The Might of Nature and the Power of Technology

Charting a Climate-Resilient Southeast Asia

A Call to Action by the Southeast Asia Climate Adaptation and Resilience (SEACAR) Alliance for the region's Road to Resilience

BCG thinkCITY

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ABOUT THIS DOCUMENT

Against the backdrop of Southeast Asia's escalating climate risks, the SEACAR Alliance was established in 2023.

Centred on collaborative action, the SEACAR Alliance emphasises the importance of nature-based solutions (NbS), climate analytics, and artificial intelligence (AI). These tools are instrumental in fortifying the resilience of cities and communities across six key, interlocking themes—agriculture, water, health, natural ecosystems, infrastructure, and trade.

This report, launched on 6 December 2023 at COP28 in Dubai, encapsulates the collective perspective of SEACAR's founding partners and a call to action for climate adaptation and resilience in Southeast Asia.

This is the first in the series of "Road to Resilience" publications by the SEACAR Alliance. As the discourse on climate adaptation and resilience in Southeast Asia continues to evolve, so will our perspectives. Future publications will reflect these ongoing refinements with spotlight on the key themes.

The SEACAR Alliance is a collaboration that emphasises the importance of nature based solutions, climate analytics and AI in advancing the resilience of cities and communities.

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FOREWORD

In April and May of 2023, a rare "once-in-200 years" heat wave struck Southeast Asia, particularly impacting countries like Vietnam, Cambodia, Lao PDR, Myanmar, and Malaysia. Unfortunately, this was but one of the many climate hazards we have seen increase in frequency and severity in the region over recent years. Four of the 11 countries in Southeast Asia find themselves among the world's top 15 most at risk from natural disasters, with five out of 11 at high vulnerability due to climate change[1]—making the region a global hotspot for climate challenges.

Southeast Asia's vulnerability is not just a regional concern. There are far-reaching implications for the global community as well. The region's economic trajectory is anticipated to make it the fourth-largest contributor to the world's gross domestic product (GDP) by 2030. It is also home to the third-largest global labour pool and renowned for rich biodiversity, both terrestrial and marine. Three of the 17 megadiverse countries of the world are in Southeast Asia. In spite of its significance, the region often finds itself eclipsed in global climate conversations, particularly on adaptation and resilience.

However, within these challenges lie immense opportunities. Southeast Asia's abundant natural assets, for example, allow the region to leverage NbS. We can see this in Myanmar's Ayeyarwady Delta project, where mangrove conservation not only reinforces defences against sea-level surges, but also fosters sustainable local livelihoods.

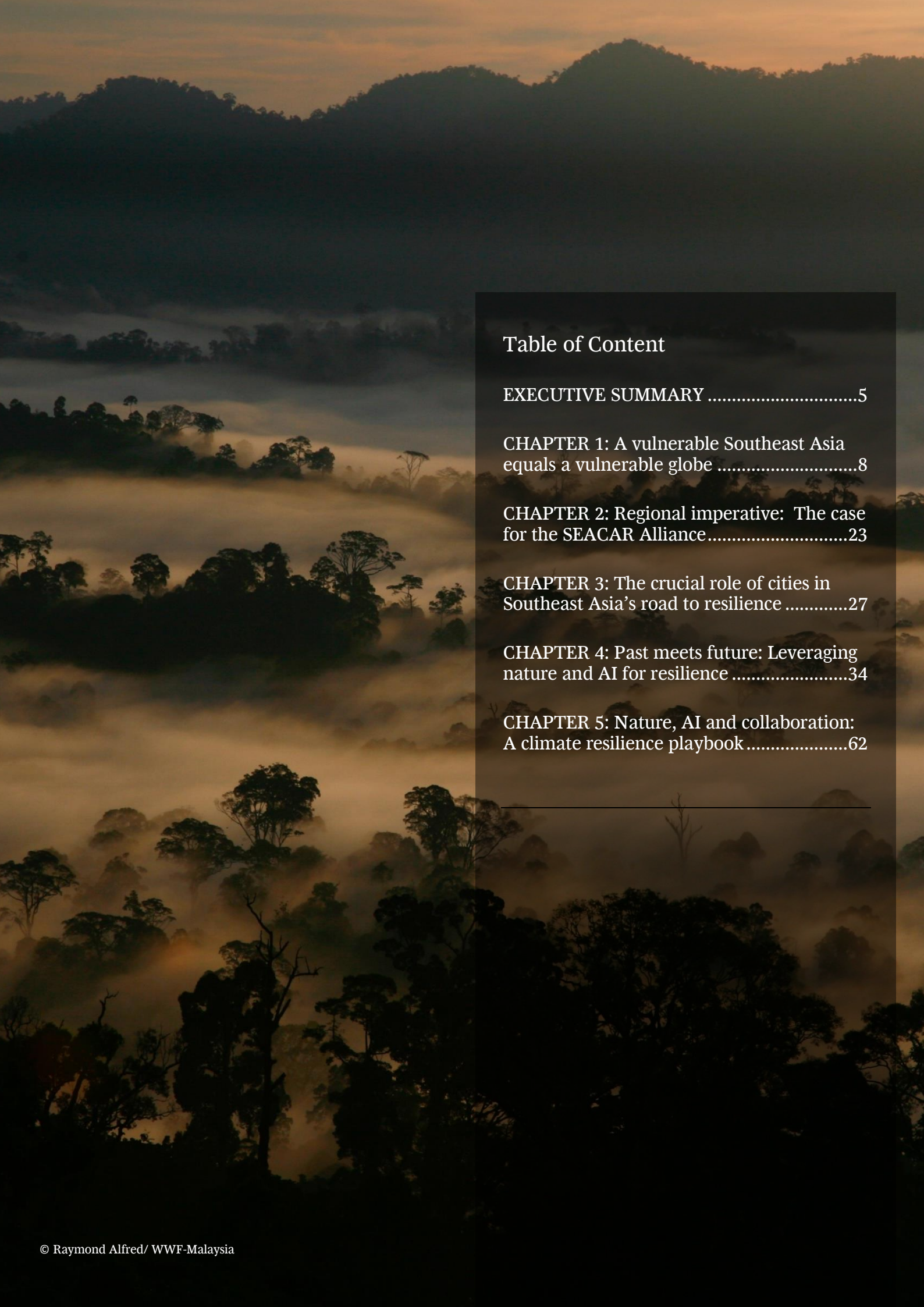
Technological advancements, especially advanced analytics and AI, offer another avenue of promise. For example, AI and advanced analytics introduce decision-making support that enables more effective deployment of climate adaptation and resilience (A&R) solutions. In the Philippines, advanced analytics and AI-enabled modelling support municipal-level planning and decision making to effectively prioritise and channel resources to protect the most vulnerable communities.

The true transformative potential, however, lies in the convergence of nature and technology, as outlined in our report. This document, the first in the Road to Resilience series called ***The Might of Nature and the Power of Technology: Charting a Climate-Resilient Course for Southeast Asia***, encapsulates this unified vision of the SEACAR Alliance. It also serves as a call to action for stakeholders across the region to tap into the combined strength of nature and technology.

Formed in 2023, the SEACAR Alliance—a collaborative endeavour between BCG, Think City, and WWF-Malaysia — is committed to raising the bar on A&R awareness and fostering impactful collaboration.

We encourage government entities, city authorities, industry leaders, and non-profit groups keen on championing A&R initiatives in the region to utilise the insights and strategies outlined in this document to forge meaningful pathways for Southeast Asia. With collaboration that extends beyond borders and industries, plus the undeniable power of nature and AI, we believe this is the perfect recipe to set the region on a climate-resilient course.

The SEACAR Alliance



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EXECUTIVE SUMMARY

Southeast Asia is a global socio-economic and biodiversity powerhouse. It is a region brimming with potential. By 2030, Southeast Asia, as a collective, is poised to stand tall as the world's fourth-largest economy, hosting the third-largest labour force globally.

The region's biodiversity is also a vital resource. Home to a third of the world's mangroves and three of the world's megadiverse rich countries, its natural terrains, both on land and at sea, don't just add to Southeast Asia's rich tapestry, but serve as a lifeline, providing ecosystem services that extend beyond its borders. In Southeast Asia, there are a few landscapes and seascapes management of natural resources that are transboundary and includes large areas. The coral triangle is one of the most biodiverse areas in the world, with more than 500 species of corals, and spanning the Philippines, Malaysia, Indonesia, Papua New Guinea, Solomon Islands, and Timor-Leste. The Heart of Borneo is one of the largest intact transboundary rainforests, and is being managed by Brunei, Malaysia, and Indonesia. The Lower Mekong Basin traverses Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. It is the "rice bowl" of Asia and is one of the world's richest areas of biodiversity.

While Southeast Asia's assets are considerable, its climate vulnerabilities are equally stark. Up to 35% of its GDP is anticipated to be wiped away by the climate crisis and natural hazards by 2050 under the projected worst-case scenario. Half of its vibrant population and over 4,000 species are also on the frontline of these impending climate impacts.

Despite the glaring stakes, the region is severely underprepared to counter these challenges. There is a pressing need to bolster local A&R plans to protect people, the economy, and nature in the region. Given the region's shared risks, interests, and interconnected fabric, there are many opportunities for collaborative action. Southeast Asia is also a major trading region with the rest of the world, generating an average annual export value of US$1.3 trillion and import value of US$1.2 trillion from 2011 to 2020. The region must assert its narrative on the global stage: a vulnerable Southeast Asia is not just a regional concern—it means a vulnerable globe.

In response to these interconnected challenges, the SEACAR Alliance was established in 2023 out of a pressing need for a united A&R narrative and agenda for the region. SEACAR's mission is twofold: heighten awareness and foster meaningful collaboration. Tapping into the collective knowledge and experience of Southeast Asia, SEACAR aims to bridge gaps across sectors, contributing to successful A&R action.

In this first perspective, we highlight the role of cities in unlocking the region's climate resilience. These urban centres are particularly vital—over half of the population resides in these areas, and they serve as the heart of socioeconomic, administrative, and governmental activities. Yet, the preparation is alarmingly inadequate. Only 25 out of 127 cities in the region have clear adaptation plans. Financial challenges further hinder progress. The US$10.42 billion received from both the public and private sectors between 2000 and 2019 only represents 1.6% of what is required annually.[2] With the prospect of 200 additional cities in the region by 2050, the planning and development of cities will set the trajectory—either paving a path of resilience or one of increased vulnerability for the region.

To effectively build climate resilience in Southeast Asian cities, we believe there is enormous potential to leverage the world's oldest and newest solutions: NbS, and technology in the form of AI to help conduct advanced analytics.

Nature-based solutions

The region, with its ecological richness, is in a prime position to leverage NbS for A&R. Solutions such as urban forests, mangrove restoration, and submerged aquatic vegetation, contribute to A&R by increasing protection against coastal erosion, storm surges, and flooding, amongst others. NbS are also unique in that they provide additional co-benefits such as natural carbon sequestration, biodiversity conservation, and local job creation to name a few. Furthermore, integrating NbS with traditional built infrastructure is emerging as an effective method to build climate resilience. An example is building a combination of mangrove forests and seawalls to decrease wave energy, thereby protecting against coastal flooding and erosion.

NbS has been growing in popularity among the public and private sectors, but there exists a significant gap in adoption. In 2020, NbS received only 0.3% of overall spending on urban infrastructure, and investments are unequally distributed across and within cities.[3] Several challenges exist hindering NbS scalability to achieve our climate goals. These challenges include difficulty in measuring impacts, its vulnerability to changing climate dynamics, and complexity in reaching consensus among a wider range of stakeholders. Nevertheless, given its potential, NbS suitability and application should be thoroughly assessed and applied as part of broader A&R strategies. NbS can contribute to potential cost savings of US$393 billion by 2050 in developing countries.[4] This provides promising options for the region. As with all A&R measures, NbS should be thoroughly assessed in each context to guard against maladaptation.

Climate AI

Technology in the form of AI and advanced analytics, when applied to climate data, provides transformative insights in the realm of climate action for adaptation. These technologies offer enormous benefits in decision-making support. For example, simulating varying climate scenarios and quantifying the cost of inaction to people, the economy, and nature enables better prioritisation and optimal resource allocation towards A&R projects and programmes. In the remainder of this publication, we will refer to this as Climate AI.

