradually lost their tropical rainforest, wetlands, and other green spaces .. Consequently, it puts some regions at greater risk of hydro-meteorological disasters, such as floods and landslides. At the same time, the changing global temperature could also lead to substantial sea level rise, coastal erosion, coastal flooding, and storm surges, and these could pose more extreme risks to ASEAN Member States (AMS) as their economic growth centres are located in urban coastal areas, such as Singapore.

Continued warming temperatures would likely expose the region's human-natural systems to more threatening rapid-onset (e.g., floods and typhoons) and slow-onset climate events (e.g., sea-level rise). With that in mind, there is a need to understand the extent of the impacts of past

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hydro-meteorological disasters and to what extent these have resulted in changing the risk landscape in the region. Hence, ASEAN and AMS can learn from past experience to move forward its disaster risk reduction efforts to deal with climate-driven hazards.

This trend report aims to present the outlook of climate-driven disasters and their implications for addressing the risk landscape in ASEAN. More specifically, this report aims to answer the following objectives:

- To capture the trend of hydro-meteorological disasters in the region
- To identify impacts from previous hydro-meteorological disasters in the region
- To identify the changing climate risk landscape and existing measures to deal with hydro-meteorological disasters in the region.

This report was composed through desk study to collect and analyse data. Peer reviews, grey literature, and news articles became the sources to seek and extract the data to describe the trend in 10 AMS, including Brunei, Cambodia, Indonesia, Lao PDR, Malaysia, Myanmar, the Philippines, Singapore, Thailand, and Viet Nam. The grey literature comprised disaster recovery and reconstruction phase situation reports, government and non-governmental organisations (NGOs) project reports, newsletters, planning documents, and other relevant publications beyond scholarly publishing, including those published by ASEAN. The report included data from the ASEAN Disaster Information Network (ADINet), the Internal Displacement Monitoring Centre (IDMC), and The Emergency Events Database (EM-DAT).

This report discusses and illustrates the trend using descriptive statistics. Descriptive statistics usually sum up a given set of statistical data. Researchers use this approach to describe the basic features of the data and summarise the trend of phenomena that can be generated from a dataset. The final purpose is to present quantitative descriptions in a manageable and simple form. The data is then presented graphically, either in the form of tables, frequency distributions, and bar charts.
Content analysis was also a research tool used in this report to define the occurrence of certain words or written statements within the extracted text data from the selected publications. It examined messages, meanings, and relationships manifested in categories of the identified words that share similar meanings and then categorised them into certain themes or concepts (Drisko and Maschi, 2016). The results inferred the messages of the writer(s), and the background contexts (e.g., culture and time) surrounding the messages.

Section 2.
The Overview of Past Hydro-meteorological Disasters in Southeast Asia

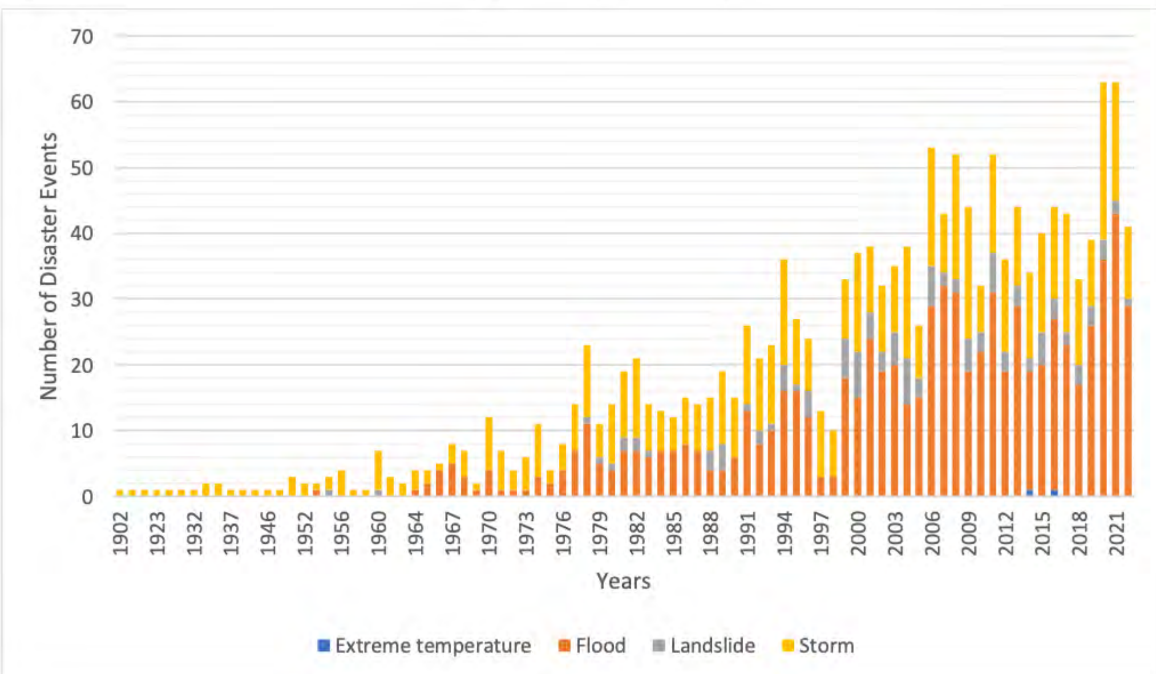
The main concern of climate change is the increase of hydro-meteorological hazard occurrences that can disrupt socio-economic activities and result in widespread impacts. Thus, this report focuses on rapid hydro-meteorological disasters, including tropical cyclones/storms, floods, and heatwaves (extreme temperature) as well as slow-onset hydro- meteorological disasters, including drought and sea level rise. This part is to better understand the trend of hydro-meteorological disasters in the region over the years.

2.1 The trend of rapid hydro-meteorological disaster events in Southeast Asia

Hydro-meteorological disasters in Southeast Asia have increased significantly over the past half a century[2] (Figure 1). There have been 1,575 hydro-meteorological disaster events in the region since 1900. The highest number of hydro-meteorological disasters ever recorded occurred in 2020 and 2021. In those years, 63 devastating events were documented. It is considered two times higher than the average of annual hydro-meteorological disasters for the past 30 years. Floods (779 events) and storms (620) were the region's most frequently reported disasters; both numbers rose significantly over the past two decades.

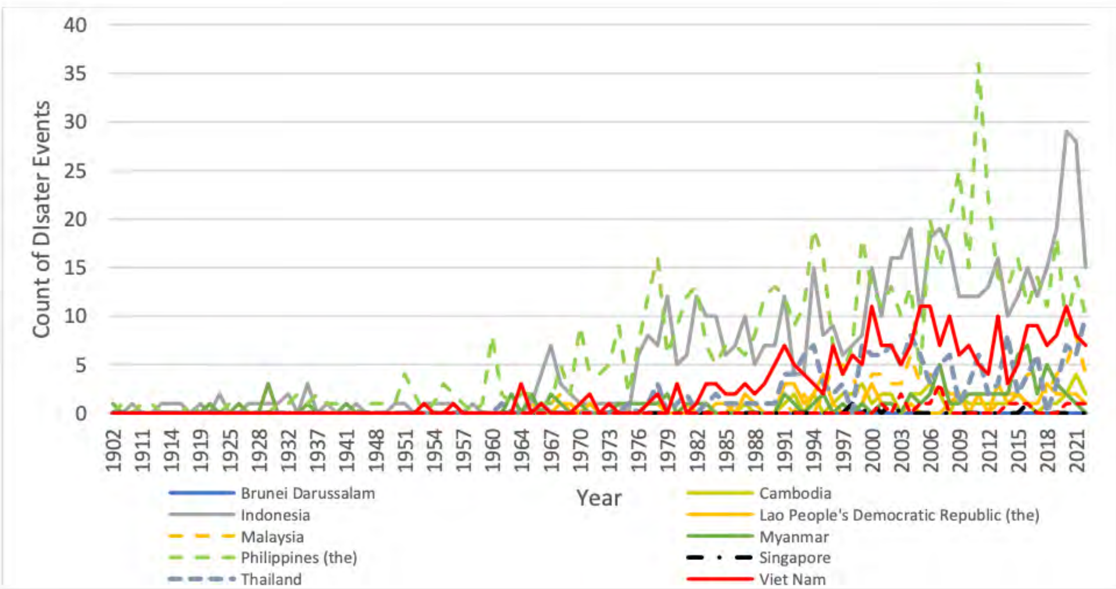
2 However, it is worth noting that the trend is also influenced by improvements that the Centre for Research on the Epidemiology of Disasters (CRED) does to update their disaster reporting and data collection in the EM-DAT. Thus, finding that situation, the report calls for a cautious interpretation of analytical results.

Figure 1. Overall trend of hydro-meteorological disaster events in Southeast Asia (1900-2021)
Source: CRED EM-DAT (accessed on 20 November 2022)



In responding to these growing threats, it is crucial to pinpoint which AMS experienced the most number of hydro-meteorological disasters over the years. Figure 2 depicts that most disaster events were reported in the Philippines and Indonesia. According to EM-DAT, both countries have recorded 679 and 600 hydro-meteorological disasters since 1900. Together with Viet Nam and Thailand, they comprised more than 80% of all disaster events during this period. Brunei Darussalam and Singapore got the least number of hydro-meteorological disasters in the same time window.

Figure 2. Trend of hydro-meteorological disaster events in AMS (1900-2021) Source: CRED EM-DAT (accessed on 20 November 2022)



This report also used data from the ADINet to identify disaster occurrences in the region from 2012 to 2022. The threats of climate-driven hazards are now concerning and alarming in the region as hydro-meteorological disasters hit 4,073 in this period (Table 1). About 2,964 floods were recorded in this period. The reported flood and landslide disaster events were from Indonesia. Meanwhile, tropical cyclones, severe local storms, and storm surges hit the Philippines the most. About 88 large tropical cyclones struck the region in this period, resulting in the most devastating losses and damages among hydro-meteorological disasters.

