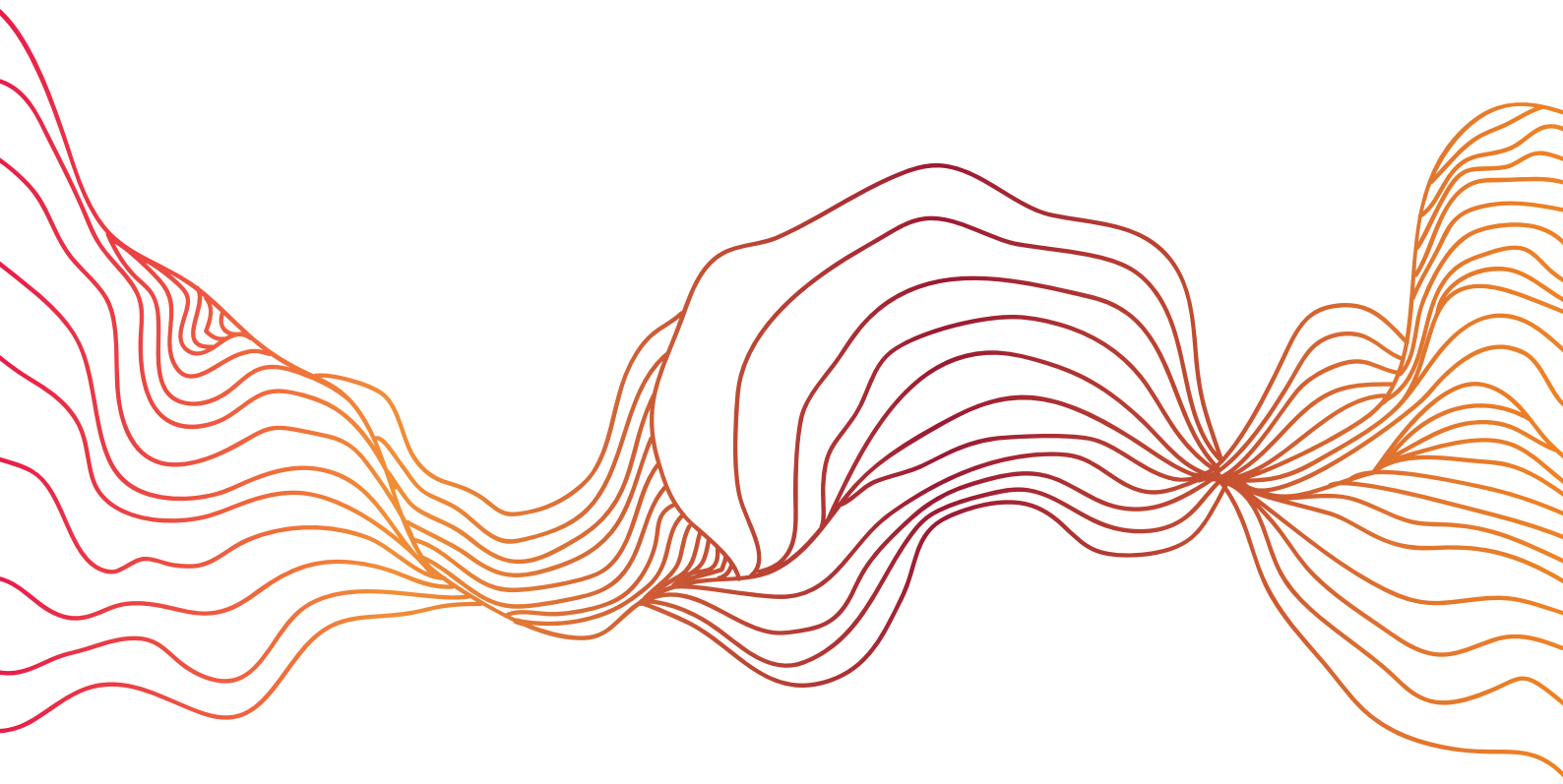
El Niño Storylines and Plausible Climate Futures for the Indo-Pacific

Myanmar Central Dry Zone Case Report



Red Cross Red Crescent Climate Centre

August 2024

Climate Centre

This document is part of a larger research project conducted by the Red Cross Red Crescent Climate Centre (Climate Centre) for the United Kingdom's Foreign Commonwealth and Development Office (FCDO) exploring plausible future El Niño impacts. Nothing herein constitutes the views of FCDO. The document employs a storylines methodology, an innovative evidence-based approach to climatologically represent various scenarios that may emerge given these uncertainties in future projections. The research examines the potential impacts of the El Niño Southern Oscillation (ENSO) which could be experienced in the Indo-Pacific region across a) the next 2-10 years (near term) and b) under the scenario in which global land temperatures exceed 2°C since the industrial revolution. **This case report focuses on the Central Dry Zone, Myanmar** and is one of three case reports (Lower Mekong Basin and East India) that comprise this project.

For more information on the findings of the project please see the summary report highlighting the findings across the regions, the methodology employed, and key recommendations.

Key contributing authors: Mikki Korodimou, Christopher Jack, Martha Vogel, Catalina Jaime, Sarah Gale, Rikke Stoffels, Pauline Trepczyk, Mauricio Santos Vega, Camila Arretche, Tesse de Boer, Evan Easton Calabria, Abdur Jamalzi, Renate Meyer.

Suggested citation: Korodimou, M., Jack, C., Vogel, M., Jaime, C., Gale, S., Stoffels, R., Trepczyk, P., Santos Vega, M., Arretche, C., de Boer, T., Easton Calabria E., Jamalzi A., & Meyer, R. (2024). *El Niño Storylines and Plausible Climate Futures for the Indo-Pacific. Myanmar Central Dry Zone Case Report.* Red Cross Red Crescent Climate Centre. May 2024.

Corresponding author: Mikki Korodimou: korodimou@climatecentre.org

Executive summary

This report investigates the potential impacts of El Niño Southern Oscillation and the Indian Ocean Dipole (IOD) in the Central Dry Zone (CDZ) of Myanmar over the near term (next 2-10 years) and longer term (with 2°C of global temperature increase since pre-industrial levels) might have on the region. To do this, plausible climatological storylines were developed and analysed according to four typologies (health, trade, mobility, and security) using a retrospective analysis approach.

The following two storylines were developed:

MYANMAR (CENTRAL DRY ZONE)

Storyline 1: near term (2-10 years)	Storyline 2: 2°C global warming
Following a La Niña period lasting 2-3 years, transition to El Niño and Positive IOD. The Central Dry Zone of Myanmar continues to experience local flooding and drought regardless of ENSO and IOD, whereas the broader neighbouring South Asia region is affected by droughts.	Myanmar continues to experience regular El Niño associated with **increasing rainfall variability**, leading to **hotter** and **drier droughts** (late onset of rain) and **more extreme flooding**.

Storyline key impacts

It is important to note, this work was conducted as a first stage desk-based research project, limited in scope to applying the methodology for the following key sectoral areas of health, trade, mobility and security. For future iterations, it would be possible to explore alternative or further sectoral impacts.

Health impacts ranged from increased transmission of water-borne and other communicable diseases, mental health challenges, the exacerbation of chronic health conditions such as kidney disease and heat stroke, food insecurity and malnutrition.

Trade impacts revolved predominantly around decreases in agricultural production and the loss of income generation, damaged infrastructure and export bans.

Mobility impacts are centred around the increase in rural to urban migration, both short term and protracted displacement of individuals and communities and the ensuing consequences such as livelihood diversification. This section also discusses the role of compounding and increased risk faced by those practicing migration and mobility whereby migration journeys are likely to become more dangerous.

Security impacts focus mainly on the ways in which human security implications create a backdrop for understanding security consequences related to violence and conflict. Under this framing, tensions around water management are explored, the role of marginalization of migrant communities and competition over control of resources are some topics discussed in this work.

The report provides several **recommended adaptation intervention** points based on the outlined impacts under each storyline. These are presented across a spectrum of time at varying windows of opportunity, ranging from long term DRR and adaptation, anticipatory action, disaster response and disaster recovery.

In conclusion, the report provides five recommendations for future action:

1. Prepare for a future with persistent oscillation between La Niña and El Niño and both positive and negative IOD events, in an increasingly warmer world with more intense precipitation.

2. Monitor climatological conditions at local, national, regional and international levels to design and implement informed action.

3. Conduct targeted research and analysis to close key knowledge gaps that currently limit evidence-based policy decisions.

4. Recognise and embrace the role of understanding and working within complexity when addressing future climate challenges.

5. Use the storylines as a discussion tool for preparedness measures within countries and regions.

Table of contents

Introduction

Figure 1: The study region for this case encompassing the Central Dry Zone

Myanmar is highly exposed to climate change risks, especially as much of the population and agricultural land are concentrated in the country's disaster-prone areas (UNDP,2023). Myanmar ranks 160th on the ND-GAIN Country Index, which combines the country's vulnerability to climate change (140th) against its readiness to adapt (178th) (University of Notre Dame, 2021). Driven by factors such as climate-related shocks, political unrest, conflict, economic downturn, and pre-existing poverty; the country is also currently experiencing one of the worst humanitarian crises in recent history (WFP, 2023). The Central Dry Zone (CDZ), which includes the regions of Sagaing, Magway, Mandalay, and Nay Pyi Taw, is one of the most climate sensitive regions and is the third most densely populated area in the country (Rapten, 2018). Geographically, the CDZ is situated in the shadow of the Rakhine mountain range and receives limited rainfall compared to country averages; rainfall in the CDZ ranges from 500 to 1000 mm compared to 5000 mm in other parts of the country (Poe, 2011). The rainy season occurs from mid-May to October followed by a dry and cool spell from mid-October to mid-February, followed by a dry hot season from mid-February to mid-May. The CDZ is prone to increasing extreme heat events and droughts, leading to several water scarcity and desertification challenges (IFRC, 2021). In the future, estimates show the CDZ is highly likely to experience more heatwaves, droughts, flash floods and landslides because of climate change (IFRC, 2021).

Challenges resulting from decreased precipitation are combined with decreasing forest cover, heat stress, drought and soil erosion. These compound one another and place local communities at greater risk of localized flash floods during times of heavy rain (Poe, 2011). In 2023, the Sagaing region had the greatest increase in the number of people in need of humanitarian assistance, reaching 2.3 million in January 2023 (WHO, 2023). Current conflicts are suspending previous government climate initiatives such as the National Climate Change Strategy (2019) and challenging measures to address the changing climatic patterns (Lo & Hoy, 2023). The compounding risks resulting from the armed conflict in Myanmar have been reported to increase vulnerability to climate change impacts, force populations into displacement, and exacerbate resource extraction (Lo & Hoy, 2023).

Overview of storylines

Overview of storyline objectives and methodology

The storyline methodology used in this research was developed by the **Red Cross Red Crescent Climate Centre** (Climate Centre) and builds on academic research in the areas of climate storylines and forensic investigations of disasters (e.g. Jack et al., 2020; Van den Hurk et al., 2023). The storyline approach combines elements of interdisciplinary methodological approaches to develop a robust and innovative way to understand risk complexity in a changing climate. Using an integrated approach, the methodology offers novelty by way of combining varying aspects of human security as a pathway to understand the risks related to climate change and climate security.

