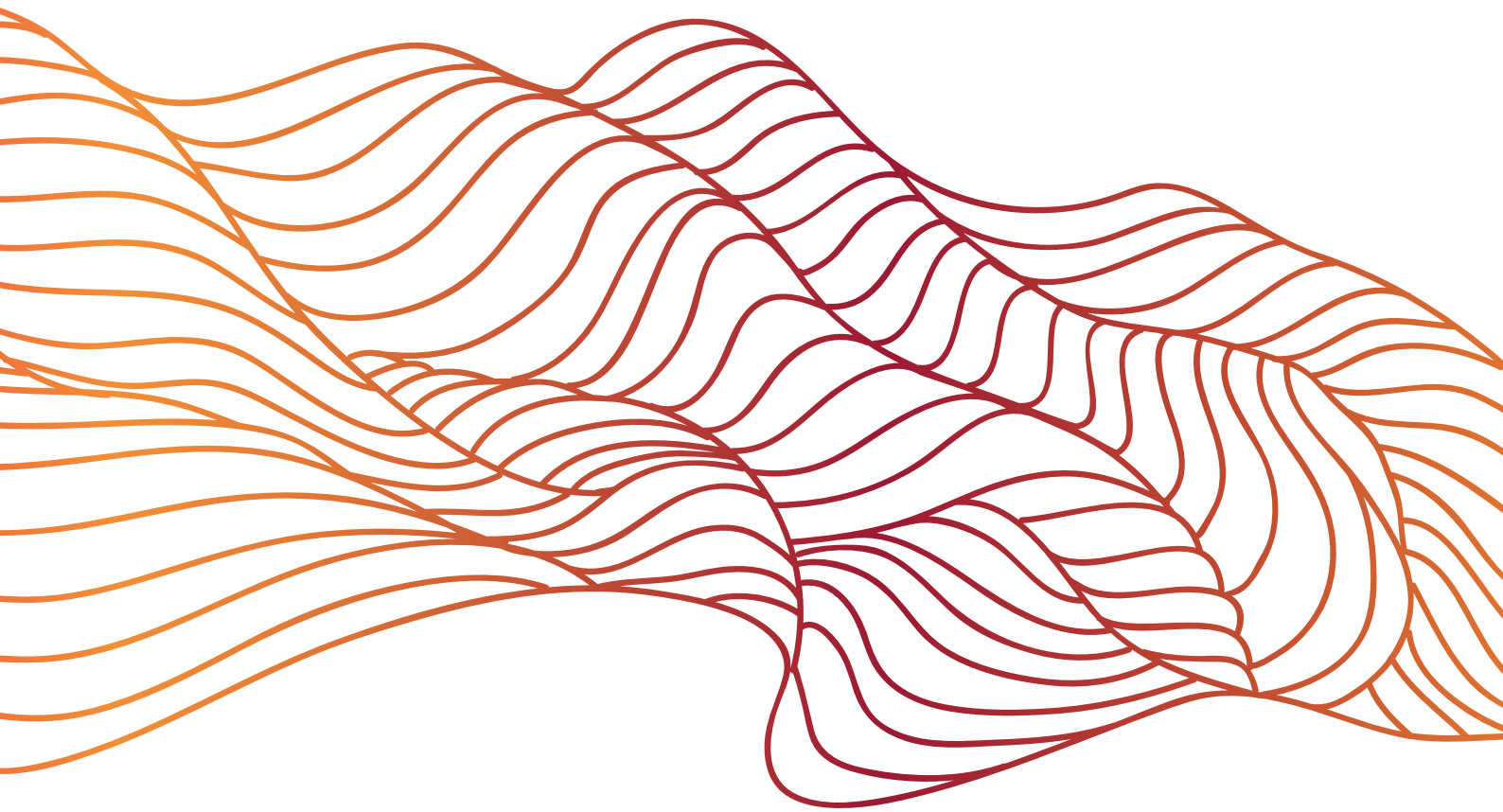
El Niño Storylines and Plausible Climate Futures for the Indo-Pacific

Summary Report



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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 document offers a summary of all cases and acts as the overarching document.**

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

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Overview of the report series

This research produced by the Red Cross Red Crescent Climate Centre was commissioned by the United Kingdom Foreign Commonwealth & Development Office (FCDO) as part of a broader project looking to understand the impacts of the El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) on the Indo-Pacific region. The goals of the project were to inform live policy discussions and future FCDO policy and action, including departmental planning, diplomacy and response regarding the current 2023 El Niño, future impacts from similar seasonal climate drivers (IOD), as well as near-term climate security implications.

This report series is made up of five documents which together form a comprehensive picture of the storylines explored in the Indo-Pacific region.

Each document is designed to be read as a stand-alone piece, yet more depth and nuance is offered by exploring the series as an interconnected whole, offering the reader a chance to see the linkages with as well as the distinctiveness of different regions.

This **Summary report** overviews the project methodology, the key findings across the three study cases, and provides overall recommendations.

The three case reports (**East India, Lower Mekong Basin** and **Central Dry Zone, Myanmar**) go into more detail on the findings for each case, delving into the four lenses of exploration under each time frame, and providing a series of causal maps to accompany the narrative.