Table 1. The number of rapid hydro-meteorological disasters in AMS (2012-2022)
Source: ADInet (accessed on 20 November 2022)

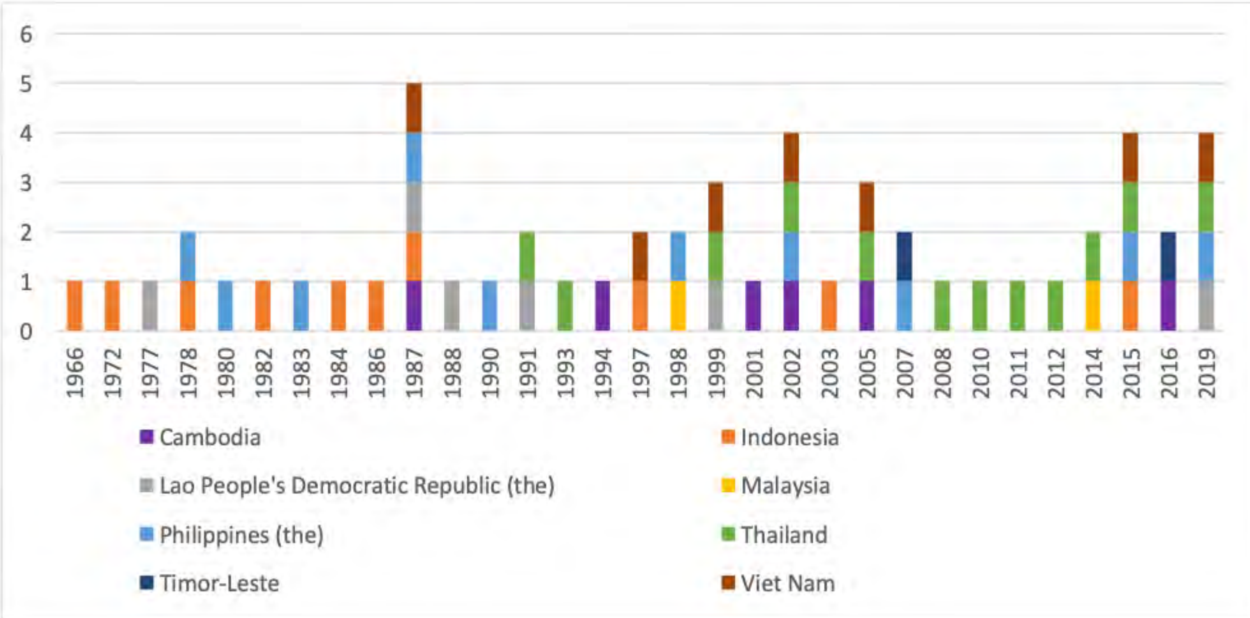
Disaster types	Flood	Landslide	Severe Local Storm and Storm Surge	Tropical Cyclone	Tornadoes	Grand Total
ASEAN	2964	159	274	88	523	4073
Indonesia	2393	116	19	2	442	3021
Philippines (the)	197	18	80	46	30	373
Thailand	122	4	74	14	14	239
Viet nam	64	10	58	15	23	171
Malaysia	131	2	5	0	1	139
Myanmar	22	8	19	3	4	57
Cambodia	18	0	14	2	7	42
Lao PDR	11	1	5	6	1	24
Singapore	3	0	0	0	1	4
Brunei Darussalam	3	0	0	0	0	3

The lowest amount of reported disasters were from Brunei Darussalam, Singapore, and Lao PDR. In the same period, the ADInet data shows that the severest flood in Brunei Darussalam happened in Tutong District in June 2018, which displaced 94 people. Singapore experienced heavy rainfall leading to flash floods in three reported locations in central and western parts of the main island on 26 June 2018 and 29 June 2018. While Lao PDR may have been one of the least reported in terms of hydro-meteorological disasters between 2012 and 2022, it nonetheless endured one of the worst floods in its history. The flood disasters in Lao PDR in 2018 showed that extensive rainfall in a short time could bring devastating impacts (The Government of Lao PDR, 2018).

2.2 The trend of slow-onset hydro-meteorological climate disasters in Southeast Asia

Droughts, especially during El Niño, have hit the region severely over the past three decaded. As indicated in Figure 3, the EM-DAT data shows that it has long suffered severe droughts every five years on average. Some drought events occurred during El Niño, such as in 1997- 1998, 2015, and 2019. Droughts in the region are frequently associated with El Niño Southern Oscillation (ENSO) events and a strong positive phase of the Indian Ocean Dipole (IOD).

Figure 3. **Overall trend of drought events in Southeast Asia (1966-2019), obtained from CRED EM-DAT (accessed on 20 November 2022)**



Thailand has been affected mainly by drought, followed by Indonesia, the Philippines and Viet Nam (Table 2). Between 2019-2022, most of the Mekong River basin experienced relatively dry conditions, including mainland Thailand and some parts of Cambodia, Lao PDR and Vietnam, because of low precipitation levels since mid 2019. The river flows have decreased to their lowest levels since the 1960s (Mekong River Commission, 2022). Meanwhile, Indonesia suffered a severe drought during the 1997-1998 El Niño. It broke the country's record for the severest drought and resulted in widespread wildfires.

Table 2. **The number of drought disasters in AMS (1966-2022)**

Source: CRED EM-DAT (accessed on 20 November 2022)

ASEAN Member States	Total Number of Reported Drought Events
Thailand	12
Indonesia	10
ASEAN Member States	Total Number of Reported Drought Events
Philippines (the)	10
Viet Nam	7
Cambodia	6
Lao PDR	6
Malaysia	2
Myanmar	0
Singapore	0
ASEAN	55

The region also faces the threat of rising sea levels. Generally, WMO (2021a) found that "*the rates of sea-level change in the Indian Ocean, western tropical Pacific region, south Pacific region and northern mid-latitude Pacific region are slightly faster than the global mean of 3.3 mm per year*". The WMO f further reported that the rate of area-averaged sea-level change over 1993-2021 was about 3.59 mm per year in the Indochina Peninsula and 3.94 mm per year in the Maritime Continent. Previously, the trends in sea level rise in the region were some of the highest observed by modern satellites (Strassburg et al., 2015).

Some observations showed that some major Southeast Asian cities have sunk below sea level due to this phenomenon, while having also experienced rapid land subsidence due to massive groundwater extraction. These included Jakarta (Indonesia), Ho Chi Minh City (Viet Nam) and Yangon (Myanmar) (Tay et al., 2022). Bangkok (Thailand) face dual threat as as over 96% of its land area lies below sea level (Wang and Kim, 2021). As a result, the confluence of coastal flooding and erosion has already led to submersion of several of these cities.

2.3 The trend of changing surface temperature and precipitation in Southeast Asia

The Sixth Assessment Report (AR6) of the IPCC Working Group (WG) 1 presents some key findings on how the Southeast Asian climate has changed over time (IPCC, 2021). These include more frequent and extreme heat and heavy rainfall events, fewer but more intense tropical cyclones, and higher sea levels (Seneviratne et al., 2021). The events of La Nina and the changes in rainfall variability that trigger rainfall frequency and intensities in their region increase the probability of flood.

The rapid rise in global average temperature influences the seasonal monsoon patterns in the region. Over the past decades, it has significantly driven monsoon rainfall variability in Southeast Asia (Loo et al., 2015). It has contributed to the extreme precipitation rate across the region, including annual and seasonal maximum daily rainfall in the Indochinese Peninsula and the east-central part of the Philippines between 1951 and 2007 (Villafuerte and Matsumoto, 2015). Monsoon land precipitation will likely increase in the region due to increasing moisture convergence by elevated temperature. In contrast, the Maritime Continent experienced decreasing trends in the frequency of rainfall. Manton et al. (2001) identified similar patterns that occurred between 1961-1998 despite the limitation of past temperature data availability in certain AMSs, including Indonesia.

In the AR6 WG 1 report, the IPCC states that the rising temperature has led to an increasing number of hot days, as well as warm nights continue to increase across Asia (high confidence) (Gutiérrez et al., 2021). A study later strengthened this finding that night-time minimum temperatures rise faster than daytime maximum temperatures (Li et al., 2022). The study also identified that the proportion of land areas affected by heatwaves has been increasing gradually in Southeast Asia. Singapore, for example, is prone to heatwaves and urban heat islands. The city suffered from extreme heatwave events 1983, 1998, 2010, and 2016 (Timbal et al., 2018). In 2016, Singapore hit a maximum temperature of 35.3°C and a relative humidity of 53%, corresponding to an apparent temperature of 43°C (Chew et al., 2021).

The ASEAN region can experience dryer conditions due to El Niño Southern Oscillation (ENSO)[3] and the Indian Ocean Dipole (IOD)[4]. The episode of El Niño in 2015-2016 was among the strongest in modern-day history. It caused extreme surface air temperatures in large parts of eastern Asia and the Pacific, leading to droughts, floods, and tropical cyclones in Southeast Asia (Thomalla and Boyland, 2017,

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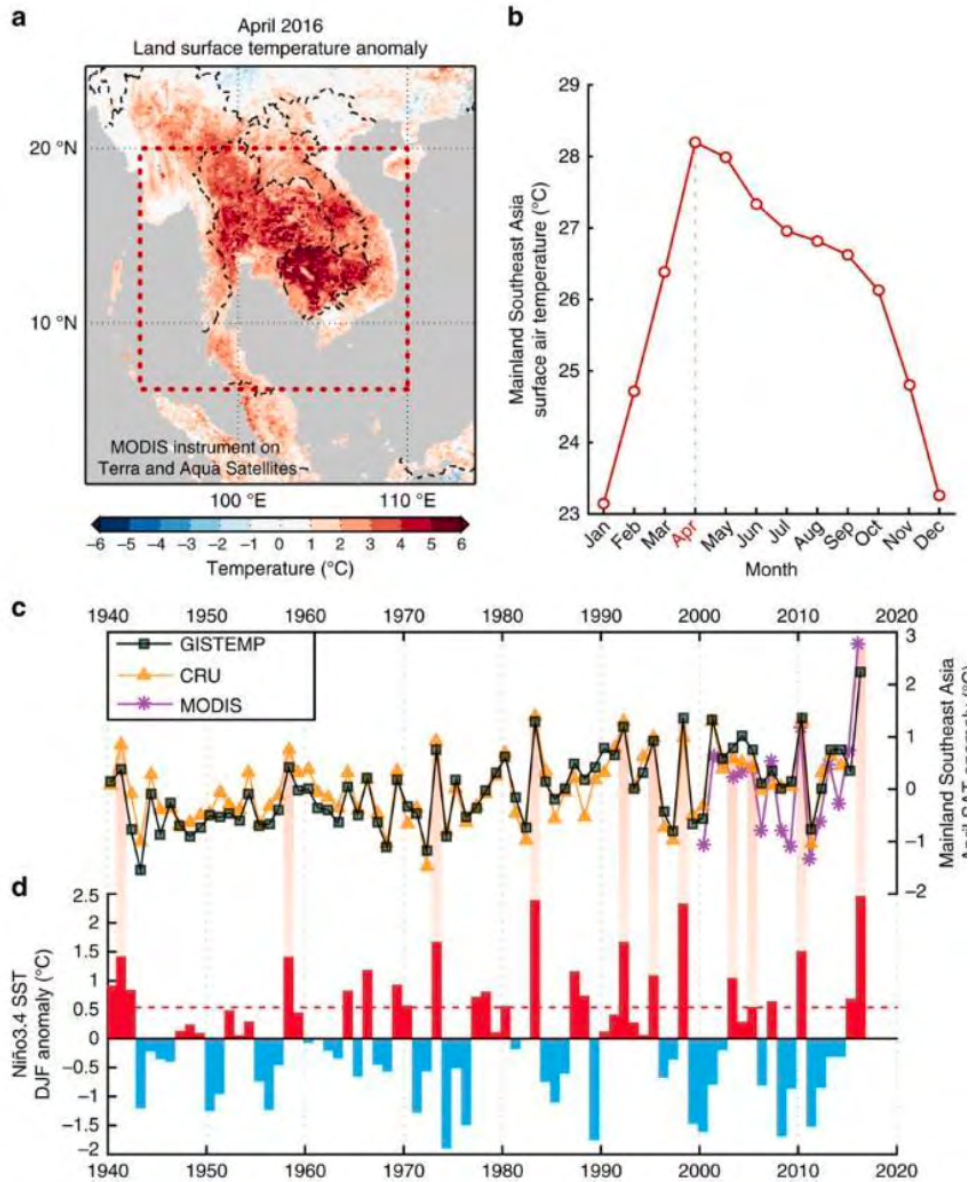
3 The El Niño-Southern Oscillation (ENSO) is a recurring climate pattern (around two to seven years) involving changes in the temperature of waters in the central and eastern tropical Pacific Ocean. El Niño and La Niña are the extreme phases of the ENSO cycle that result respectively result in the warm phase and cold phase of ENSO. See: https://www.weather.gov/mhx/ensowhat (Access on 26 July 2022)