Climate projections refer to the future scientific estimates of climate conditions. They are based on climate models that simulate the interactions between the atmosphere, oceans, land and ice. These models consider factors such as greenhouse gas emissions, solar radiation and natural climate variability. However, they are not exact predictions of the future but rather, simulate climate change based on different assumptions such as greenhouse gas emissions. As climate model projections are associated with uncertainties, storylines are used in this research to represent various scenarios that may emerge given these uncertainties in future projections. **The aim of the storylines is to help readers translate uncertain climate projections into more tangible plausible outcomes or scenarios**. Each storyline represents a plausible (supported by observed and modelled evidence) climate future for the country, or regions within the country. A storyline represents a physically self-consistent unfolding of plausible future events or pathways (Shepherd et al., 2018). **The storyline methodology can spark discussion and thought processes, which can add nuance, structure, and meaning to evidence-based yet hypothetical scenarios.**

In the cases explored as part of this research, the scientific evidence base substantiating the storylines is derived from a retrospective analysis of the evolution and outcomes of similar past El Niño and IOD events combined with current observed trends. The analysis of likely impacts following the development of a storyline draws on both past examples and future evidence-based projections to substantiate and exemplify the plausible future impacts individuals, communities and societies might face.

Storylines for the Central Dry Zone, Myanmar

For the Myanmar case report, three storylines were developed. Two focus on the near-term timeframe (2-10 years) and one focuses on a 2°C world. These are presented below with the immediate impacts on the elements of temperature and precipitation highlighted. These are then further expanded upon in the causal maps and accompanying narrative analysis.

Storyline 1: near term (2-10 years)	Storyline 2: a 2°C World
Following a La Niña period lasting 2-3 years, transition to El Niño and Positive IOD. Central Dry Zone of Myanmar continues to experience local flooding and drought regardless of ENSO and IOD, whereas the broader neighbouring South Asia region is affected by droughts.	Myanmar continues to experience regular El Niño associated with increasing rainfall variability, leading to hotter and drier droughts (late onset of rain) and more extreme flooding.

Datapoints for the retrospective analysis

The impact of this chain of events in the Central Dry Zone has been explored under the lenses of health, mobility, trade and security. The following storylines explore the various plausible scenarios and the implications of this chain of events on the study region.

The information that substantiates these storylines is derived from a retrospective analysis of past El Niño and IOD events which exhibited similar conditions (see Figure 2 below). Using this information combined with the current trends, the following storylines have been developed. In the analysis, information from the past is drawn upon to substantiate and exemplify plausible future scenarios. The following events have been used to predominantly draw analysis from:

Dates	Configuration of El Niño and IOD	Main hydrometeorological events
1997-98	Dominant El Niño event and positive IOD	Hot and dry conditions, accompanied by floods
2009-2010	El Niño, delayed and drier monsoon	Drought and extreme heat
	Dominant El Niño and neutral IOD	Very wet 2009 after La Niña from 2007. Tropical cyclone Ondoy/Ketsana in September 2009. Very hot and dry pre-monsoon in 2010, late onset. Flooding in parts of Thailand in August 2010

The data drawn upon to substantiate understanding of the potential impacts of the developed storylines and formulate an understanding of the plausible impacts that might be seen under both storylines 1 and 2 for this research, spans a range of sources. In the analysis, academic peer-reviewed literature, news reports, humanitarian bulletins and also government and non-governmental actor reports were drawn upon. This process was substantiated with findings from a systematic review and then cross-referenced by interactive workshops with FCDO expert practitioners across the region of study. More information on the process can be found in the overarching report and methodology document that form part of this report series.

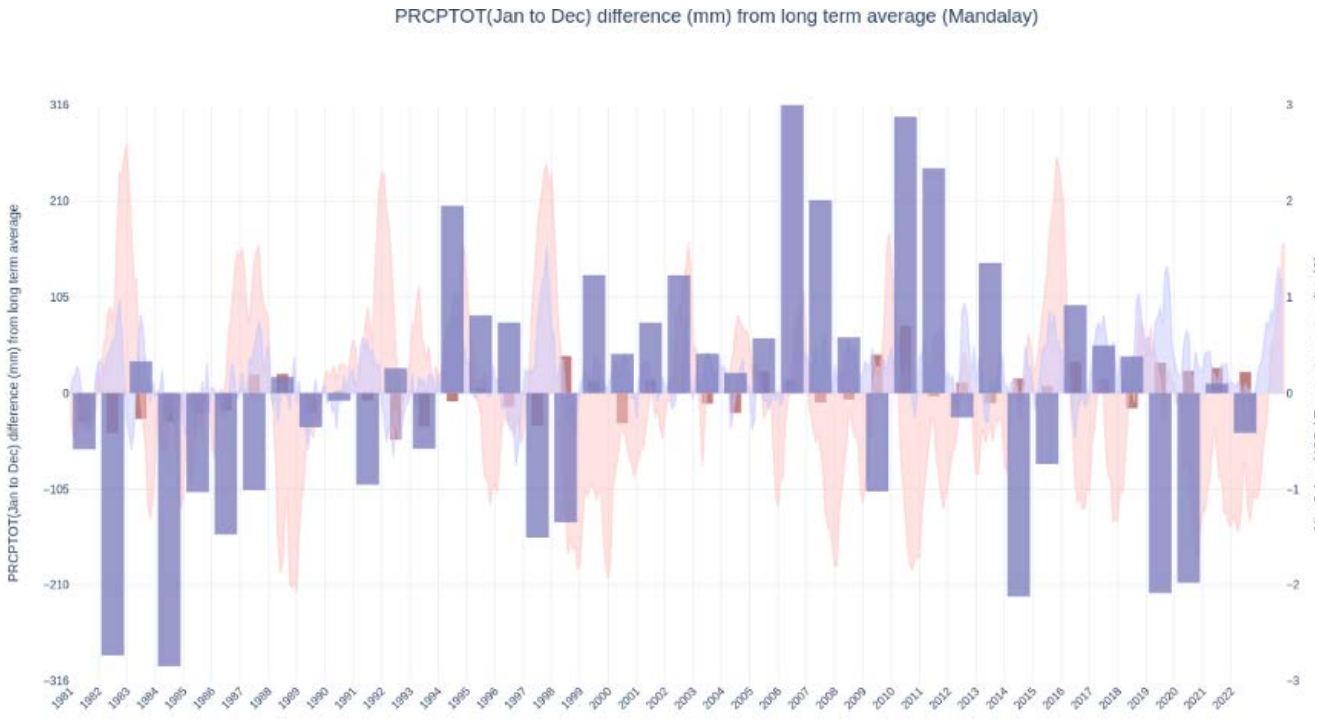


Figure 2: Annual (Jan to Dec) total rainfall anomalies (% of normal) (1981-2022, blue bars), temperature anomalies (C) (red bars), ENSO Nino3.4 index where values > 0.5 indicate El Niño conditions and values less than –0.5 show La Niña conditions (pink curve), IOD DMI index showing positive and negative phases of IOD (blue curve).

Storyline 1: near term (2-10 years)

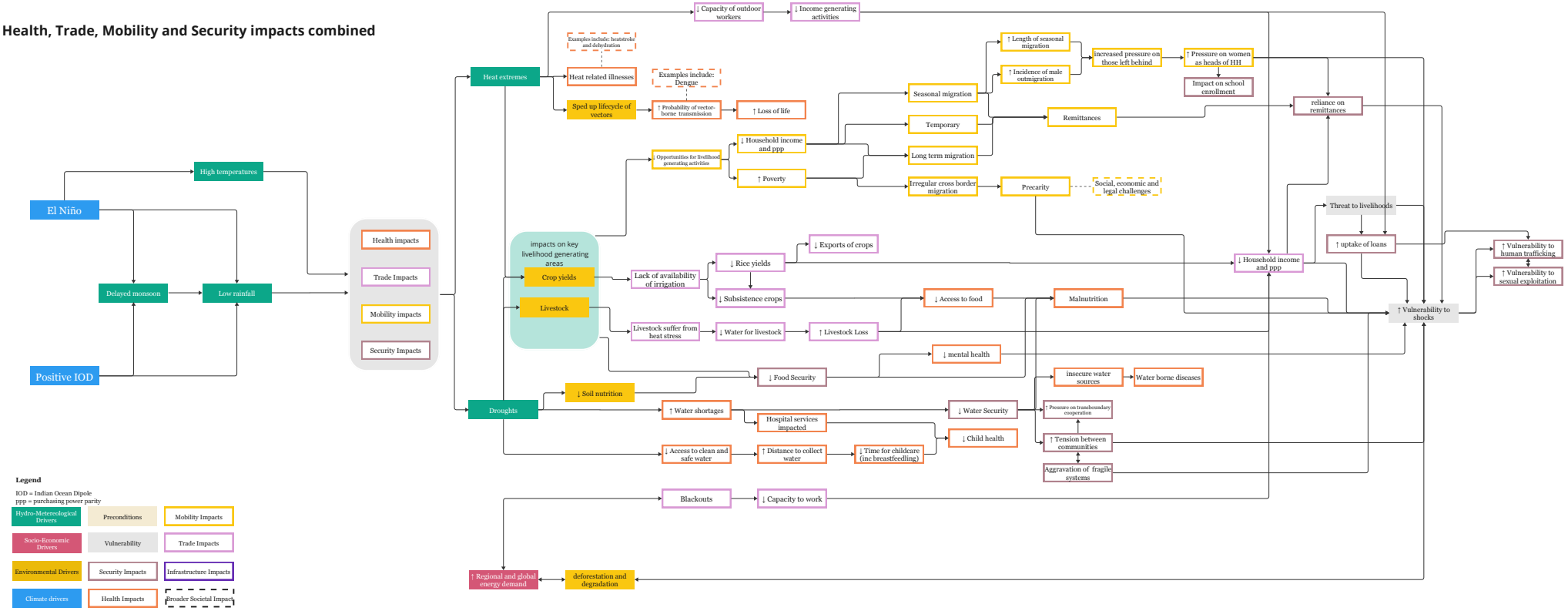
Storyline 1 – near Term (2-10 years): Following a La Niña period lasting 2-3 years, transition to El Niño and Positive IOD. The Central Dry Zone of Myanmar continues to experience local flooding and drought regardless of ENSO and IOD, whereas the broader neighbouring South Asia region is affected by droughts.

The following **causal maps** depict a visualisation of the interactions of impacts faced under Storyline 1 and is divided into heat and drought (map 1) and impacts of rainfall and flooding (map 2).

