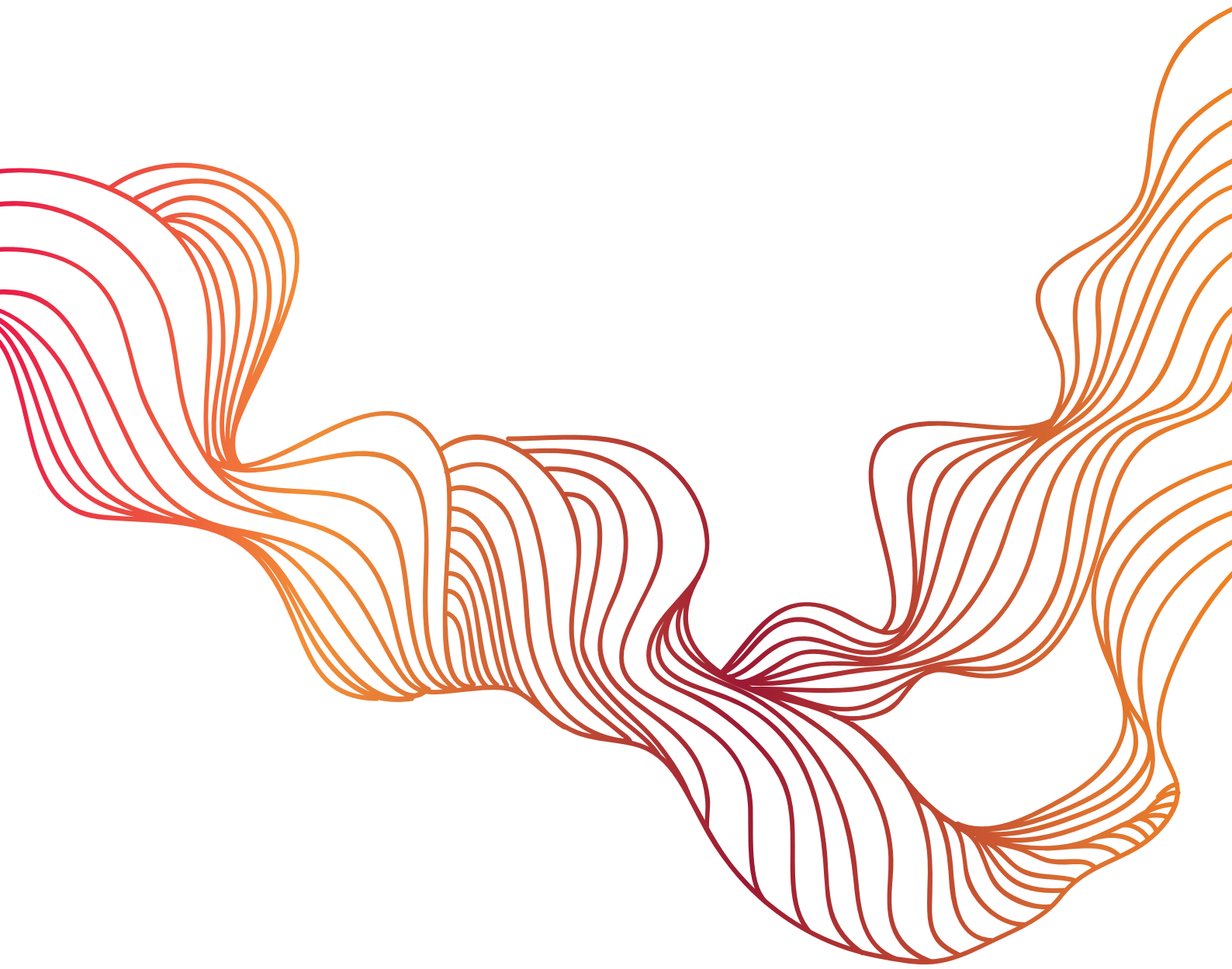
El Niño Storylines and Plausible Climate Futures for the Indo-Pacific

Lower Mekong Basin Case Report



Red Cross Red Crescent Climate Centre

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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 Lower Mekong Basin** and is one of three case reports (East India and the Central Dry Zone, Myanmar) 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.

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Executive summary

This report investigates the potential impacts of El Niño Southern Oscillation and the Indian Ocean Dipole (IOD) in the Lower Mekong Basin over the near term (next 2-10 years) and longer term (assuming 2°C of global temperature increase since pre-industrial levels) might have on the region. To do this, plausible climatological storylines were developed, overviewed below. Using these storylines as a starting point, the research explored the potential impacts that could be seen across the four sectors of health, trade, mobility and security, using a retrospective analysis approach.

Table 1. Lower Mekong Basin storylines

LOWER MEKONG BASIN		
Storyline 1: near term (2-10 years)	**Storyline 2: 2°C global warming**	
El Niño conditions increase the probability of hot and dry conditions and **drought** over the Lower and Upper Mekong Basin.	Storyline 2A: An El Niño event with 2°C global warming would very likely result in **more than 3°C higher temperatures** than contemporary El Niño events. Combined with positive IOD, this would likely result in **very hot and dry pre-monsoon conditions, late monsoon onset and very low intermittent rainfall during the monsoon.** When the rain does fall, rainfall intensities are higher than the region typically experiences in contemporary climates.	Storyline 2B: High temperatures increase evaporation from upstream dams, leading to **significantly reduced water levels and flow in the Mekong River** and its main tributaries, including in the delta region. In addition, **higher sea-level in the delta region caused by** El Niño results in **coastal flooding. Low river levels reduce delta flooding risk but increase salt-water intrusion.**

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 impacted healthcare quality and availability, increases in water and vector- borne diseases, undernutrition and malnutrition, heat-related illnesses, and issues arising from decreased availability of potable water due to sea-level rise and salination.

Trade impacts revolved predominantly around decreased income generation from declining crop yields and reduced river flow, which impacts the availability of hydropower generation. Significant impacts could be seen in freshwater lakes such as Tonle Sap, with fishing projected to be a less viable livelihood and trade potential reduced. Finally, the role of non-timber forested products is discussed, with particular emphasis on gender disparities and economic opportunities.

Mobility impacts centre around the changes in length of seasonal or long-term economic migration, flows of irregular cross-border migration, increased prevalence of rural to urban migration and migration journeys themselves becoming more dangerous. Additionally, there is discussion on the role increased displacement will play under these storylines and its impacts on affected people.

Security impacts focus 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 the marginalization of migrant communities, and competition over control of resources.

The report provides several **recommended adaptation intervention** based on the outlined impacts under each storyline. These are presented across different durations and varying windows of opportunity, ranging from long term disaster risk reduction (DRR) and adaptation, anticipatory action, disaster response, and disaster recovery.

In conclusion, the report provides five recommendations going forward:

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.

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Figure 1: Map depicting study region for this report developed by the Red Cross Red Crescent Climate Centre

Introduction

According to the Intergovernmental Panel on Climate Change Sixth Assessment Report (IPCC AR6), the Asia-Pacific region has a disproportionate share of the world's population vulnerable to climate change (IPCC 2022). The Mekong region, excluding China, is home to nearly 350 million people. As the region experiences rapid urbanisation it is crucial to build resilience to climate change impacts and provide sustainable energy and food security for its long-term development pathway (USAID 2014).

The Lower Mekong Basin (LMB) is predominantly agricultural, with more than 100,000km^2 cultivated land dedicated to rice production. Vietnam and Thailand fully utilise their arable land for growing paddy, rice, and other crops. During the past two decades, the ecological transformation of the LMB has accelerated, primarily due to large-scale infrastructure development such as hydropower projects and road networks. These developments provide access to other resource uses, contributing to significant changes in the region's ecology (Kuntiyawichai et al., 2015).

Laos, also known as Lao PDR, has a tropical climate influenced by the southeast monsoon, which brings 70 per cent of the annual rainfall and high humidity. It experiences two seasons: the rainy season, or monsoon, from May to mid-October, and the dry season from mid-October to April. The latest climatology (1991–2020) indicates that average rainfall can reach up to 3,000 millimetres (mm) per year. Mean annual temperatures are around 20°C in the northern and eastern mountainous areas and plateaus, while temperatures are higher in the plains, ranging from 25–27°C (MRC 2017).

Climate change impacts the Mekong River Basin causing a basin-wide temperature increase of 0.79°C, with colder catchment areas in the north experiencing greater warming. Annual rainfall has increased by 200 mm, with a 13.5 per cent overall increase. This is evident particularly in dry-season rainfall in northern catchments, whereas southern catchments have seen a decrease in rainfall. Total annual runoff has increased by 21 per cent, leading to increased flooding across the basin, especially in downstream catchments of the Mekong River. These changes are expected to disrupt natural ecosystems and agriculture, posing challenges in meeting the resource demands of the growing population in the region (MRC 2019).

As climate and weather patterns become increasingly volatile, flood and drought events in the Mekong River Basin have become more frequent and intense, posing a growing threat to the region's food security and economies. Communities that were unprepared have suffered the most from these extreme events, facing devastating damage to their livelihoods and resources.