4 The Indian Ocean Dipole (IOD) is defined by the difference in sea surface temperature between a western pole in the Arabian Sea (western Indian Ocean) and an eastern pole in the eastern Indian Ocean south of Indonesia. See: http://www.bom.gov.au/climate/enso/history/ln-2010-12/IOD-what.shtml (Access on 26 July 2022)

Thirumalai et al., 2017). Meanwhile, El Niño and positive IOD contributed to severe drought and forest and peatland fires in Borneo and Sumatra Island over the past decade (Nurdiati et al., 2022). The Indochinese Peninsula experienced an anomaly of surface air temperature in April 2016 due to El Niño (49%) and long-term warming (29%) (Thirumalai et al., 2017) (Figure 4a and Figure 4b). Figure 4c shows that the event in April 2016 topped the previous record in April 1998.

Figure 4. **Surface temperatures of Southeast Asia**

Source: Thirumalai et al., 2017)



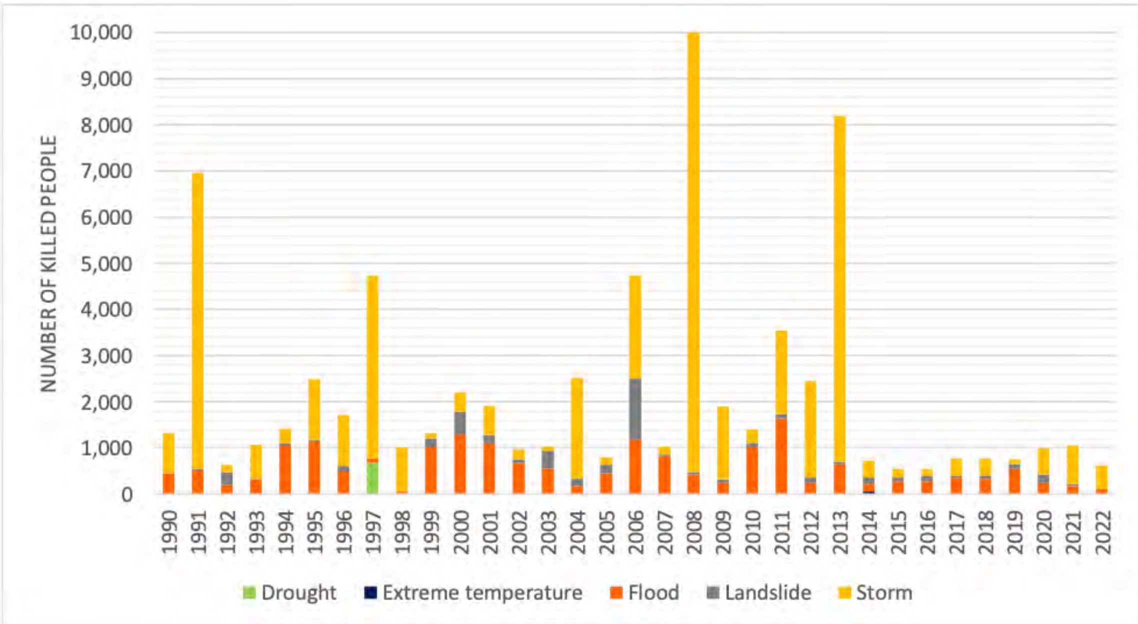
Section 3.
The Overview of Past Hydro-meteorological Disaster Impacts

This section shows the impacts of hydro-meteorological disasters in six disaster types: droughts, extreme temperatures, floods, landslides, and storms. The figures below depict the affected number of people in terms of deaths, injuries, displacement, as well as economic damages since 1990.

3.1 Human Impacts

In the past 32 years, 202,393 people were killed by hydro-meteorological disasters, including droughts, extreme temperature, floods, landslides, storms and wildfire in the Southeast Asia region (Figure 5). Storms contributed to the highest number of deaths at 178,231, followed by flood (18,305 deaths), landslide (4,768 deaths), drought (691 deaths), wildfire (321 deaths), and extreme temperature (77 deaths).

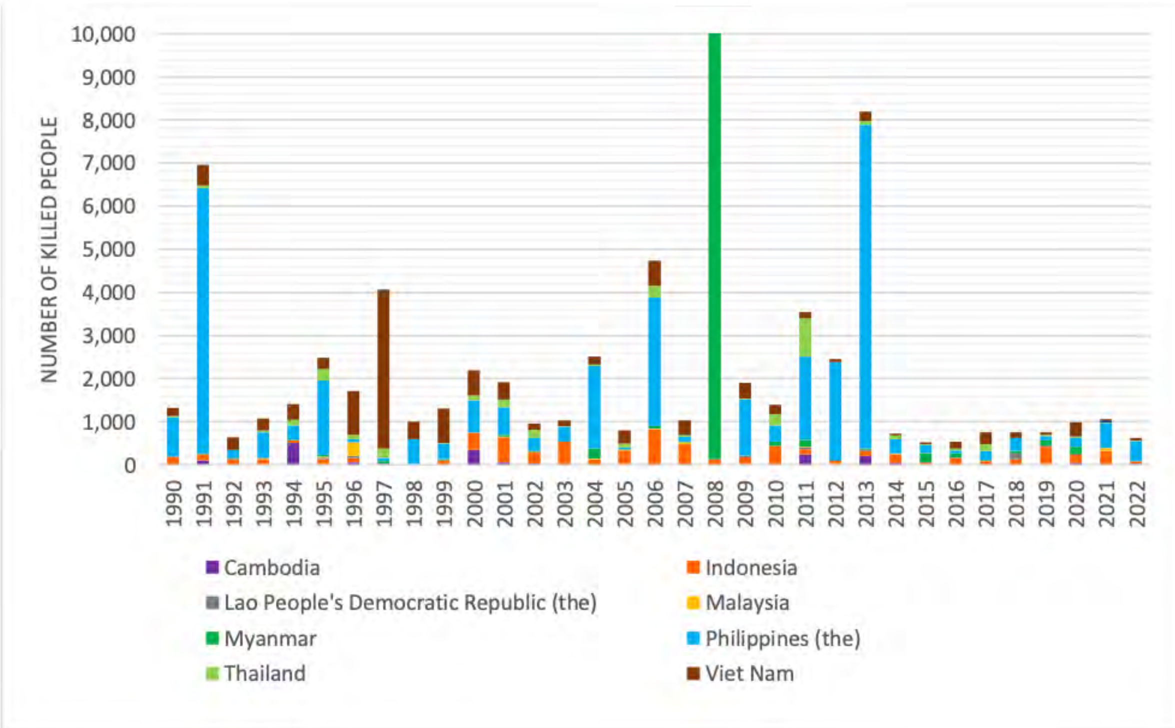
Figure 5. Number of deaths by hydro-meteorological disaster type 1990-2022
Source: CRED EM-DAT (accessed on 20 November 2022)



Storm surges and typhoons have been responsible for human fatalities for the past three decades (Figure 6). Firstly, Cyclone Nargis (2008) struck Myanmar and claimed 138,000 lives. Secondly, Typhoon Haiyan, mainly known by the Philippines as Typhoon Yolanda, hit the Philippines on 8 November 2013 and became the strongest typhoon ever recorded in world history, with a wind gust reaching its highest speed at 320 km/hour (AHA Centre, 2014). Typhoon Haiyan had a devastating impact, resulting in substantial damage and loss of 6,300 lives. Thirdly, Typhoon Thelma, known in the Philippines as Typhoon Uring, struck in 1991 and tragically claimed the lives of more than 5,000 people.

Figure 6. **Number of deaths by hydro-meteorological disaster per AMS 1990-2022**

Source: CRED EM-DAT (accessed on 20 November 2022)



Meanwhile, the deadliest flood in the region occurred in 2011 when severe flooding hit mainland Southeast Asia during the 2011 monsoon season. The highest death toll was in Thailand (567 deaths), while floods also struck Cambodia (248 deaths), Viet Nam (85 deaths), Lao PDR (30 deaths) and the Philippines (102 deaths) (Torti, 2012).

The most devastating landslide in the region occurred in 2006 in the Philippine province of Southern Leyte. The main causes were a 10-day period of heavy rain and a minor earthquake. The local authorities of the Philippines managed to recover 51 deceased individuals, and 951 persons were identified by the residents of the village as having been buried alive during the landslides (Luna et al., 2011).

Many people in Southeast Asia were affected by hydro-meteorological disasters, especially between 2006 and 2013 (Figure 7). Several severe disasters occurred during that time, including Cyclone Nargis, the 2011 Thailand Flood, and Typhoon Haiyan. In total, around 413,778,158 people were affected by hydro-meteorological disasters during this period. The Philippines has been significantly impacted by climatic disasters, affecting a substantial portion of its population. Over the last 32 years, at least 199,025,713 of its communities have experienced disruptions due to disasters, making it the country with the highest proportion of affected population among the other AMS. It is followed by Thailand (101,896,274), Viet Nam (57,107,795) and Cambodia (23,579,728).