Map 1

Storyline 1: CDZ of Myanmar continues to experience both local flooding and drought regardless of ENSO and IOD, whereas the broader South Asian region is affected by droughts

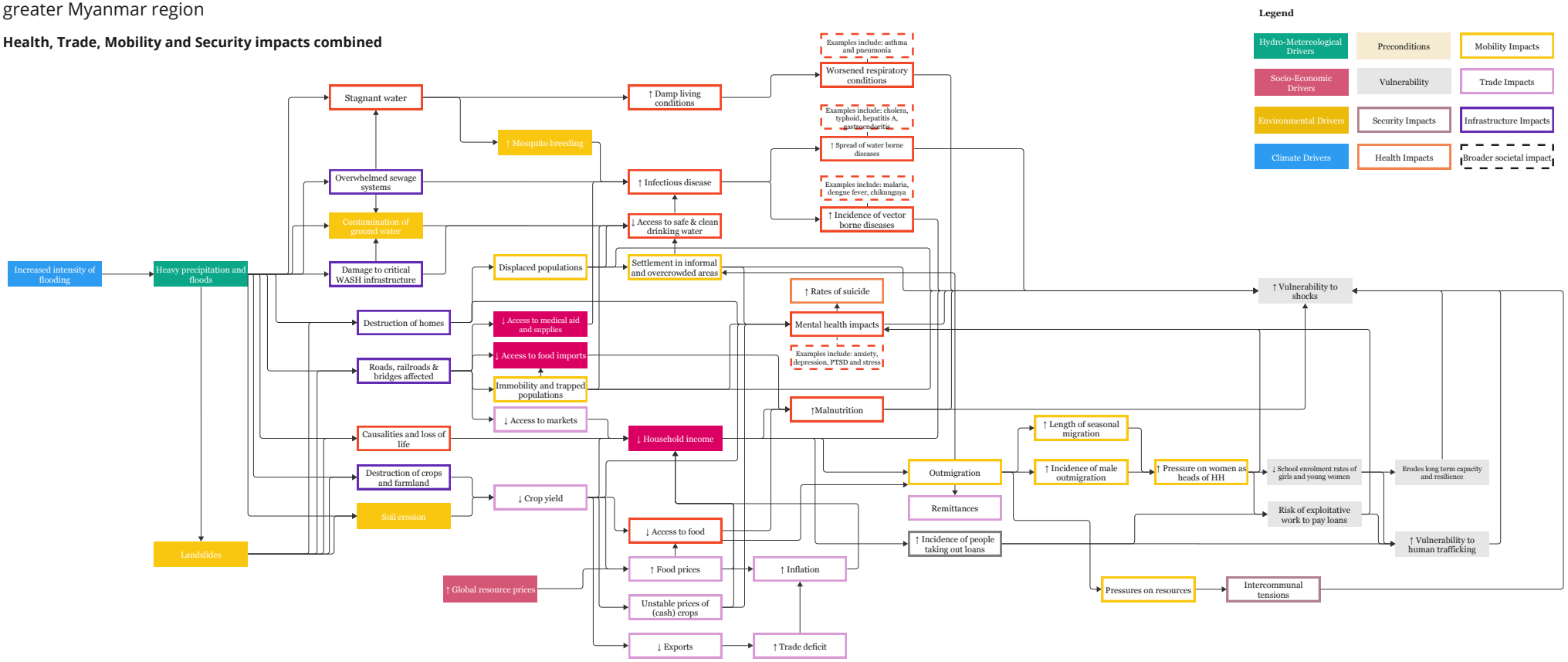
Health, Trade, Mobility and Security impacts combined



Map 2

Storyline 1 continued: Impacts of Heavy precipitation and floods in the CDZ and greater Myanmar region

Health, Trade, Mobility and Security impacts combined



Storyline 2:
2°C increase in global temperatures above pre-industrial levels

Storyline 2°C: Myanmar continues to experience regular El Niño associated with increasing rainfall variability leading to hotter and drier droughts (late onset of rain) and more extreme flooding.

El Niño and La Niña conditions continue to occur in the CDZ, but will be associated with stronger climate-related hazards as a consequence of global warming. The CDZ will experience more extreme precipitation, both during El Niño and La Niña resulting in flooding and impacts on infrastructure and the development of infectious diseases.

El Niño periods will also be associated with drier monsoon regions and the late onset of monsoon will be associated with hotter and drier droughts, with strong impacts on agriculture and health.

These climate-related hazards have had major impacts on livelihood opportunities related to agriculture and livestock cycles, especially for those who depend on rainfed agriculture and the predictability of monsoons to prepare fields (Jones, 2021).

For this storyline, no new elements appeared and so the causal maps remain the same, but the amplification of impacts should be noted.

Impacts

Impacts on health

Summary of impacts on health

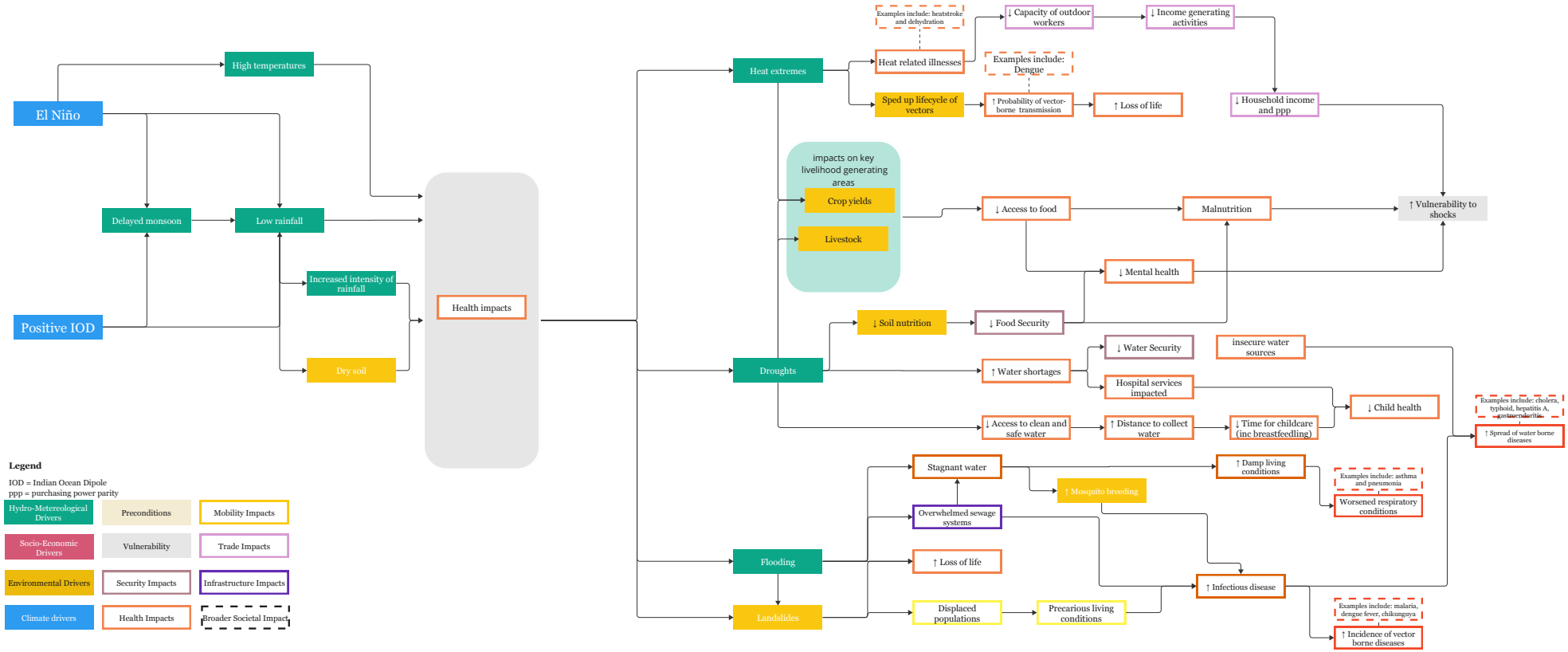
Under Storyline 1 the following impacts could be felt in the Central Dry Zone:

- As a result of flooding and ground water contamination, there could be an increase in the transmission of infectious waterborne diseases.
- Chronic conditions like kidney diseases and heatstroke are common among outdoor workers, the elderly and individuals with pre-existing health issues. Prolonged droughts and elevated temperatures could exacerbate these conditions.
- Increased prevalence of drought can exacerbate food insecurity and lead to nutrition problems.
- Drought can exacerbate mental health issues among male farmers, leading to increased suicide rates due to the stresses of lost incomes and associated indebtedness.

Under Storyline 2, the following impacts could be felt in the Central Dry Zone:

- Extreme heat can lead to heatstroke, kidney issues and other heat-related illnesses.
- Increased prevalence of drought can exacerbate food insecurity and lead to malnutrition.
- The risk of communicable diseases, particularly oral-faecal diseases, will likely increase in flooded areas.
- Extreme floods will likely have a negative impact on the mental health of some vulnerable communities forced to cope with the loss of livelihoods, assets, family members and friends.

Health impacts CDZ



Impacts on health under Storyline 1

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

As a result of flooding and ground water contamination, there could be an increase in the transmission of infectious waterborne diseases. The stagnant water left in the wake of floods is an immediate breeding ground for mosquitos, which are carriers of vector-borne diseases such as malaria and dengue fever.

Overwhelmed sewage systems and contaminated water sources are a particular risk, especially if there are disruptions in water treatment and water storage protocols. This can lead to outbreaks of waterborne disease including diarrhoea (Sojobi & Zayed, 2022). Excess rainfall can exacerbate the severity of flooding events, leading to ground water contamination and significantly increasing the risk of waterborne diseases such as cholera, typhoid, hepatitis A and gastroenteritis.

- **Example:** The droughts and floods that occurred due to the 2015/2016 El Niño event in Myanmar have been associated with cholera, dengue, hantavirus infection, malaria, respiratory illness, and ross river virus diseases (Burki et al. 2019).

Mental health challenges are frequently associated with a disrupted monsoon season, which could further impact populations in the region in the future.

The rise in mental health difficulties stems from heightened psychological distress caused by a combination of factors, including decreased crop productivity, loss of material possessions, and the lingering effects of traumatic experiences (Crabtree, 2012). Heavy rains and floods can cause immense psychological stress due to displacement and loss of property and livelihood. Anxiety, depression, and post-traumatic stress disorder (PTSD) are common among flood survivors. This is compounded when people who are already victims of conflict and displacement are further subjected to the impacts of flood events.

- **Example:** Uncertainty and economic hardship during a disrupted monsoon season can lead to anxiety, depression, and stress among farmers and other dependent communities (Htay, 2009).

Chronic conditions like kidney diseases and heatstroke are common among outdoor workers, the elderly population, and individuals with pre-existing health issues. Prolonged droughts and elevated temperatures could exacerbate these conditions.

Heatwaves have been linked to heightened cardiovascular and respiratory morbidity and mortality rates. They also elevate the risk of acute renal failure and hospitalizations associated with renal diseases, leading to increased mortality. Recurrent dehydration, particularly in individuals frequently exposed to high temperatures, appears to be an overlooked factor contributing to chronic kidney disease (Gallagher et al., 2023). Example: An increase in the number of days with extremely hot temperatures will put the population at risk of heat-related illnesses and deaths and exacerbate cardiovascular and respiratory diseases, particularly in the dry region of the country (MCCA, 2017).

Increased prevalence of drought can exacerbate food insecurity and lead to nutrition problems.

Dry spells and droughts are common occurrences in Myanmar, making access to irrigation a critical factor for household food security. As a predominantly agricultural country with a high percentage of smallholder farmers, extreme weather events are likely to adversely affect Myanmar's food security, nutrition, and livelihoods (WFP & FAO, 2016).

The impacts of droughts, especially in the dry region of the country, are particularly challenging for poor rural women and children. They suffer even more from hunger, food insecurity, and a lack of adequate health services; exacerbated by the risks of heat-related illnesses and deaths, and cardiovascular and respiratory diseases (SEI, 2018).

- **Example:** Warmer El Niño conditions are associated with increased child malnutrition across Myanmar. The 2015 El Niño event likely contributed significantly to exacerbating hunger (Boori et al., 2017). Specifically, populations face an increasing risk of acute malnutrition and micronutrient deficiencies, particularly among infants, young children and pregnant/lactating women (RIMES, 2011).

Drought can exacerbate mental health issues among male farmers, leading to increased suicide rates due to the stresses of lost incomes and associated indebtedness.

Lower income households are affected slightly worse by El Niño, experiencing a 0.72 per cent consumption loss, compared to a 0.61 per cent consumption loss, on average, for all households (Sutton et al., 2019).

The absence of rains during the monsoon season can significantly affect crop productivity, leading to water stress. Moreover, delays in the monsoon season can pose challenges during harvest time due to unexpected rains. These circumstances create anxiety and stress among farmers, who must exert extra effort and face potential revenue losses from their crops.

- **Example:** : Important levels of financial debt, coupled with unstable prices of cash crops, crop loss, and inadequate state support for capacity building to adapt, could potentially result in an elevated rate of farmer suicides in Myanmar (Phillips, 2017).