The **Methodology case study** offers readers an understanding of both the process of developing storylines as well as the specifics of how the storyline approach was utilised alongside the FCDO expert practitioners.

Through these different outputs a variety of users can be supported, from local practitioners to global experts. At the same time, it is important to recognize that this work forms part of a larger research project and thus some relevant information may be contained in other reports.

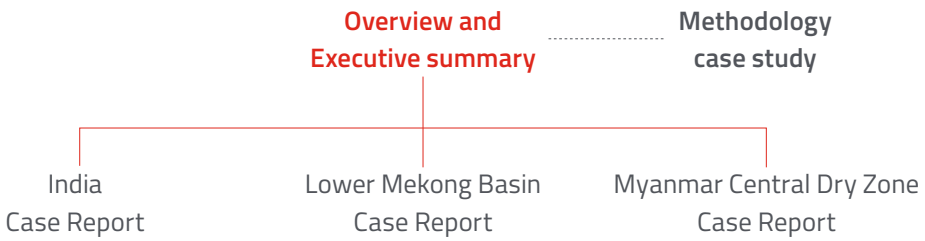

Figure 1: Overview of documents in report series exploring the plausible future storylines of El Niño and IOD in the Indo-Pacific across timescales

Introduction

Using evidence on projected climatic change and its likely impacts to guide current and future policy and decision making is a complex but critically important process. Given the numerous uncontrollable and unpredictable human and natural variables, it is inherently difficult to produce defensible probabilistic forecasts that can guide decision making. Thus, it is necessary to explore alternative approaches to navigating future plausible scenarios.

Acknowledging this need for an alternative understanding of feasible future impact scenarios, this research has adopted the "storyline" approach. Storylines highlight descriptions of the plausible unfolding of multiple related drivers and outcomes under a changing climate, examined in relation to each other to provide an insight into the various future impact scenarios that could be encountered. Climate impact storylines do not serve to predict exactly what will happen at a specific point in time, but rather to try to answer the question: what would be the possible implications of a particular climate-related shock or trend occurring at some point in the future?

Taking the phenomenon of the El Niño Southern Oscillation (ENSO) as a starting point, this research applies the storylines approach to understand the likely implications of a combination of the El Niño phase of ENSO and the Indian Ocean Dipole (IOD) on the socioeconomic elements of health, mobility, trade, and security across three regions in the Indo-Pacific region over the short term (the next 2-10 years) and longer term time frames, the latter depicting a context of a 2°C increase of global land surface temperatures since the industrial revolution.

The cases explored in this research are as follows:

Myanmar	Central Dry Zone
India	West Bengal, Odisha, Jharkhand and Bihar
Lower Mekong Basin	Cambodia, Thailand and Laos

These cases were chosen through a consultative process with FCDO staff and expert practitioners and were deemed representative of these interest areas. Details of the specific findings of these cases can be found in the corresponding case reports.

Report overview

The report takes the following structure: First an overview of the storyline approach and methodology is provided, followed by a section on key climate and weather influences in the Indo-Pacific region. Findings on key impacts are then presented, along with suggested adaptation interventions. The report closes with key recommendations and a conclusion, presenting potential next steps to advance this research and area of interest.

Storyline approach and methodology

The storyline methodology used in this research was developed by the 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 storylines approach enables the integration of multiple types and sources of evidence including expert insights, which traditional probabilistic methods might exclude. As climate model projections are associated with uncertainties, storylines are used 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.

Increasing risks complexity under a changing climate is a significative threat to human security. A better understanding of possible plausible scenarios that consider a multitude of risk factors, which can trigger societal disruptions, is essential to inform policies, strategies and practical measures that ensure resilience of humanity and socio-ecological systems. With this research the Climate Centre offers FCDO a new methodological approach that integrates retrospective disasters analysis with future climate projections in the form of climate storylines. This approach explores and presents the complexities of socio-economic, environmental and political systems under climate change.

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. Storylines can be constructed that represent very extreme or “worst case scenario” events that would have low probability but potentially produce very large impacts. However, determining the plausibility of very extreme storylines, particularly the plausibility of the cascading impacts, would require more intensive analysis to ensure sufficient rigour. Here we have focused on climate storylines that are more likely than not, so relatively high probability, but which still have the potential to produce significant impacts. This approach strikes a good balance between plausibility and considering significantly large impacts.

These are presented in the following report series which highlights the causal pathways arising from the storylines, enriched by added insights from discussions with FCDO practitioners in the three regions. Together, the findings enhance FCDO awareness about the plausible future social implications of El Niño and IOD impacts under a changing climate.

Perceived benefits and limitations of storylines

The storyline approach is a participatory methodology to explore uncertainty in future predictions of climatological dynamics. In this case the methodology has been applied with a broader socio-political lens, focussing on climate security, health, mobility and trade across the Indo-Pacific region. As a relatively new approach to climate risk assessment and capacity strengthening in FCDO, the workshops and research process offer valuable insights into future applications and areas of further study. Overall, the experience highlighted the benefit of using the storylines as a tool for further discussions, with national and regional engagement on key issues and foresight for the next 2-10 years, especially in contexts with limited (academic) literature. However, the approach also has several limitations, including limited information on the

probability of particular storylines. This last point can be mitigated by following up on this research with a clear monitoring plan for the coming years, to track how ENSO, IOD, as well as local conditions and responses are developing.