In a case study from the Philippines, for example, Climate AI was instrumental to quantify the social, economic, and natural impacts of sea level rise in a local municipality. Findings include the number of people at risk, cost of inaction in GDP terms, critical infrastructure (e.g., hospitals and schools) and natural assets (e.g., wetland areas) exposed. These insights help the prioritisation of specific vulnerable communities and economic sectors, identifying opportunities for private-public partnerships and potential sources of funding for A&R. Beyond higher resolution risk assessments, Climate AI can also be used to build early warning systems, strengthen infrastructure, predict large-scale migrations and preserve biodiversity, amongst others.

Despite its substantial potential, Climate AI still faces some notable limitations. These include challenges in data availability and uncertainty, limited data accessibility due to technological infrastructure constraints and the technical capacity needed to apply AI for climate A&R where it is most needed. Notwithstanding these challenges, rapid progress is being made to ensure responsible and effective integration of AI into the climate A&R efforts.

One fundamental aspect to consider in the deployment of these adaptation and climate-related solutions is the interrelation of various risk factors. Recognising these interactions and relations is essential for decision-makers. It is critical to understand both opportunities and challenges for solutions with multi-faceted impacts across multiple risks. The understanding of how risks intersect and affect each other can lead to more comprehensive and effective strategies for climate adaptation.

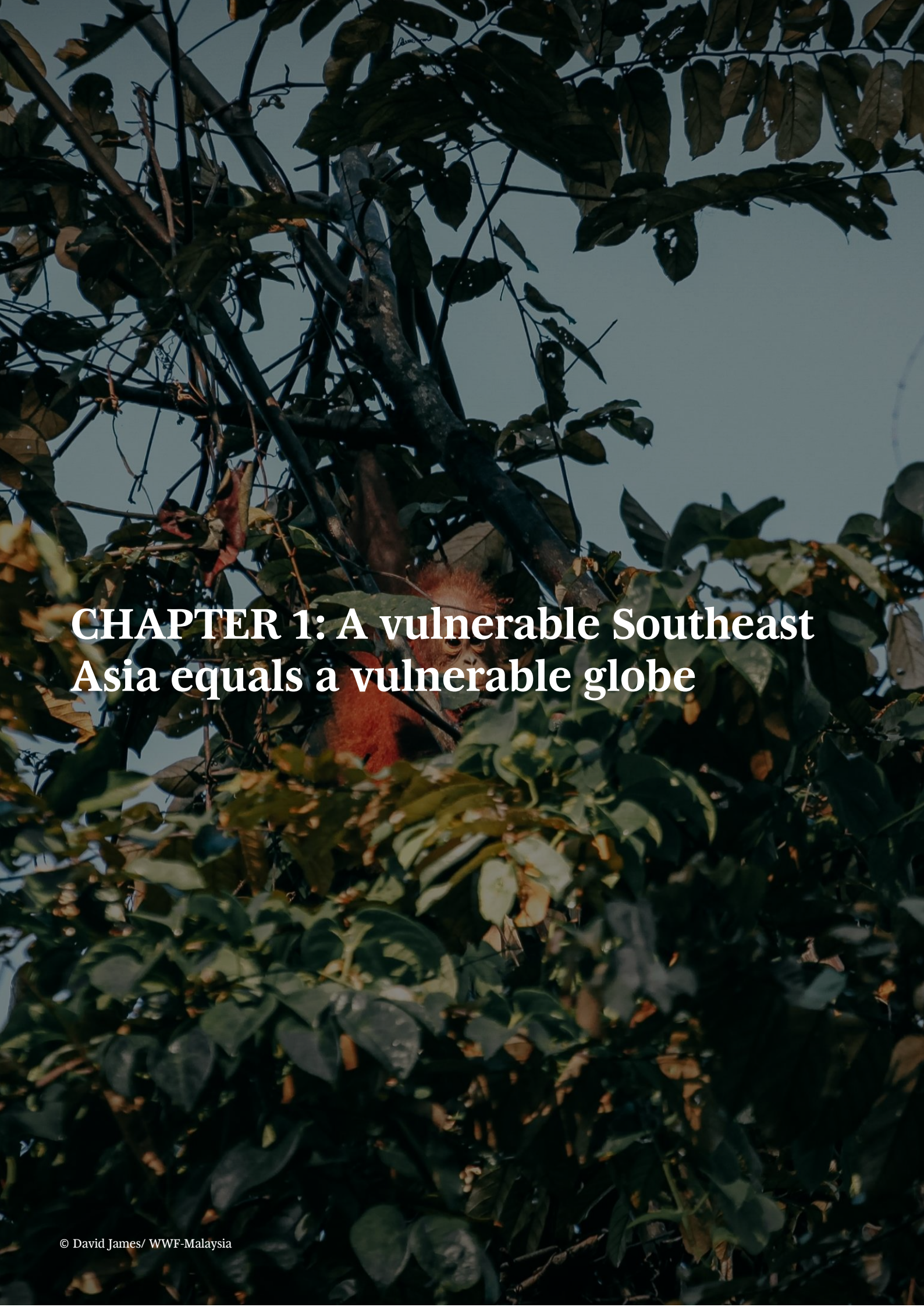
Combining nature and AI to build A&R for Southeast Asia

While nature and AI are high-impact solutions to adaptation, we believe the combination holds great potential to bring about transformative change for the region. Therefore, consolidating learnings from the collective experience of the SEACAR Alliance and several case studies from across the globe, Chapter 5 offers a playbook to actionably combine and deploy NbS and AI for A&R in Southeast Asian cities.

This playbook is designed as a simple framework involving three primary phases—each of which contains specific sub-steps leveraging nature, AI and collaborative action, and case studies that depict how these are implemented in real-world settings.

1. **Planning:** Engage diverse stakeholders such as local communities, academia, and governmental bodies; undertake rigorous climate risk modelling and assess the natural landscape and its value.
2. **Financing:** Involve relevant entities, devise strategies for funding, and emphasise project prioritisation.
3. **Implementation:** Ensure consistent stakeholder engagement, conduct technical assessments of priority A&R solutions, and create mechanisms for ongoing monitoring and learning.

In this light, our perspective is not just an analysis—it is a call to action to stakeholders from across sectors to collaborate, leverage, and take full advantage of the potential of these solutions for climate A&R, and deliver meaningful outcomes for Southeast Asia's journey to resilience.



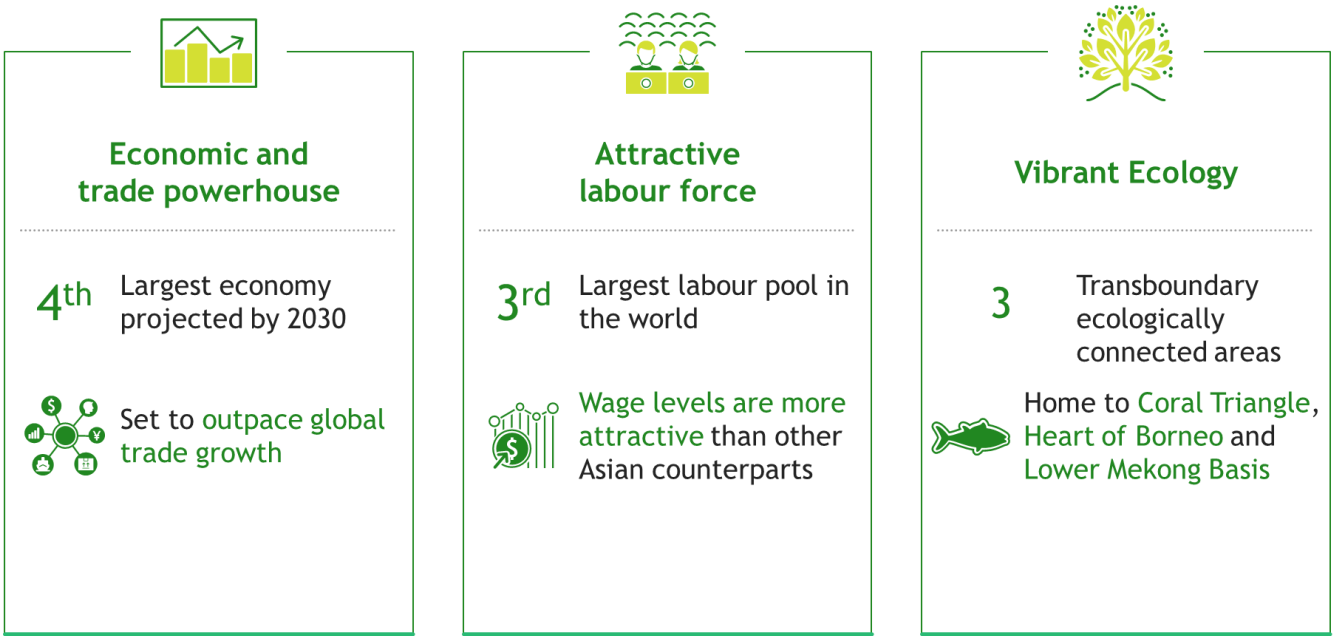
CHAPTER 1: A vulnerable Southeast Asia equals a vulnerable globe

Southeast Asia is a vibrant region comprised of 11 distinct nations with significant combined economic, social, and cultural importance. The region is woven together by a rich tapestry of history, culture, and innovation, with each nation standing as a distinct entity. [Exhibit 1.1]

Diverse landscapes, from lush forests to bustling cities, varying socio-economic backdrops, and rich cultural heritages coalesce to give Southeast Asia its undeniable character. Yet, beneath this tapestry, lies a concerning thread—the region's acute vulnerability to climate change. Four out of its 11 countries are ranked as the top 15 most climate-threatened countries worldwide.[5] The shared experience of rising temperatures, coastal flooding, droughts, and heatwaves casts a shadow over our collective future.

The implications are not just environmental. These climate challenges also pose threats to the region's GDP and population. Yet, despite the looming threats, comprehensive A&R measures across the region are more aspirational than realised. Less than half of the countries have formulated an adaptation plan, and most lack the critical components necessary for effective action, such as data-driven decision-making, a pipeline of bankable projects, and private sector involvement.

Exhibit 1.1: Southeast Asia as a global economic, labour, and biodiversity powerhouse