Impacts on health under Storyline 2

HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS

Extreme heat can lead to heatstroke, kidney issues, and other heat-related illnesses.

Heatwaves are arguably the deadliest type of extreme weather event, often resulting in underreported fatalities. Hundreds of deaths have already been reported in most affected countries, including Palestine, Bangladesh, India, Thailand, Myanmar, Cambodia, and the Philippines, exacerbating the loss of life and causing decreased income for outdoor workers (WWA, 2024).

Similar to Storyline 1, this challenge will be particularly pertinent among outdoor workers, elderly populations, and those with pre-existing health conditions.

Increased prevalence of drought can exacerbate food insecurity and lead to malnutrition.

This is significant, especially for the development of babies and young children. Warmer El Niño conditions are associated with increased child undernutrition across most developing nations. In Myanmar exposure to extreme climate events further jeopardises vulnerable groups, increasing the likelihood of food and nutrition crises (WHO 2016).

- **Example:** In Myanmar, the heat has a significant impact on vulnerable groups like the elderly and young individuals, who face a heightened risk of heat-related illnesses. Outdoor workers also suffer severe consequences from prolonged exposure to high temperatures. The situation is concerning, with approximately 40 people losing their lives daily in Myanmar due to the soaring temperatures (Horton et al., 2017).

MORE EXTREME FLOODING

The risk of communicable diseases, particularly oral diseases , will likely increase in flooded areas.

The number of cases will be exacerbated in flood-affected areas, where faecal-oral transmission occurs due to diminished sanitation facilities, limited access to safe drinking water and consumption of contaminated foods. The more prevalent diseases during floods are cholera, typhoid fever, poliomyelitis, and hepatitis. Contaminated water poses a significant threat by facilitating the spread of waterborne diseases, particularly endangering vulnerable populations, such as women and children, who are at elevated risk.

- **Example:** During floods, concerns continued regarding the contamination of water sources and the destruction of latrines, heightening the risk of waterborne diseases like diarrhoea. Inadequate environmental sanitation and stagnant floodwaters provide optimal conditions for mosquitoes to breed, escalating the transmission of diseases such as malaria and dengue (IFRC 2017). In Myanmar, hastily constructed camps were susceptible to monsoon flooding and storm surges, while families residing on hillsides faced the threat of landslides (Kenedy & Coy, 2017).

Extreme floods will likely negatively impact the mental health of some vulnerable communities forced to cope with the loss of livelihoods, assets, family members and friends.

The impact of floods extends beyond physical damage, often resulting in overwhelming emotional trauma for affected individuals. Many are forced to relocate to government shelters, leading to a weakened sense of place and identity. Mental health challenges, including post-traumatic stress disorder, suicide risk, sleep disturbances, irritability, anger, and schizophrenia, become more prevalent and burdensome during and after floods (Htay 2009).

Impacts on trade[1]

Storyline 1's description of increased drought has major impacts on livelihood opportunities related to agriculture and livestock cycles, especially for those who depend on rainfed agriculture and the predictability of monsoons to prepare fields (Jones, 2021). The CDZ is a significant economic and agricultural area for Myanmar, especially for pulses and rice. Approximately 58 per cent of local economies depend directly on agriculture, while 25 per cent of the population work as labourers in farming. Farmers in the CDZ have suffered from the impacts of prolonged droughts, compounded by the economic downturn induced by the COVID-19 pandemic.

Summary of impacts on trade

Under Storyline 1, the following impacts could be felt in the Central Dry Zone:

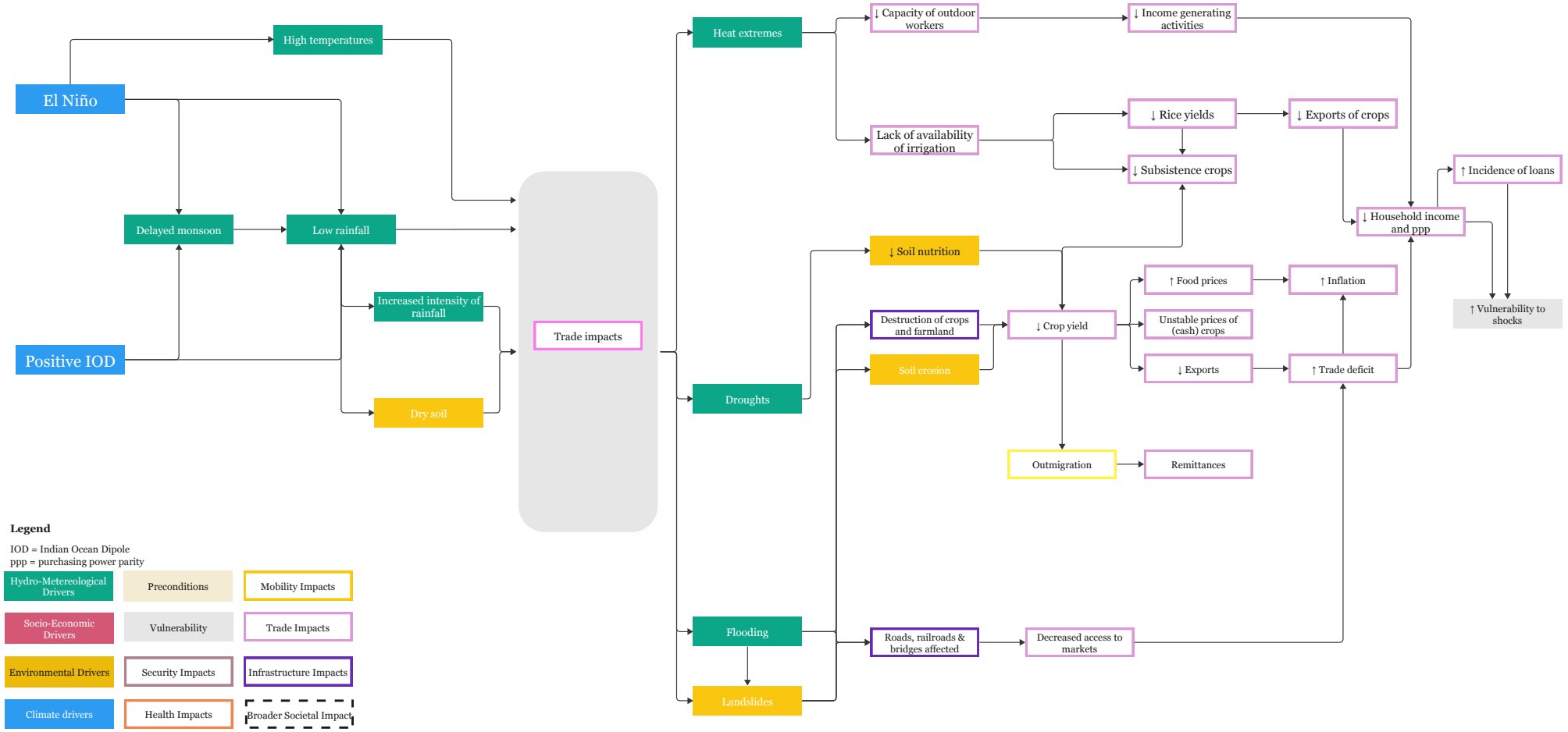
- Local flooding and droughts can cause significant decreases in agricultural production, leading to limited supply and higher market prices for both local populations and yields intended for export.
- Floods, wind damage and fallen trees can damage infrastructure such as roads essential in transporting food items to market. This would further increase the risk to the income security of farmers.
- Floods can not only limit agricultural production available for export, but in fact lead to export bans.

Under Storyline 2, the following impacts could be felt in the Central Dry Zone:

- Increased temperatures associated with El Niño directly affect crop yields as plants experience heat stress (Arshad et al., 2017; Ludher & Teng, 2023), especially for farmers with limited irrigation options.

1 It is important to note, the scope of this study was to focus on the key trade impacts, the scope did not enable a review of the broad economic impacts, but storyline approaches could be used for this in future iterations.

Trade impacts CDZ



Impacts on trade under Storyline 1

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

Local flooding and droughts can cause significant decreases in agricultural production, leading to limited supply and higher market prices for both local populations and yields intended for export.

Shorter and more intense periods of rain can increase the risk of flooding and accelerate land erosion, degrading soils and increasing the loss of productive land, particularly for those who depend on rainfed agriculture (Adaptation Fund, 2020; IFRC, 2021; Mercy Corps, 2013; MIMU, 2018).

Extreme temperatures and drought are also increasing evapotranspiration and therefore the risk of forest fires which greatly threatens the already exploited ecosystem and nearby human settlements (IFRC, 2021). This phenomenon further intensifies erosion through overgrazing, fuelwood harvesting, and poor farming practices, which also leads to land degradation and a reduction of yields (MIMU, 2018; Mercy Corps, 2013).

- **Example:** In late July 2015, the intense monsoon rains that followed Cyclone Komen caused flooding and landslides which led to significant losses of cattle and agricultural land, with adverse effects on rice fields, fish and shrimp ponds. (IOM, 2015; FAO, 2015). This phenomenon led to rice shortages and sharp increases in rice prices in the areas affected by the flooding (USDA, 2015). Exports reduced by 12 per cent nominally compared to 2014 because of an agriculture supply shock (World Bank, 2016b). The decline in exports occurred during an election year and led to slowing foreign investments and pressure on the exchange rate (World Bank, 2016b; 2016a).

Floods, wind damage and fallen trees can damage infrastructure, such as roads essential in transporting food items to market. This would further increase the risk to farmers' income security.

- **Example:** The 2015 flooding destroyed many roads and bridges and generated major logistical challenges in relation to transportation and accessibility to the most affected regions. The floods also affected navigation in most of the Ayeyarwady River due to increased water levels. This caused significant economic losses and impacted the transport of food and other supplies to affected people (Vasconcelos et al., 2016).

- Another **example** can be seen in 1997, when although El Niño conditions and positive IOD intensified, extreme rainfall in July led to flash floods which affected several states countrywide. This resulted in the destruction of roads and bridges, hampering the movement of goods. Rice crops were affected as paddy fields were inundated and the floods destroyed cattle and livestock.

Floods can not only limit agricultural production available for export, but in fact lead to export bans.

To avoid further increases in pricing and maintain food security caused by the 2015 floods, the Myanmar Rice Federation (MRF) declared a ban on rice exports until the new monsoon rice crops were expected to enter the market. The private sector also agreed to collaborate with the government to prevent exports during this time (USDA, 2015).

Impacts on trade under Storyline 2

Storyline 2°C: Myanmar continues to experience regular El Niño associated with increasing rainfall variability leading to hotter and drier droughts (late onset of rain) and more extreme flooding.

Under Storyline 2, trade could be impacted in the following ways:

HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS

Increased temperatures associated with El Niño directly affect crop yields as plants experience heat stress (Arshad et al., 2017; Ludher & Teng, 2023), especially impacting farmers with limited irrigation options.

It is reported that less than 16 per cent of cultivated land in the Dry Zone has irrigation infrastructure, generating constraints when it comes to managing variability in water resources, one of the main reasons for insecurity in the region (MIMU, 2018).

The dry conditions due to reduced rainfall limit soil moisture, contributing to water stress for crops (Selvaraju, 2003). With limited irrigation options, agricultural activities are vulnerable to the duration of the rainy season. Low productivity in the agriculture sector also means slower recovery, affecting the poor and vulnerable most negatively (World Bank, 2016c).

- **Example:** In the CDZ, many villages struggle with the impacts of insufficient rains and report they have begun to buy water due to dried up ponds. Water scarcity is greatly affecting crop production and livestock raising, generating the migration of many rural farmers to cities in search of alternative sources of livelihoods (SEI, 2018).