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 Lower Mekong Basin

For the Lower Mekong Basin (LMB) case, two storylines were developed, one of which focuses on the near-term timeframe (2-10 years) while the other focuses on a 2°C world. The storylines highlight the immediate impacts of changes in temperature and precipitation and are further expanded upon in the causal maps and accompanying narrative analysis.

Storyline 1: near term (2-10 years)	**Storyline 2: 2°C 2°C global warming above pre-industrial temperatures:**	
El Niño conditions increase the probability of hot and dry conditions and drought over the Lower and Upper Mekong Basin.	Storyline 2A: An El Niño event with 2°C global warming would very likely result in **more than 3°C higher temperatures** than contemporary El Niño events. Combined with positive IOD, this would likely result in **very hot and dry pre-monsoon conditions, late monsoon onset and very low intermittent rainfall during the monsoon.** When the rain does fall, rainfall intensities are higher than the region typically experiences in contemporary climates.	Storyline 2B: High temperatures increase evaporation from upstream dams, leading to **significantly reduced water levels and flow in the Mekong River** and its main tributaries, including in the delta region. **Low river levels reduce delta flooding risk but increase salt-water intrusion** whereas **higher sea-level caused by El Niño in the delta region, causes coastal flooding.**

Datapoints for the retrospective analysis

The impact of this chain of events on the Lower Mekong Basin is explored under the lenses of health, mobility, trade, and security. The following storylines summarise 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 exhibit similar conditions (see Figures 2 and 3 below). Using this information combined with current trends seen, the following storylines are 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 positive IOD	Main hydrometeorological events
1997-1998	Very strong dominant El Niño event and positive IOD	Dry 1997 season followed by very hot pre-monsoon in 1998 and very dry monsoon season in 1998.
2002-2003	Weak but dominant El Niño event and later emergence of positive IOD	Dry start to the 2002 season followed by flooding in August and September. Moderately dry 2003 monsoon season. Flooding in parts of Vietnam in September 2003.
2009-2010	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.
2015-2016	Very strong El Niño and weak positive IOD	Severe drought and extreme temperatures in 2015 and pre-monsoon 2016. Late monsoon onset 2016. Several flooding events August to December 2016.
2019-2020	Strong positive IOD, but also El Niño event.	Hot and dry end to the 2018 rainfall season, very hot and dry 2019 season. Tropical storm Linfa causes flooding in October 2020.
2023-2024	Strong El Niño and positive IOD	Flooding across Laos, Thailand and Vietnam in July 2023. *2024 data not yet available.*

The data drawn upon to substantiate the 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 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 summary report and methodology document that form part of this report series.

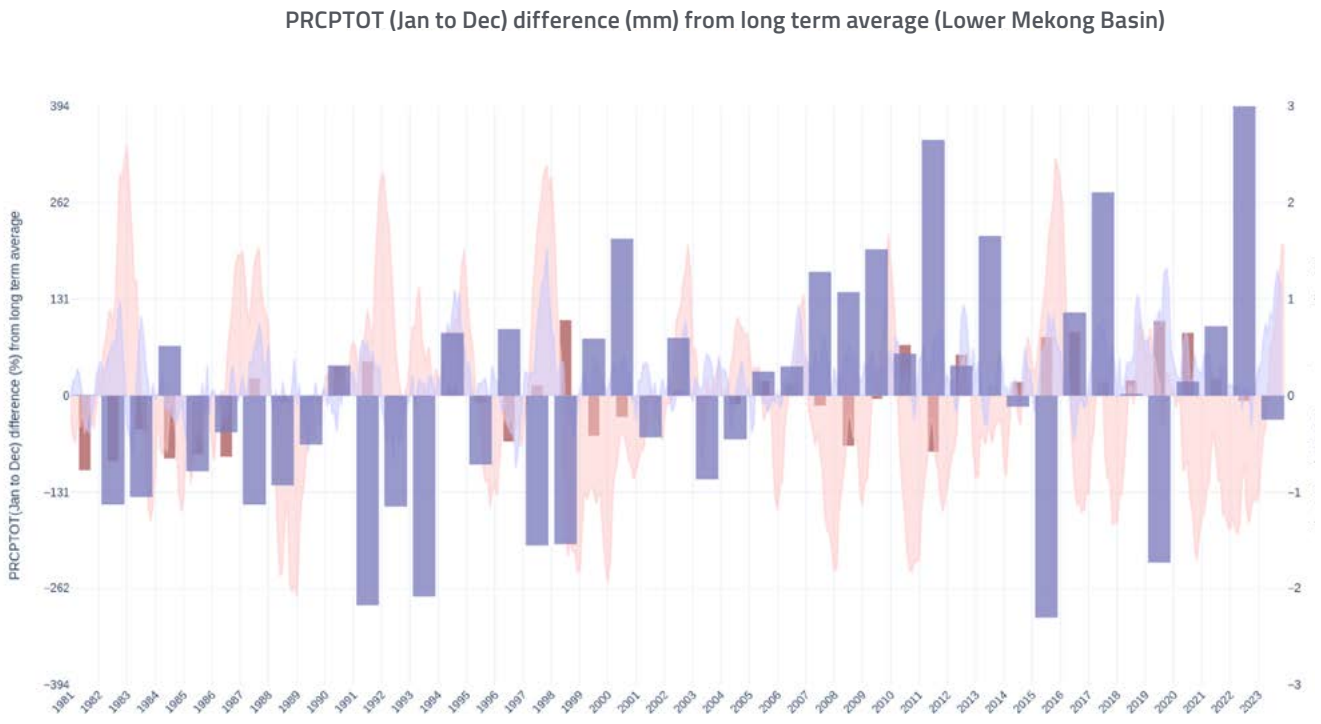


Figure 2: January to December total rainfall anomalies (in mm of normal) for the **Lower Mekong Basin** (1981-2022, blue bars), temperature anomalies (C) (red bars), ENSO Nino3.4 index where values > 0.5 indicate El Niño conditions and values less than –0.5 show La Niña conditions (pink curve), IOD DMI index showing positive and negative phases of IOD (blue curve).

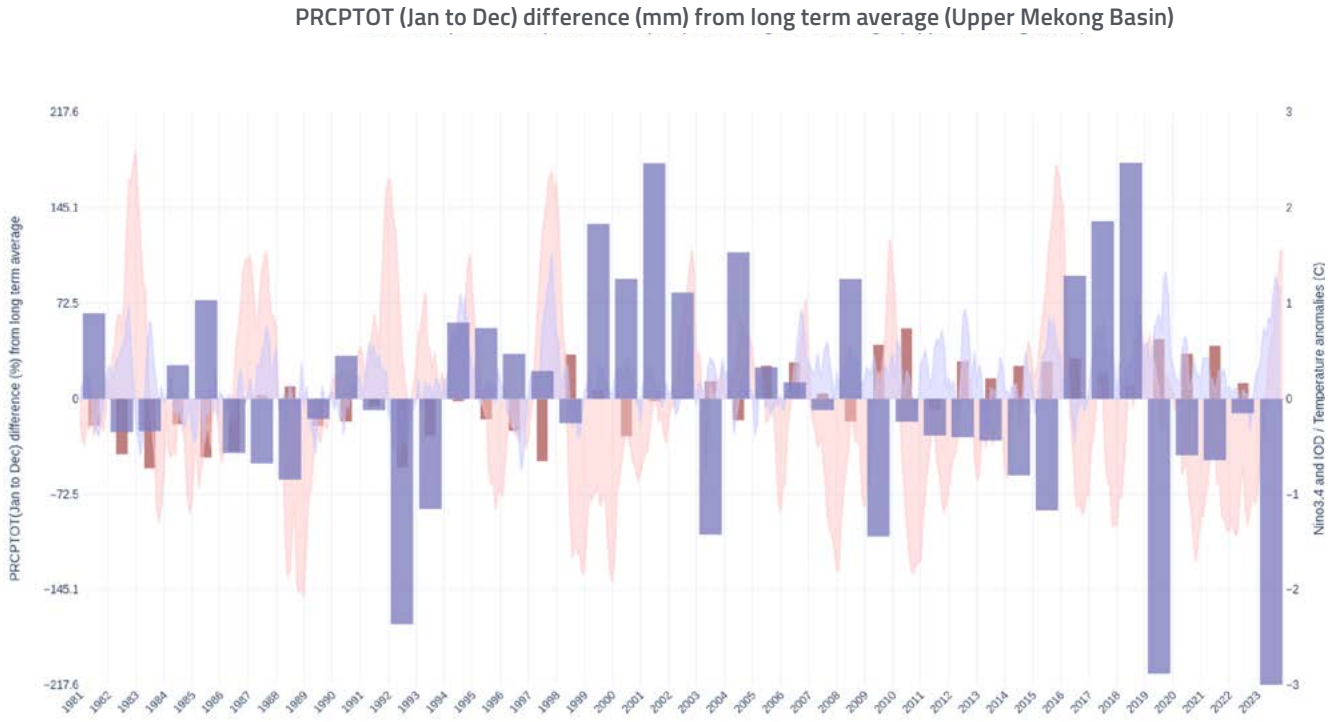


Figure 3: January to December total rainfall anomalies (in mm of normal) for the **Upper Mekong Basin** (1981-2022, blue bars), temperature anomalies (C) (red bars), ENSO Nino3.4 index where values > 0.5 indicate El Niño conditions and values less than –0.5 show La Niña conditions (pink curve), IOD DMI index showing positive and negative phases of IOD (blue curve).