Across workshops, participants emphasized the utility of the storylines approach:

- New way to include non-academic literature in explorative approach; allows teams to operate in a more evidence-based manner. Participants emphasized the importance of evidence-based policy and the need for better data to inform decision-making. They acknowledged the lack of evidence and described drawing information from grey literature.
- Exploring the draft storylines in the workshop format was considered very useful by participants as it enables them to engage with the complex topic effectively.

Limitations of the storylines approach include:

- Limited information on probability and the robustness of particular impact connections, as storylines in essence constitute plausible scenarios without attaching probabilities.
- Limited information on the strength of the causal relationships and the magnitude of the associated impacts. Some evidence of the magnitude of impacts from past events is provided and the approach would allow for estimates of magnitudes given more in-depth analysis.
- The storylines primary focus on climatological dynamics and futures leaves an opportunity to integrate more political economy analysis into discussions.
- The storylines lack discussion on temporal evolution of hazard occurrence, adaptation strategies, and limits to adaptation. For example, these storylines do not address the limitations of agricultural adaptation strategies and what implications limitations to adaptation may have for other sectors.
- The storylines contain a wide array of plausible futures, but the application of the research to make operational policy decisions was out of the scope of this explorative approach. The storylines offer insights into potential issues to monitor, and for which to raise awareness. In the Lower Mekong Basin workshop, participants emphasized the political sensitivities surrounding climate-related issues and the need for more comprehensive solutions that consider migration dynamics and broader geopolitical factors. Many of the impacts of the causal maps would therefore be assumptions, which in turn may be sensitive to use as the basis for engagement with host countries.
- This was a desk-based study to develop and test the storyline approach. The current scope does not enable a full assessment of existing adaptation action and therefore would not allow the project to weigh the relative severity of the different impacts for a process of action prioritisation. This would be an important next step as storylines offer a useful tool for enabling this prioritisation through engagement with impacted stakeholders and actors with responsibility/power acting to improve resilience.

Overview of key climate and weather influences in the Indo-Pacific region

Weather and climate in the Indo-Pacific region are strongly influenced by variations in tropical ocean temperatures and the interconnected atmospheric response. A key driver of these dynamics is the positive feedback between the east-west contrast in sea surface temperature (SST) and the intensity of the trade winds (McPhaden et al., 2006). This ocean-atmosphere interaction also gives rise to two of the most profound climate phenomena in the region: the El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). ENSO affects SST patterns in the Pacific, while IOD affects the Indian Ocean. In both cases, these phenomena cause persistent changes in SSTs (Anderson et al., 2018), leading to long-lasting weather conditions that can have a significant impact on ecosystems, agriculture, and society. As such, it is critically important to understand what the implications of the combined impact of ENSO and IOD might be in the region in the nearand longterm future.

- ENSO and IOD are a result of several elements coming together with various drivers and can be understood as different phases. This report focuses predominantly on the phase of El Niño within the greater ENSO phenomenon and the Positive IOD Phase in the greater IOD phenomenon.

- The El Niño phase of ENSO influences SSTs, atmospheric pressure and wind patterns. A positive IOD phase typically results in increased SST and reduced rainfall over the Indian Ocean, which are typical for a positive IOD phase. When these are combined with the other drivers of climate variability depicted in Figure 1, we see three key impact areas for the Indo-Pacific region, namely in temperature, precipitation and tropical cyclone activity.

- Across the Indo-Pacific region, La Niña is expected to result in increased precipitation and increased incidence of flooding. It is important to understand the generalist impacts of La Niña on the region as the impacts of flooding act as a compounding element in increasing vulnerability to shocks and risks that might arise from the El Niño and IOD event explored in this research.

- In a 2°C warmer world, many of the impacts discussed in the cases will be exacerbated, occurring at a wider scale or with more frequency and intensity. The IPCC sixth assessment report has explored the broader impacts of climate change in the region. There are a number of global and regional drivers which will play a role in the way that both the compounding impacts from Storyline 1 will impact Storyline 2, as well as how the interactions between the storyline and the four lenses explored in this research will interact with one another. These include ecosystem degradation; energy; destruction of infrastructure; health; food; cryosphere and water (IPCC 2021).