Impacts on mobility

The CDZ is currently one of the most food insecure and water stressed areas of the country (Boori et al., 2017). At its peak, the floods of 2015 affected over nine million people across 12 of Myanmar's 14 states and regions; 149 people died and the floods temporarily displaced over 1.6 million people from 405,958 households (IFRC, 2017). Over 15,000 homes were destroyed together with more than 840,000 acres of agricultural crops (IFRC, 2017).

Summary of impacts on mobility

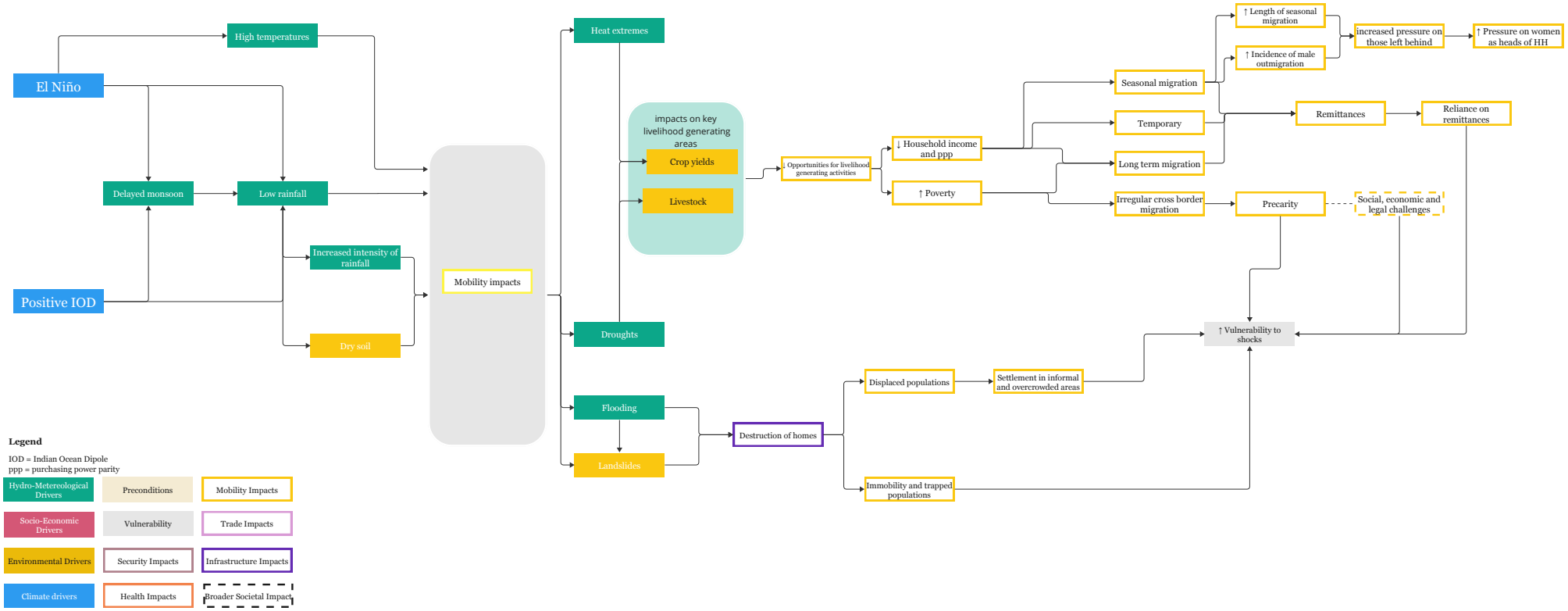
Under Storyline 1, the following impacts could be felt in the Central Dry Zone:

- Rates of outward migration away from rural areas are already increasing in the CDZ, influenced by the industrialization of agriculture, food insecurity, and social unrest. Under Storyline 1, which describes a situation of increased drought in the CDZ, an increase in migration may occur due to the exacerbation of these factors.
- People in CDZ are likely to experience temporary or protracted displacement due to flooding and landslides projected under this storyline.
- People already living in precarious, often informal or temporary settlements, are severely and disproportionately impacted by climate-related hazards and may be prone to displacement.
- Destruction of infrastructure such as roads and bridges during flooding events can lead to populations becoming trapped and immobile with limited access to resources or disrupted means of communication.
- Drought is one of the major drivers of migration for farmers. Under this storyline, the risk of drought poses a significant threat to people who rely on agriculture as a main form of subsistence and livelihood. This could lead to increased migration as a form of livelihood diversification or means of adaptation to decreased crop yield or crop failure.

Under Storyline 2, the following key impacts could be felt in the Central Dry Zone:

- Increased drought has the capacity to compound drivers of outmigration from the study region and result in more rural to urban migration.
- With increased migration due to higher drought intensity, there may be a rise in those on the move without documentation, increasing the risk of exploitation and forced return.
- With more extreme flooding, there would be a compounding and increasing risk of those in the CDZ experiencing temporary or protracted displacement.

Mobility impacts CDZ



Impacts on mobility under Storyline 1

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

Rates of outward migration away from rural areas are already increasing in the CDZ, influenced by the industrialization of agriculture, food insecurity and social unrest. Under Storyline 1, which describes a situation of increased drought in the CDZ, an increase in migration may occur due to the exacerbation of these factors.[2]

Due to a lack of work options, the migration pattern of young people between 15-24 years who have left the region in search of economic opportunity and a more reliable income, has increased in recent years to urban areas or abroad. (Philipps, 2017). Combined with increased agricultural drought and food security issues, these factors may compound and push more people towards urbanization away from the rural CDZ area.

- **Example:** Under this storyline, it is likely that the increasing pattern of migration will continue, or perhaps grow further. More frequent and intense droughts, such as those predicted under this storyline and seen in 2009-2010, negatively impact people's livelihoods and lead to an increase in mobility (SEI, 2018). Migration in CDZ is often a result of the compounding factors of water scarcity, chronic poverty, and ensuing challenges in practicing agricultural livelihoods. Migration in CDZ has been utilized as an adaptation strategy to deal with the interconnected challenges (SEI, 2018). Typical migration routes are both internal (within Myanmar) with people travelling to locations such as Mandalay and Yangon, as well as cross-border, with some migration to Thailand and Malaysia.

People in CDZ are likely to experience temporary or protracted displacement due to flooding and landslides projected under this storyline.

The impacts of displacement are especially pronounced for highly impoverished people in CDZ and are potentially compounded by increased vulnerability due to ongoing conflict.

- **Example:** The combination of heavy rainfall, strong winds, and tropical cyclones in 2015/2016 resulted in widespread flooding and landslides across 12 of Myanmar's 14 states and regions (northwest, west, south and southwest). At its peak, the floods affected over nine million people across 12 of Myanmar's 14 states and regions. In June to August of 2015, the flooding led to the displacement of 1.7 million people across Myanmar, including across the CDZ. Most people returned to their homes within several months but by the end of the year approximately 9,000 people were still displaced (UN OCHA, 2016).

2 This point arose as an element to consider in the expert practitioner workshops

People already living in precarious, often informal or temporary settlements, are severely and disproportionately impacted by climate-related hazards and may be prone to displacement.

Migrants tend to live in overcrowded informal settlements without access to basic services such as water and sanitation, increasing exposure to discrimination, and several health risks (IFRC, 2021). In Myanmar, these areas tend to be highly vulnerable to hazards which often generate major impacts (Lo & Hoy, 2023). Lack of resources, poor supply of goods, and disruption of market systems pose a challenge for internally displaced populations to access food, illustrating high vulnerability even without the additional challenge of climate hazards (Market Analysis Unit, 2022).

- **Example:** Approximately 50 per cent of households recently displaced by flooding in the Sagaing Region (one of the regions with higher number of internally displaced populations), had poor access to food, health care and security (ACAPS, 2024). Most households also struggled with access to jobs and therefore rely on cash assistance to meet their needs. Around 64 per cent of households had to travel more than 30 minutes to reach the nearest food market, although 33 per cent could not travel to the food market in the month of the survey due to poor transportation, safety or roadblocks. Many households had to rely on negative coping mechanisms, such as running out of food and/or going a day without eating (Market Analysis Unit, 2022). Under this storyline, as the likelihood of flooding increases due to tropical cyclones, the potential for these impacts to be exacerbated rises, particularly for populations already displaced due to both conflict and previous climate-related events.

Destruction of infrastructure such as roads and bridges during flooding events can lead to populations becoming trapped and immobile with limited access to resources or sometimes disrupted means of communication

Immobility is important to consider in this storyline because it means that people are forced to rely on limited supplies and have reduced access to essential services such as health care. When essential infrastructure is destroyed, the option of evacuating is taken away and this has implications on health, livelihoods and mortality.

- **Example:** During Cyclone Mocha in 2023, both Sagaing and Magway provinces were affected by flooding. Due to infrastructure damage in the surrounding regions, access to support relief efforts was challenging, with roads and bridges damaged by the storm. Communication and power infrastructure was also limited due to cyclone damage, compounding both relief access and immobility of affected populations (ACAPS, 2023).

2 This point arose as an element to consider in the expert practitioner workshops

REGIONAL IMPACTS OF STORYLINE ON STUDY REGION

Drought is one of the major drivers of migration for farmers.[3] Under this storyline, the risk of drought poses a significant threat to people who rely on agriculture as a main form of subsistence and livelihood. This could lead to increased migration as a form of livelihood diversification or adaptation to decreased crop yield or crop failure.

- The outmigration of rural communities has been documented as ranging across timescales and durations. In this region and under this storyline, drought and reduced agricultural yield could result in increased migration of rural populations (IFPRI, CGIAR, USAID, 2024). As the numbers of migrants increase, more may cross borders within the region, seeking economic opportunities in Thailand and China in particular.

- **Example:** Based on interviews by the Stockholm Environmental Institute with local community members in certain villages across the CDZ, interviewees highlighted that a large number of households have at least one person who has migrated in search of better livelihood opportunities (SEI, 2018). This is resulting in changes to the social fabric of these communities, further impacting the resilience and coping capacity of those who remain (IFRC, RCCC, 2021).

3 This point arose as an element to consider in the expert practitioner workshops

Impacts on mobility under Storyline 2

Under Storyline 2, **mobility** could be impacted in the following ways:

HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS		MORE EXTREME FLOODING
Increased drought has the capacity to compound drivers of outmigration from the study region and result in more rural to urban migration.	**With increased migration due to higher drought intensity, there may be a rise in those on the move without documentation, increasing the risk of exploitation and forced return.**	**With more extreme flooding, there would be a compounding and increasing risk of those in the CDZ experiencing temporary or protracted displacement due to flooding.**
▪ In a 2°C scenario, which depicts increased intensity of agricultural droughts, farming livelihoods will likely face continued and exacerbated impacts. These may be intensified by conditions that amplify vulnerability such as limited viability of rain-fed agricultural livelihoods, limited access to credits, low household incomes or lack of land tenure.	▪ According to UNDP, undocumented Myanmar migrants in Thailand are often exposed to poor working conditions, without access to services (UNDP, 2023). In addition, undocumented migrants throughout the region, are at risk of arrest and prosecution, as well as deportation and forced return to Myanmar where they may face economic hardship due to climate impacts on livelihoods, as well as compounding risks related to the conflict (Frontier, 2024).	▪ As the risk of extreme flooding rises, so too does the exposure of vulnerable populations to displacement. This is likely to be particularly true in the CDZ region where resilience to the impacts of climate change and flooding is already diminished due to existing climate impacts on livelihoods and food security, reducing coping capacity (NUPI, 2024). There is also a compounding risk of repeat displacement as the rate of extreme flooding increases.
		▪ The risk of more extreme flooding will also likely place already displaced populations at even higher risk, due to their exposure and vulnerability to flooding events. Informal and temporary settlements lack sufficient infrastructure to cope.