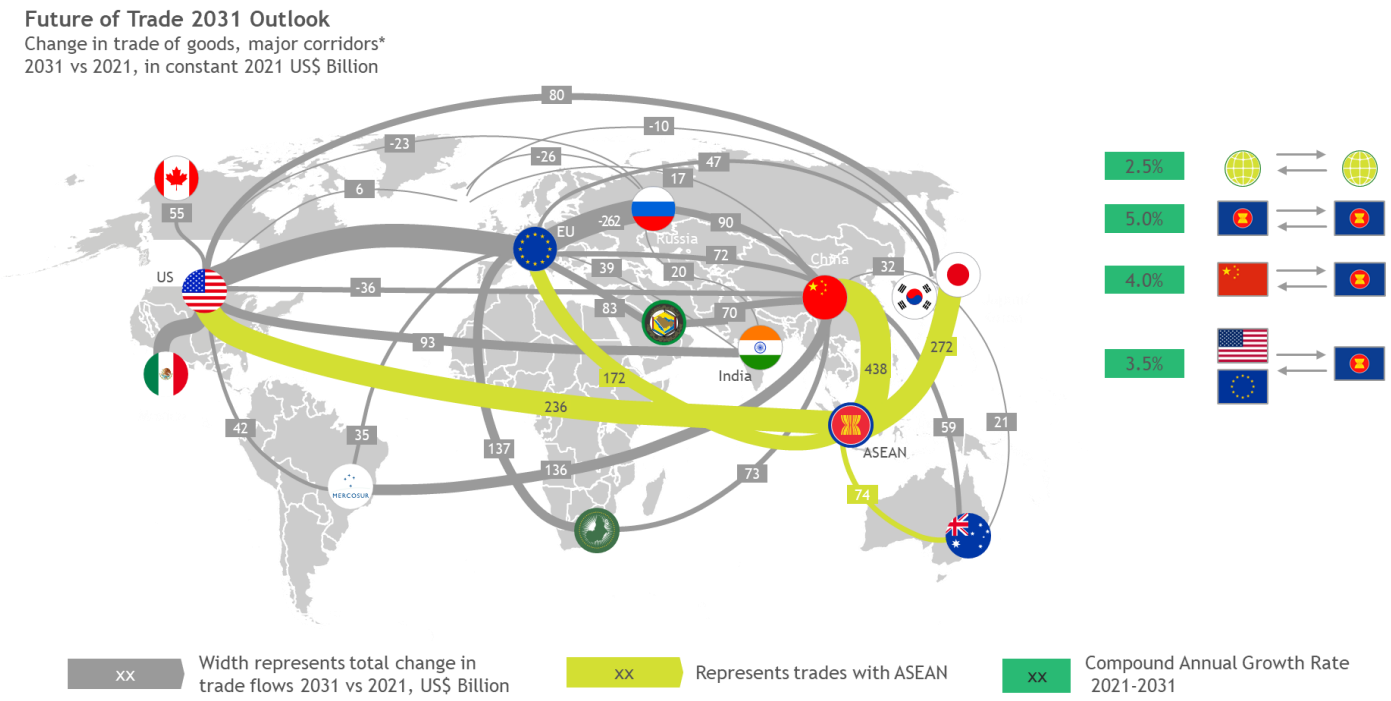


Economic powerhouse and global trade giant

By 2030, Southeast Asia is projected to be the fourth-largest global economy with an anticipated GDP of US$7 trillion, trailing only the United States (US), China, and India.[6] Within the context of emerging markets, it has consistently outperformed, boasting the swiftest economic growth. Additionally, the International Monetary Fund (IMF) projects that the region will have a GDP growth of 4.9% by 2028, surpassing the global projection of 3.1%.[7]

As the region continues to gain traction in global trade, Southeast Asia is set to become an even stronger economic player on the world stage. The increasing need to diversify global supply chains, combined with the region's attractive manufacturing costs and capabilities, further reinforce IMF's projection that Southeast Asia GDP growth will surpass that of the global GDP growth. [Exhibit 1.2.]

Exhibit 1.2: Global trade corridors



*Corridors in the map above represent ~46 % of global trade.
Note: EU Intra trade estimated to grow by 1.5T US$ by 2031 CAGR 1.8%; inflation adjusted
Source: UN Comtrade, Oxford Economics, IHS, WTO, BCG Global Trade Model 2022, BCG analysis

Southeast Asia's exports are also steadily growing, as the region garners attention for being both an attractive trade party and a reliable investment destination. Several of its key trade sectors are already integral components of global supply chains:

- **Semiconductors.** Efforts to diversify the global supply chain have benefited Thailand and Malaysia. Singapore is also poised to reap similar advantages in the coming years.
- **Metals and mining.** With production on the rise in Malaysia, Indonesia, and the Philippines, major automotive players are increasingly incorporating Indonesian nickel into their battery supply chains.
- **Additional sectors.** There is a noticeable growth across sectors such as consumer growth, manufacturing, and agriculture, highlighting the region's diverse trade landscape.

Competitive labour advantage

Southeast Asia is currently home to more than 670 million people. By 2030, this number is expected to rise to 720 million, making it the third-largest populated region globally.

With 67% of its populace within the working age bracket,[8] the region is expected to emerge as the second-most rapidly expanding labour market globally in the lead-up to 2030.[9] The number of individuals eligible to work will continue to rise, spearheaded by nations like Indonesia and the Philippines. This surge corresponds to an escalating demand for employment, subsequently moderating labour costs. According to a Japan External Trade Organization (JETRO) survey, wage levels in most Southeast Asian nations are lower than in other Asian counterparts, including South Korea, Taiwan, and China, thus boosting competitiveness.

Given the region's progressively favourable business environment, it is possible to forecast an influx of foreign investments lured by Southeast Asia's compelling labour offerings.

Biodiversity hotspot

The region is a bastion of biodiversity—it is home to an impressive array of flora and fauna, both on its terrains and beneath its waters.

- The Coral Triangle is the most biodiverse marine region that includes the Philippines, Malaysia, Indonesia, Papua New Guinea, Timor-Leste, and the Solomon Islands. The area is named after the number of coral species, with diversity spanning more than 500 species and a staggering 2000 species of reef fish. Six of the seven species of marine turtles can also be found in the Coral Triangle. Almost 120 million people live in and rely on the marine resources that the Coral Triangle provides for sustenance, livelihoods, and protection.
- The Heart of Borneo refers to one of the largest transboundary forests in the world, and extends into the territory of Brunei, Malaysia, and Indonesia on the island of Borneo. The forest covers the size of Victoria in Australia or the whole of England and Scotland put together. The forest is not only a natural treasure, but it also provides life and livelihood to 11 million Borneans.
- The Mekong River region encompasses transboundary landscapes inhabited by more than 20,000 species of plants, 1,300 bird species, 1,000 species of reptiles and amphibians, and 500 mammal species. The Lower Mekong Basin traverse Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. Many rare, threatened, and endemic species live in the region, including crested gibbons, forest pheasants, box turtles, the Irrawaddy dolphin and the elusive saola.

The region's marine biodiversity is particularly astonishing. Despite only covering 1% of the world's surface, the region is home to one-third of the world's mangroves, seagrass, and coral reefs. Furthermore, it is the source of 80% of worldwide aquaculture production and 60% of global capture fisheries.[10]

Preserving biodiversity is critical in ensuring the health of ecosystems that yield manifold socio-economic benefits, spanning sectors like agriculture, forestry, and fisheries. Beyond the region's borders, these thriving ecosystems contribute to global imperatives such as climate regulation and carbon sequestration. Notably, Southeast Asia boasts the largest blue carbon stocks in the world, offering an essential carbon sink for the planet.[11] Given that the region also shelters a significant portion of the world's mangroves and seagrass meadows, the need to protect these ecosystems extends beyond the region to the rest of the world.

Southeast Asia's climate risks

Southeast Asia, while rich in its offerings to the world, faces formidable threats from climate change. The World Risk Index, which evaluates the disaster risk of 193 countries, places four Southeast Asian countries—Philippines, Indonesia, Myanmar, Vietnam—in its top 15 list, underscoring the region's vulnerability. [Exhibit 1.3.]

Exhibit 1.3: World Risk Index 2023

Rank	Country	Risk
1.	Philippines	46.82
2.	India	42.31
3.	Indonesia	41.46
4.	Colombia	38.37
5.	Mexico	37.55
6.	Myanmar	35.49
7.	Mozambique	34.37
8.	China	28.70
9.	Bangladesh	27.90
10.	Pakistan	26.75
11.	Russian Federation	26.54
12.	Vietnam	25.85
13.	Peru	25.41
14.	Somalia	25.07
15.	Yemen	24.26

Source: WorldRiskIndex 2023

Several climate-related hazards persist across the region. The most common of these are heatwaves, rising land temperatures, coastal flooding, and droughts that affect agriculture. [Exhibit 1.4.]

Exhibit 1.4: Climate hazards in Southeast Asia

Note: Non-exhaustive
Source: ASCCR; IPCC AR6; WHO Climate and Health reports, Em-dat 2022, BCG analysis

Climate impacts in Southeast Asia

Climate challenges impact the region in various ways. From an economic perspective, there is tangible damage to infrastructure, productivity loss from extreme heat, and costs associated with relocation and business disruptions. Socially, climate risks bring about physical and mental health repercussions, as well as impacts on well-being with damage to homes, loss of school days, and threats to food and water security. Environmentally, habitats and species suffer losses, which has a ripple effect on society and the economy due to the attendant disruptions to ecosystem services. Another direct consequence of these hazards is climate migration, leading to further impacts such as heightened resource conflicts, intensified demographic and cultural disparities, and an increased vulnerability to crimes and human rights violations. Critically, it's the vulnerable populations—those with limited adaptive capacity and resources—who bear the brunt of these climate risks.

According to the UN Office for the Coordination of Humanitarian Affairs (OCHA), this is already occurring. It highlights "The Southeast Asian countries with the highest incidence of displacements due to natural disaster in 2021 were the Philippines (5,681,000), Indonesia (749,000), Vietnam (780,000) and Myanmar (158,000). Although Southeast Asia is known as being a 'hot spot' for acute severe weather events, it is also vulnerable to the effects of more chronic environmental degradation or slow onset events. For example, the large low-lying coastal areas of the region – such as in Vietnam, Thailand and around the Mekong delta – are already being affected by sea level rise and its impacts on settlements through coastal erosion and saltwater intrusion."[12]

Recent research estimates up to 35% of Southeast Asia's GDP is at risk of being wiped away by the climate crisis and natural hazards by 2050.[13] The Philippines, Cambodia, and Lao PDR face the greatest losses, with potential yearly reductions of 8-9% of their GDP annually under an RCP8.5 scenario. [Exhibit 1.5.]

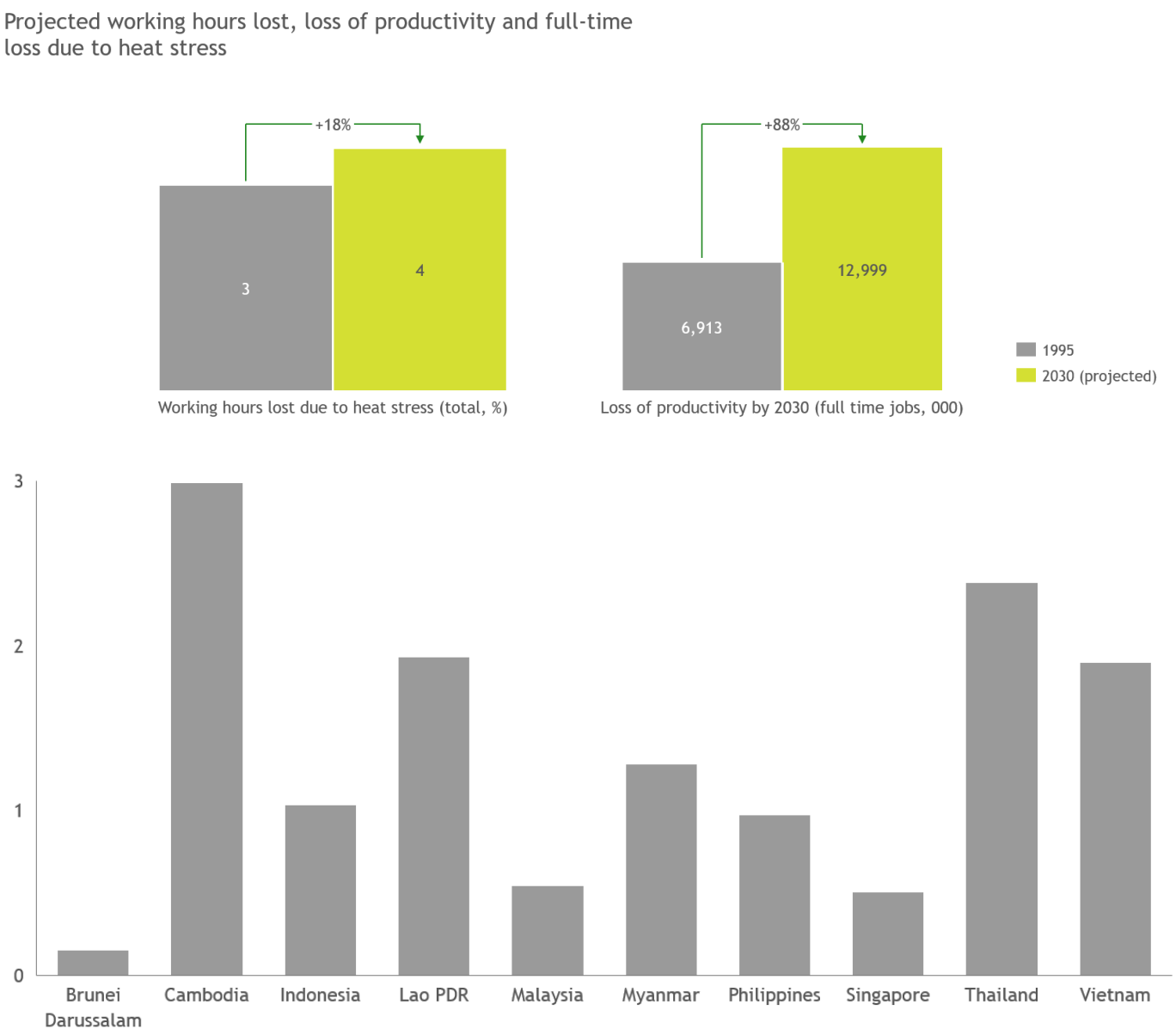
Exhibit 1.5: Average annual loss across Southeast Asia