Figure 7. **Number of injured persons by hydro-meteorological disaster per AMS 1990-2022**

Source: CRED EM-DAT (accessed on 20 November 2022

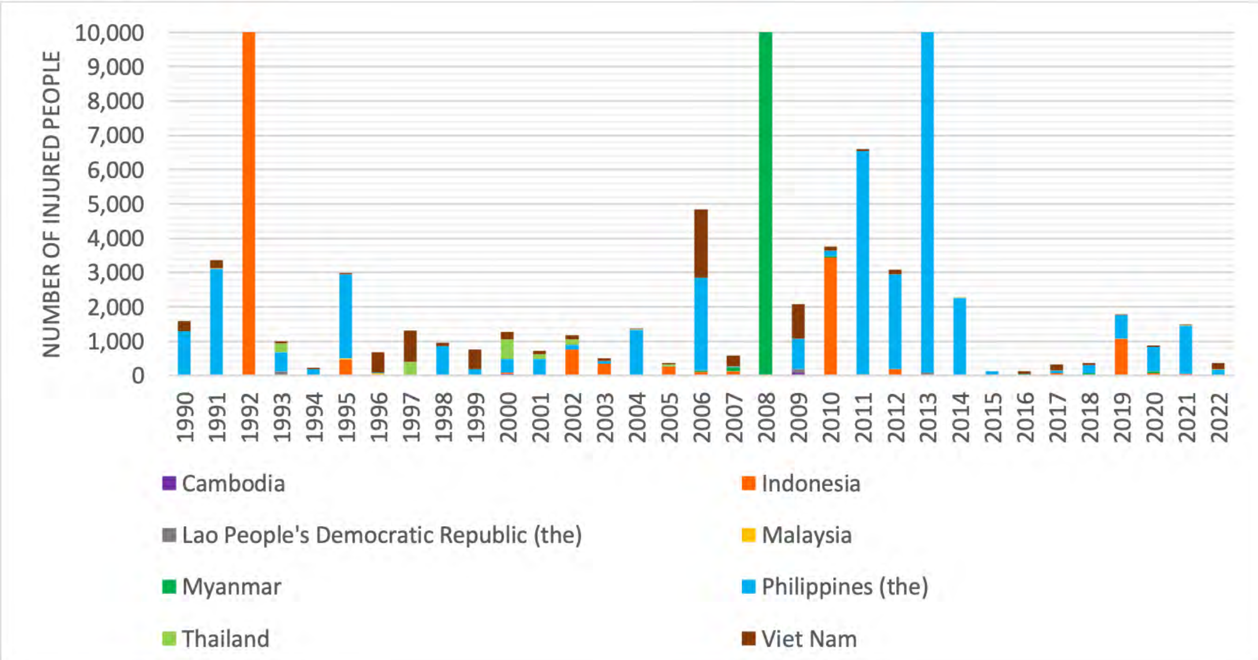


Figure 8 shows the total number of affected communities by hydro-meteorological disasters, including storms (201,004,715 people were affected), floods (141,365,810 people were affected), and drought (66,055,129 people affected). Among hydro-meteorological disasters, landslides are the least impactful to the population since they only affected around 908,540 people in 32 years. Among AMS, in 2013, at least 32,851,094 people were affected by floods and storms. The Philippines hit the highest number, with 22,415,992 affected mainly by storms. Meanwhile, the others were from Viet Nam (4,121,350 people), Thailand (3,500,000 people), Cambodia (1,500,000 people), Lao PDR (574,176 people), Indonesia (591,276 people), Malaysia (75,000 people), and Myanmar (73,300 people).

Figure 8. Number of affected people by hydro-meteorological disaster type 1990-2022

Source: CRED EM-DAT (accessed on 20 November 2022)

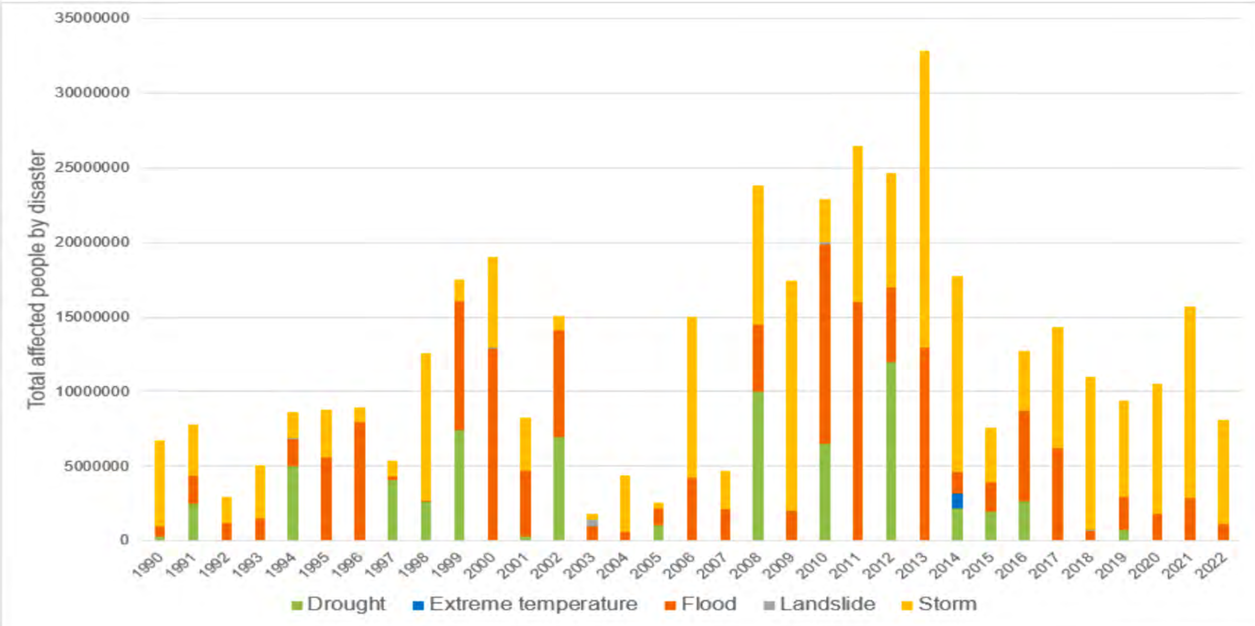
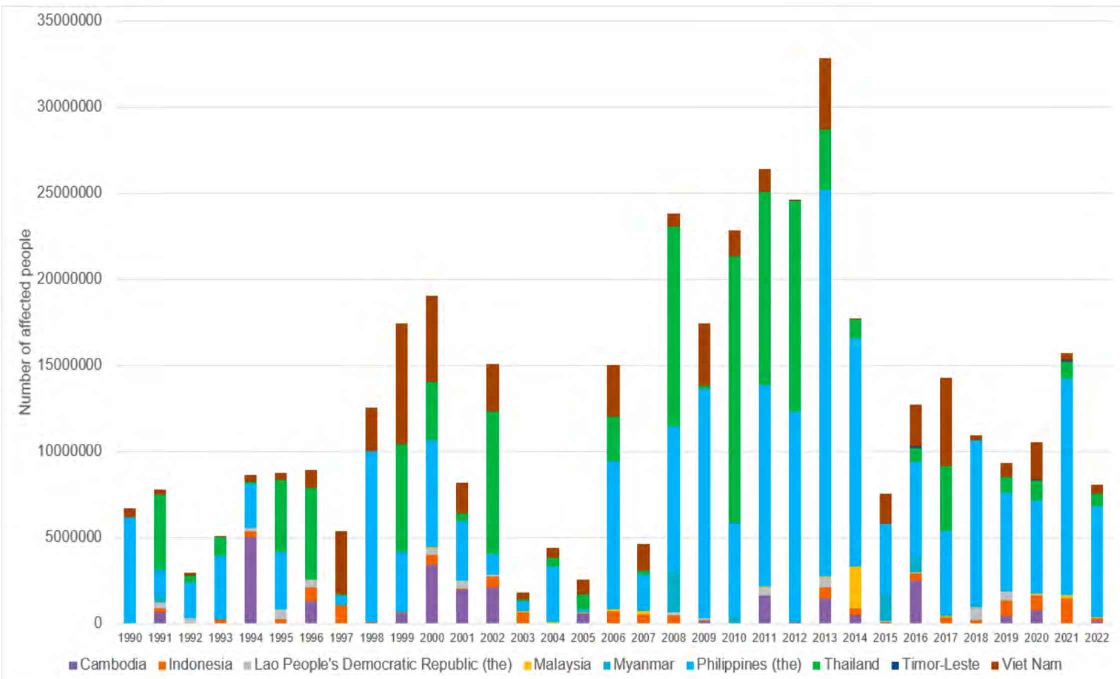


Figure 9. Number of affected people by hydro-meteorological disaster in Southeast Asia 1990- 2022

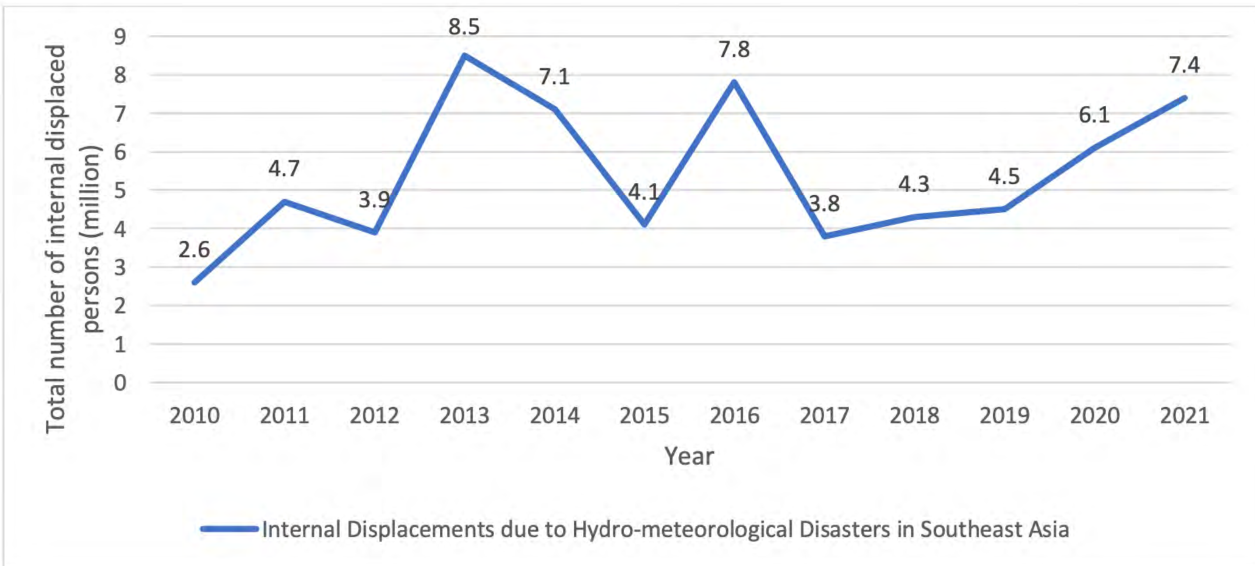
Source: CRED EM-DAT (accessed on 20 November 2022)



The devastating impacts of hydro-meteorological disasters extend to the destruction of housing, leading to the displacement of communities. Figure 10 represents the total number of Internally Displaced Persons (IDPs), as of the end of the year, or it could be understood as the total number of people living in a situation of displacement as of the end of the reporting year. According to the IDMC, between 2008 and 2021, hydro-meteorological disasters displaced 77,4 million of Southeast Asia's population(Figure 10) (IDMC, 2022). The displacement by storms contributes the highest proportion to the number of displaced persons. Storms and floods caused at least 52 and 20 million people to be displaced, respectively. The Philippines has the highest proportion of displaced persons among other countries in Southeast Asia in this period (53 million displaced people).