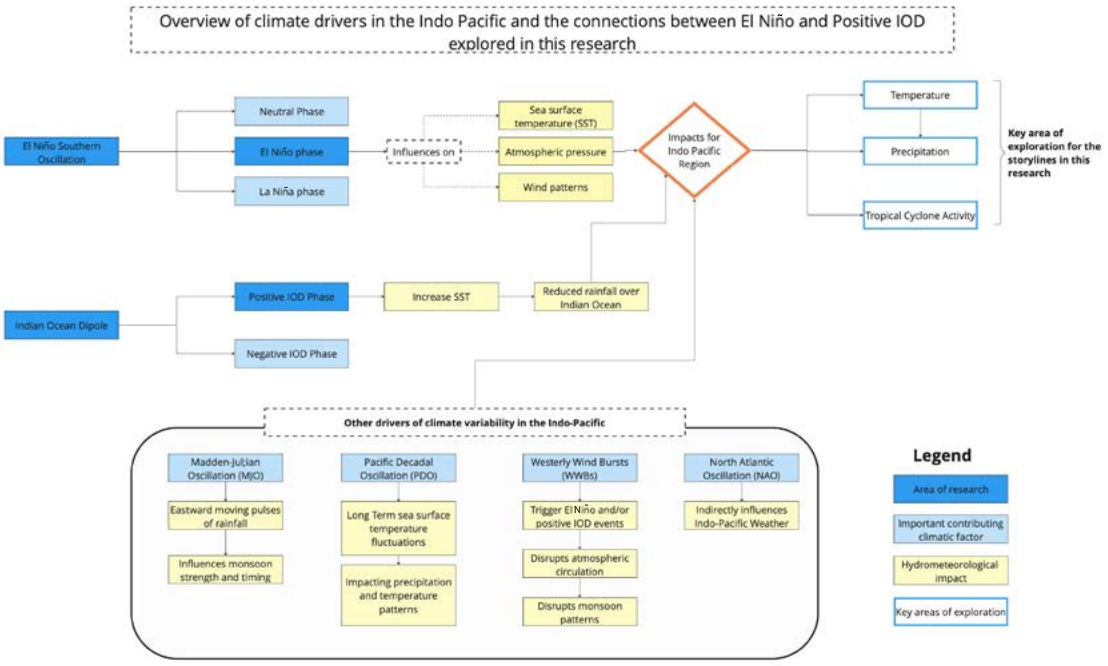

Figure 2: Diagram depicting the various climatic drivers in the Indo-Pacific and the overarching impacts that El Niño and Positive IOD (the two elements explored in this study) have on the Indo-Pacific region

Summary of storylines

The following storylines were developed for each of the three study cases:

EAST INDIA (WEST BENGAL, ODISHA, JHARKHAND AND BIHAR)

Following a La Niña phase, which will likely last two to three years, a transition to an El Niño Pacific event is likely to occur. A positive IOD phase in the Indian Ocean could also be simultaneously triggered. This storyline has two subsections:

Storyline 1: near term (2-10 years)

Sub-storyline 1 A:
If the effects of the positive IOD are more dominant than the El Niño, **increased high temperatures will persist throughout the seasons**, combined with a delayed monsoon which is **wetter than normal**. Once the monsoon arrives, there is also a likelihood **of increased precipitation** and **flooding** during the **wetter monsoon season**.

Sub-storyline 1 B:
If the effect of **El Niño is more dominant than the IOD, increased high temperatures** will persist throughout the seasons, combined with a delayed monsoon which is **drier than normal**.

Storyline 2: 2°C global warming

Under a 2°C warmer world the **Indian monsoon rainfall will likely increase**. However, we also anticipate ongoing El Niño and La Niña variability and **increased magnitude rainfall and temperature responses to El Niño and La Niña**.

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, which leads 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 causes coastal flooding**, which occurs because El Niño increases sea-levels. **Low river levels reduce delta flooding risk but increase salt-water intrusion**.

MYANMAR (CENTRAL DRY ZONE)

Storyline 1: near term (2-10 years)	Storyline 2: 2°C global warming
Following a La Niña period lasting two to three 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 impacts associated with **increasing rainfall variability**, leading to **hotter** and **drier droughts** (late onset of rain) and **more extreme flooding**.

Findings on key impacts

Using the storylines that were developed for each study case as a starting point, the research employed a retrospective analysis approach to explore the potential impacts that could be seen across the four sectors of health, trade, mobility, and security. The key findings are summarised across cases here in terms of impacts in these sectors based on the developed storylines.

Key impacts for East India

HEALTH

Under Storyline 1A and 1B, impacts on health could be seen in the following ways:	Under Storyline 2, impacts on health could be seen in the following ways:
▪ The impacts of increased precipitation and associated flooding may lead to both increased and decreased agricultural production across states, leading to differentiated nutrition impacts. However, positive effects in India are minor and only found with a positive IOD. ▪ Due to flooding and ground water contamination from a wetter monsoon, the region could see an increase in the transmission of infectious waterborne diseases. ▪ The increase in heavy rains and floods could impact vector-borne diseases, driven by changes in breeding sites, which could modify the burden of malaria, dengue, and chikungunya diseases. ▪ Mental health challenges associated with a disrupted monsoon season, including anxiety and depression, could further impact populations in the region in the future. ▪ Rising temperatures associated with droughts can lead to heatstroke, kidney damage, and other heat-related illnesses. ▪ Increased prevalence of drought can exacerbate food insecurity and lead to malnutrition.	▪ Warmer El Niño conditions could be associated with increased child malnutrition across the region. ▪ Increase in temperatures and heatwaves could affect vector-borne disease risk in complex ways.