Impacts on security

The security implications presented in this storyline depend on the responses provided to the outlined risks. The impacts of climate risks on security are highly interrelated with pre-existing vulnerabilities related to human security, which informs the capacity of communities to cope with increasing and more frequent climate-related risks. Adaptation is essential to minimize the likelihood of security risks compounding the potential climate-related challenges, and to address underlying causes of vulnerability. While strict security related concerns cannot be predicted, this section attempts to illuminate some of the human security impacts of the storylines. While some light connections are drawn identifying key areas where human security related concerns can act as a threat multiplier for violence and conflict, the analysis here primarily presents the broader context which may intersect with risks related to violence and conflict. Bearing this in mind, **it is important to consider the risk of climate impacts on human security, which create the backdrop in which to understand the potential for security consequences related to violence and conflict.**

Summary of impacts on security

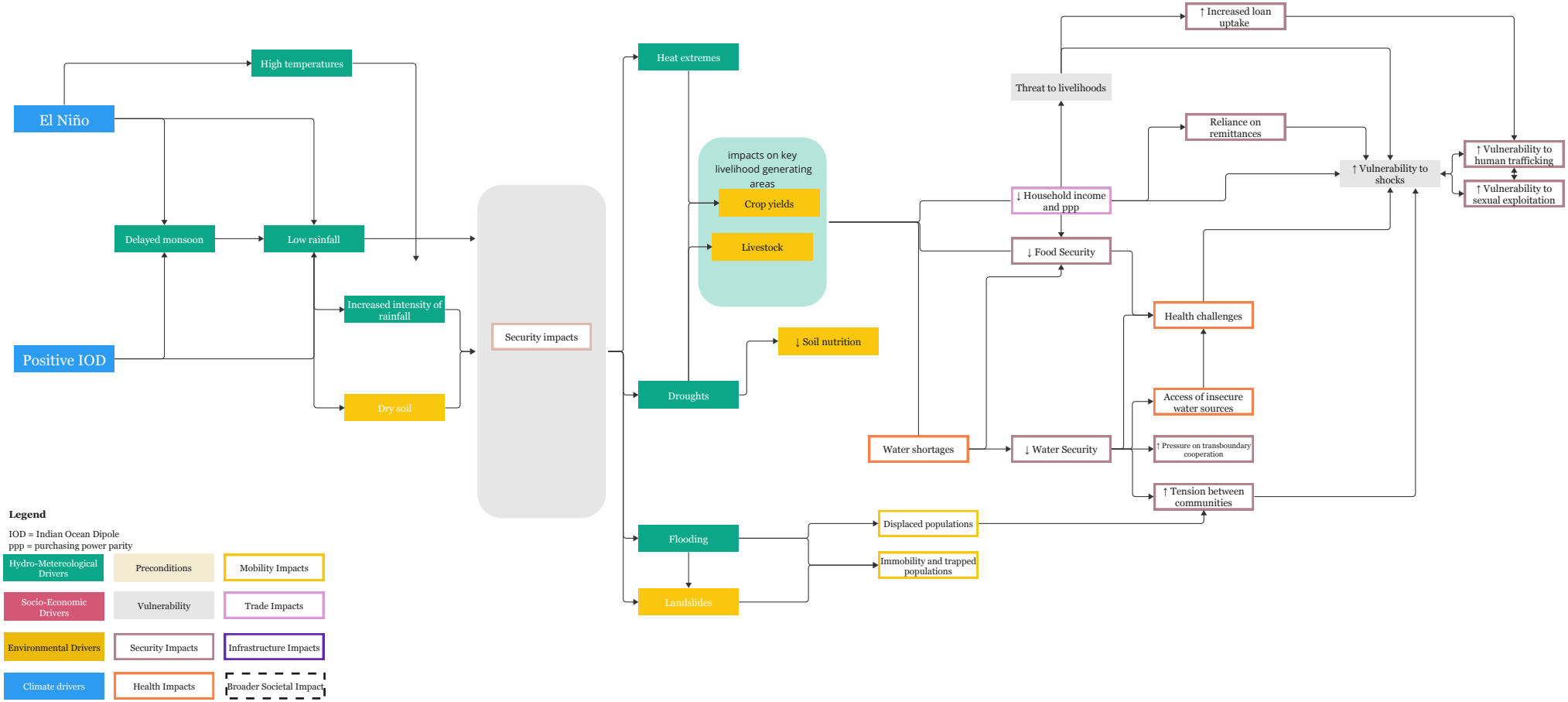
Under Storyline 1, the following impacts could be felt for the Central Dry Zone:

- Food insecurity is a significant consequence of both flooding and drought, expected under this storyline.
- The CDZ is one of the most water stressed regions in Myanmar, and water insecurity is likely to rise with increasing likelihood of both drought and flooding. This has an impact on overall well-being and is interconnected with other forms of human security.
- Economic security is threatened during and after flood and drought events. Diminished economic security can act as a compounding element that erodes coping capacity and adaptive response.
- Floods and droughts can increase risks to personal security with heightened vulnerability to human trafficking and exploitative conditions.
- Without transboundary cooperation between the region, increasing drought conditions will exacerbate risks to water and food security as well as livelihoods throughout the region.

Under Storyline 2, the following key impacts could be felt in the Central Dry Zone:

- Economic security will likely be further impacted by both drought and heat.
- Food security is threatened especially for poorer populations with limited capacity and adaptation measures.
- Competition over the control of resources under pressure from climate change impacts, may exacerbate pre-existing tensions.
- As populations are impacted and displaced by more extreme flooding, this may contribute to pre-existing inter-communal and ethnic tensions.

Security impacts CDZ



Impacts on security under Storyline 1

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

Food insecurity is a significant consequence of both flooding and drought, expected under this storyline.

- The growing impacts of climate change are exacerbating pre-existing food insecurity challenges in the CDZ. Already in 2010, it was found that drought and dry spells were negatively affecting the food security of 41 per cent of households in the CDZ (Boori et al., 2017). With drought expected to rise, such consequences are likely to be compounded.

- Flooding presents the risk of damage to crops, decreasing crop yields and contributing to food insecurity. Both paddy and dryland crops, both common in the CDZ can be impacted. For instance, in one village in the region, land was inundated with water for over seven weeks due to extreme monsoon flooding, meaning that crop yields were reduced because famers couldn't access their crops or cultivate. This has a significant impact particularly for landless farmers, who are then forced to search for alternate work while fields are inaccessible (IWMI, 2015).

The CDZ is one of the most water stressed regions in Myanmar (Boori et al., 2017). Water insecurity is likely to rise with increasing likelihood of both drought and flooding. This has an impact on overall well-being and is interconnected with other forms of human security.

- Decreased access to water due to drought, can lead to the use of unsafe water resources as a coping mechanism and people may be forced to travel farther to access water resources. (SEI, 2018). This exposes people to increased risk of water borne diseases (Davies et al., 2015). In addition, malnutrition which is common during drought, can also increase the risk of infectious diseases, such as cholera and other diarrhoeal diseases found in water. This can also increase exposure to risks along the route to water sources, particularly for women and girls who are often responsible in the CDZ for collecting water (Mekong Eye, 2023).

- Water insecurity is closely connected to food security, particularly as the majority of agriculture in the CDZ is rainfed, with less than 16 per cent of cultivated land using irrigation infrastructure. During times of drought, there is insufficient infrastructure and high associated costs which inhibit the ability of communities to access stored water for agricultural use (IWMI, 2015).

- In 1997-1998, 2010 and 2014, droughts in the CDZ resulted in significant agricultural losses due to a lack of water for crops, which resulted in serious consequences for food and water insecurity in the region (MIMU 2022).

- Flooding can result in the contamination of water resources, decreasing the availability of safe drinking water and leading to significant health consequences. Excess rainfall can exacerbate the severity of flooding events, leading to ground water contamination and significantly increasing the risk of waterborne diseases such as cholera, typhoid, hepatitis A, and gastroenteritis.

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

Economic security is threatened during and after flood and drought events. Diminished economic security can act as a compounding element that erodes coping capacity and adaptive response.

- Economic security in the CDZ has been significantly affected by drought, due to the high number of households relying on rainfed agriculture for their livelihoods. According to one study, 11 million people in the region have been financially impacted (MIMU, 2022). The loss of livelihoods is compounded by rising prices and the risk of debt and landlessness, resulting in greater overall levels of economic insecurity (NUPI, 2024). This risk is exacerbated for landless agricultural workers.

- Flood events can further worsen economic security with acute losses to crops, jobs and assets because of damage from flood waters. In addition, landholders may have decreased funds to afford hiring farm workers, further exposing vulnerable households to economic stress (FAO et al., 2015).

- As a result of flooding in 2015, it was reported that in affected districts, including in the CDZ, the most common coping mechanism was borrowing money to purchase food and essential supplies (FAO et al., 2015). This can further increase household vulnerability, reducing the ability to cope with subsequent impacts from floods or droughts and exacerbating poverty. The culmination of these factors also contributes to increased migration as families seek alternative livelihoods to survive (IOM, 2024).

Floods and droughts can increase risks to personal security with heightened vulnerability to human trafficking and exploitative conditions.

- Floods and droughts are considered a major stressor for household livelihoods, especially as households take out loans to cope with some of the consequences. As households lose access to their livelihoods, they can be forced to enter exploitative work environments or debt bondage labour. It has been reported that traffickers sometimes use debt-based coercion to engage children in sex-trafficking or forced labour (US Department of State, 2023).

REGIONAL IMPACTS OF STORYLINE ON STUDY REGION

Without transboundary cooperation between the region, increasing drought conditions will exacerbate risks to water and food security as well as livelihoods throughout the region.

- With an increasing risk of droughts, effective water management and cooperation between regions in Myanmar and with neighbouring countries, is essential to reduce the impacts of climate change on communities in the CDZ. As water, food and economic security diminishes, migration will likely be seen as the only option for survival.

- See mobility section for examples.

Impacts on security under Storyline 2

Under Storyline 2, **security** could be impacted in the following ways:

HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS

Economic security will likely be further impacted by both drought and heat.

- High risk that increasing heat will decrease productivity and thus economic security for households.
- Livelihood losses, particularly for the agricultural sector, combined with high prices and uncertain livelihood alternatives, will likely have a serious impact on economic security. This may also have an impact on recruitment rates into local armed groups involved in the conflict (NUPI, 2024).
- This impact is connected in this way:
  - *Drivers:* Drought
  - *Impacts:* decreased household income; increased vulnerability to shocks; search for alternative sources of income; increased recruitment.

Food security is threatened especially for poorer populations with limited capacity for adaptation measures.

- Marginalized communities may be further exposed to food security risks from drought without being able to access resources and tools for effective adaptation. This will further expose the 43 per cent of people living below the poverty line in the CDZ, with particular risks for 50 per cent of the rural population who are landless and rely on causal labour for their livelihoods (Boori et al., 2017).
- Given that 60 per cent of all croplands are located in the CDZ, increased intensity of drought may have larger national impacts on food security (Tun Oo et al., 2023).
- This impact is connected in this way:
  - *Drivers:* decreased crop yields; unstable prices of crops; decreased access to food; decreased household incomes; increased incidence of people taking out loans.
  - *Impacts:* increased loan uptake; risk of exploitative work to pay for loans; vulnerability to human trafficking; decreased capacity to engage in adaptation; increased vulnerability to shocks; decreased school enrolment rates; loss of life.