Figure 10. Internal displacements due to hydro-meteorological disasters in Southeast Asia (2010-2021)

Source: IDMC (accessed on 20 November 2022) (IDMC, 2022a)



3.2 Economic Impacts

According to Figure 11 and Figure 12, floods are frequent disasters throughout the year. Floods ranked as the leading cause of economic damage, resulting in a total of USD49,705,047 economic losses for Thailand. Specifically, the Thailand flood of March 2011 in Thailand, triggered by incessantly heavy rainfalls across many areas, led to unprecedented flash floods across most of the southern provinces. This was followed by Typhoon Haiyan/Yolanda in 2013, which resulted in a with a total economic loss USD14.390.037 (Government of Thailand, 2011).

Figure 11. Number of total damages by hydro-meteorological disaster type 1990-2021, obtained from CRED EM-DAT (accessed on 20 November 2022)

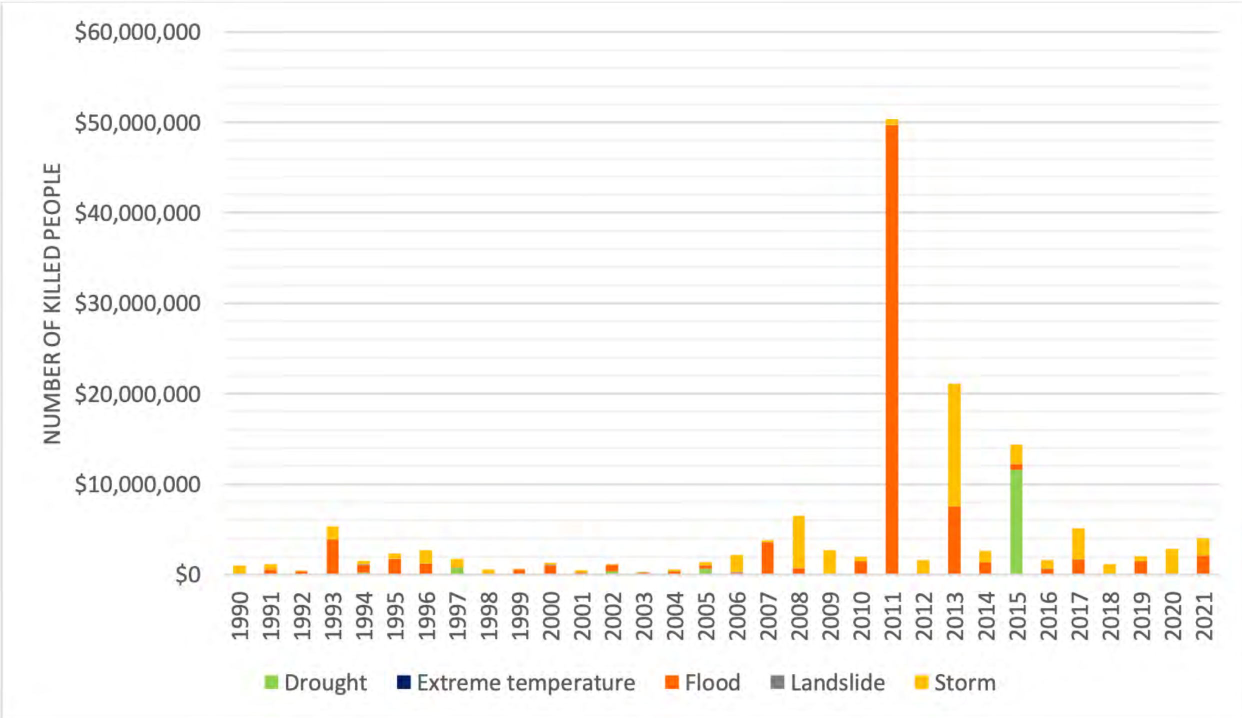
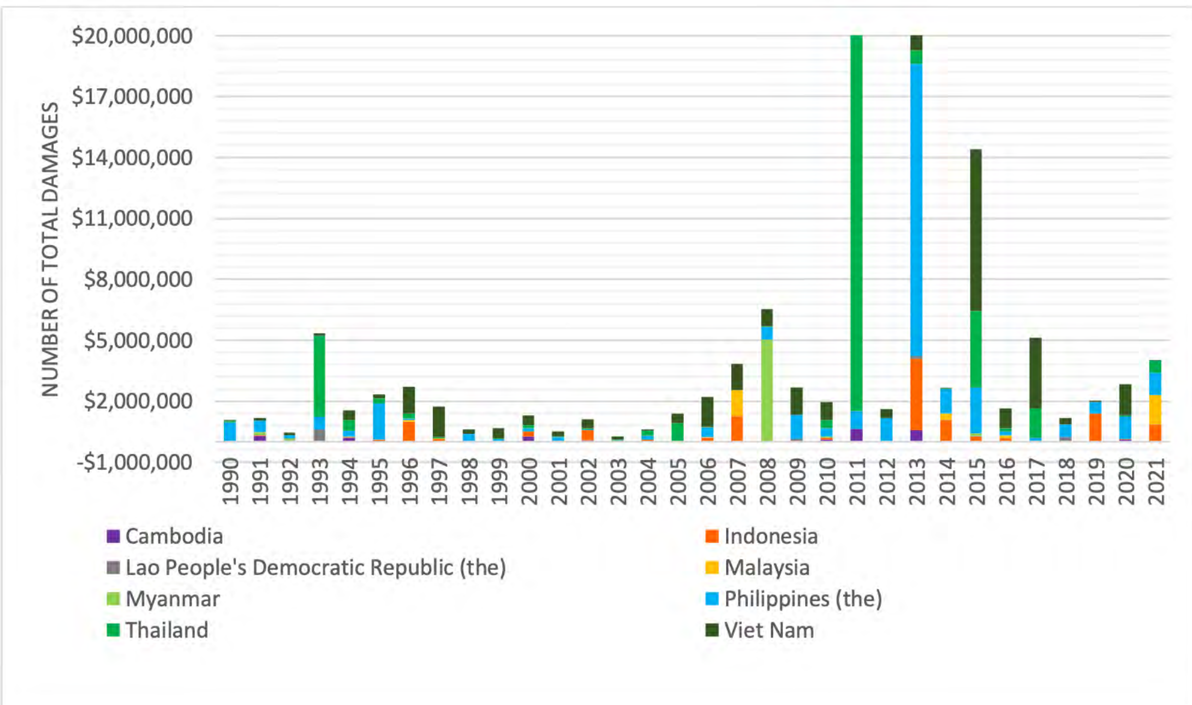


Figure 12. Number of total damages by hydro-meteorological disaster per AMS 1990-2021



Below are several cases of different hydro-meteorological disasters that occurred in the past decade that severely impacted AMS that can be highlighted. These include flood disasters in Lao PDR in 2018, the 2013 Typhoon Haiyan/Yolanda disaster in the Philippines, and the drought disasters in Java Island, Indonesia, between 2012-2022.

The 2018 Lao PDR Flood

In 2018, Lao PDR experienced heavy flooding within a month of heavy rainfall and two tropical cyclones: Tropical Storm Son-Tinh (18-19 July) and Tropical Storm Bebinca (17-18 August). This event was the most devastating flood in this century in the country. The floods struck 17 provinces, including Vientiane, encompassing 90 districts. The event resulted in 56 fatalities, 35 people missing, 2,400 villages and 126,736 households. About 1,620 houses and 102,481 hectares of land were destroyed The Government of Lao PDR, 2018 #49}(The Government of Lao PDR, 2018).

The Government of Lao PDR (2018) reported that the overall cost of the damage was about USD371.5 million, or equal to 2.01% of Lao PDR's projected GDP in 2018. The major damages were physical infrastructure and assets, reaching approximately USD 147 million, which became the largest part of the recovery cost. Agriculture and transport were the most heavily affected economic sectors. Transportation, which includes roads, bridges, transportation services, and government buildings, accounted for the largest share of the overall damages at 65.6%. Meanwhile, agriculture, including the sub-sectors of crops, fisheries, livestock, forestry, and irrigation, experienced more than half of the total losses.

Typhoon Haiyan in 2013, the Philippines

Typhoon Haiyan made a devastating impact, causing extensive damage to both lives and property, with estimated damages totaling over USD 142 million, and resulting in the tragic loss of approximately 6,300 lives. The most considerable damage and loss were in the infrastructure sectors (NEDA, 2013). The electricity sector was hit the hardest by Typhoon Haiyan, with 76% of electricity damaged. At least 40 airports and many ports were damaged in the transport sector. More than 6,700 km of national primary arterial roads and eight bridges were also affected. In the infrastructure sector, there were 19 reported damages to the water supply system, although the damage suffered was relatively minor, and the main damages were only in the water sources, reservoirs, and pipelines.

In the economic sector, more than 600,000 hectares of agricultural land were affected, and around 1.1 million metric tons of crops were estimated to be lost. Coconut was the most damaged commodity, with more than 441,517 hectares affected, followed by rice and corn commodities. Meanwhile, the fisheries and livestock sectors suffered a loss of USD 626 million. For the industry and service sectors, at least 80% of business sectors were affected in Eastern Visayas, followed by 58% in Western Visayas, 30% in Central Visayas, and 20% in Palawan and Occidental Mindoro regions.

The Philippines also suffered from losses in the social sector. The estimated total value of damage and loss in the social sector was more than USD 8,204 million, which affected education, health, and housing infrastructure (NEDA, 2013). Around 2,905 elementary and

470 middle schools were affected, resulting in more than 5,800 classrooms being completely damaged, roughly estimated to equate to USD 377 million loss. Eastern Visayas suffered the most significant damage to educational facilities. In terms of health facilities, the disaster caused a total loss estimated at USD 56.5 million due to the demolition, deployment of medical teams, and injury treatment.

Drought in Java Island, Indonesia

There were 442 cases of drought events in Java reported from January 2012 to July 2022 (BNPB, 2022). The worst events happened in 2015 and 2019 (BNPB, 2015). In 2015, El Niño together with a positive IOD inflicted drought not only in most parts of Java but also in other islands such as the southern part of Sumatra, Bali, West Nusa Tenggara, and East Nusa Tenggara (Lestari et al., 2018). A similar event was repeated in 2019 due to the same cause (Siswanto et al., 2022). Although there is no official report on the losses and damages, both events caused significant negative impacts on the agricultural sector. The Provincial Plantation Agency of Central Java reported crop failures in more than 6,500 hectares of land in northern parts of the province in 2015 (The Jakarta Post, 2015). The drought disrupted the cultivation of rice, corn, and soybean in 29 out of 35 regencies/cities in the province. As a result, those who worked in the agriculture sector experienced productivity loss although some benefitted from the situation, such as salt farmers and fishermen due to cooler sea surface (National Geographic, 2015).

Section 4.
The Emerging Trends of Changing Risk Landscape

The report reviews three emerging trends of climate risks in Southeast Asia that IPCC (2022, p. 22) also highlighted in other parts of the world: displacement and forced migration, food insecurity, and critical infrastructure damage. Some of them have already emerged from past disaster events in the region.