TRADE

Under Storyline 1A and 1B, impacts on trade could be seen in the following ways:	Under Storyline 2, impacts on trade could be seen in the following ways:
▪ Floods, wind damage, and fallen trees can impact trade through damaging infrastructure such as roads which are essential in the transport of food items to market. ▪ Floods could damage rice crops and consequently reduce rice yields in the region, leading to a limited rice supply and higher prices, both for local populations and of rice intended for export. However, coastal regions may see instead a small positive increase in production (Floridi et al. N.d.). ▪ Heatwaves and droughts will likely decrease agricultural production, leading to fewer exports and decreasing the livelihoods viability of both farmers and middlemen in the agricultural sector (Bergman, 2022). ▪ Drought and heatwaves can not only limit agricultural production available for export, but in fact lead to export bans, as was the case in 2022 when the Indian government banned private wheat exports after wheat prices increased over 60% (Ober, 2023). ▪ Heatwaves increase the country's electricity demand for cooling and further threatens India's trade potential by reducing the country's coal stockpiles and contributing to blackouts.	▪ Implications on crop yields will have knock on impacts for rural farming populations and also for the greater region. ▪ Communities who are already living with lack of land tenure and access to land, who often rely on non-timber forest products could see a decrease in the income generating activities that they get from forested areas.

MOBILITY

Under Storyline 1A and 1B, impacts on mobility could be seen in the following ways:	Under Storyline 2, impacts on mobility could be seen in the following ways:
▪ Can lead to short term and protracted displacement. ▪ Multiple and consequential displacement which can erode coping capacity and resilience. ▪ The destruction of infrastructure such as roads and bridges from flooding events can lead to populations becoming trapped and immobile with limited access to resources or means of communication. ▪ Increased cross border migration from neighbouring countries such as Bangladesh to the Indian study region may occur, due in part to increased flooding from the joint impacts of heavy monsoon rains and sea-level rise (Quencez, 2012; The Nansen Initiative, 2015). ▪ Under this storyline, increased migration as a form of livelihood diversification or adaptation could occur, as the risk of drought poses a significant threat to subsistence farmers. This is particularly likely as drought is already one of the major drivers of migration for farmers across India (Jha et al. 2017). ▪ Drought conditions will likely disproportionately increase the rate of migration by those from a marginalised lower caste.	▪ Migration as a form of searching for livelihood diversification. ▪ Increased duration of seasonal migration. ▪ Climate-induced displacement. ▪ Migration journeys may become more dangerous.

SECURITY

Under Storyline 1A and 1B, impacts on security could be seen in the following ways:	Under Storyline 2, impacts on security could be seen in the following ways:
▪ Flooding and heavy precipitation can significantly impact human security, which can manifest in several ways: physical, economic, water and food security and vulnerability. ▪ Economic security is threatened during and after flood events, as livelihoods and livelihoods systems are destroyed or interrupted. Reduced economic security can erode coping capacity and adaptive response. ▪ Food and water security are also at increased risk due to flooding, with impacts on well-being and other forms of human security. ▪ Droughts and floods can increase risks to personal security, including vulnerability to human trafficking. ▪ Food security is threatened especially for populations with fewer financial resources to implement adaptive measures. ▪ Economic security will likely be impacted by both drought and heat. ▪ Rising temperatures and drought can create risks to personal and health security, particularly for rural communities.	▪ The impacts from Storyline 1 are exacerbated. ▪ Conflicts related to border disputes and water in Odisha, may be exacerbated as climate change affects the availability and quality of water in the region, with a direct impact on livelihoods, water security and health.

Key impacts for Lower Mekong Basin

HEALTH

Under Storyline 1 the following impacts could be felt in the Lower Mekong Basin:		Under Storyline 2, the following impacts could be felt in the Lower Mekong Basin:
Drought related impacts: ▪ Drought could impact healthcare quality and reduce the availability of care. ▪ Water shortages could have disproportionate impacts on women who face additional burdens of sourcing water, which could also impact infant and child healthcare. ▪ 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 present themselves across the region. ▪ 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. ▪ Heat waves in urban areas reduce air quality and increase respiratory infections and heat strokes.	▪ 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 increases in risks 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.

TRADE

Under Storyline 1, the following impacts could be felt in the Lower Mekong Basin:	Under Storyline 2, 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.	▪ 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. ▪ The role of saltwater intrusion significantly increases the array of risks faced by farmers across the Lower Mekong Basin. ▪ The role of saltwater intrusion could have significant impacts on non-timber forest products (such as mushrooms, wild berries, medicinal plants), which will have implications for livelihoods. Women are projected to be especially vulnerable to such changes. ▪ Increasing temperatures, combined with other anthropogenic activities such as sand mining and hydroelectric power, which will directly impact fishing livelihoods and therefore trade locally and regionally.

MOBILITY

Under Storyline 1 the following impacts could be felt in the Lower Mekong Basin:	Under Storyline 2 the following key 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 longterm 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.	▪ 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 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.

SECURITY

Under Storyline 1, the following impacts could be felt for the Lower Mekong Basin:	Under Storyline 2 the following key impacts could be felt in 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**. ▪ Livelihoods could be seriously threatened with the combined impacts of hot and dry and drought conditions and the majority of livelihoods along the Lower Mekong Basin 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**.	▪ 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.

Key impacts for Central Dry Zone (CDZ), Myanmar

HEALTH

Under Storyline 1 the following impacts could be felt in the Central Dry Zone, Myanmar:	Under Storyline 2 the following impacts could be felt in the Central Dry Zone, Myanmar:
▪ 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 population, 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.	▪ 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 negatively impact the mental health of some vulnerable communities forced to cope with the loss of livelihoods, assets, family members and friends.