Country	AAL unit	Average Annual Loss (AAL)		
		1.5°C (RCP2.6)	2°C (RCP4.5)	4°C (RCP8.5)
Brunei	US$, Millions	82	97	108
	% of GDP	< 1	< 1	< 1
Cambodia	US$, Millions	1,530	1,797	2,035
	% of GDP	6	7	8
Indonesia	US$, Millions	31,224	37,081	44,238
	% of GDP	3	4	4
Lao PDR	US$, Millions	1,077	1,274	1,429
	% of GDP	6	7	8
Myanmar	US$, Millions	3,864	4,628	5,293
	% of GDP	2	3	3
Malaysia	US$, Millions	7,694	9,140	10,286
	% of GDP	5	6	7
Philippines	US$, Millions	20,822	24,651	28,533
	% of GDP	6	7	9
Singapore	US$, Millions	354	418	468
	% of GDP	< 1	< 1	< 1
Thailand	US$, Millions	13,041	15,237	17,807
	% of GDP	3	3	4
Vietnam	US$, Millions	11,423	13,781	16,375
	% of GDP	5	6	7

Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) "Risk and Resilience Portal"; BCG analysis

Further economic setbacks arise from decreased productivity due to heat stress. By 2030, an estimated 18% increase in lost working hours and an 88% surge in productivity loss from 1995 levels are projected. Cambodia, Thailand, Vietnam, and Lao PDR, with sizeable agricultural and construction workforces, are particularly vulnerable. [Exhibit 1.6.]

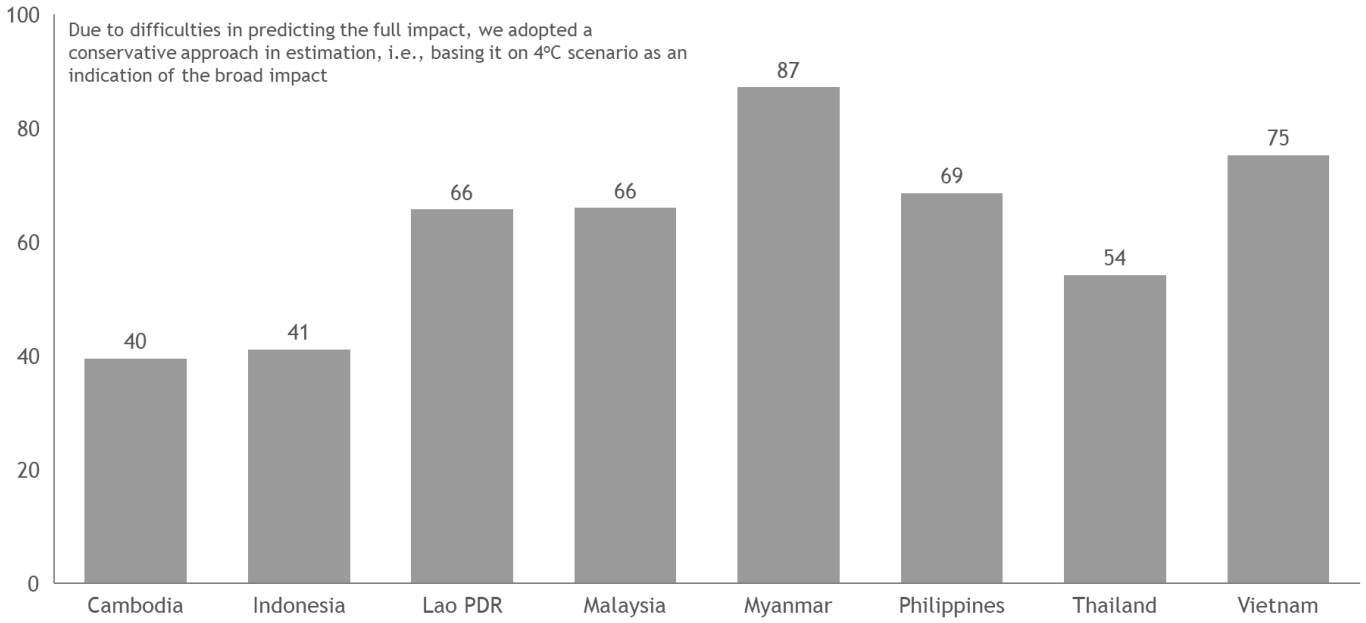
Exhibit 1.6: Impact of heat stress on working hours, productivity, and jobs in Southeast Asia



Note: 1. Data is based on 1.5C pathway (RCP2.6). Current trajectory of warming likely will exceed 1.5C pathway
The methodology used does not take into account Urban Heat Islands or heatwaves. Consequently, it is likely that the results presented here underestimate the magnitude of labour productivity losses for highly urbanised countries and those with high degree of employment in service sector e.g., Singapore.
Source: International Labour Organisation (ILO) 2019, BCG analysis

Over 50% of the populations of Vietnam, Thailand, Philippines, Myanmar, Malaysia, and Lao PDR are anticipated to face exposure to climate-induced disasters leading to death, displacement, or diseases, due to susceptibility to multiple climate hazards with 4°C temperature rise. [Exhibit 1.7.] These underscores clearly that every feasible mitigation effort must be taken to ensure average global temperatures do not exceed the 1.5°C limit. As we seek to adapt to a 1.5°C world, there must be matching efforts to reduce GHG emissions to secure this future. Adaptation and mitigation are two sides of the same coin. Failure in either will result in a greater extent of loss and damage.

Exhibit 1.7: Southeast Asian populations at risk of climate-induced disasters with 4°C temperature rise

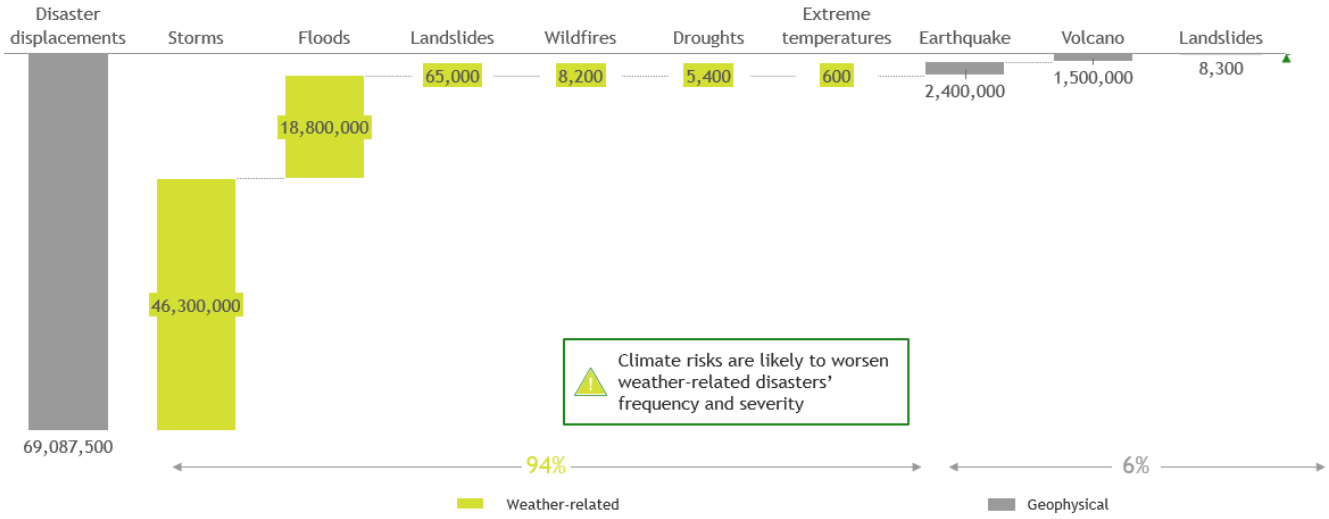


Note: 1. "Affected" is defined as death, displacement or diseases due to climate related disasters 2. 'Multi-hazard hotspots' defined as locations of medium to high exposure to more than one climate risk and/or hazard 3. Data for Brunei and Singapore not available 4.
Source: United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) "Risk and Resilience Portal"; EM-Dat 2022.

Flood-related disasters are also projected to affect up to 600 million people under a 4°C pathway. Cambodia, the Philippines, and Vietnam are especially at risk, given their significant coastal populations.

Weather-induced hazards like storms and floods have displaced more than 65 million people in the past decade. As climate risks amplify these events in both frequency and severity, displacements will escalate, leading to challenges such as increased competition for resources, potential civil unrest, and heightened vulnerability to criminal activity and human rights violations. [Exhibit 1.8.]

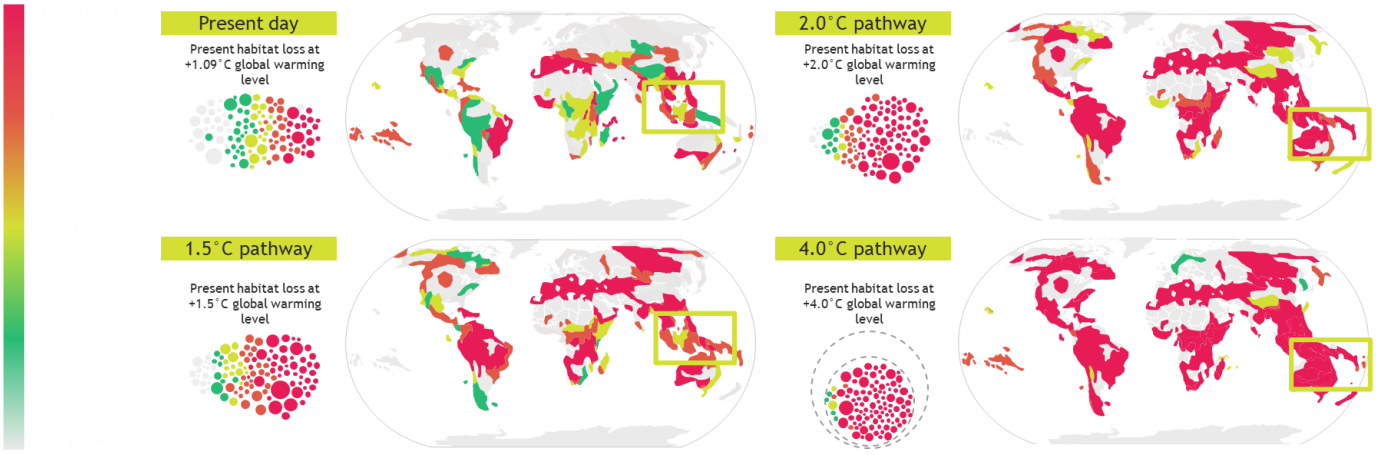
Exhibit 1.8: Weather-induced displacement in the last decade



Source: International Displacement Monitoring Centre (IDMC)

All climate pathways (1.5°C/2.0°C/4.0°C) project a medium to very high habitat loss in the region, threatening food sources and reproductive conditions for diverse plant and animal species.[14] [Exhibit 1.9.]