4.1 Risk of widespread displacement and forced migration

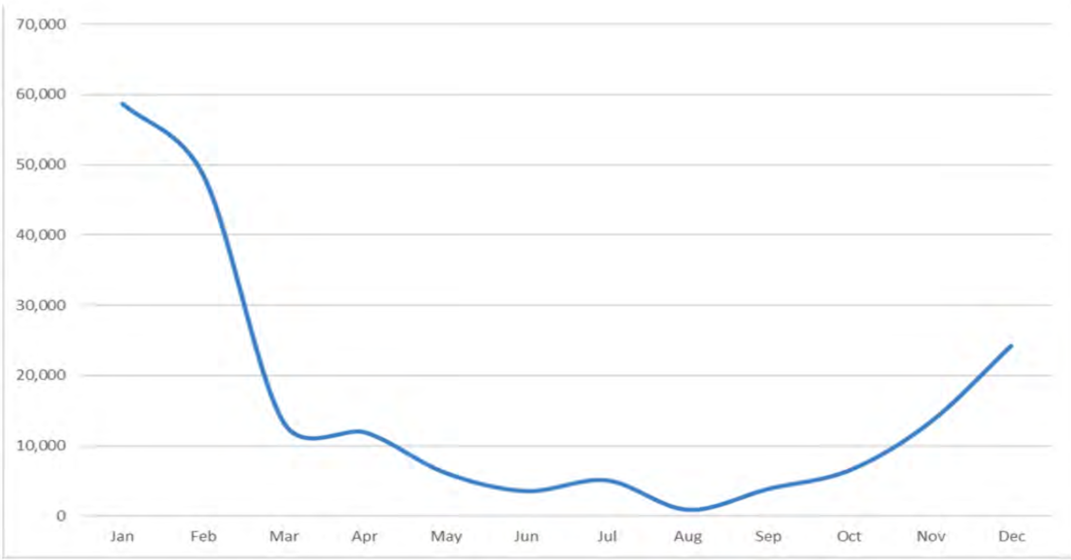
The earlier part of this report shows that weather-related disasters have caused increasing forced displacement in Southeast Asia. Hence, it is about losing their destroyed homes and other assets, such as agricultural land. Being displaced means leaving to seek a new place to live or relying on assistance, often in temporary accommodation where access to education or services is limited.

As climate change increases hazard levels, the possibility of displacement is increasing as well, especially in communities living in low-lying and coastal areas. They are prone to recurring floods, storms or droughts. In urban areas, the increased risk is also caused by factors related to poverty, urbanisation, and declining environmental conditions to support physical, economic and social development. The rapid urbanisation of Southeast Asia has led to the conversion of green spaces such as wetlands and forests, into urban built-up areas.

The combination of the above processes exposes city dwellers and their assets to climate hazards. Some major cities in the region have witnessed and experienced forced displacements and migration due to floods and sea level rise. For instance, the Government of Jakarta relocated informal dwellers around the Pluit reservoir in Northern Jakarta after the 2013 Flood to dredge the reservoir and extend its water body area. Between 2014 and 2016, the government resettled more than 5,725 households and 5,379 small and medium size businesses from 12 slum areas to mitigate flood risks (Chew et al., 2021). In addition to these, the city also faces other threats: sea level rise and land subsidence.

In general, IDMC noted that flood disasters have displaced more people in Indonesia than any other natural hazard. Between 1990-2021, most flood-driven displacements started in October and declined around March (Figure 13). It peaked around the end of the year and the beginning of the year when the highest rainfall tends to be recorded when precipitation level is high.

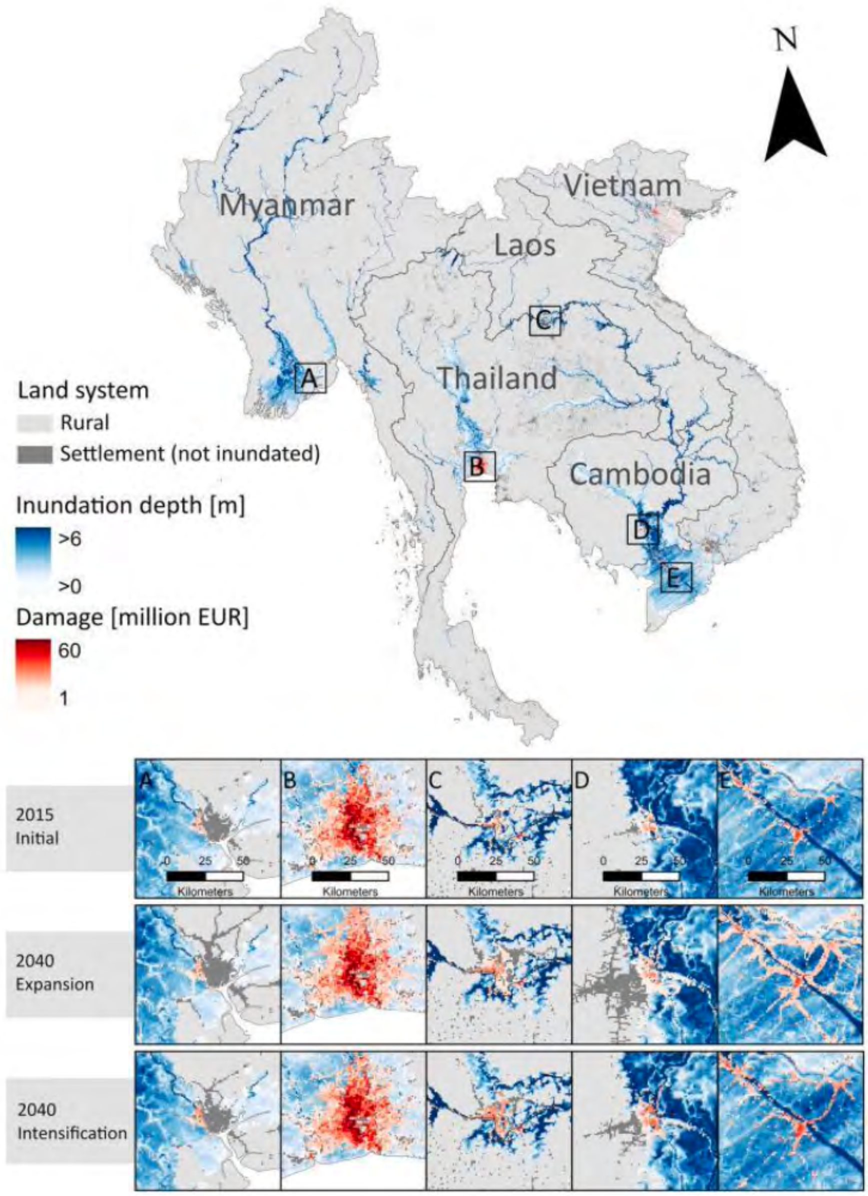
Figure 13. Frequency of displacement per month due to floods in Indonesia (1990-2021)
Source: (IDMC, 2022b)



Other big cities in the region also encounter similar challenges, and the risks of being displaced due to floods are expected to be more significant in the next few years, including those in the mainland of Southeast Asia. Tierolf et al. (2021) assessed river flood risk in five big cities in mainland Southeast Asia (Figure 14). According to their research, extensive settlement development and urban area expansion are estimated to worsen the depth of flood inundation and increase flood damage in the cities.

Additionally, the risks of forced displacement can also be experienced by those living in rural areas due to extreme temperatures and weather-related disasters. To illustrate, it is likely for families of small and medium-sized farms in the Upper and Lower Mekong Region that experienced more climate impacts to have more family members who migrated out from their villages. arvest failure due to flood and drought, decrease in the land surface due to erosion, and declining land productivity due to water salinisation and soil degradation could influence their decision to migrate (Jullien et al., 2022, Nguyen and Sean, 2021).

Figure 14. Estimated flood damage maps for a 10-year return period for the entire study area as well as for a. Yangon, b. Bangkok, c. Vientiane, d. Phnom Penh, and e. Can Tho (Tierolf et al., 2021)



4.2 Risks of food insecurity: rapid food production loss

Previous disasters have shown an example of how such disturbance can pose risks to the loss of agricultural production and disturb farming communities. These disruptive events, whether slow-onset or rapid-onset,have far-reaching impacts across various sectors. The El Niño years affected agriculture production in the region. For instance, Thailand's annual rice production decreased by about 20 million tons between 2014 and 2016 due to droughts strongly driven by El Niño (Limsakul, 2019). Sudden food production losses caused by heat and drought will not only lead to increased food prices but also result in reduced household incomes within the agricultural and fisheries economic community. Crop failures can also affect demand and supply in the agribusiness supply chain and thus impact market prices. For example, farming households reported increased food prices in Central Java due to droughts in 2012 (Fedele et al., 2016). They could not fulfil their needs from their production and were forced to buy food stocks.

The increasing frequency and severity of hydro-meteorological disasters will challenge the sustainability of the food production system because the agriculture sector highly relies on climate conditions. Tangang et al. (2020) projected changes in seasonal mean precipitation relative to the historical period 1976-2005 for the mid and late twenty-first century. In their models, there will be increases in mean rainfall (10-20%) projected throughout the twenty-first century over Indochina and the eastern Philippines during December, January and February, especially in northern Thailand, Lao PDR and northern Viet Nam. On the other hand, warmer conditions slightly prevail over the Maritime Continent. Their model suggests that during June, July and August, the region's mean rainfall may decrease by as much as 30%, especially over the Maritime Continent, by mid and end of this century.

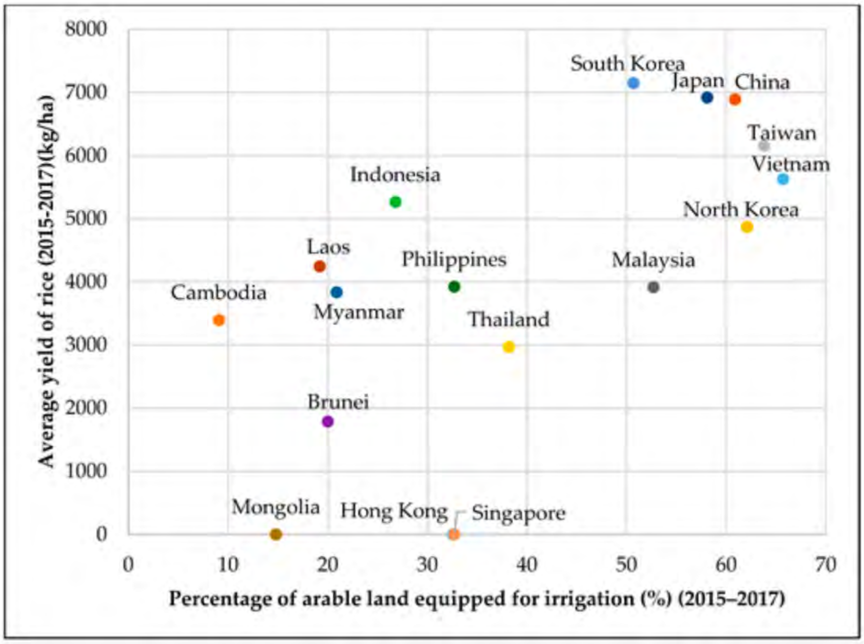
Moreover, climate factors are not the only influencing factors. The Southeast Asia region has experienced a significant decline in the availability of freshwater resources per capita from around 12,000 cubic metre per capita in 2000 to approximately 8,000 cubic metre per capita in 2018 (FAO, 2021). Table 3 depicts the trend per country (Ismail and Go, 2021). Aside from the variability of climate and river basin size, water availability from river basins is decreasing due to the significant population growth in urban areas along rivers. It causes river pollution and potential land subsidence due to the extractive use of groundwater. Attention is drawn to countries such as the Lao PDR and Cambodia where below 80% of their population have access to adequate sanitation facilities and water sources.