Storyline 1: near term (2-10 years)

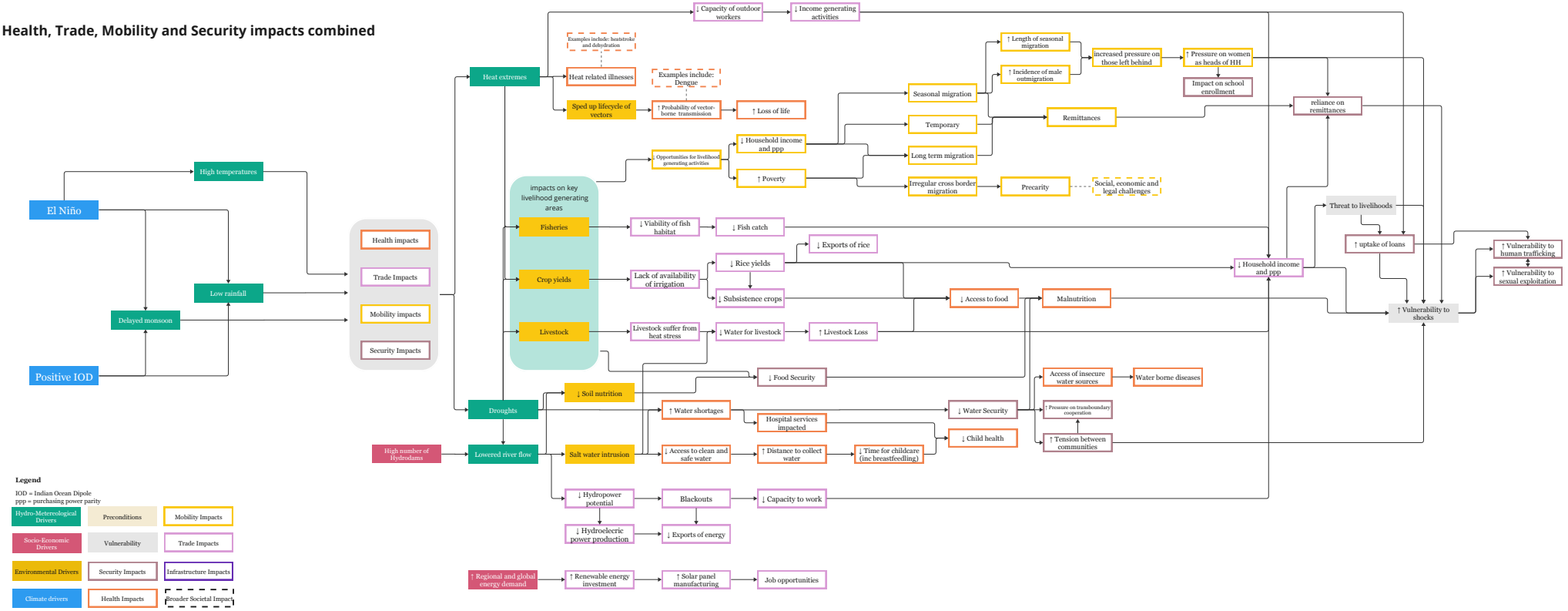
Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower and Upper Mekong Basin. This storyline explores both the local and regional impacts of likely near-term impacts in the Lower Mekong Basin region. These are expanded upon and depicted in the sections below.

Causal maps are visual depictions of the interactions between different climate hazards and impacts described in this research. The following pages present the causal maps which were developed as part of the process to highlight the connectedness and complexity of the impacts.

Storyline 1: El Niño conditions increase the probability of hot and dry conditions and drought over the Lower and Upper Mekong Basin.

Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower Mekong Basin as well as the upper Mekong basin. A combined positive IOD would likely increase the probability of dry conditions and **late monsoon onset**.

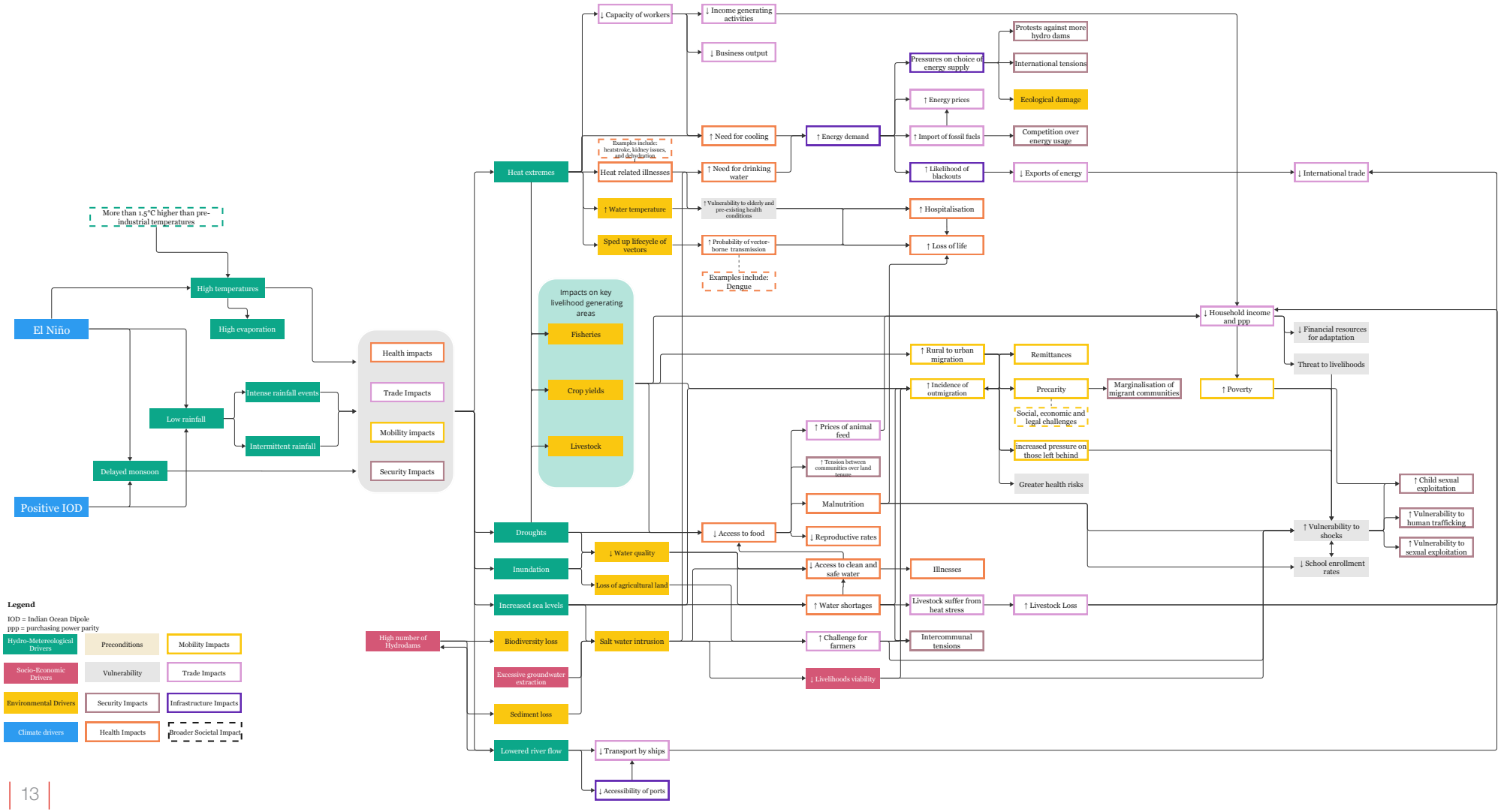
Health, Trade, Mobility and Security impacts combined



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

Storyline 2°C: An El Niño event with 2°C global warming (relative to pre-industrial temperatures) would very likely result in **more than 1.5°C higher temperatures** than contemporary El Niño events. **Combined with positive IOD**, this would likely result in very **hot and dry pre-monsoon conditions**, **late monsoon onset and very low intermittent rainfall during the monsoon**. When the rain does fall, the rainfall intensities are higher than the region typically experiences in contemporary climates.
High temperatures increase evaporation from upstream dams, which leads to **significantly reduced water levels and flow in the Mekong River and its main tributaries**, including in the delta region. **Higher sea-level in the delta region causes inundation** of delta areas. El Niño **increases sea-levels**. Low river levels reduce delta flooding risk but increase **salt-water intrusion**.