Exhibit 1.9: Present and projected habitat losses across three climate pathways

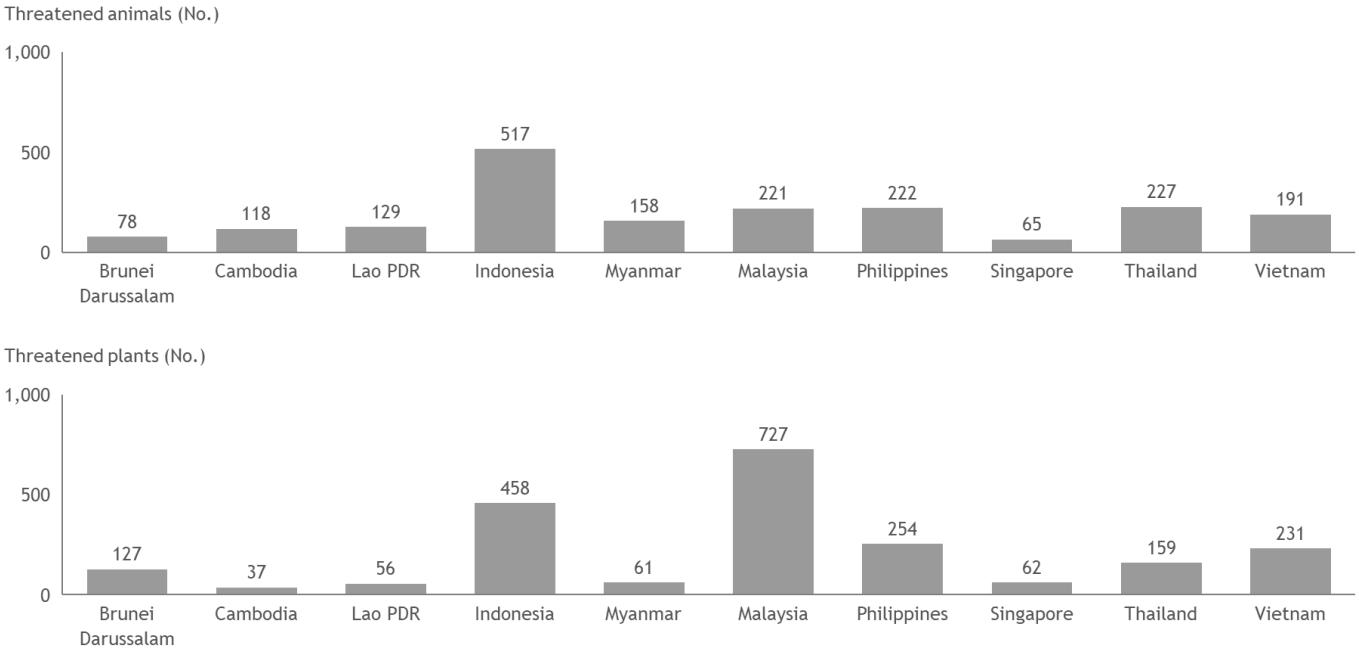


Present and projected habitat losses of climatically suitable area in terrestrial biodiversity hotspots
Projected loss for present day (around 1°C warming) and at global warming levels of 1.5°C, 2°C and 3°C. Maps show the regional distribution of losses in five categories of loss (very low loss 0-20%, low loss 20-40% medium loss 40-60%, high loss 60-80%, very high loss 80-100%). The clusters of circles show losses in the five categories of loss in each of the 143 hotspots areas of high importance for terrestrial biodiversity conservation with circles scaled by area size.

Source: IPCC AR6 WGII Annex I

Furthermore, as global warming intensifies in Southeast Asia, an essential biodiversity hotspot, the existence of over 4,000 plant and animal species is at potential risk. [Exhibit 1.10.]

Exhibit 1.10: Climate change further exacerbates the risks to ~4,000 threatened plant and animal species



Note: Species assessed as Critically Endangered (CR), Endangered (EN) or Vulnerable (VU) are referred to as "threatened" species
Source: World Bank Databank, assessed 2022; International Union for Conservation of Nature (IUCN) Red List of Threatened Species, 2019

Cross-border climate risks

The interconnected nature of Southeast Asia's geography and climate has led to the emergence of hazards that transcend national borders.

The issue of transboundary haze pollution has grown notably in prominence, impacting Indonesia, Malaysia, and Singapore. Originating from smouldering peat fires due to unsustainable agricultural practices, the problem is further aggravated by climate-driven shifts in rainfall patterns. Drier seasons, which are anticipated to become more frequent, are expected to magnify the intensity and duration of transboundary haze.[15]

Water quality, too, is an issue that is not limited by national borders. For example, the Mekong Delta in Vietnam has faced declining water quality and saltwater intrusion. Unusual weather patterns altered water levels, and dam projects by China and Lao PDR intensify these challenges. Such issues not only negatively impact farming communities but have also triggered migration away from the Mekong Delta.[16]

Presently, most climate-induced migrations are within national boundaries. However, it is anticipated that the Greater Mekong subregion, encompassing Vietnam, Cambodia, Thailand, and Lao PDR, will see a surge in cross-border migration. A report by the World Bank estimates that by 2050, the lower Mekong subregion could witness between 3.3 to 6.3 million new climate migrants.[17] Such movements can lead to heightened resource competition, potential civil conflicts, and increased human rights violations.

Moreover, the global supply chain remains vulnerable to disruptions caused by climate hazards. The 2011 floods in Bangkok demonstrate this vulnerability. While the direct economic impact on Thailand was approximately 1.1% of its GDP, its ripple effects extended far beyond Thailand. Over 550 Japanese-affiliated companies faced disruptions, which in turn affected factory operations in Indonesia, Malaysia, and Vietnam. In total, this event resulted in an estimated decline of 2.5% in global industrial production that year.[18]

Climate hazards across SEACAR's six key themes

The SEACAR Alliance aims to build A&R across six key themes which correspond to sectors most impacted by climate hazards. These themes are especially significant to Southeast Asia's survival and development, as detailed in the table below.

Theme	Significance	Nature of climate hazards	Example
Agriculture	• Agriculture is pivotal to the region, ensuring food security for its vast population, while also being a major contributor to GDP and employment. • It accounts for approximately 15% of GDP and 27% of jobs in the region's five primary agricultural economies.[19]	• This sector is highly vulnerable to the increasing frequency and severity of extreme weather events such as erratic rainfall, drought-driven water shortages, and flood-induced soil erosion. • Such events compromise crop yields and livestock productivity.	• In the Philippines, from 1990 to 2006, damages to agricultural production averaged US$227 million annually. Typhoons were responsible for 70% of this damage, droughts 18%, and floods 5%.[20] • Prolonged drought caused supply disruptions in palm oil production and caused a significant impact on the Malaysian economy in the fourth quarter of 2019.
Water	• Water, vital for human survival, serves as a crucial resource for drinking, sanitation, and hygiene. • It also underpins sectors like agriculture, manufacturing, and energy, highlighting its economic significance.	• Climate changes threaten water availability and quality through factors like erratic rainfall, flood-driven saltwater intrusion, temperature-induced algal blooms, and degradation of ecosystems such as forests and wetlands which provide water services like storage and water quality.	• In Vietnam, saltwater intrusion in the Mekong Delta has intensified since 2016, persisting for four months compared to the usual one month. Factors include sea level rise, drought, and unpredictable weather patterns. This phenomenon affects both agriculture and household water usage. • On 16 December 2021, torrential downpours landed on the eastern coast of Peninsular Malaysia which later spread across the whole peninsula, resulting in a "once-in-a-century" flood that lasted over a month and displaced over 125,000 people. Malaysia was not prepared for the calamity, leading to victims being trapped on the roof for several days in wait for rescue.

Theme	Significance	Nature of climate hazards	Example
Health	• Apart from the direct impact on life and well-being, climate-induced health issues strain economic activities by driving up healthcare costs, diverting resources from other economic areas, and reducing worker productivity. Loss of productivity is expected to increase by 88% by 2030 from 1995 levels.	• Physical health: There is a surge in heat-related illnesses, water-borne diseases, and vector-borne ailments. • Mental health: Disasters, displacement, and loss escalate psychological distress. • Healthcare infrastructure: Climate events strain healthcare capacities, damage facilities, and pose challenges to the system.	• In April 2023, continental Southeast Asia faced a once-in-200-years heatwave, caused by climate change. This led to a spike in hospitalisations and fatalities. Although exact numbers remain uncertain, if this trend persists, the ensuing two decades could see an increase of 30 deaths per million in Thailand and Myanmar, and 40 in Cambodia.[21]
Ecosystems	• Ecosystems deliver vital services such as carbon sequestration, water regulation, and soil stabilisation. • They furnish critical habitats supporting agriculture, fisheries, and tourism sectors. • They also serve as natural defence barriers against extreme weather events, safeguarding coastlines from erosion and storm surges.	• Rising sea levels reduce ecosystems' capacity to serve key functions. For instance, submerged mangroves cannot offer protection and become uninhabitable for fish and other wildlife. • Heavy rainfall intensifies flooding and soil erosion, which degrade forest habitats and increase tree mortality. • Dry spells and heatwaves can also cause forest fires and severe haze that impact human health due to an unhealthy air pollutant index (API).	• In the Coral Triangle marine bio-ecoregion, warming sea surface temperatures, amplified by El Niño, triggered coral bleaching in various areas, especially the coral reefs in Malaysia, Philippines (Masinloc Fish Sanctuary and the Tubbataha Reef in the Sulu Sea), and Indonesia.

Theme	Significance	Nature of climate hazards	Example
Infrastructure	• Infrastructure underpins our quality of life, facilitating essential services like housing, education, healthcare, transportation, water, sanitation, and energy. • It is pivotal for a nation's economic development, fuelling growth across various industrial sectors.	• Rising sea levels threaten coastal cities and settlements, potentially causing damages to buildings, transportation systems, bridges, and more. • Increased flooding heightens the risk of landslides and erodes the foundations where vital infrastructure stands. • Severe weather events can displace communities and cause damage to buildings.	• In Indonesia, approximately 23 million people residing in coastal cities, along with a significant portion of Jakarta, face potential inundation risks from rising seas by 2050. Sea level rise has already impacted Java's coastal areas, notably in Pekalongan and Karawang.[22]
Trade	• Trade within and outside Southeast Asia significantly bolsters the region's economy, with an impressive ~US$3 trillion in goods traded in 2021 alone.[23] • The region is poised to surpass global trade growth due to pressures to diversify global value chains and attractive manufacturing costs.	• Rising sea levels and flooding can damage trade routes, including roads, bridges, ports, railways, and airports. • Erratic rainfall alters water levels, posing challenges to maritime navigation.[24] • The intricate web of global value chains magnifies the effect of climate disruptions, as impacts in one region can ripple across and impact another.	• Experts project that El Niño will worsen in 2023 and 2024 in Southeast Asia, reducing rice production and affecting global trade and food security, as Thailand and Vietnam are major rice exporters.[25]

A&R status in Southeast Asia

Despite the climate challenges faced by the region, Southeast Asia remains severely underprepared. Four countries in the region—Cambodia, Myanmar, Lao PDR, and the Philippines—rank in the bottom 30% globally for climate hazard readiness. [Exhibit 1.11.]