Competition over the control of resources under pressure from climate change impacts, may exacerbate pre-existing tensions.

- Given current ongoing armed conflicts in Myanmar, compounding climate risks reducing the availability of water and food resources because of drought, may aggravate political and community tensions within this context by exacerbating grievances (NUPI, 2024).

MORE EXTREME FLOODING

As populations are impacted and displaced by more extreme flooding, this may contribute to pre-existing inter-communal and ethnic tensions.

- For instance, following flooding from Cyclone Mocha in 2023, responses from different government and non-governmental actors resulted in varying perspectives on the adequacy of the humanitarian response, contributing to tensions between communities and armed actors (NUPI, 2024).

Suggested adaptation interventions

Adaptation interventions can take a variety of forms and can be implemented across different scales, from small community-level interventions to large scale national government policy interventions. These can be divided into four windows of opportunity for action:

1. Long term DRR and adaptation
2. Anticipatory action
3. Disaster response
4. Disaster recovery

Importantly, each of these windows of opportunity and interventions timescales provide scope for policy incentives to advocate for different interventions.

The following table summarises an array of interventions to exemplify how action on some of the challenges explored in this report series could be taken, all of which cut across the areas of health, trade, mobility and protection. This information is provided with the aim of sparking thinking on how pathways depicted in the causal maps might be adjusted or even changed, given that these are influenced by a variety of drivers, including actions taken in policy spheres, on the lived environment, and societally at local and global levels.

POTENTIAL FUTURE HAZARDS	SELECTED IMPACTS	CLIMATE ADAPTATION INTERVENTION POINT OR ACTION	TYPE
DROUGHT	Crop failure and food insecurity	**Income support for small-scale farmers.** Introduction of small-scale, affordable drip irrigation, good seeds, and plant nutrition, including switching to crops that give continuous supply with limited processing and logistics, thereby increasing smallholders' income while using less land and water.	Investment in small holder
	Water insecurity	**Dissemination of water purification systems.** Provides a temporary solution to support communities who are being pushed further towards unreliable and unsafe water sources.	Disaster response
		Investment in desalination infrastructure. Early investment in desalination infrastructure, especially in areas projected to see a decrease in river flow and rise in sea-level, could provide support for communities struggling to access water.	Medium investment
		Support for transboundary cooperation efforts. Backing of policy incentives to engage in peace- building and cooperation incentives.	National government or policy intervention
	Decreased household income	**Vocational training and education to build skills.** Connect these groups with job markets or entrepreneurship opportunities.	Network and capacity building
	Deteriorated mental health	**Investment and support of social protection programmes**. These can identify and support those with increased risk of mental health challenges.	Social protection

POTENTIAL FUTURE HAZARDS	SELECTED IMPACTS	CLIMATE ADAPTATION INTERVENTION POINT OR ACTION	TYPE
HEAT	Heat stress	**Climate-resilient production and system services.** **Micro investments in modern technology to improve farm acreage and work capacity of farmers.** **Investment in nature-based solutions to extreme heat.** Supporting local governments to invest in planting shade structures and incentivising afforestation could help alleviate the impacts of heat on outdoor workers and vulnerable populations.	Investment (small scale)
	Crop failure	**Increasing more equal access to and support in adoption of improved rice cultivars in rainfed farming systems.** For more, see similar interventions under drought.	Investment (medium scale)
FLOODS	Destruction of infrastructure	**Flood safety guidance.** Ensure people have access to information on flood risk zones, landslide zones, and other routes which maybe be dangerous to travel along. It is important that information is easily understandable and doesn't need high levels of technology to engage.	Networking and capacity building
	Trapped populations and immobility	**Development and maintenance of early warning infrastructure.** Effective communication systems have the capacity to inform communities of when to take action and the lead time to a hazard **Engagement with and development of early warning early action triggers and financing for communities.**	Anticipatory action and early warnings infrastructure
	Short term displacement	**Early warning communication.** Dissemination of early warning messages to communities at risk of being affected by floods. **Food and water provisioning services for displaced populations.**	Anticipatory action and early warnings
	Protracted displacement	**Income support** for displaced populations to ensure continued livelihood opportunities, decreased risk of exploitation. **Ensure marginalized and vulnerable populations have adequate access to social protection initiatives** and programming to meet basic needs.	Investment (small to medium scale)
		Ensure government recognition of climate displacement and other forms of climate mobility.[4]	National government or policy intervention
	Destruction of crop or livestock	**Evacuation of livestock.** Identification of safe havens or alternative pastureland for animals and/or relocate livestock to elevated grounds. **Early warning systems for early harvest (wherever possible) to minimise risk to crop yield.**	Anticipatory action and early warnings

4 This point arose as an element to consider in the expert practitioner workshops

Recommendations

Storylines can be used inform programmes, strategies and adaptation plans and further data-gathering. They provide a useful starting point for discussion and planning and can be further built on through deeper dives together with impacted stakeholders as well as those with the responsibility and power to take action.

It is recommended to use the storylines and impact information from this report as a discussion tool with national and regional teams and counterparts in government to explore preparedness measures, ideally low-regret options that would benefit local populations under multiple storylines. It is also important to reflect the potential different realities of El Niño or positive IOD dominance, and the impacts nationally. The storylines emphasize the importance of local monitoring of hydro-meteorological conditions, going beyond ENSO or IOD forecasting.

Core recommendations include:

Recommendation 1

Prepare for a future with persistent oscillation between La Niña and El Niño and positive and negative IOD, in an increasingly warmer world with more intense precipitation.

While the storylines highlight the various trajectories of climatological drivers of risk in the region, an overall conclusion is that locally, hydro-meteorological extremes such as floods and drought will persist and likely intensify under global warming. The storylines offer an opportunity to support relevant governments to reflect further on near-term and longer-term impacts of climate variability and climate change in national adaptation plans and disaster risk management strategies and protocols. Strengthening the awareness of existing modes of climate variability, and enhancing preparedness and risk reduction now, will support long-term adaptation, as risks are expected to intensify under a global **2°C** warming scenario. Many of the impacts observed under the near- and longer-term storylines are rooted in local vulnerabilities. This suggests that investment in improvements in food availability and accessibility, education, transportation, and local economic systems can help buffer the impacts of extreme hydro-meteorological events influenced by ENSO and IOD in the near future, albeit with limitations. In line with the systematic review, the most robust academic evidence exists for prevention activities for vector-borne diseases, support to increase drought and flood resilience in agricultural systems (particularly for rice farming) and prevention of disaster-related displacement through early evacuation and livelihood support.

Recommendation 2

Monitor climatological conditions at local, national, regional, and international levels to design and implement informed action

Given the potential variability in the next 2-10 years, further aggravated under climate change, it is crucial to monitor conditions to take informed action. Beyond monitoring the various ENSO and IOD indices and forecasting tools, it is crucial to review local conditions. For example, La Niña in the coming years may produce high antecedent vulnerabilities to subsequent El Niño /IOD events that can inform policy-makers about the potential severity of El Niño and positive IOD impacts. Regularly updating information will be important, as the storylines outline potential impact based on current knowledge, but rapid socioeconomic and climatological tipping points may change dynamics in the near future. The 2023/2024 El Niño and positive IOD phase highlighted the opportunity to use forecasting and monitoring tools, yet also illustrated a lack of proactive action based on the available warnings. While the capacity of governments to act on warnings varies widely across the Indo-Pacific region, it is recommended to engage with local stakeholders and interlocutors to discuss current approaches to monitoring ENSO, IOD and local hydro-meteorological conditions, and the capacity to act based on warning signals.

3

Recommendation

Conduct targeted research and analysis to close key knowledge gaps that currently limit evidence-based policy decisions.[5]

Workshops and background research highlighted key knowledge gaps that are currently limiting the ability of national and regional staff to make evidence-based decisions on FCDO policy and support. It is recommended that further research is considered for the key knowledge gaps raised, to further operationalize the storylines research. Given the short timeframe and specific focus on climatic drivers of different scenarios in the case study areas, some important areas deserve greater attention in subsequent research. These include other sectors that will experience climate impacts, and non-climatic drivers of change such as geopolitical shifts, rapid policy changes, or local dynamics of environmental degradation. The priority knowledge gaps include:

- The Central Dry Zone of Myanmar is an under-researched region (also evidenced in the findings of the systematic review research). [6]
- Environmental degradation (e.g. pollution, deforestation) was emphasized as a key concern across the workshops and extended to issues of land governance and land grabbing.
- Tipping points and temporal evolution of impacts and adaptation strategies, climatological tipping points and systemic risks.
- Further analysis of social, economic and policy-related drivers of change in the case study contexts and the wider region, for example the role of China in the Lower Mekong Basin and that of wider ASEAN relating to trade and hydroelectric dams.[7]
- Analysis of existing or missing policies in study regions and their likely impact on outcomes (e.g. adaptation policies).
- Analysis of the strength of pathways in the causal maps and described storylines.
- Impacts on additional sectors, such as energy dynamics, infrastructure, and housing.

5 This point arose as an element to consider in the expert practitioner workshops
6 This point arose as an element to consider in the expert practitioner workshops
7 This point arose as an element to consider in the expert practitioner workshops

4 Recommendation

Recognise and embrace the role of understanding and working within complexity when addressing future climate challenges.

Findings on impacts drawn from the storyline methodology have provided an insight into the inherent and underlying complexity and interrelatedness of the challenges populations may face in the future. The causal maps presented across all plausible future storyline scenarios outline the ways in which it is extremely challenging, if not sometimes impossible, to consider impacts in silos or view them as simple. More work remains to be done to highlight the interwoven and inextricable connections that underline vulnerability and decreased well-being and resilience.

The same can be said regarding complexity for the phenomena being researched, such as El Niño and IOD, whereby anthropogenic drivers such as deforestation, pollution, and resource extraction cannot be divorced from the ensuing implications in a given community. By embracing complexity and acknowledging the role of interconnectedness that is inherent to the socio-ecological systems within which we all reside, future research can create space for more nuanced, contextually appropriate, and innovative information sharing and uptake. This, in turn, can lead to more effective support to practitioners, including helping them identify holistic, long-term sustainable solutions and adaptation interventions.

5 Recommendation

Use the storylines as a discussion tool for preparedness measures within countries and regions.

It is recommended to use the storylines and impact information from this report as a discussion tool with national and regional teams and counterparts in government to explore preparedness measures, ideally low-regret options that would benefit local populations under multiple storylines. In these discussions, it is important to reflect the potential different realities of El Niño or positive IOD dominance, and the impacts nationally. The storylines emphasize the importance of local monitoring of hydro-meteorological conditions, going beyond ENSO or IOD forecasting to obtain as locally accurate information as possible to guide current and future policymaking and practice.

Conclusion

This report has utilised a storyline methodology to understand the role that El Niño Southern Oscillation and the Indian Ocean Dipole could play in the near and longer term future of the Indo-Pacific region. Two storylines were developed based on retrospective analysis to inform potential future impacts and refined through desk research and engagement with FCDO expert practitioners.

This work highlights the clear need and scope for further research to be conducted on the topic in this region given existing evidence gaps. Furthermore, using causal mapping and analysis of four sectors, the report has shown the importance of understanding and engaging with complex systems to better understand the possible future scenarios that may arise. This has presented a variety of points for intervention that bodies such as the FCDO could engage in, which could occur across timelines and windows for opportunity. If the FCDO is to act on these, it is advisable that the four recommendations presented in this research are taken up, and that more complex, systems-based research is commissioned. This research has shown that communities across the Indo-Pacific region face increased vulnerability to shocks as a result of ENSO, IOD, and global temperature increases. Substantive effort and initiative are needed to urge governments to take more responsibility and action towards minimising the impacts of current and future climate events, as climate change will continue to shape the lives of people in the Indo-Pacific region and globally.