Health, Trade, Mobility and Security impacts combined



Impacts

Impacts on health

Summary of impacts on health

Under Storyline 1 the following impacts could be felt in the Lower Mekong Basin:

Drought-related impacts:

- Drought could impact healthcare quality and reduce availability of care.
- Water shortages could have disproportionate impacts on women who face additional burdens of sourcing water and could also impact infant and child health care.
- Disrupted crop yields could have impacts on access to food and lead to malnutrition or food insecurity.

Heat-related impacts:

- Increase in heat-related illnesses such as heatstroke could emerge across the region.
- Higher temperatures and variable precipitation could accelerate microbial growth, transmission, and virulence of diseases, leading to changes in the seasonal and geographic distribution of vector-borne and water-borne diseases.
- Heatwaves in urban areas reduce air quality and increase respiratory infections and incidence of heatstroke.

Under Storyline 2, the following impacts could be felt in the Lower Mekong Basin:

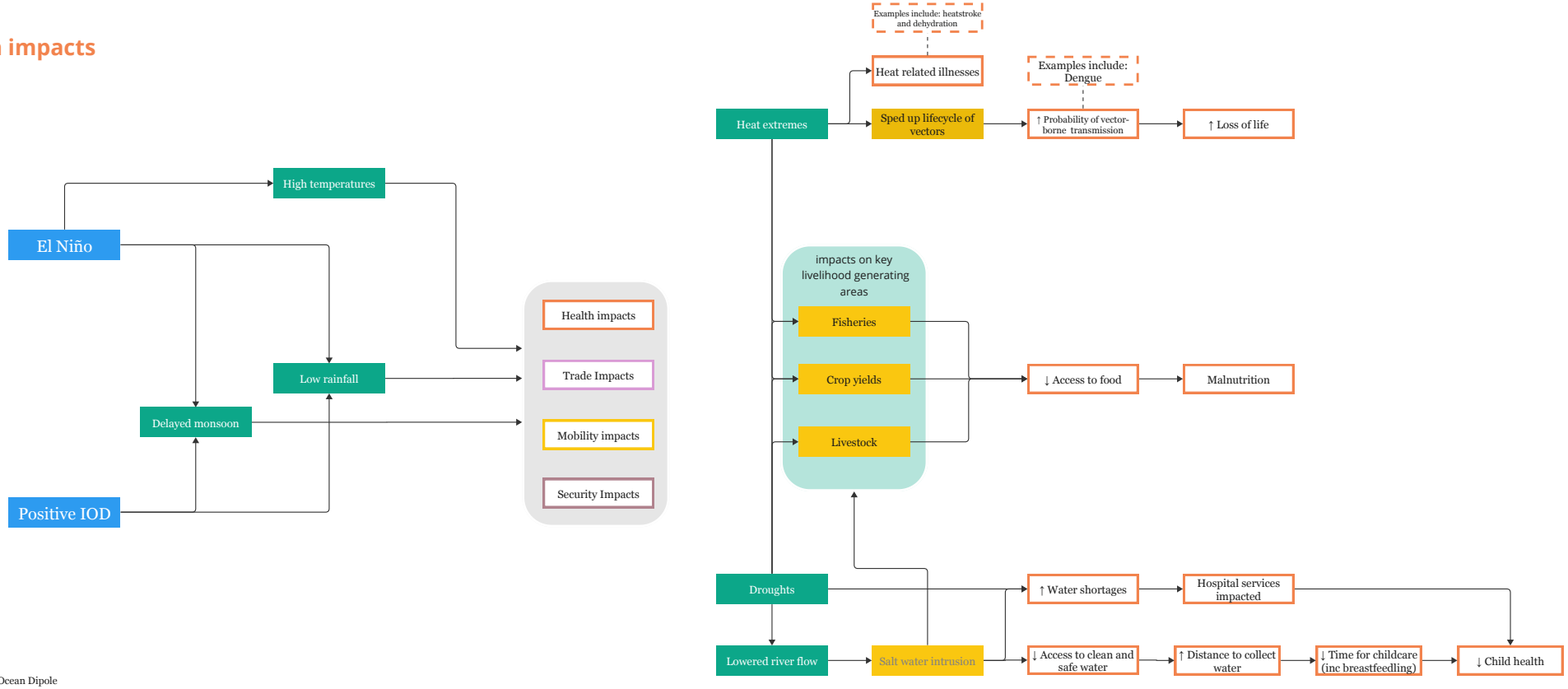
- The impacts of heat and drought seen in Storyline 1 will be exacerbated and could present in more intensity or frequency.
- Increased workloads of women combined with climate change related stress during pregnancy could contribute to low infant birth weight, leading to increased risk of undernutrition and non-communicable diseases (Government of Cambodia, 2022).
- Saltwater intrusion could pose significant impacts on health, especially when combined with decreased availability of water, which could push people towards less-than-ideal water sources.

The impacts seen in Storyline 1 will be compounded by the additional elements presented in Storyline 2, including sea-level rise and saltwater intrusion. Salination of water (due to the combined impacts of lower river flow and increased sea level rise) could pose significant threats to health, especially when combined with decreased availability of water, which could push people towards less-than-ideal water sources.

Considering the amplification of impacts that will be seen across Storyline 1 and 2 and the role of compounding impacts in Storyline 2 early on will be critical for taking action that mitigates risks to communities in the Lower Mekong Basin.

Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower Mekong Basin as well as the upper Mekong basin. A combined positive IOD would likely increase the probability of dry conditions and **late monsoon onset**.

Health impacts



Impacts on health under Storyline 1

Under Storyline 1, health could be impacted in the following ways:

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

Drought conditions experienced in the Lower Mekong Basin impact health care infrastructure by reducing the quality and availability of care.	**Heat extremes, such as those described in this storyline, can lead to heat-related illnesses such as heatstroke.**	**Water shortages can increase the allocation of labour on women, placing additional burden on mothers, while also impacting babies and children.**
Water shortages, especially protracted and frequent shortages, have negative impacts on public health facilities such as hospitals and medical centres which consequently cannot provide effective and necessary care for their patients.	Heat-related illness cases usually peak in the summer affecting the working age population the most because of outdoor work. Professions with the highest morbidity are farmers followed by outdoor labour workers and military draftees. High temperatures increase risks of heat-related illnesses and significantly increase the risk of all-cause hospitalizations. The impact was greater in the north than in the south of Vietnam (5.4 per cent vs. 1.3 per cent) (Tran et al. 2023). Vulnerable groups include older people, children, and outdoor workers. Heatwaves also worsen air quality and health outcomes, particularly in tropical regions like Vietnam (Giang et al. 2014).	Lower access to water supplies means that additional time is needed to source water or pastures for livestock. This can particularly affect women who in traditional roles are responsible for collecting water, limiting the time they have available for childcare and feeding (e.g. breastfeeding and preparing healthy meals). This can lead to lowered health metrics for children and babies (Government of Thailand, 2024).
▪ **Example:** In Thailand, during the 2015 El Niño, over 15 public health facilities in drought areas experienced water shortages, negatively impacting the services provided to the people in the area (Stanke et al. 2013).	▪ **Example:** According to Zhao et al. (2021), non-optimal temperatures are associated with around five million deaths annually, comprising 9.43 per cent of all deaths. Of these, 8.52 per cent are cold-related, and 0.91 per cent are heat-related. Heatwave events in Ho Chi Minh City were also linked to a 12.9 per cent increase in the risk of hospitalization due to cardiovascular diseases (Phung et al 2017). Heatwaves are associated with a 36 per cent increase in the risk of hospital admissions due to mental disorders in Hanoi City (Phung 2016).	▪ **Example:** In Vietnam maternal and perinatal health faces a variety of threats caused by nutritional deficiencies, infections, heavy physical labour, and chronic conditions like diabetes and obesity. Climate change exacerbates these risks, complicating pregnancy outcomes (Unicef 2022).

Higher temperatures and variable precipitation can accelerate microbial growth, transmission, and virulence of diseases, which can lead to changes in the seasonal and geographic distribution of vector-borne and water-borne diseases.

Long-term drought may have negative effects on water quality, such as temperature, dissolved oxygen, biochemical oxygen demand, and concentrations of pathogens and certain other compounds (Mosley, 2015; Levy et al., 2018; Graham et al.,2024). Therefore, poorer water quality may lead to an increased risk of waterborne disease due to changes in pathogen concentration and transmission, which may lead to a significant risk to human health.

- **Example:** Persistent drought prevalent in the Mekong Delta has resulted in the infiltration of salt water into freshwater sources (Park et al., 2022) leaving many coastal communities reliant on saltwater for their daily needs, including agriculture and cooking. This saltwater intrusion can exacerbate the drought situation, influencing the overall water quality by impacting parameters such as temperature, dissolved oxygen, biochemical oxygen demand, as well as the concentration of pathogens and other compounds (Mosley, 2015; Levy et al., 2018; Graham et al., 2024).

The negative impacts of drought on agricultural production can lead to the breakdown of food systems, placing vulnerable groups at risk of undernutrition and malnutrition.

Dry rivers are one factor exacerbating the hydrological drought, particularly in lower river streams, leading to a variety of environmental and human health consequences. Previous research has shown that drought decreases the quantity and quality of residents' nutritional intake, increasing the risk of nutrition-related illnesses and deaths (Kang et al. 2021).