Table 3. **Trend of freshwater resources in ASEAN (Ismail and Go, 2021)**

Region	Internal renewable freshwater resources			Access to improved water source			Access to improved sanitation facilities			Urban population		
	Per capita m³/year			% of total population			% of total population			% Growth		
	2011	2013	2014	2010	2012	2015	2010	2012	2015	1990 - 2011	2012 - 2013	2013 - 2014
Brunei Darussalam	20,939	20,345	20,364	-	-	-	-	-	-	2.2	1.8	1.8
Cambodia	8,431	7,968	7,868	64	71	76	31	37	42	2.1	2.7	2.6
Indonesia	8,332	8,080	7,935	82	85	87	54	59	61	2.5	2.7	2.7
Lao PDR	30,280	28,125	28,463	67	72	76	63	65	71	4.7	4.9	4.6
Malaysia	20,098	19,517	19,397	100	100	98	86	96	96	2.5	2.7	2.5
Myanmar	20,750	18,832	18,770	83	86	81	76	77	80	2.5	2.5	2.5
Philippines	5,050	4,868	4,832	92	92	92	74	74	74	2.2	1.3	1.3
SIngapore	116	111	110	100	100	100	100	100	100	2.1	1.6	1.3
Thailand	3,229	3,350	3,315	96	96	98	96	93	93	1.7	3	2.9
Viet Nam	4,02	4,006	3,961	95	95	98	76	75	78	3.1	3.1	3.0

The availability of the region's agriculture infrastructure is key to ensuring water resources, especially during the dry season. As the leading global rice exporter, the region heavily relies on irrigated rice production as a critical input in its agricultural system. Lin et al. (2022) found a positive relationship between the percentage of arable land equipped for irrigation and the average rice yield. Higher arable land with irrigation is in-line with a higher average yield of rice production, and, as a comparison, the stronger association was found in South Korea, Japan, and Taiwan between 2015-2017, where their topography is highly diverse and lacking in extensive flood plains or river deltas (Figure 15). In Southeast Asia, farmers usually receive water from rainfed and deep-water rice ecosystems. As the water supply tends to be uncontrolled in the region, it is prone to the risk of losing rice production due to drought and even flood inundation.

Figure 15. Relationship between the percentage of arable land equipped for irrigation and the average yield of rice (2015-2017) in East and Southeast Asian economies (Lin et al., 2022)



4.3 Risks of critical infrastructure damage and operation disruption

The increasing frequency and severity of hydro-meteorological disasters are expected to expose critical infrastructures more frequently. These critical infrastructures include energy, transport, water, and health systems, forming the essential backbone to bolster the resilience of communities, especially in times of emergency. Previous regional disasters have shown how climate-driven threats tested the extent to which critical infrastructure can maintain its functions and even not cause another disaster to communities. For instance, the occurrences of flood disasters in the Lao PDR in 2018 show that extensive rainfall in a very short time could exceed human systems' current capacity to cope. The series of torrential rain caused a dam collapse in 2018. It led to a flash flood and destroyed houses and farmland in Sanamxay District in Southern Lao in July 2018. About 3600 villagers were still living in temporary shelters and struggling to get permanent housing as of July 2021(RFA, 2021).

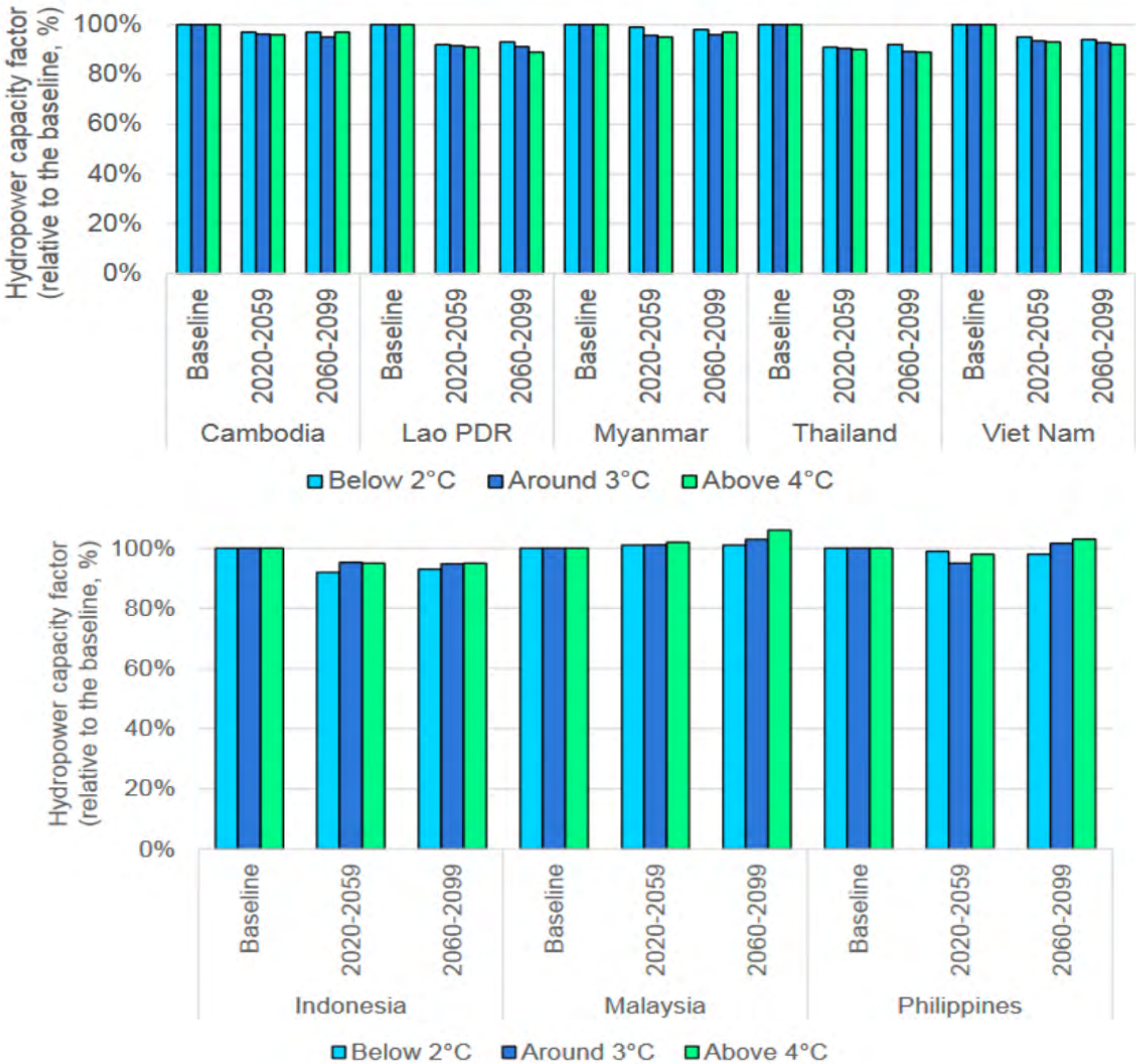
Previous studies have shown how energy infrastructures are prone to climate change effects. A natural gas power plant in Priok, Jakarta, which lies at 0-2 m above sea level, has been occasionally inundated (Handayani et al., 2019). The 2013 Jakarta Flood forced a steam power plant to shut down its operation due to inundation. The electricity generation was forced to be turned off as some power substations were flooded and the transmission cables were broken in some locations.

There are many power plants located in coastal areas of Northern Java, Indonesia, already under threat of tidal flooding (Suroso and Firman, 2018, Handayani et al., 2019). Meanwhile, Indonesia experienced a gradual sea level rise from 2 to 10 mm annually between 1993 and 2012. The future situation is even more worrying for the presence of power plants in the coastal areas of Indonesia. Sofian et al. (2013) compared sea level projections using tide gauges, satellite altimetry, and IPCC-Assessment Report 4 model data, and they found that the sea level rise in Indonesia is projected to reach up to 80 cm by the year 2100.

The rising temperature and low rainfall patterns could also disrupt the operation of power plants. During the 2018 dry season, severe drought in the Mekong Region caused a reduction in power generation and led to a blackout in Cambodia. It contributed to Cambodia's hydroelectricity production drop by 30% (400 MW out of an installed capacity of 1,341 MW) in 2019 (Weatherby, 2021).

Future climate projection also indicates a potential shift in the timing and intensity of rainfall, affecting the Mekong River's hydrology. A simulation over 30 years by Chowdhury et al. (2021) shows that prolonged droughts in the Mekong basin could reduce hydropower production by about 4,000 GWh/year. By the end of this century, the mean hydropower capacity factor for Southeast Asian hydropower plants is expected to drop significantly in all three climate scenarios set by International Energy Agency(IEA) (2021). This trend will occur in the mainland of Southeast Asia (i.e. Cambodia, Lao PDR, Myanmar, Thailand and Viet Nam) due to inconsistent water flow and a decreased number of wet days (Figure 16). The report noted that the hydropower capacity factors of Lao PDR and Thailand are projected to be the most significant declines under all climate scenarios (IEA, 2021). The projected decrease in the hydropower capacity factors in this region could create a region-wide power shortage. However, Indonesia will decrease its hydropower capacity factors from 2060 to 2099 due to a decrease in rainfall during the dry season.

Figure 16. **Climate impacts on the hydropower capacity factor in Mainland Southeast Asia (above) and the Maritime Continent (below) by country, 2020-2099 compared to the baseline period, 1970-2000 (IEA, 2021)**



Section 5.

The Current State of Disaster-Climate Risk Management Approaches to Accelerate Actions against Changing Climate Risk Landscape

The average global temperature is heading towards 1.5°C above the pre-industrial level. With that in mind, the climate is rapidly changing and magnifying the risks of hydro-meteorological disasters. Thus, there is a need to accelerate efforts to expedite and actualise specific actions. United Nations Office for Disaster Risk Reduction (UNDRR, 2021) set out four short-term areas of work that are required to accelerate the implementation of the Sendai Framework vis a vis disaster risk reduction (DRR) and climate change adaptation (CCA). This section reviews the extent to which ASEAN and its Member States' efforts align with those priorities.