TRADE

Under Storyline 1, the following impacts could be felt in the Central Dry Zone, Myanmar:	Under Storyline 2, the following impacts could be felt in the Central Dry Zone, Myanmar:
▪ 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.	▪ 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.

MOBILITY

Under Storyline 1 the following impacts could be felt in the Central Dry Zone, Myanmar:	Under Storyline 2 the following impacts could be felt in the Central Dry Zone, Myanmar:
▪ 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 the 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 sometimes interrupted 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 and could thus lead to increased migration as a form of livelihood diversification or adaptation to decreased crop yield or crop failure.	▪ Increased drought has the capacity to compound drivers of out-migration 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.

SECURITY

Under Storyline 1, the following impacts could be felt in the Central Dry Zone, Myanmar:	Under Storyline 2 the following key impacts could be felt in 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 wellbeing 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.	▪ 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.

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 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 marginalised 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 minimise 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 and incorporate further local data, reflect adaptation action underway and 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 additionally 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.

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 longterm adaptation, as risks are expected to intensify under a global **2°C** warming scenario. Many of the impacts observed under the near and longerterm 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 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 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 pro-active 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 interl ocutors to discuss current approaches to monitoring ENSO, IOD, and local hydro-meteorological conditions, and the capacity to act based on warning signals.

Recommendation 3

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, in order 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 and certain states in eastern India, are under researched regions (also evidenced in the findings of the systematic review research).[1]
- 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.
- 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 Region and that of the wider ASEAN membership relating to trade and hydroelectric dams.[2]
- 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.

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

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

Recommendation 4

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 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 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, longterm 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 the use of 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 to 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.

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Annexe

Annexe 1.
Additional background on the science underpinning this work

The combination of El Niño-Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) in the Indo-Pacific region and the study cases for this project

This annex briefly outlines the important scientific elements behind ENSO and the functioning of IOD, what other drivers of climate variability might be seen in the Indo-Pacific, and how they all come together to produce impacts on people and environments across the three study regions.

ENSO and IOD are a result of several elements coming together, various drivers and can be understood as different phases. This report focuses predominantly on the phase of El Niño within the greater ENSO phenomenon and the Positive IOD Phase in the greater IOD phenomenon. Figure 1 depicts how the key climate drivers that influence the Indo-Pacific region come together and how they interact and add to the impacts in the event of an occurrence of an El Niño phase combined with a positive IOD phase. As figure 1 shows, the El Niño phase of ENSO influences sea surface temperatures (SSTs), atmospheric pressure and wind patterns. A positive IOD phase typically results in increased SST and reduced rainfall over the Indian Ocean which are typical for a positive IOD phase. When these are combined with the other drivers of climate variability depicted in Figure 1, we see three key impact areas for the Indo-Pacific region, namely in temperature, precipitation, and tropical cyclone activity.

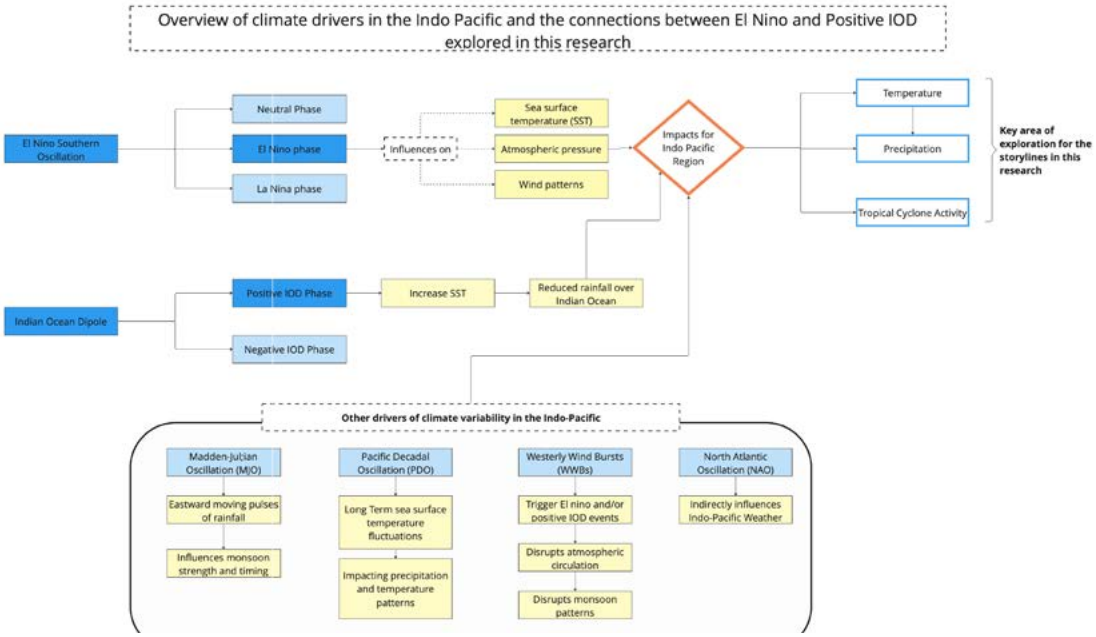


Figure 1: Diagram depicting the various climatic drivers in the Indo-Pacific and the overarching impacts that El Niño and positive IOD (the two elements explored in this study) have on the Indo-Pacific region