- **Example:** The Lower Mekong Basin (LMB) is one of the most vital regions for rice production, providing food for over 70 million inhabitants. However, severe droughts occur during the dry season and a warm ENSO phase (El Niño/Southern Oscillation), significantly restricts rice production in the LMB (Adamson 2010). Studies have indicated that rice production could decrease by up to 4.2 per cent due to extreme drought conditions, with the most significant reductions seen in Thailand and Lao PDR (Baskoti et al. 2013). Golden et al. (2019) reported that by 2030, compared to 2010, inadequate hydropower-related intakes could have impacts on food production which put people at risk of nutritional deficiencies especially for essential nutrients such as protein, zinc, niacin, thiamine, riboflavin, and calcium (Golden et al. 2019).

Heatwaves in urban areas reduce air quality and increase respiratory infections and heat stroke.

Heatwaves in urban centres have two significant impacts on health. Firstly, they increase the risk of mortality and morbidity, especially among aging groups and the urban poor. As cities experience growing variability and extreme climates, newly urbanized areas become susceptible and vulnerable. Climate change exacerbates this vulnerability, potentially causing adverse health impacts for urban residents (Promphakping et al. 2016). Research has shown that a 1°C increase in average temperature leads to significant health impacts in lower-income urban centres. Hospital admissions increased by 1.3 per cent (95 per cent CI, 0.9–1.8) for all causes, by 2.2 per cent (95 per cent CI, 1.4–3.1) for infectious diseases, and by 1.1 per cent (95 per cent CI, 0.5–1.7) for respiratory diseases. Factors such as population density, poverty rate, and illiteracy rate exacerbate the risk of hospitalization during high temperatures. Conversely, higher household income, access to safe water, and hygienic toilets are associated with a reduced risk of hospitalization due to heat-related illnesses (Phung 2016).

- **Example:** In the Lower Mekong Basin, heatwaves worsen air pollution and reduce the availability of safe and clean air in urban centres. This leads to respiratory issues such as pneumonia and exacerbates conditions like hypertension.

Impacts on health under Storyline 2

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

STORYLINE 2A: HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS			**STORYLINE 2B: REDUCED LEVELS AND FLOW OF MEKONG RIVER, INCREASED SEA-LEVEL RISE RELATED COASTAL FLOODING**
Heat extremes can lead to various health implications including heatstroke, kidney issues and other heat-related illnesses.	**Increased prevalence of drought can exacerbate food insecurity and lead to malnutrition.**	**Increased workloads of women combined with climate change related stress during pregnancy, could contribute to low infant birth weight, leading to increased risk of undernutrition and non-communicable diseases. (Government of Cambodia, 2022).**	**Saltwater intrusion could pose significant impacts on health, especially when combined with decreased availability of water which could push people towards less-than-ideal water sources.**
Similar to Storyline 1, this challenge will be particularly pertinent among outdoor workers, elderly populations and those with pre-existing health conditions. Continued and increased income disparity, combined with unequal access to electricity could mean that it is harder for lower income populations to access air conditioning and necessary health care required to mitigate worsened health impacts.	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 (Anttila-Huges et al., 2021).	Research on reproductive health, baby birthweight and heat extremes has shown that thermal stress exposures can increase dehydration and induce oxidative stress and systemic inflammatory responses which could lead to negative fetal health outcomes (Nyadanu et al., 2023).	Chakraborty et al. (2019) found that increased salinity in water sources resulting from sea-level rise in Bangladesh was associated with cardiovascular diseases and increased hospital visits for reasons such as abdominal pain and diarrhoea (Chakraborty et al., 2019). In the LMB, where long-term drought in the Mekong Delta has led to saltwater intrusion (Park et al., 2022) combined with the future risks of sea level rise, similar issues could present themselves under this storyline.
▪ **Example:** In 2024, a heatwave in Vietnam caused severe droughts in the south, pushing temperatures to nearly 104 degrees Fahrenheit (40 degrees Celsius) and causing significant damage to the country's crucial agriculture sector. As one of the world's leading rice exporters, Vietnam's Mekong delta region is particularly vulnerable to low rainfall, posing challenges for local farmers (CNN 2024).		▪ **Example:** In the Lower Mekong Basin, where heat extremes and increased drought form a central tenet of Storyline 2, it is likely that pregnant women will be at increased risk of such health challenges.	

Impacts on trade[1]

Current and projected trade in the Lower Mekong Basin is heavily influenced by both climate-related hazards as well as geopolitics. ASEAN has had a hands-off approach in trade and other areas, likely due in part to the sensitivity of engaging with China in competition over the basin. The ASEAN-Mekong Basin Development Cooperation (AMBDC) was developed in the 1990s to strengthen the region's economic linkages across ASEAN member countries but has not been active since 2014, and ASEAN is a largely passive actor in economic relations, including trade, in the region (ISEAS 2016). In its place a variety of other economic cooperative frameworks have emerged with countries including China, the United States, Japan, and India (ibid.). However, all of these are dependent on the supply of agricultural and other goods from the lower basin, most of which are declining due to climate change and other challenges such as the impact of hydropower dams on water availability.

Summary of impacts on trade

Under Storyline 1, the following impacts could be felt in the Lower Mekong Basin:

- Water level declines will likely continue to have a devastating impact on both crops and fisheries in the region, reducing its trade potential.
- Hot and dry conditions, including drought, in the region could disrupt trade and decrease food security, necessitating alternate livelihoods for many.
- Reduced hydropower production due to lower river flow could reduce energy availability and impact trade and the economy.

Under Storyline 2, the following key impacts could be felt in the Lower Mekong Basin:

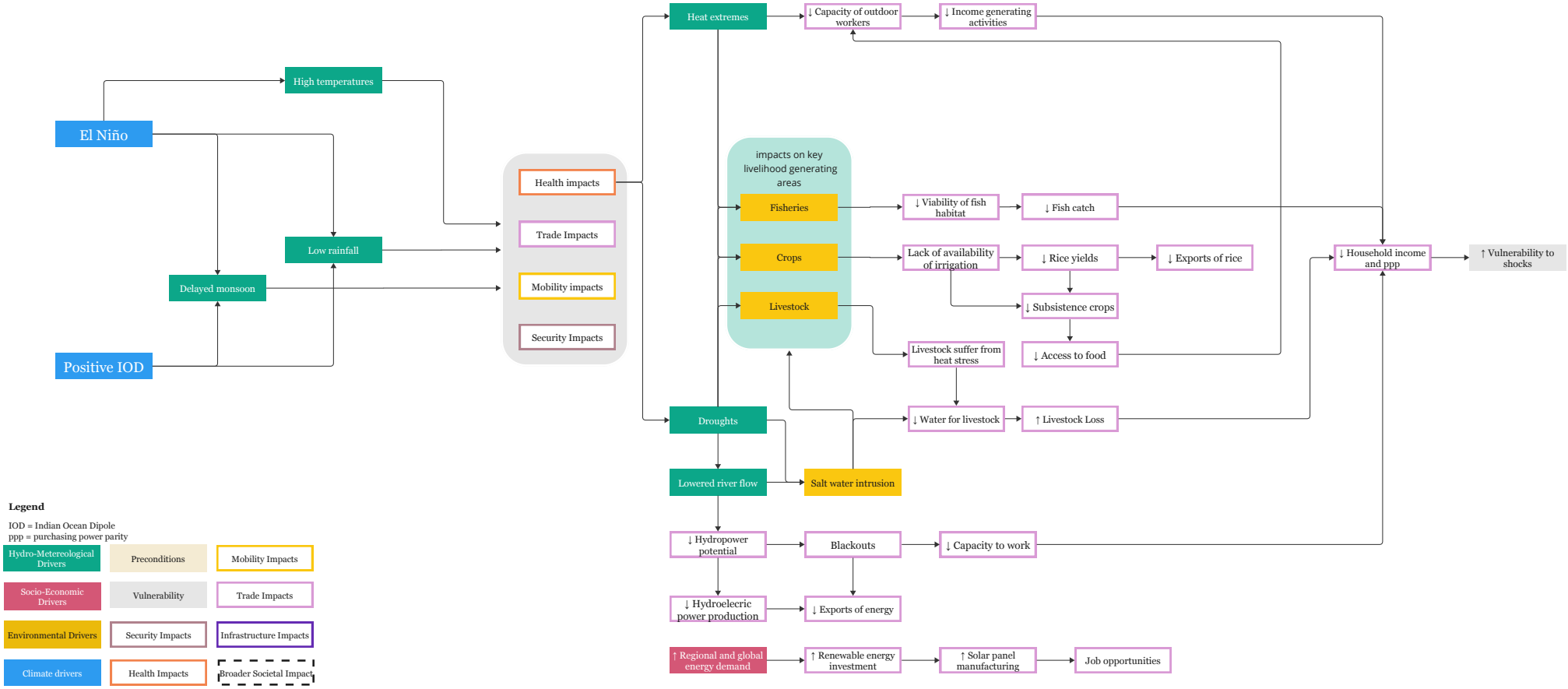
- Implications on crop yields will have knock on impacts for rural farming populations and for the greater region.
- Extreme heat could potentially have serious impacts on non-timber forest products, which make up a significant contribution to national and local economies.
- Saltwater intrusion significantly increases the array of risks faced by farmers across the Lower Mekong Basin.
- Saltwater intrusion could have significant impacts on non-timber forest products such as mushrooms, wild berries and medicinal plants. This will have implications for livelihoods with women projected to be especially vulnerable to such changes.
- Increasing temperatures, combined with other anthropogenic activities such as sand mining, hydroelectric power, will directly impact fishing livelihoods and therefore trade locally and regionally.