5.1 Generating robust evidence, innovation, and good practices on risk to inform decision-making processes.

To anticipate future climate risks that evolve rapidly, there is a need to enhance systems that support existing risk identification to provide evidence of the likelihood of future climate hazards and their potential climate-driven disaster impacts. It is essential to identify actions to prioritise and investments needed in disaster-climate risk reduction. These include promoting integrated pre-disaster risk assessment, weather forecasts, early warning systems and impact analyses.

The state of risk assessment mechanisms across the AMS is not uniform, which may affect their capacity to provide robust and comprehensive risk information vis-à-vis potential climate impacts. The main constraints involve data quality, quality of climate projections, and technical capabilities to get reliable downscaled climate projections that are compatible with local-level analyses (Table 4) (ASEAN, 2021). Several countries have established disaster data systems, such as InaRISK (Indonesia) and GEORiskPH (the Philippines), although some are still developing such systems. The latter example is the latest innovation that the country has been developing to not only integrate climate and disaster risk assessment but to support policy- making and planning (DOST-PHIVOLCS, 2022).

Table 4. Current status of integrated risk assessment for climate change adaptation and disaster risk reduction (ASEAN, 2021)

Risk Assessments	BRN	KHM	IDN	LAO	MYS	MMR	PHL	SGP	THA	VNM
Disaster data system										
Meteorological data systems										
Downscaled CC projections										
Risk maps with CC impacts										

Regarding early warning systems (EWS), there have been some substantial efforts to improve EWS for hydro-meteorological threats. The ASEAN Coordinating Centre for Humanitarian Assistance and Disaster Management (AHA) Centre, the ASEAN Specialised Meteorological Centre (ASMC), the non-ASEAN Mekong River Commission (MRC) and Regional Integrated Multi-Hazard Early Warning System for Africa and Asia (RIMES) are already present in the region to facilitate cooperation among AMS on EWS and disaster monitoring for flood and drought. They support disaster analyses (AHA Center), seasonal and sub-seasonal weather information and climate forecast (ASMC and RIMES), and data and information sharing platform for data regarding floods and droughts (MRC). Chin et al. (2020) summed up key challenges in flood and drought EWS in ASEAN:

1. Maintaining complex EWS systems that requires coordination among various subcomponents including hardware, software, people, and processes.
2. Lack of data harmonisation, sharing, and integration between sectors.Data quality that lacks localised climate change scenarios and inadequate density of meteorological and hydrological stations.
3. Communicating climate science effectively to the general public.
4. False information that rapidly spreads in communities with limited digital literacy. Lack of legislation and clear delineation of roles and responsibilities among relevant organisations at the national level.
5. Development constraints, particularly the challenge of prioritising EWS within the development agenda.

5.2 Accelerating financing for DRR and CCA and de-risking investment

In addition to public budget allocation, there have been efforts to develop alternative financing instruments to support DRR and CCA, including using sovereign risk transfer and insurance instruments to cope with climate-driven impacts. For example, the Philippines utilised the Catastrophe-Deferred Drawdown Option (CAT-DDO) on a Development Policy Loan (DPL). It served as a contingent financing instrument for the Pantawid Pamilyang Pilipino Program (4Ps) that delivered cash-for-work and cash-for-asset rebuilding in the post-Typhoon Yolanda recovery (World Bank, 2015).

De-risking investment means making risk-informed investments to mitigate potential negative impacts. Risk transfer can offer financial protection to those insured for their physical assets and livelihood against climate shocks. However, its contribution to addressing the effects is still underdeveloped in the region, although some practices have been established in the region recently. In 2018, five AMS and Japan established Southeast Asia Disaster Risk Insurance Facility (SEADRIF) to develop a regional catastrophe risk insurance pool that facilitates ASEAN member countries to secure financial resources through affordable parametric insurance solutions before a disaster strikes (World Bank, 2020). The initial financial solution within the SEADRIF involves the establishment ofa flood risk insurance pool for the Lao PDR and Myanmar, supported by technical assistance from the World Bank's Disaster Risk Financing & Insurance Program (DRFIP). SEADRIF has its Risk Monitoring Tool, which uses various data sets to determine near real-time magnitudes of a flood and its potential impacts. It becomes the basis for the SEADRIF Insurance Company to determine the payout.

Another example is the expansion of parametric weather index insurance that offers affordable premiums and pay out benefits based on pre-determined indices such as precipitation level for loss of productive assets due to extreme climate events. Thailand has developed its weather index insurance since 2005 with the assistance of the World Bank to offer this approach to maize farmers. Later, Sompo Japan Insurance (Thailand) Co., Ltd., in cooperation with the Japan Bank for International Cooperation (JBIC) and the state-owned Bank for Agriculture and Agriculture Cooperatives (BAAC), commenced weather index insurance in 2010 to protect rice farmers from the loss of profit due to drought (Sirimanne et al., 2015). Since 2019, it has expanded its market to longan, cassava, and sugarcane farmers. Now, the company collaborates with the Japan Aerospace Exploration Agency (JAXA) to use remote sensing technologies to provide real-time satellite-derived global rainfall data and makes damage assessment possible without a field survey.

5.3 Scaling up communication and public advocacy for building highest political traction and commitment to DRR

At the regional level, the AHA Centre is key to communicating disaster risk through its management platforms and tools. These include the ADInet, the ASEAN science-based Disaster Management Platform (ASDMP) and the Disaster Monitoring and Response System (DMRS) of ASEAN. Also, the AHA Centre as the host of One ASEAN, One Response has facilitated coordinated emergency preparedness and response operation in the region. Since its establishment in 2011, it has played a central role in facilitating the flow of information and resource mobilisation, including during some major hydro-meteorological disasters in the past decades in the region.

ASEAN's commitment to promote DRR and CCA has been manifested for years through its legally binding ASEAN Agreement on Disaster Management and Emergency Response (AADMER). It becomes the main reference for the regional disaster management and response. Under the agreement, ASEAN and the AMS agencies for disaster management and climate change have been involved in several joint initiatives, including strengthening policy frameworks, DRR and CCA integration, and incorporating climate projection into disaster risk assessment in the Lao PDR and Myanmar (ASEAN, 2020).

Under the AADMER Work Programme 2021-2025, ASEAN has set out regional prevention programmes to incorporate climate change adaptation into the ASEAN DRR strategy and governance (ASEAN, 2020). These include holding capacity building and cooperation between relevant regional actors, continuously sharing knowledge on DRR and CCA good practices, and platform, and building a platform for climate change impact knowledge sharing. Regarding emergency response, the work programme also planned to enhance collective response through standby arrangements and partnership for new risk scenarios as anticipative actions toward changing riskscape.

5.4 Integrating the DRR agenda with the climate agenda

The integration of both CCA and DRR policies has been significant in the region, although there are some notes in the initiative. Both are generally separated at the operational level because some countries still lack unified policy and institutional frameworks to integrate the principles, means and resources of both CCA and DRR (ASEAN, 2021). As a result, these factors have significant implications across various aspects, including risk assessment and planning.

For instance, Indonesia has two laws for each stream, so two agencies work separately to implement the regulatory mandates. Consequently, this arrangement is governed sectorally, separating institutional arrangements and policy instruments. Such arrangements lead to incoherent risk management approaches, including risk assessment due to differences in standardised measurement processes, lack of data to support existing and projected risk profiles, sectoral scattered data, and data mismatch. As of 2021, three AMS have not yet fully implemented efforts to arrange the policy integration (ASEAN, 2021).

However, in recent years, some initiatives have been made in the region to advance integration. Some AMS have also established practical guidelines to help the integration, such as the Philippines, Brunei Darussalam, Singapore, and Malaysia (ASEAN, 2021). At the regional level, ASEAN (2020) facilitated the integration through:

- A baseline study on Strengthening Institutional and Policy Framework on Disaster Risk Reduction (DRR) and Climate Change Adaptation (CCA) Integration from July 2016- April 2017
- A project on Disaster Risk Reduction by Integrating Climate Change Projection into Flood and Landslide Risk Assessment.

Section 6.
Conclusion

The report captures the trend of climate-driven disasters, their implications to risk landscape change, and strategies to cope with them in Southeast Asia. The report concludes that Southeast Asia has experienced frequent and more intense extreme heat and heavy rainfall events. These led to increasing hydro-meteorological disasters, including several notable disasters in the past decade, such as the 2011 Thailand Flood and Typhoon Haiyan in 2013. The threats of climate-driven hazards are now concerning and alarming because the future trends of climate surface temperature and precipitation suggest more frequent and intense extreme heat and heavy rainfall events, fewer but more extreme tropical cyclones, and higher sea levels. The events of La Nina and the changes in rainfall variability that trigger rainfall frequency and intensities in their region increase the probability of flood. Alongside the effects of ENSO and IOD, the rising temperatures have contributed to an increasing occurrence of hot days, with warm nights becoming more prevalent in the region, particularly during the dry season.

In terms of impacts, storm surges and typhoons have proven to bethe deadliest and most disruptive threats in the region over the past three decades. Meanwhile, the severest flood in the region occurred in 2011 when severe flooding hit several countries in mainland Southeast Asia during the 2011 monsoon season. Landslides were the least lethal threat, but the impact can be locally devastating, such as the 2006 landslide in Southern Leyte in the Philippines. The Philippines was the most affected AMS by storms and typhoons, while Thailand suffered due to floods between 1990 and 2021. It is worth noting that the number of displacements has shown an increasing trend over the past decade.

However, past disasters have indicated emerging trends in the changing risk landscape that need to be taken into account. Firstly, as climate change increases hazard levels, the possibility of displacement is increasing as well, especially in communities living in low-lying and coastal areas. Some major cities in the region have witnessed and experienced forced displacements and migration due to floods and sea level rise. Additionally, the risks of forced displacement can also be experienced by those living in rural areas due to extreme temperatures and weather-related disasters. Secondly, the increasing temperature and water resource depletion will challenge the sustainability of the food production systems because the agriculture sector highly relies on climate conditions. Thirdly, previous regional disasters have shown how climate-driven threats have tested the resilience of critical infrastructure and the extent to which it can maintain its functions without causing further harm to communities. Future climate projection also indicates a potential shift in the timing and intensity of rainfall that could disrupt the operation of hydropower stations.

This report highlights the growing frequency of climate-related disasters, underscoring the impreative for better preparedness, for financing, and prevention planning. There is still a need for better integration of DRR and CCA approaches or mechanisms to determine at-risk communities before a disaster occurs and deliver required assistance in a timely manner. Alternative financial instruments are increasingly becoming available and viable, such as sovereign risk transfer pools, asset-based risk transfer mechanisms and other insurance instruments. However, much effort is still needed to integrate CCA and DRR into development and local spatial planning processes and it will be the key to mobilising necessary resources and appropriate measures to address climate-disaster impacts.

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