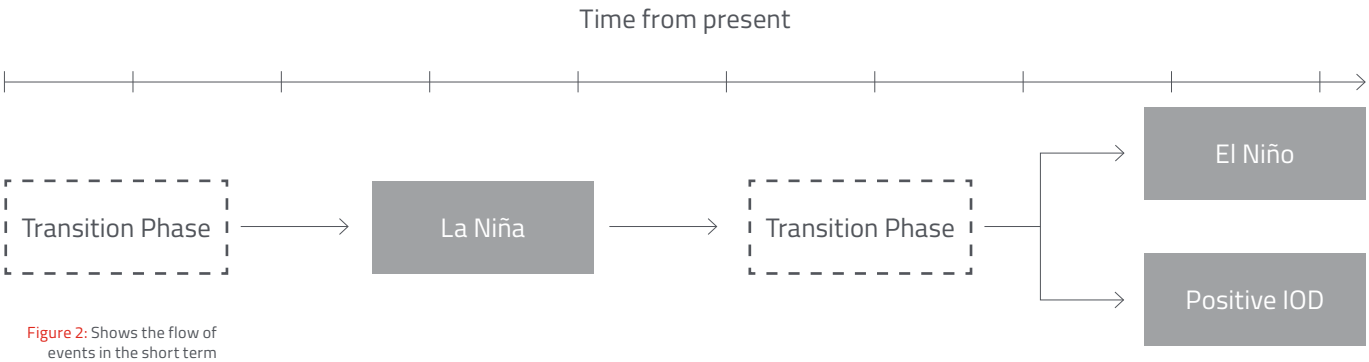


Figure 2: Shows the flow of events in the short term timescale from present - 10 years. With La Niña expected to last 2-3 years, followed by a combination of El Niño and positive IOD.

In the near-term scenario, the three cases mentioned above all follow a similar trajectory in terms of the phases that will be experienced. This is outlined in Figure 2 which excludes the broader role of the other climatic drivers mentioned above and offers an insight into the key elements that will be explore in the research across all three cases.

The impacts of La Niña act as a precondition of vulnerability occurring across all cases

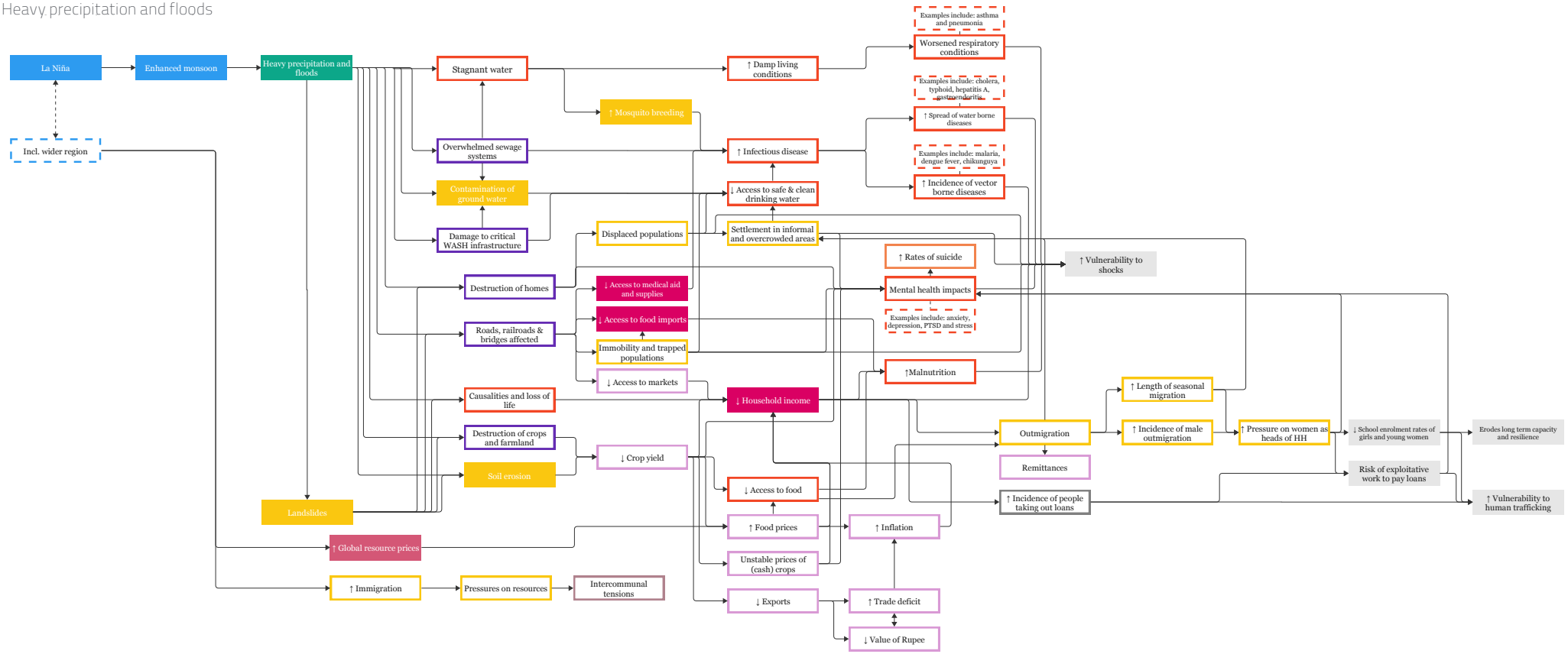
Despite the predominant focus in all the proposed storylines being El Niño and Positive IOD, the role of La Niña is also critical. Analysis shows that Myanmar will enter a La Niña Phase over the next year (Australian Government, 2024; Columbia Climate School, 2024). La Niña phases tend to persist for multiple years so 2 to 3 years of La Niña conditions is a plausible storyline. Across the Indo-Pacific region, La Niña is expected to result in increased precipitation and increased incidence of flooding. It is important to understand the generalist impacts of La Niña on the region as the impacts of flooding act as a compounding element in increasing vulnerability to shocks and risks that might arise from the El Niño and IOD event explored in this research. The following diagram below depicts a causal map, developed by using historical evidence, that highlights some of the general impacts of flooding on health, trade, mobility and security across the Indo-Pacific and can be used as an additional resource in understanding the broader picture of the next 2-10 years and the potential plausible scenarios that might be faced in the region.