Exhibit 1.11: Southeast Asian countries are underprepared for climate hazards

Country	Vulnerability[1] Ranking #	Readiness[2] Ranking #	Income group
Brunei Darussalam	41	45	Upper
Malaysia	46	53	Upper middle
Singapore	65	1	Upper
Thailand	98	62	Upper middle
Indonesia	107	103	Lower middle
Philippines	115	132	Lower middle
Vietnam	126	91	Lower middle
Cambodia	133	164	Low
Lao PDR	145	142	Lower middle
Myanmar	147	164	Lower middle
Timor-Leste	129	110	Low

1. Vulnerability relates to Exposure, Sensitivity, Adaptive Capacity. Lower ranking indicates lower level of risk. 2. Readiness relates to level of Economic, Governance, and Social readiness. Lower ranking indicates higher readiness 3. National adaptation plan, policy, strategy, or law in place; Countries with no national adaptation plan, policy, strategy, or law may have an existing climate action plan with A&R embedded
Note: Colour categories based on 3 equal distributions by ranking in the Climate Vulnerability and Readiness list
Source: Notre Dame Global Adaptation Initiative 2019 data, Based on 182 countries, UNFCCC, BCG analysis

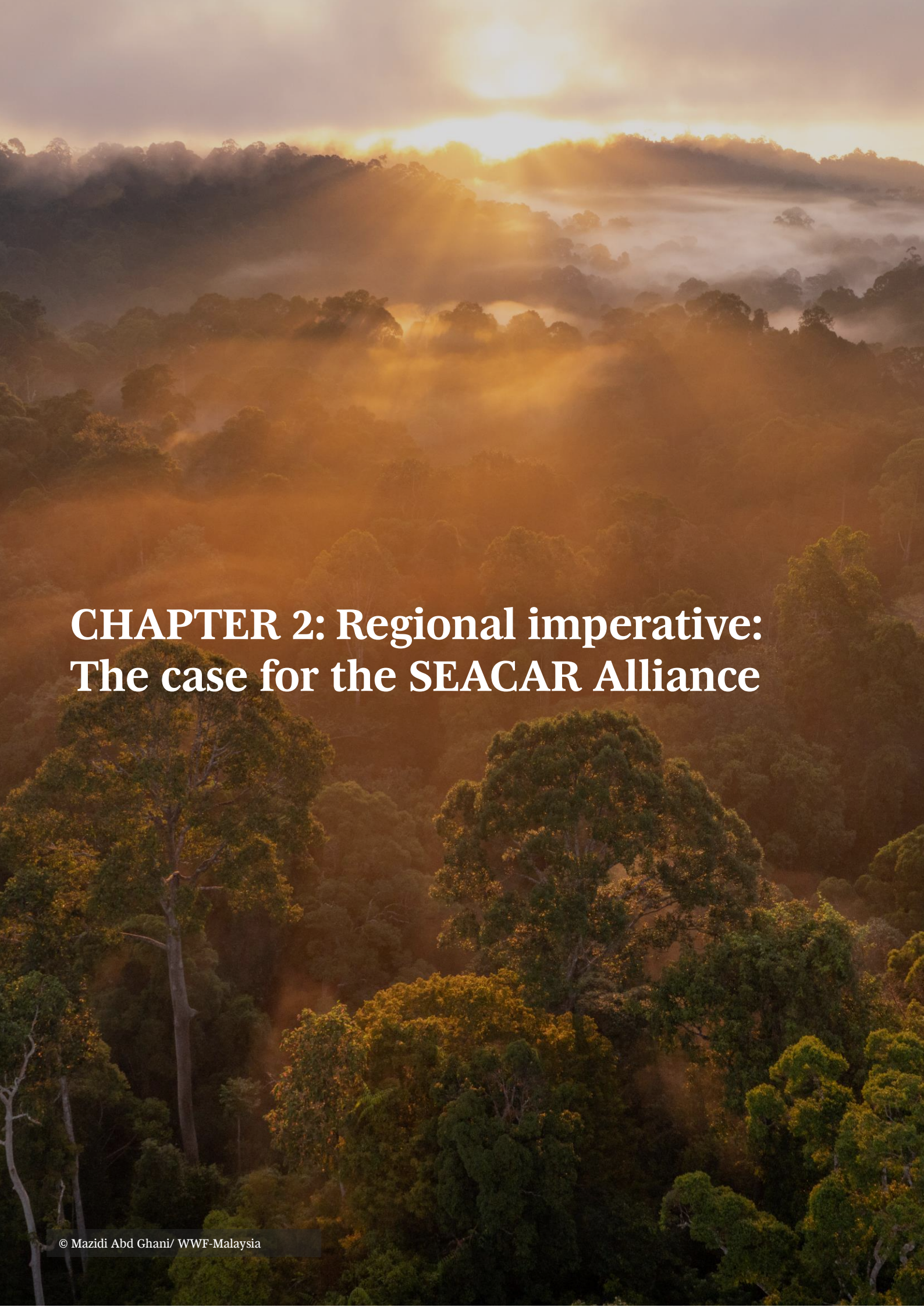
Though there is growing attention to climate action in the region—as evidenced by nationally determined contributions (NDCs) that pinpoint adaptation priorities in Southeast Asian countries—there remain substantial gaps:

- The majority of climate strategies emphasise mitigation, often side-lining A&R; notably, only two of 11 countries have put forth a National Adaptation Plan (NAP).
- Current disaster risk management often responds after-the-fact instead of taking preventative measures.
- Effective action components are missing in adaptation strategies, such as data-informed decision-making, a pipeline of bankable projects, clear financial requirements, and robust involvement from both the government and private sectors. [Exhibit 1.12.]

Exhibit 1.12: Countries' NDCs leave room for improvement

Country	NDC identify adaptation priorities	NDC identify financial needs for implementing adaptation priorities identified	NDC mention loss and damage from climate change	NAP submitted to UNFCCC as of 20 Nov 2023
Brunei (BN)	N	N	Y	N
Cambodia (KH)	Y	Y	Y	Y
Indonesia (ID)	Y	N	N	N
Laos (LA)	Y	N	N	N
Malaysia (MY)	Y	N	Y	N
Myanmar (MM)	Y	Y	Y	N
Philippines (PH)	Y	N	Y	N
Singapore (SG)	Y	N	N	N
Thailand (TH)	Y	N	Y	N
Vietnam (VN)	Y	Y	Y	N
Timor-Leste (TL)	Y	N	Y	Y

Note: Outside-in analysis, subject to validation by relevant stakeholders
Assessment of status ranked in order of data availability, adaptation strategy, national adaptation plans, expert input.
Source: UNESCAP Risk and Resilience Portal, 2022; Country policy papers, BCG analysis



CHAPTER 2: Regional imperative: The case for the SEACAR Alliance

Southeast Asia is uniquely positioned to coordinate regional A&R against climate change. Common climate hazards such as heatwaves, increasing land temperatures, coastal flooding, and agricultural drought affect many countries across the region. Moreover, numerous climate hazards are transboundary in nature, impacting the entire region rather than individual countries. A unified narrative for Southeast Asia can amplify the region's significance and vulnerability to climate change.

Historically, the region has thrived on collective strength. The Association of Southeast Asian Nations (ASEAN), encompassing ten Southeast Asian countries as members and Timor-Leste with observer status, has been instrumental in facilitating collaboration. Within the realm of climate action, ASEAN has published several critical reports such as the State of Climate Change Report and the Regional Plan of Action on Adaptation to Drought. It has also fostered initiatives like the ASEAN Climate Resilience Network, emphasising agricultural adaptation, and the ASEAN Smart Cities Network, promoting smart and sustainable urban development.

However, a glaring gap remains in regional coordination for climate A&R. Nations often act individually, leading to a fragmented approach within the region. This fragmentation is often evident at global climate events, such as COP27, where Southeast Asia was noticeably underrepresented, thus losing out on potential funding and support opportunities.

There is an urgent need for A&R in Southeast Asia, as many of its nations are already facing the impacts of climate change. When referring to the definition of loss and damage, the UN states that "to refer to the consequences of climate change that go beyond what people can adapt to, or when options exist but a community doesn't have the resources to access or utilise them." The same article also states that "loss and damage is and will continue to harm vulnerable communities the most, making addressing the issue a matter of climate justice." Loss and damage can be divided into economic and non-economic losses:

Economic L & D	Non-economic L & D
Loss of resources, goods, and services Loss of income, property, and physical assets	Individual losses and damages (losses to life, health, and mobility) Societal losses and damages (such as loss of cultural and indigenous knowledge) Environmental losses and damages (such as biodiversity loss and damage to our ecosystem services)

It is against this backdrop that the idea for a regional coalition dedicated to bolstering climate A&R was conceived. In 2023, three founding partners—BCG, Think City, and WWF—established the SEACAR Alliance. The SEACAR Alliance prioritises collaborative action and emphasises NbS, climate analytics, and AI to enhance resilience in cities and communities across six crucial themes—natural ecosystems, infrastructure, trade, water, agriculture, and health. [Exhibit 2.1.]

SEACAR differentiates itself from other initiatives by highlighting the combined potential of nature and AI in addressing climate risks at a city scale. We believe that Southeast Asia is in a prime position to harness the power of nature, climate analytics, and AI to accelerate this endeavour. The actions we take in cities and communities will shape Southeast Asia's resilience in the upcoming decades.

Exhibit 2.1: SEACAR Alliance's priorities

SEACAR is committed to building knowledge capital, drawing from current data, research, and scientific insights on A&R. By collaborating with diverse stakeholders, it also seeks to harness regional expertise and establish essential partnerships for the successful delivery of A&R solutions. SEACAR will drive the region's A&R agenda through representation at global climate conferences and forums, amplifying Southeast Asia's collective resilience narrative as a call to action at these events.

CHAPTER 3: The crucial role of cities in Southeast Asia's road to resilience

© Think City

In the vibrant tapestry of Southeast Asia, cities emerge as bustling hubs of activity, innovation, and influence. Their steady evolution has positioned them as indispensable nerve centres in our modern world.

However, as crucial as cities are to the region's socio-economic fabric, they also face mounting climate challenges. These urban environments not only generate a significant share of worldwide emissions, but also find themselves on the frontline of climate-induced hazards.

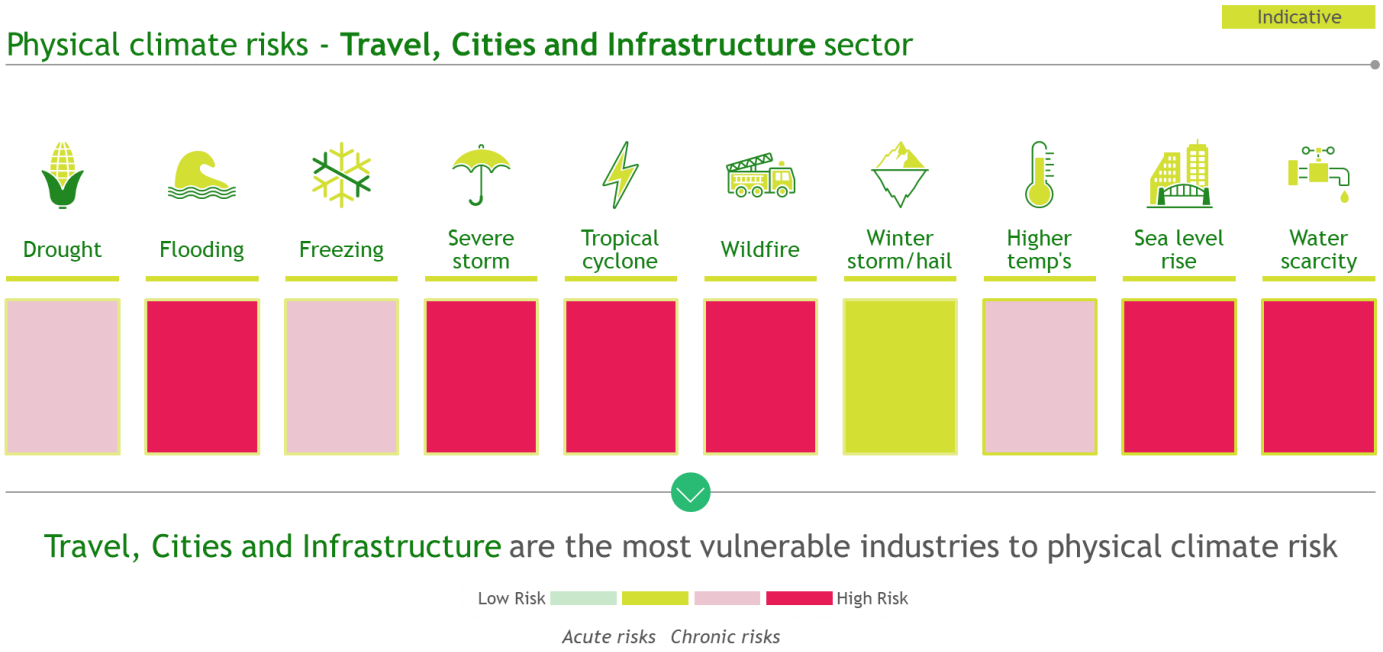
While the gravity of their position is undeniable, the potential for positive transformation is profound. The SEACAR Alliance believes that cities, combined with the power of NbS and cutting-edge tools like climate analytics and AI, will be instrumental in forging Southeast Asia's resilient future.