References

Adaptation Fund. (2020). Addressing Climate Change Risks on Water Resources and Food Security in the Dry Zone of Myanmar. Project Completion Report. https://fifspubprd.azureedge.net/afdocuments/project/40/40_Project-Completion-Summary_Final.pdf

Arshad, M. S., Farooq, M., Asch, F., Krishna, J. S. V., Prasad, P. V. V., & Siddique, K. H. M. (2017). Thermal stress impacts reproductive development and grain yield in rice. *Plant Physiology and Biochemistry*, 115, 57–72. https://doi.org/10.1016/j.plaphy.2017.03.011

Boori, M. S., Choudhary, K., Evers, M., & Paringer, R. (2017). A review of food security and flood risk dynamics in central dry zone area of Myanmar. *Procedia Engineering,* 201, 231–238. https://doi.org/10.1016/j.proeng.2017.09.600

Boori, M. S., K. Choudhary, M. Evers, and A. Kupriyanov (2017). "Food vulnerability and alluvial farming for food security in central dry zone area of Myanmar." *The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences* 42 (2017): 31-38. https://doi.org/10.5194/isprs-archives-XLII-4-W5-31-2017

Crabtree, A. (2012). Climate change and mental health following flood disasters in developing countries, a review of the epidemiological literature: what do we know, what is being recommended. *Aust J Disaster Trauma Stud,* 1, 21-30. https://trauma.massey.ac.nz/issues/2012-1/AJDTS_2012-1_Crabtree.pdf

Gallagher A, Smyth B, Jha V. (2023). Climate Change, Heat-Related Acute Kidney Disease, and the Need for Action. *Am J Kidney Dis*. 2023 May;81(5):501-503. https://doi.org/10.1053/j.ajkd.2022.11.002

Daniel, R. (2018, April 19). *In rural Myanmar, more frequent and intense droughts are affecting local livelihoods.* Stockholm Environment Institute. https://www.sei.org/features/rural-myanmar-frequent-intense-droughts-affecting-local-livelihoods/

FAO (2015). Myanmar floods deal major blow to country's agriculture. Retrieved from: https://www.fao.org/newsroom/detail/Myanmar-floods-deal-major-blow-to-country-s-agriculture/en

Horton, R., De Mel, M., Peters, D., Lesk, C., Bartlett, R., Helsingen, H., Bader, D., Capizzi, P., Martin, S. and Rosenzweig, C. 2016. *Assessing Climate Risk in Myanmar.* New York, NY, USA: Center for Climate Systems Research at Columbia University, WWF-US and WWF-Myanmar. https://unhabitat.org/sites/default/files/2019/10/assessing-climate-risk-in-myanmar_technical-report.pdf

IFRC (2017). *Myanmar: Floods - Final Report* (MDRMM006). ReliefWeb. https://reliefweb.int/report/myanmar/myanmar-floods-final-report-mdrmm006

IFRC (2021). *Climate change impacts on health and livelihoods: Myanmar assessment.* IFRC. https://www.climatecentre.org/wp-content/uploads/RCRC_IFRC-Country-assessments-MYANMAR-V7.pdf

IOM (2015). Myanmar Floods & Landslide Response. Retrieved from: https://www.iom.int/sites/g/files/tmzbdl486/files/situation_reports/file/IOM-Myanmar-Floods-and-Landslide-Response-2015.pdf

IWMI. (2015). Improving water management in Myanmar's dry zone for food security, livelihoods and health. *International Water Management Institute* (IWMI). https://doi.org/10.5337/2015.213

Htay, H. (2009). Mental health and psychosocial aspects of disaster preparedness in Myanmar. *International Review of Psychiatry,* 18(6), 579-585. https://doi.org/10.1080/09540260601108952

Jack, C. D., Jones, R., Burgin, L., & Daron, J. (2020). Climate risk narratives: An iterative reflective process for co-producing and integrating climate knowledge. *Climate Risk Management*, 29, 100239. https://doi.org/10.1016/j.crm.2020.100239

Jones, B. (2021, October 18). Competing over climate: Myanmar's valuable and climate-vulnerable geography. Brookings. https://www.brookings.edu/articles/competing-over-climate-myanmars-valuable-and-climate-vulnerable-geography/

Kennedy, J., & McCoy, D. (2017). WHO and the health crisis among the Rohingya people of Myanmar. *The Lancet*, 389(10071), 802-803. https://doi.org/10.1016/S0140-6736(17)30507-X

Lo, A., & Hoy, S. T. (2023, November 9). Conflicts intensify climate change risks in Myanmar. *East Asia Forum.* https://eastasiaforum.org/2023/11/09/conflicts-intensify-climate-change-risks-in-myanmar/

Ludher, E., & Teng, P. (2023). *Rice Production and Food Security in Southeast Asia under Threat from El Niño.* ISEAS - Yusof Ishak Institute, 53. https://www.iseas.edu.sg/wp-content/uploads/2023/06/ISEAS_Perspective_2023_53.pdf

MAU. (2022). Sagaing Region IDPs. Market Analysis Unit (MAU). https://themimu.info/sites/themimu.info/files/mau_public/Survey_MAU_Sagaing_-_Aug_2022_-_IDPs.pdf

MCCA, Myanmar Climate Change Alliance (2017). Managing climate risks for people's health and well-being. *Policy Guidance Brief 5*. https://lpr.adb.org/sites/default/files/resource/686/myanmar-policy-brief-sap-5.pdf.pdf

MercyCorps. (2013). *Myanmar Dry Zone Vulnerability and Capacity Assessment.* MercyCorps. https://www.fsnnetwork.org/sites/default/files/TSU_MyanmarDryZone_Final.pdf

MIMU. (2018). *Vulnerability in Myanmar: A Secondary Data Review of Needs, Coverage and Gaps.* Myanmar Information Management Unit (MIMU). https://themimu.info/vulnerability-in-myanmar

Phillips, K. (2017, June 26). *Climate of uncertainty fuels anxiety, exodus in Dry Zone.* ReliefWeb. https://reliefweb.int/report/myanmar/climate-uncertainty-fuels-anxiety-exodus-dry-zone

Poe, C. A. (2011). *Food Security Assessment in the Dry Zone Myanmar.* World Food Program (WFP). https://www.burmalibrary.org/sites/burmalibrary.org/files/obl/2011-02-00-Food-Security-Assessment-in-the-Dry-Zone-Myanmar_WFP-en-red.pdf

Rapten, K. (2018, October 26). *Adapting to Climate Change: Greening the Dry Zone of Myanmar.* Medium. https://medium.com/@karmarapten/adapting-to-climate-change-greening-the-dry-zone-of-myanmar-3a3cce68165b

RIMES. (2011). *Managing climate change risks for food security in Myanmar.* Food and Agriculture Organization. https://www.ipcinfo.org/fileadmin/user_upload/eufao-fsi4dm/docs/Myanamr%20-%20RIMES%20(2011-07)%20Managing%20Climate%20Change%20Risks%20for%20Food%20Security.pdf

Selvaraju, R. (2003). Impact of El Niño–southern oscillation on Indian foodgrain production. *International Journal of Climatology*, 23(2), 187–206. https://doi.org/10.1002/joc.869

Shepherd, T. G., Boyd, E., Calel, R. A., Chapman, S. C., Dessai, S., Dima-West, I. M., ... & Zenghelis, D. A. (2018). Storylines: an alternative approach to representing uncertainty in physical aspects of climate change. *Climatic change*, 151, 555-571. https://doi.org/10.1007/s10584-018-2317-9

Sojobi, A. O., & Zayed, T. (2022). Impact of sewer overflow on public health: A comprehensive scientometric analysis and systematic review. *Environmental Research*, 203, 111609. https://doi.org/10.1016/j.envres.2021.111609

Sutton, W. R., Srivastava, J. P., Rosegrant, M., Thurlow, J., & Vasileiou, I. (2019). *Striking a balance: Managing El Niño and La Niña in Myanmar's agriculture*. World Bank. https://documents1.worldbank.org/curated/en/142691554202690382/pdf/Striking-a-Balance-Managing-El-Ni%C3%B1o-and-La-Ni%C3%B1a-in-Myanmar-s-Agriculture.pdf

Tun Oo, A., Boughton, D., & Aung, N. (2023). Climate Change Adaptation and the Agriculture–Food System in Myanmar. *Climate*, 11(6), 124. https://doi.org/10.3390/cli11060124

UNDP. (2023). *Strengthening food security in Myanmar: A roadmap for localized action.* United Nations Development Program (UNDP). https://www.undp.org/sites/g/files/zskgke326/files/2023-12/undp_mmr_strengthening_food_security_in_myanmar_dec_2023_v2.pdf

University of Notre Dame. (2021). ND-GAIN Country Index. Notre Dame Global Adaptation Initiative. https://gain.nd.edu/our-work/country-index/rankings/

USDA (2015). Burma: Floods in Myanmar Impact Rice Production Export Ban Now in Place. https://fas.usda.gov/data/burma-floods-myanmar-impact-rice-production-export-ban-now-place

Van den Hurk, B. J., Pacchetti, M. B., Boere, E., Ciullo, A., Coulter, L., Dessai, S., ... & Witpas, K. (2023). Climate impact storylines for assessing socio-economic responses to remote events. *Climate Risk Management*, 40, 100500. https://doi.org/10.1016/j.crm.2023.100500

Vasconcelos, V. V., Krittasudthacheewa, C., & Apirumanekul, C. (2016). *Hurricanes and Floods: a study case of Myanmar flood in 2015*.

WFP and FAO, 2016. FAO/WFP Crop and Food Security Assessment Mission to Myanmar. http://www.themimu.info/sites/themimu.info/files/documents/Report_Crop_Food_Security_Assessment_FAO-WFP_Mar2016.pdf

WFP. (2020, May 20). *Myanmar*. World Food Program. https://www.wfp.org/emergencies/myanmar-emergency

WHO. (2016). Health and climate change: country profile 2015: Myanmar. Retrieved from https://www.who.int/publications/overview/health-and-climate-change-country-profile-2015-myanmar

WHO. (2023). *Public health situation analysis Myanmar.* World Health Organization (WHO). https://cdn.who.int/media/docs/default-source/searo/myanmar/documents/public-health-situation-analysis-phsa_myanmar_august-2023.pdf?sfvrsn=d01829f9_1&download=true

World Bank. (n.d.-b). Myanmar [dataset]. World Bank. Retrieved April 29, 2024, from https://data.worldbank.org/country/myanmar

World Bank. (2016a). Myanmar Economic Monitor, December 2016. World Bank. https://www.worldbank.org/en/country/myanmar/publication/myanmar-economic-monitor-december-2016

World Bank. (2016b). Myanmar Economic Monitor, May 2016. World Bank. https://www.worldbank.org/en/country/myanmar/publication/myanmar-economic-monitor-may-2016

World Bank. (2016c). Myanmar Economic Monitor, May 2016. World Bank. https://themimu.info/sites/themimu.info/files/documents/Report_Myanmar_Economic_Monitor_WB_Jun2016.pdf

WWA, World Weather Attribution. (2024, May 14). *Cl*imate change made the deadly heatwaves that hit millions of highly-vulnerable people across Asia more frequent and extreme. Retrieved from https://www.worldweatherattribution.org/climate-change-made-the-deadly-heatwaves-that-hit-millions-of-highly-vulnerable-people-across-asia-more-frequent-and-extreme/

Climate
Centre