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.

Under this storyline, El Niño conditions will increase the probability of hot and dry conditions and drought over the Lower Mekong Basin and the Upper Mekong basin. A combined positive IOD would likely increase the probability of dry conditions and late monsoon onset. This could have impacts on trade in the following ways

Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower Mekong Basin as well as the Upper Mekong Basin. A combined positive IOD would likely increase the probability of dry conditions and **late monsoon onset**.

Trade impacts



Impacts on trade under Storyline 1

Under Storyline 1, **trade** could be impacted in the following ways:

LOCAL IMPACTS OF STORYLINE IN THE STUDY REGION	REGIONAL IMPACTS OF STORYLINE ON STUDY REGION	
Water level declines will likely continue to have a devastating impact on both crops and fisheries in the region, reducing its trade potential.	**Hot and dry conditions, including drought in the region will disrupt trade and decrease food security, necessitating alternative livelihoods for many.**	**Trade power may further drop through reduced hydropower production due to increased droughts.**
Flood peaks in many areas have declined annually, with notable steep dips during the 2015-2016 and 2020 droughts (Vietnam's General Statistics Office).	Rice yields in Thailand and Vietnam, as well as Indonesia and the Philippines, may drop by up to 50 per cent by 2100 compared to 1990 levels unless major adaptation takes place (IMF 2018).	Southeast Asia's electricity demand is rising, and there is pressure in the Mekong region to meet the increased demand through a clean energy transition. This is a challenge even without drought, yet in 2019 and 2020 severe drought and changes in the Mekong River's flow lowered the flood pulse and limited hydroelectric power generation, leading to blackouts and a shocking 30 per cent drop in hydroelectric power production in Cambodia in 2019 (Weatherby 2021).
▪ Two-thirds of Cambodia's fish-catch (the primary protein source for the population) comes from Tonle Sap Lake,[2] yet fish catches have dwindled. At the end of 2020 Cambodia's Ministry of Agriculture, Forestry and Fisheries stated that the overall freshwater fish catch had dropped by over a third compared to the previous year. (ASEAN Today 2020). This trend poses significant risks for both food insecurity and trade in the region.	▪ As an important diversification strategy, Thailand and Malaysia may continue to become influential in the manufacturing of solar panels, with the support of Chinese investors, and may continue to have growing markets as investment in renewable energy continues to grow in Southeast Asia (IMF 2018).	▪ Limited hydropower production is particularly potent as energy demand in the LMB is projected to grow by six to seven per cent each year (MRC n.d.), increasing the likelihood of ongoing and increased disruptions to trade and other economic activity.

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

3 Ibid

Impacts on trade under Storyline 2

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

STORYLINE 2A: HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS

Implications on crop yields will have knock on impacts for rural farming populations and for the greater region.

USAID (2013) projected that by 2050 maize yield across the Lower Mekong Basin could decrease by between 3-12 per cent because of increased temperatures or rainfall (USAID, 2013). If temperatures reach above 35°C during the growing season for rice, it is projected that significant impacts on rice yield will be seen across the LMB region (US AID, 2013).

Extreme heat could potentially have serious impacts on non-timber forest products, which make up a significant contribution to national and local economies.

USAID estimates that non-timber and forest products make up over 30 per cent of the income of individual farming families across the Lower Mekong Basin. Increasing heat could have negative impacts on the ecosystems which bees, fungi, and various types of wild plants depend on for life. This impact would be exacerbated by other anthropogenic factors such as deforestation and clearing of forested lands.

STORYLINE 2B: REDUCED LEVELS AND FLOW OF MEKONG RIVER, INCREASED SEA-LEVEL RISE RELATED COASTAL FLOODING

The role of saltwater intrusion could have significant impacts on non-timber forest products such as mushrooms, wild berries, medicinal plants. This will have implications for livelihoods with women projected to be especially vulnerable to such changes.

USAID (2013) reports how in Kien Giang, women play the primary role in gathering non-timber forest products for use in both subsistence and medicine (Nguyen et al 2010; US AID 2013). Sea-level rise poses a significant threat to mangrove ecosystems which would reduce the access to this form of income opportunity.

Increasing temperatures, combined with other anthropogenic activities such as sand mining, hydroelectric power will directly impact fishing livelihoods and trade locally and regionally.

Lakes such as Tonle Sap in Cambodia, a major floodplain and lake fed directly by the Mekong River system are impacted by a variety of anthropogenic factors, including climate change. Under this storyline, the role of reduced river flow, combined with heat extremes could have significant implications for the ecosystem which is one of the largest inland fishing locations in the world (McCann et al., 2015).

Impacts on mobility

The Lower Mekong Basin is projected to experience between 3.3 million and 6.3 million new climate migrants between now and 2050 (1.4-2.7 per cent of the country population) depending on different scenarios (World Bank 2021). Locations of out-migration are projected along coastal areas of the Vietnam Mekong Delta and in the north, near Thanh Hao and Vinh, and in Ho Chi Minh City; as well as in central Thailand and Myanmar (ibid.). The impacts of sea-level rise and related challenges due to coastal erosion and saltwater intrusion will likely lead to migration as crops are reduced due to saltwater intrusion and flooding, and as housing and overall living standards drop due to the impacts of sea-level rise (IPS 2023). While government planned relocations have taken place, these are still small-scale and it is currently unclear to what extent they will impact mobility in the region. Under both storylines, populations in the Lower Mekong Delta are likely to experience a mixture of forced displacement, migration, and planned relocation.

Summary of impacts on mobility

Under Storyline 1, the following impacts could be felt in the Lower Mekong Basin:

- An increase in hot and dry conditions would likely lead to pronounced drought impacts, affecting rice and other crop production, and increasing the likelihood of seasonal or long-term economic migration (Le 2024).
- The projected increased intensity of intermittent rainfall in some areas during monsoon seasons will likely lead to displacement due to flash flooding.
- Without increased government recognition of climate displacement, as drought increases, rates of irregular cross-border migration may increase across the region.
- Increased migration will likely be based on recent historical trends, although rates of migration may not be as pronounced as in the previous storyline due to less dry temperatures.

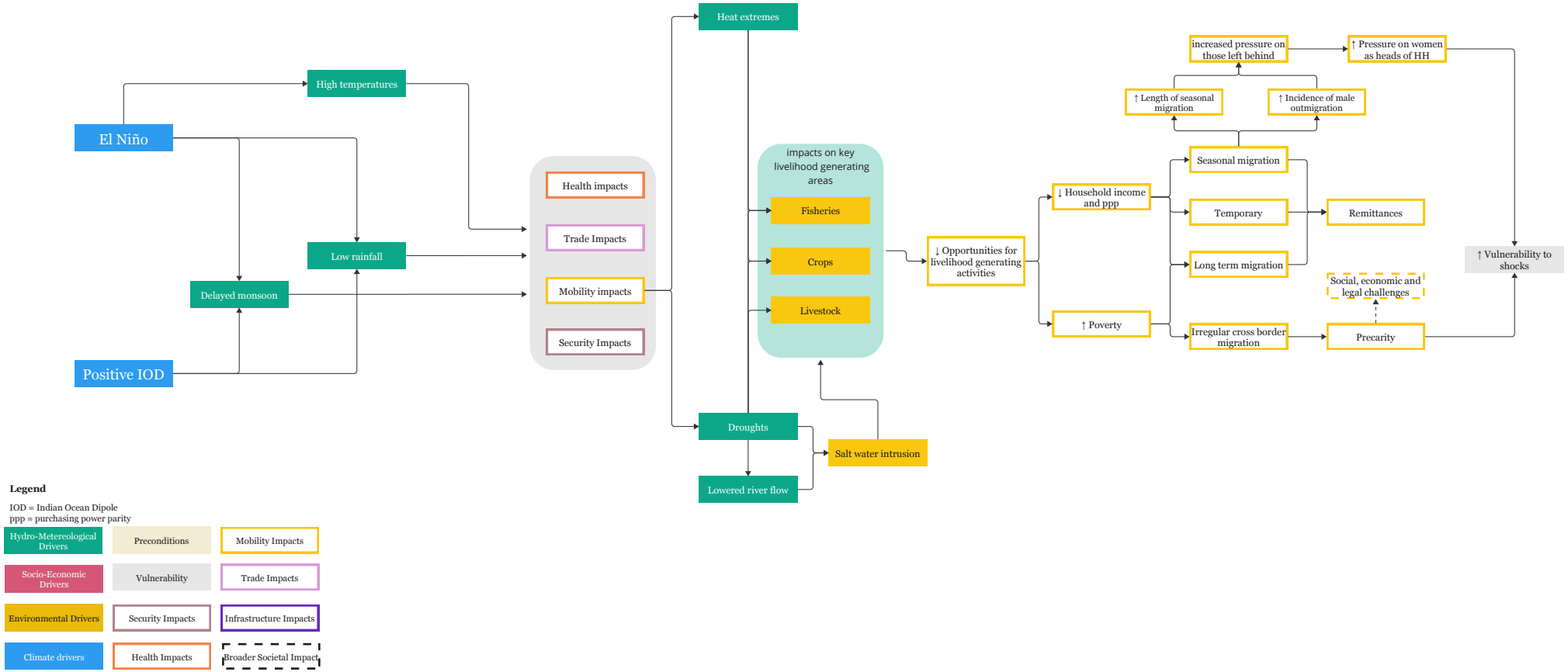
Under Storyline 2, the following key impacts could be felt in the Lower Mekong Basin:

- Increased drought has the capacity to compound the reasons that people might engage in outmigration from the study region and result in more people practicing rural to urban migration across a varying duration of time or distances.
- Migration journeys themselves could become more dangerous.
- Coastal flooding will lead to climate-induced displacement, which may become permanent because of sea-level rise (IPS 2023).
- Depending on government will and action, there may be an increase in government-led voluntary relocation initiatives.

Under this storyline, El Niño conditions will increase the probability of hot and dry conditions and drought over the Lower Mekong Basin as well as the Upper Mekong Basin. A combined positive IOD would likely increase the probability of dry conditions and late monsoon onset.

Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower Mekong Basin as well as the Upper Mekong Basin. A combined positive IOD would likely increase the probability of dry conditions and **late monsoon onset**.

Mobility impacts



Impacts on mobility under Storyline 1[4]

Under Storyline 1, mobility could be impacted in the following ways:

REGIONAL IMPACTS OF STORYLINE ON STUDY REGION

Without increased government recognition of climate displacement, as drought increases, rates of irregular cross-border migration may increase across the region.	**Increased migration will likely be based on recent historical trends, although rates of migration may not be as pronounced as in the previous storyline due to less dry temperatures.**
▪ Countries comprising the Lower Mekong Delta are members of the Association of Southeast Asian Nations (ASEAN). ASEAN states have a principle of non-interference in member states' domestic policies, as sated in the Bangkok Declaration,[1] which has often led to ad hoc, temporary, and inadequate refugee responses and only bilateral migration agreements, with many countries viewing their role as offering temporary protection or work (Kneebone 2014). Large-scale drought-induced migration has already been documented from Southeast Asia, with an estimated eight million people having moved towards the Middle East, Europe and North America (NYT 2020).	▪ Even without extreme dryness, out-migration from the delta is likely to continue to increase as net out-migration has more than tripled since 1999 (Ghosal 2024).
▪ Much of the current migration in the region is temporary, informal (irregular), and undocumented, due in part to a lack of regional migration policies (see above). This is also driven by cost; for example, smuggling is cheaper for migrants from Cambodia and Lao PDR to move to Thailand than the cost of legally entering the country (UNODC 2017). If ongoing migration policy incoherence or lack of policy continues, the region is likely to see higher rates of informal, undocumented migration as overall rates of migration increase due to climate pressures from places of origin. ▪ Migration trends in the region showing growing rates of rural-urban migration, in line with global trends (Migration Data Portal 2023). Extreme temperatures and drought conditions impacting both livelihoods and health will likely continue to drive migrants and displaced people into urban areas. Without proper urban management and migration policies, these influxes may exacerbate the already challenging economic and health conditions of major urban areas. Research on rural-urban migration documents how migrants from the Mekong Delta entering Ho Chi Minh City are likely to experience precarity in the city, including social, economic, and legal challenges (Jullien et al. 2022).	▪ There has been a striking drop in the Mekong Delta's contribution to GDP in the last 20 years, from 27 per cent in 1990 to less than 18 per cent in 2019, likely due to a complex interplay of climate impacts and economic change that has influenced out-migration (Ghosal 2024).

4 Important to note that reflections on mobility were particularly important in the workshop with expert practitioners

Impacts on mobility under Storyline 2

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

STORYLINE 2A: HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS		**STORYLINE 2B: REDUCED LEVELS AND FLOW OF MEKONG RIVER, INCREASED SLR RELATED COASTAL FLOODING**
Increased drought has the capacity to compound the reasons that people might engage in out-migration from the study region and result in more people practicing rural to urban migration across a varying duration of time or distances.	**Migration journeys themselves will become more dangerous.**	**Depending on government will and action, there may be an increase in government-led voluntary relocation schemes away from coastal areas or those most at risk of hazards.**
▪ Under Storyline 2, there is a likelihood that out-migration from the LMB may be accelerated due to livelihoods becoming non-viable more quickly, such as repeated crop losses or low fishing yields due to the rise in water temperatures. These may be intensified by conditions that amplify vulnerability such as rain-fed agricultural livelihoods, limited access to credit, low household incomes or lack of land tenure.	▪ This is partly due to heat stress being more likely. To compound this, more migration will likely take place through undocumented means, as people leaving the LMB may increasingly use smugglers for cross-border migration or be at risk of trafficking, which may increase because of increased out-migration (UNODC 2018).	▪ Vietnam is a regional example of where this has already occurred, whereby the Vietnamese government with former LMB inhabitants subsequently moved to Ho Chi Minh City province (Dun 2009, 2011).
▪ Projections for increased out-migration from the Mekong Delta are based mainly on sea-level rise, while out-migration in central Thailand and Myanmar are projected to occur due to reduced water availability and decreased crop productivity respectively (World Bank 2021).		

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

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 influences 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 Lower Mekong Basin:

- With water from the Mekong being an important input for both irrigation and soil nutrition, increased likelihood of drought and low river flows may have a significant impact on food security.
- Hot and dry conditions and drought will further exacerbate communities' ability to access clean water, increasing risks of water insecurity. This could lead to resource management challenges.
- The combined impacts of hot and dry and drought conditions pose a serious threat to livelihoods along the Lower Mekong Basin most of which are reliant on agriculture and fishing.
- Increased stress on livelihoods and food security from hot and dry and drought conditions, may increase vulnerability to human trafficking and sexual exploitation.

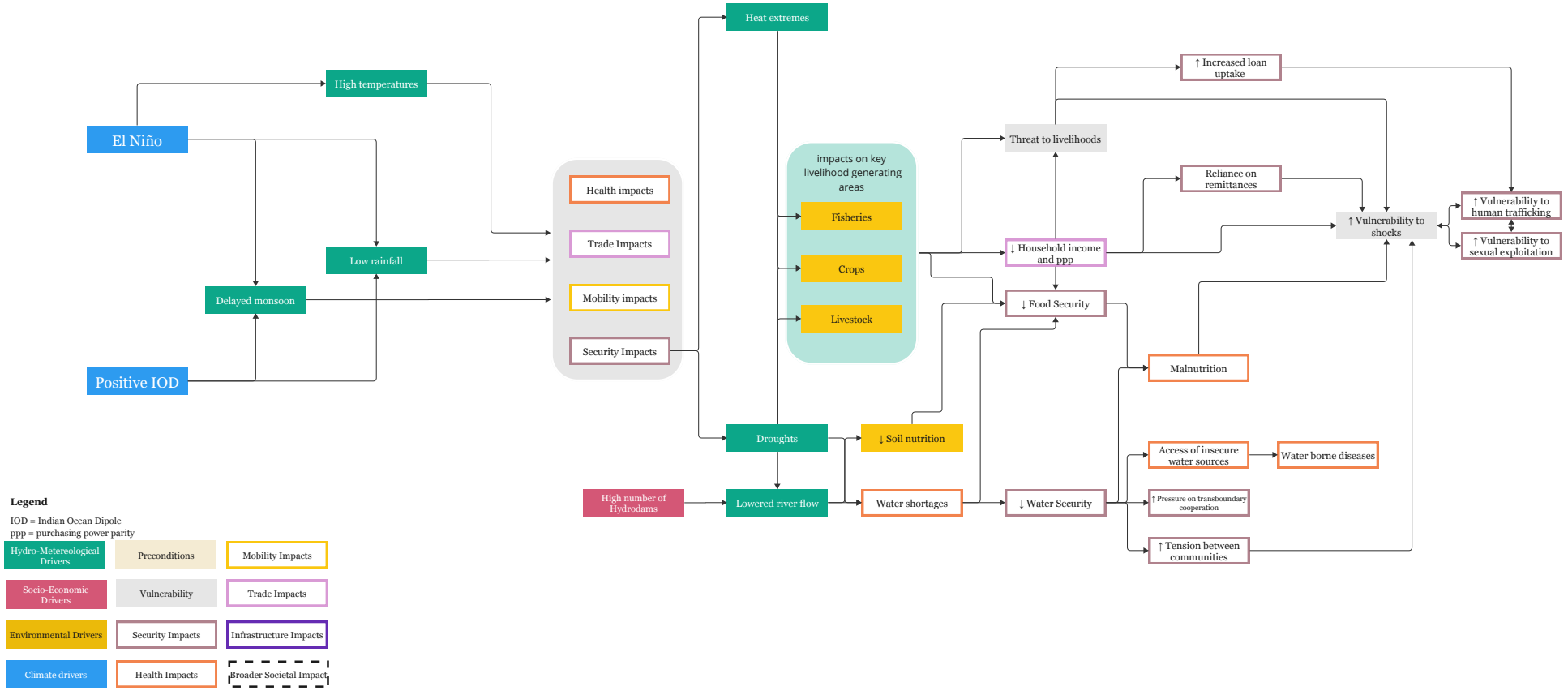
Under Storyline 2, the following key impacts could be felt in the Lower Mekong Basin:

- Economic security will likely be impacted by both drought and heat.
- Food security is threatened especially for populations with lower access to financial resources needed for adaptation.
- Without transboundary cooperation between Mekong Basin countries, increasing hot and dry conditions and drought will exacerbate risks to water and food security as well as livelihoods throughout the region.