Cities as both catalyst and casualty

Cities play a dual role in the climate saga—while they contribute significantly to climate change, they also face its most pressing consequences. Consuming over two-thirds of global energy, cities produce more than 70% of worldwide CO2 emissions.[26] At the same time, they grapple with climate hazards like flash floods, heat waves, intense rainstorms, extreme temperatures, and droughts. These challenges pose direct threats to the urban population through increased heat and drought exposure, place urban infrastructure in harm's way with risks of flooding and severe weather events, and increase health concerns due to air and water pollution.[27]

In 2022 alone, climate-induced calamities caused damages nearing US$400 billion globally, with major cities shouldering much of this cost.[28] Research from a C40 Cities study reveals those costs from climate events approach US$200 billion annually for prominent cities within the C40 Network.[29] This observation is echoed by a BCG analysis, which highlights the acute and sustained physical climate risks that cities face. [Exhibit 3.1.]

Exhibit 3.1: Physical climate risks faced by the travel, cities, and infrastructure sectors



Source: BCG analysis

Current climate threats are not mere predictions, cities are already living these realities. Yet, there is a discernible gap in how they project future vulnerabilities. While 42% of hazards reported by cities are anticipated to materialise in the near term—aligning with current global experiences[30]—there seems to be an underreporting of medium- to long-term climate risks.

Existing city infrastructures and services are already strained due to rapid urban expansion. Adding to this is the intensifying impact of climate change, along with socio-economic stressors magnified to a level that could jeopardise governance and business operations. The cost of inaction is particularly high for Southeast Asia, which is primarily made up of low- and middle-income nations. For these countries, the annual damage bill for natural disasters on essential assets like power and transportation could reach a staggering US$18 billion. Furthermore, infrastructure disruptions on households and firms could skyrocket to an astounding US$641 billion yearly.[31]

Southeast Asia's unique urban landscape also presents a pressing concern as a significant proportion of the region's cities are coastal, rendering them highly susceptible to the detrimental effects of climate and ocean drivers. Coastal cities and communities are at the forefront of climate risk, as significant ocean and climate-related drivers such as rising sea levels, increasing frequency of severe storms, and precipitation unpredictability lead to evident consequential physical impacts.[32] Adaptation actions in these cities are vital, as they face an escalating risk profile, making resilience-building strategies an urgent priority.

Being reactive is not a feasible strategy. Addressing damages in the wake of climate catastrophes is not only challenging, but also exorbitantly expensive. Thus, it is imperative for countries to invest in making their city infrastructure resilient from the start. In fact, making our infrastructure climate-resilient from the outset could result in savings amounting to US$4.2 trillion for developing nations over the long run.[33]

However, a glance at the global landscape reveals a disheartening picture. Only 459 out of 812 cities which have disclosed data through the Carbon Disclosure Project (CDP) worldwide have A&R strategies in place. About 9,000 cities have not disclosed to CDP,[34] and many of these often overlook climate risks or actionable countermeasures. Furthermore, only five out of 35 countries under the Organisation for Economic Co-operation and Development (OECD) have modified at least one building code to account for climate risks.[35]

For Southeast Asia, many hinges on its cities. Over half the region’s population call urban areas home. With urbanisation showing no signs of slowing down, cities are expected to house nearly 68% of the population by 2050.[36] This urban concentration is not just about numbers, but also about influence:

- Cities are responsible for 80% of the region’s GDP, with secondary urban areas projected to drive 40% of its future GDP growth.[37]
- Cities serve as epicentres for essential services such as healthcare and education, alongside venues for recreational, religious, and cultural activities.
- Cities are the nerve centres for governmental operations, housing key government agencies, parliaments, and judiciaries.

Given their critical role, it is evident that cities and their administrations have a monumental role to play in driving climate action and spearheading the A&R movement. Their jurisdiction often includes systems intrinsic to daily life, such as water, waste, transport, and energy, and they shoulder the weight of safeguarding residents from an array of climate health threats.

On a more positive outlook, globally, cities are beginning to rally together, forming influential alliances to champion sustainable practices and combat climate change. C40 Cities, which connects the world’s megacities in a united effort against climate action, and the Local Governments for Sustainability (ICLEI), an expansive network of over 2,500 local and regional governments championing sustainable urban development, are prime examples. In addition, the Resilient Cities Network, backed by the Rockefeller Foundation, helps cities to face physical, social, and economic challenges head-on.

Yet, a closer look at Southeast Asia reveals a concerning delay in A&R initiatives. Only 25 out of 127 cities have reported to the CDP with clear adaptation plans. [Exhibit 3.2.] Furthermore, over half of the climate-focused projects reported in the region—covering mitigation, adaptation, and more—remain in the

pipeline. Many are in their infancy, hovering at the scoping, pre-feasibility, or project feasibility stages, and are in dire need of technical guidance and funding to advance towards implementation. [Exhibit 3.3.]

Exhibit 3.2: Southeast Asian cities that have reported an adaptation plan to CDP

Cities that reported an adaptation plan to CDP

Indonesia

1. Jambi
2. Balikpapan
3. Bontang
4. Jakarta
5. Tanjungpinang
6. Bogor
7. Sukabumi

Malaysia

1. Iskandar
2. Seberang Perai
3. Kuala Lumpur

Vietnam

1. Ho Chi Minh
2. Can Tho
3. Hanoi

Singapore

1. Singapore

Thailand

1. Bangkok

Philippines

1. Davao
2. Dipalog
3. Makati
4. Ormoc
5. Puerto Princesa
6. Quezon
7. San Carlos
8. San Francisco
9. San Jose del Monte
10. Tagum City

Source: 2022 Cities Adaptation Plans, CDP; World Urbanisation Prospects 2018, World Bank.
Note: Definition of cities in the World Urbanisation Prospects 2018 are urban agglomerations with 300,000 inhabitants or more

Exhibit 3.3: Climate-related projects reported to

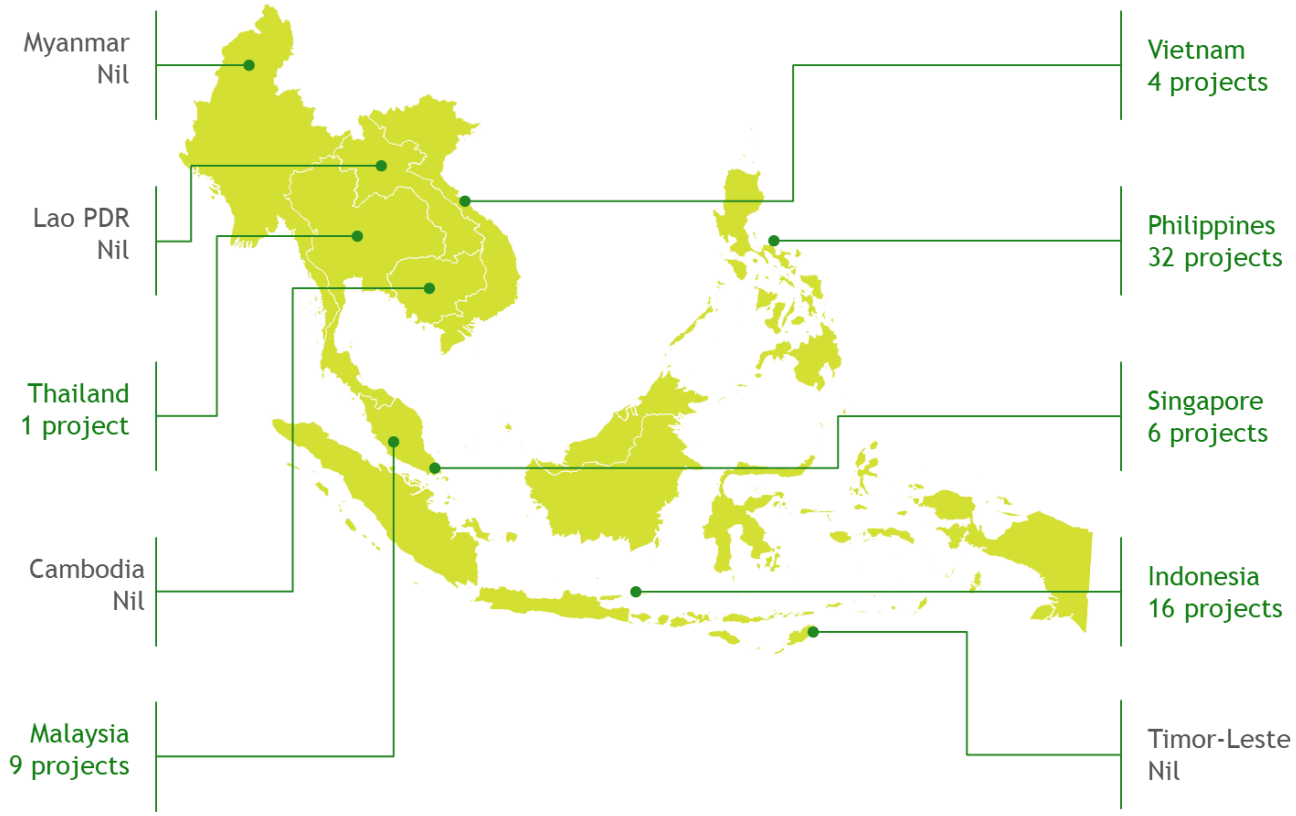


Exhibit 3.4: Over 50% of climate-related projects require assistance to advance towards implementation

Source: Asia Pacific Cities Climate Finance Snapshot, CDP

The reported projects fall under different project sectors. However, more than half of them is reported as being at early stages of development (scoping, pre-feasibility or project feasibility), requiring further technical/funding assistance to advance towards implementation.

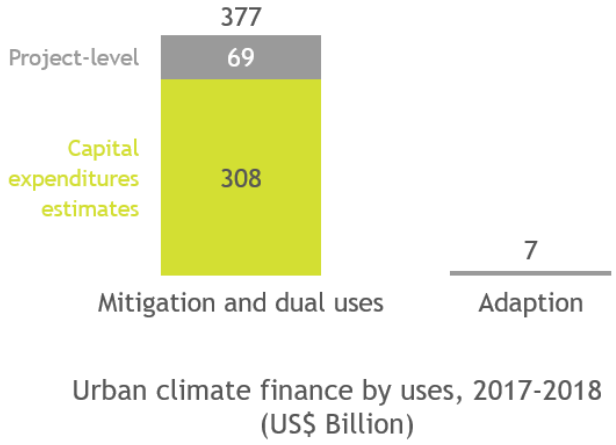
Even when initiatives are reported, there is a glaring imbalance in distribution. Of the 68 climate-related projects that were reported to the CDP, over 70% were concentrated in the Philippines and Indonesia, hinting at possible disparities in regional awareness, funding accessibility, and institutional capacities. This imbalance is even more alarming considering that several countries in the region, particularly those with lower to medium incomes, have not reported any climate initiatives at all.

Without structured plans and ready-to-implement projects, A&R strategies risk becoming disjointed, suffering from a lack of coordination among stakeholders, and resulting in maladaptive outcomes. These challenges are especially pronounced for developing nations, given their increased vulnerability to climate impacts and their often limited institutional and technical means to incorporate climate concerns in planning. Yet, this very limitation underscores the gravity and urgency of the situation.