The role of understanding the broader picture and the impacts that flooding and precipitation might have on the following El Niño and positive IOD phase is important, as it allows for a bigger temporal context and for a broader understanding and nuanced analysis of how the various future storylines might unfold.

In a 2°C degree warmer world, many of the impacts discussed in the cases will be exacerbated, occurring at a wider scale or with more frequency and intensity. The IPCC sixth assessment report has explored the broader impacts of climate change in the region. There are a number of global and regional drivers which will play a role in the way that both the compounding impacts from Storyline 1 will impact Storyline 2, as well as how the interactions between the storyline and the four lenses explored in this research will interact with one another. The following diagram summarises the findings from this report as these are key areas to consider when discussing the 2C storyline.

Broader regional impacts of La Niña

Heavy precipitation and floods



Legend

Hydro-Metereological Drivers	Preconditions	Mobility Impacts
Socio-Economic Drivers	Vulnerability	Trade Impacts
Environmental Drivers	Security Impacts	Infrastructure Impacts
Climate Drivers	Health Impacts	Broader societal impact

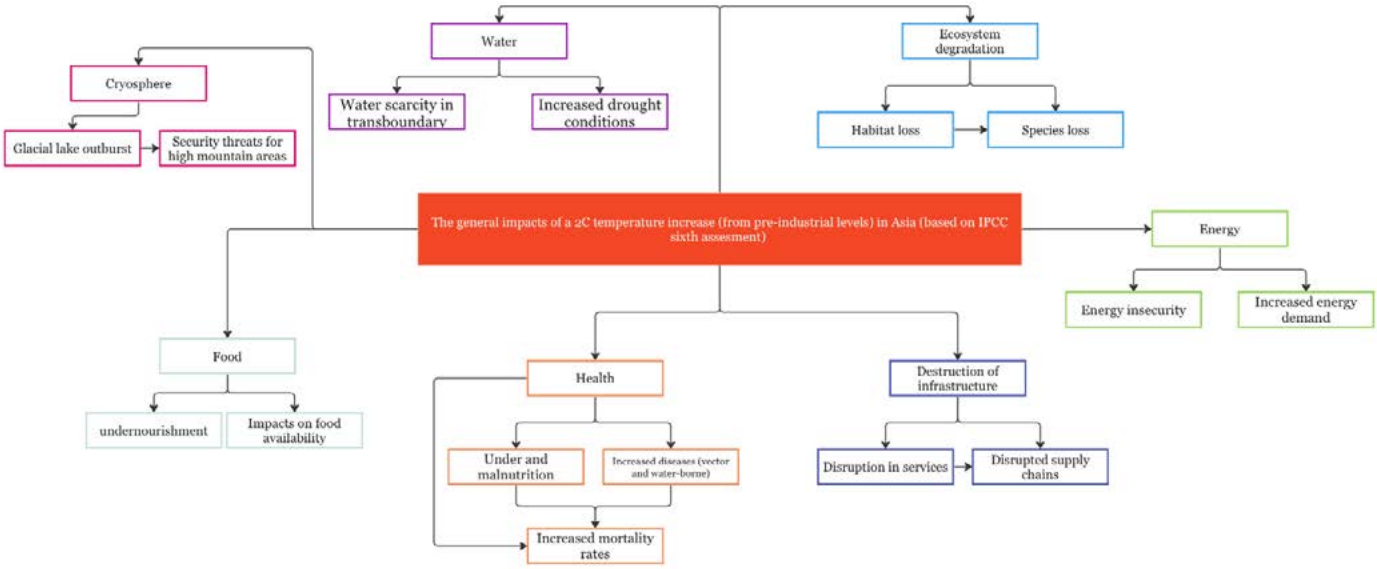


Figure 4: The general impacts of 2°C of temperature increase across Asia

The elements presented in the figure above – ecosystem degradation; energy; destruction of infrastructure; health; food; cryosphere and water – are all important to consider as they act as compounding elements for consideration in the storylines presented in this study.

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