Under this storyline, if El Niño conditions increase the probability of hot and dry conditions and drought over the Lower Mekong Basin as well as the Upper Mekong Basin. A combined positive IOD would likely increase the probability of dry conditions and late monsoon onset.

Storyline 1: El Niño conditions increase the probability of **hot and dry conditions** and **drought** over the Lower Mekong Basin as well as the Upper Mekong Basin. A combined positive IOD would likely increase the probability of dry conditions and **late monsoon onset**.

Security impacts



Impacts on security under Storyline 1

Under Storyline 1, **security** could be impacted in the following ways:

LOCAL IMPACTS OF STORYLINE ON STUDY REGION

With water from the Mekong being an important input for both irrigation and soil nutrition, increased likelihood of drought and low river flows may have a significant impact on food security.	**Hot and dry conditions and drought will further exacerbate communities' ability to access clean water, increasing risks of water insecurity.**
▪ Irrigation is the largest consumer of water in the Lower Mekong Basin. Vietnam accounts for over half of this consumption, followed by Thailand, Lao PDR and Cambodia (Mehmood, 2023). Drought in the Mekong basin threatens the productivity of crops with decreased water available for irrigation across the region. Hot and dry conditions pose a further risk for rain-fed agriculture. With rice production in the Lower Mekong Basin needing to increase by 50 per cent to meet the demands of a growing population (Kang et al., 2021), the threat of lower crop yields due to hot and dry conditions will have significant impacts on local and regional food security.	▪ With decreased access to water due to drought, people may be forced to travel farther to access water resources. This can lead to the use of unsafe water resources as a coping mechanism and 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.
▪ As sediments are trapped by development projects such as dams, this reduces the replenishment of nutrients into the soil, essential for the agricultural productivity of wetland areas in the Lower Mekong Basin (Mehmood, 2023). This, combined with the impacts of hot and dry conditions and drought, is likely to further decrease productivity of rice farms and reduce crop yields. ▪ During the drought of 2016 in the Lower Mekong Basin, more than 200,000 tonnes of rice were damaged and the Mekong Delta region suffered agricultural losses amounting to 44.64 million US dollars (UNECE, 2024). In Vietnam, the households most affected by the 2016 drought lost between 30 and 70 per cent or more of their annual paddy yields and in some areas, the number was as high as 90 per cent (FAO, 2016a).	▪ In Cambodia, drought has been linked to higher risks of water-borne diseases (Davies et al., 2015). In 2016, Cambodia had to carry out emergency drinking water distributions for drought affected communities (Magiera, 2016).

REGIONAL IMPACTS OF STORYLINE ON STUDY REGION

If conditions in the Lower Mekong Basin remain relatively normal, but there will be drier than normal conditions across the region generally, the most significant challenge with regards to security will likely remain water resource management.	**Increased stress on livelihoods and food security from hot and dry and drought conditions, may increase vulnerability to human trafficking and sexual exploitation.**	**The majority of livelihoods along the Lower Mekong Basin rely on agriculture and fishing. The combined impacts of hot and dry and drought conditions pose a serious threat to these livelihoods.**
▪ Even under current conditions, human security factors of food, water, economic and personal security remain a challenge. Much of these are interconnected with water resource management and infrastructure. A regional drying trend may further aggravate the challenge, as water stress increases across the region. Connected to the migration analysis above, this will likely continue to result in migration throughout the Lower Mekong region, exposing migrant communities to vulnerabilities. It may also potentially exacerbate complicated relationships between communities and countries in the basin (Martin, 2018).	▪ Drought is one of the leading factors why approximately 24,000 people leave the Lower Mekong Basin every year due to loss of livelihoods, increasing their risk of exposure to trafficking and exploitation (U.S. State Department, 2023).	▪ The natural environment and Lower Mekong Basin ecosystem primarily support rural livelihoods. The impacts of drought together with already significant levels of poverty, threaten the resources on which communities survive. . (Pal et al., 2023). Increased economic insecurity can then further reduce the coping capacity of communities to deal with subsequent climate related hazards. These threats to livelihoods, are already resulting in migration of people from rural communities along the lower Mekong to cities in search of alternate sources of income (Tran et al.,2023).
	▪ Droughts are also identified as being a driving force for people migrating from regions along the Mekong in Cambodia, to Thailand for work. This migration increases risk of trafficking and sexual exploitation. Men from Cambodia are often trafficked into forced labour, and women from Cambodia are trafficked into the sex industry in Thailand (UNODC, 2017). Such risks are likely to grow as hot and dry conditions are expected to increase under this storyline, placing a further stress on livelihoods.	▪ For example, in Laos, during the 2016 drought, many farmers lost their source of income as their livelihoods were destroyed (Lipes, 2015). At the beginning of 2016, there were already 200,00 households who had lost their livelihoods and were at risk of food insecurity (FAO, 2016b). Various reports have cited the connection between drought and migration in Laos as a coping mechanism for loss of income.

Impacts on security under Storyline 2

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

STORYLINE 2A: HEAT EXTREMES AND INCREASED INTENSITY OF HYDROLOGICAL AND AGRICULTURAL DROUGHTS

Without transboundary cooperation between Mekong Basin countries, increasing hot and dry conditions and drought will exacerbate risks to water and food security as well as livelihoods throughout the region.[6]

- With an increasing risk of droughts, effective water management and cooperation between Mekong Basin countries, due to the interconnectedness of infrastructure controlling river flows, is essential to reduce the impacts of climate change on communities. As water, food and economic security diminishes, migration will likely be seen as the only option for survival.
- See mobility section for examples.

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

- Similar to the information presented above for health and trade, as well as under Storyline 1, there is a high risk that increasing heat will decrease productivity and economic security for households. The impacts, particularly in the agricultural sector, include loss of livelihoods and high prices. The resulting instability had a serious impact on economic security.

Food security is threatened especially for populations with lower access to financial resources needed for adaptation.

- Marginalized communities may be further exposed to food security risks from drought witho ut being able to access resources and tools for effective adaptation.

STORYLINE 2B: REDUCED LEVELS AND FLOW OF MEKONG RIVER, INCREASED SEA-LEVEL RISE RELATED COASTAL FLOODING

Tensions related to water management and infrastructure development, may be exacerbated as climate change affects the availability and quality of water in the region.

- This could have impacts on livelihoods, water and food security and health.

Already marginalized populations could face further challenges from increasing resource competition.

- If climate impacts result in higher numbers of migration as a form of adaptation, it could result in increased competition over resources as well as marginalization of migrant communities.

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

- For example, the armed conflict in 2011 between Cambodia and Thailand over an important heritage site arose due to overlapping historical claims that had security consequences. Given the role the river plays in the economy of several LMB states, as river flow decreases, competition over resources could arise.

Suggested adaptation interventions

Adaptation interventions can take a variety of forms and 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 that 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 and the 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** that 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.	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 minimize risk to crop yield.	Anticipatory action and early warnings

Recommendations

Storylines can be used to 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 stakeholders impacted as well as those with the responsibility and power to take action to incorporate further local data, reflect adaptation action underway and to prioritise causal links (due to severity and opportunity) for new adaptation 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 their 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 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 next years may produce high antecedent vulnerabilities to subsequent El Niño/IOD events that can inform policymakers 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 socio-economic 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.

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, which is an under-researched region (also evidenced in the findings of the systematic review research).
- Environmental degradation (e.g. pollution, deforestation), which 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.[7]
- 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 LMB and that of wider ASEAN relating to trade and hydroelectric dams.[8]
- 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.

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

Recommendation 4

Recognize and embrace the role of understanding and working with 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 be done to highlight the interwoven and inextricable connections that underline vulnerability and decrease wellbeing 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 socioecological 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.

Recommendation 5

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, through 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 of 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 face increased vulnerability to shocks because of ENSO, IOD and global temperature increases. Substantive effort and initiative are needed to urge governments to take more responsibility and action to minimise 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.

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