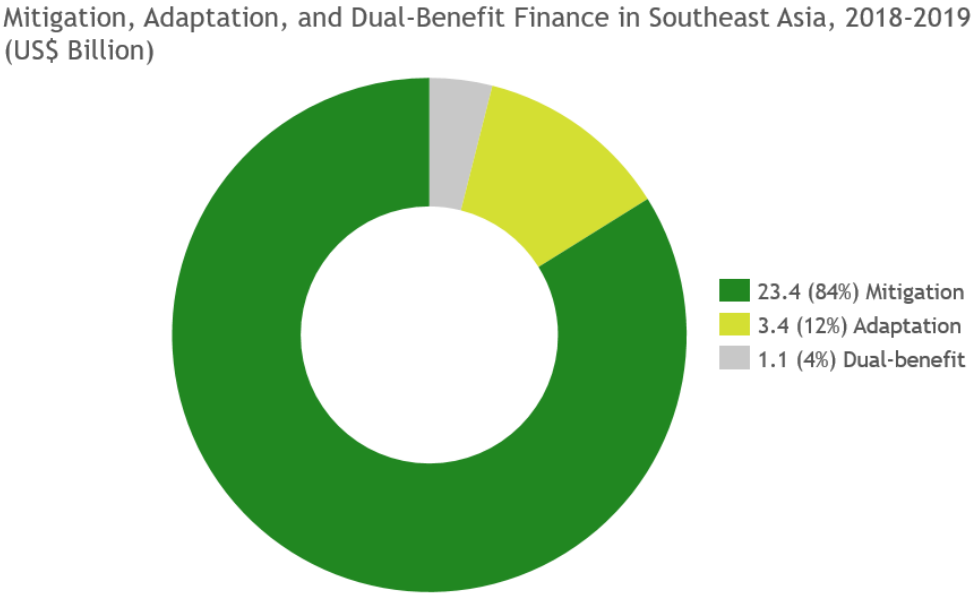
As Southeast Asia's urban landscape continues to evolve, it is anticipated that 200 new urban centres will emerge within the next three decades.[39] By 2050, urban areas are likely to accommodate 70% of the region's populace. Every decision made today, every piece of infrastructure built, and every policy formulated, has profound implications for tomorrow. How we build these cities will determine whether we are able to steer the region towards resilience or vulnerability.

Financial mobilisation remains a challenge, especially in light of disparities in climate initiative funding. In 2018-2019, Asia and the Pacific spent US$519.9 billion in climate finance. Southeast Asia only had a 5% share (US$27.8 billion), with most of it publicly sourced through national, multilateral, and bilateral development finance institutions. Mitigation projects in Southeast Asia accounted for 84% of its climate finance, sevenfold the funds compared to adaptation efforts (12% or US$3.4 billion).[40] [Exhibit 3.5] Despite clear evidence highlighting Southeast Asia's urgent need for climate adaptation, the financial support for such projects remains insufficient. Southeast Asia needs to invest US$210 billion per year to construct climate-resilient infrastructure that the region needs to maintain its economic growth, tackle poverty, and address climate impacts.[41] To rectify this, both the regional nations and global donors need to recalibrate their commitments, ensuring that adaptation projects are not just viable, but are actively prioritised.

Exhibit 3.5: Estimated flows of urban mitigation finance far outweigh those of urban adaptation finance



Source: The State of Cities Climate Finance (Cities Climate Finance Leadership Alliance, 2021)



Source: ADB. 2023. Climate Finance landscape of Asia and the Pacific.

The road to climate resilience for Southeast Asia is undeniably intertwined with the fate of its cities. They are the heartbeat of the region, where economic potential meets cultural richness, where governance is centralised, and where the majority of the population resides. As cities go, so does the region. Recognising and responding to this pivotal role can determine whether Southeast Asia stands resilient against the climate challenges of the future. The time for decisive, coordinated, and proactive action is now.

CHAPTER 4: Past meets future: Leveraging nature and AI for resilience

Throughout history, nature has provided the solutions for many of humanity's challenges. As we face the multifaceted challenges of climate change, nature, unsurprisingly, has a compelling answer for climate A&R, found in NbS. These solutions offer multiple additional benefits, including biodiversity conservation, livelihood enhancement, and carbon mitigation.

Conversely, AI offers a relatively new technological development, reshaping industries and paradigms—including our approach to climate action. Within the field of A&R, Climate AI refines and enhances our approach. It provides us with more precise risk assessments, elevates our prioritisation strategies, and guides better decision-making and resource utilisation.

For Southeast Asia, the real potential lies in combining NbS with AI's precision. This integrated approach has already shown promising results, with notable applications observed in Kenya and Sri Lanka.

BCG – Climate Vision 2050: The Mangrove Manifesto

Click scan QR to listen

Listen to a fictional imagination of the year 2050, where Southeast Asia is a global leader in using NbS to address climate challenges. Learn what it is like to live in harmony with nature, and the importance of beginning such efforts today.

The power of nature: An ancient solution for modern challenges

Nature has long provided solutions to many human challenges. It stands to reason that nature also offers key solutions for climate A&R. For instance, trees can help manage flooding, while coastal mangroves can mitigate the effects of storm surges. Yet, as cities urbanise and land use changes, solutions that harness the power of nature have become less common. Instead, there has been a growing reliance on traditional engineered infrastructure, commonly known as "grey infrastructure", such as dams, barriers, and seawalls made of concrete. While these structures often serve a specific purpose, they can have downsides such as high energy consumption, disruption to natural ecosystems and processes, and other maladaptation effects.

Southeast Asia is primed to harness the power of nature because of its wealth of natural assets. Despite covering only 3% of the world's surface, the region contains a significant share of the world's vital ecosystems. This includes 15% of the world's tropical forests, 35% of its coral reefs, 25 million hectares of peatland, and a significant portion of global mangroves and seagrass beds—31% and 33%, respectively.[42]

The region contains several ecologically important areas such as the Coral Triangle, Heart of Borneo, and Lower Mekong Basin. The Coral Triangle is one of the most biodiverse regions in the world, with more than 500 species of corals, and spanning the Philippines, Malaysia, Indonesia, Papua New Guinea, Solomon Islands and Timor-Leste. The Heart of Borneo is one of the largest transboundary rainforests that is still intact and is being managed by Brunei, Malaysia, and Indonesia. The Lower Mekong Basin traverses Myanmar, Lao PDR, Thailand, Cambodia, and Vietnam. It is the "rice bowl" of Asia and is one of the world's richest areas of biodiversity.

As climate threats intensify in the region, so does the urgency to adopt NbS. The Fifth Session of the United Nations Environment Assembly (UNEA-5) defines NbS as 'actions to protect, conserve, restore, sustainably use and manage natural or modified terrestrial, freshwater, coastal and marine ecosystems, which address social, economic and environmental challenges effectively and adaptively, while simultaneously providing human well-being, ecosystem services and resilience and biodiversity benefits.'

These solutions also offer advantages in adaptation, resilience, economy, nature, and societal well-being.

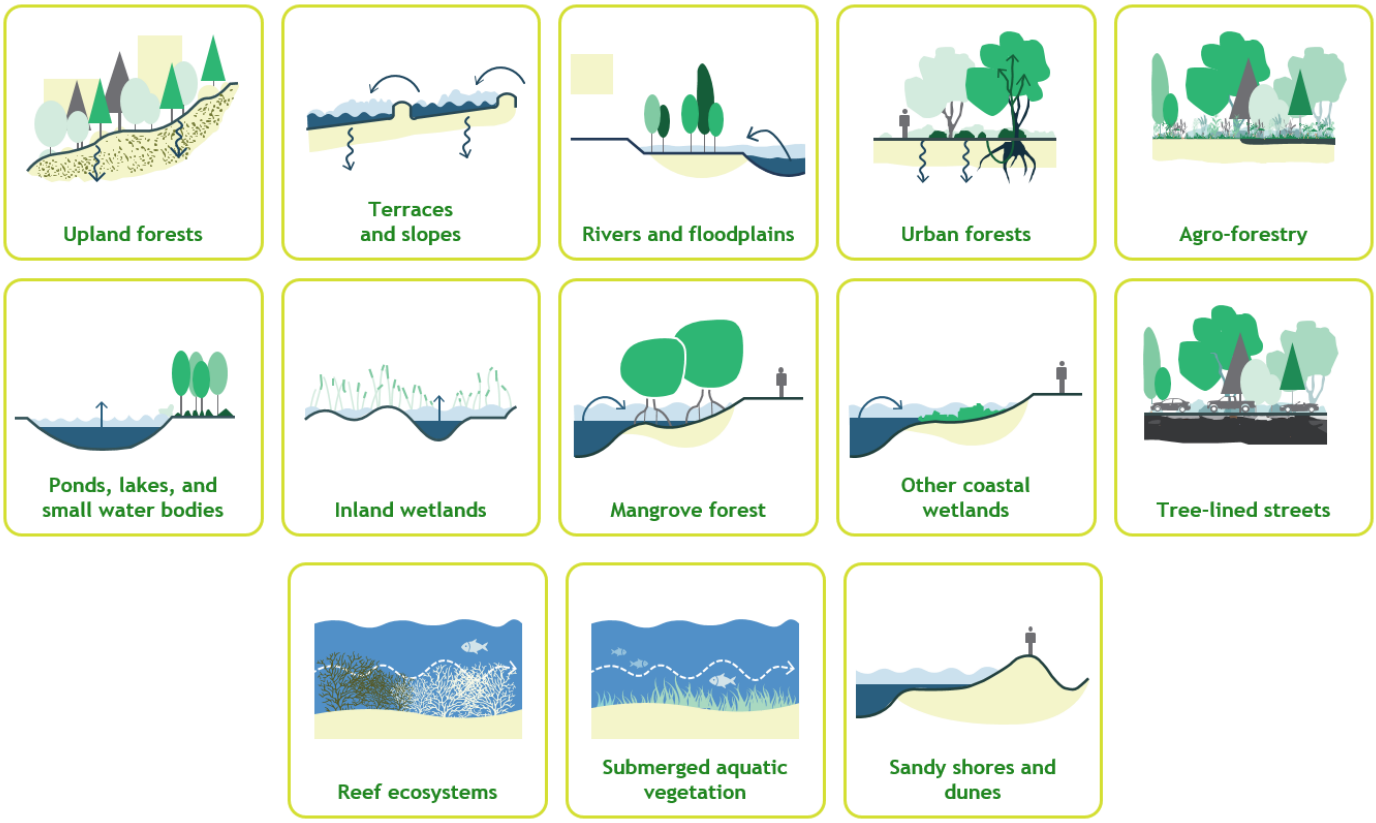
NbS can be categorised into four main types:[43]

1. **Ecosystem protection.** Focused on safeguarding marine, freshwater, and natural or semi-natural terrestrial ecosystems. Examples include reserves, conservancies, and locally managed marine areas.
2. **Ecosystem restoration.** Aimed at reversing ecosystem degradation to enhance their productivity and societal benefits. Reforestation is a prime example.
3. **Ecosystem management.** Holistic, comprehensive strategies for long-term ecosystem sustainability that also address socioeconomic, political, and cultural needs. Examples include ecosystem-based fire management and integrated coastal management.
4. **Ecosystem creation.** Interventions involving the establishment, protection, or management of artificial ecosystems, such as non-natural tree stands or created wetlands.

Urban NbS is also gaining traction to address multiple challenges

Click or scan QR Code to watch:

Exhibit 4.1: Examples of NbS for climate A&R



Source: World Bank

NbS not only bolsters A&R, but also delivers multiple other benefits due to the essential ecosystem services they provide. Some of these benefits include:

1. **Carbon sequestration.** Robust ecosystems, such as forests and oceans, function as carbon sinks, absorbing and storing carbon through their rich vegetation. NbS could contribute to 20-30% of global cost-effective strategies required to meet the emissions targets under the Paris Climate Agreement.[44]
2. **Biodiversity preservation.** Effective protection, restoration, management, or creation of ecosystems inherently safeguards the diverse life within—ranging from plants to animals. For instance, forest restoration in Borneo and Sumatra does not just bring back tree species, it also aids orangutans that rely on these forests for sustenance and habitat.[45]
3. **Job creation.** NbS offers long-term economic benefits, including the generation of sustainable jobs. In Sabah, Malaysia, locals partner with the government in a Payment for Ecosystem Services (PES) programme that remunerates them for sustainable water ecosystem management.[46] Meanwhile, a village in Indonesia's West Kalimantan manages over 70,000 hectares of mangrove forests, running agroforestry and honeybee businesses, yielding monthly profits of US$22,000.[47]
4. **Water security.** NbS helps ensure consistent water supplies by conserving natural water systems. For example, China preserves its watershed to guarantee water for over 400 million residents in the Pearl Delta, emphasising sustainable agricultural and forestry initiatives.[48]
5. **Food security.** NbS can strengthen food systems by improving agricultural yields and sustainability. In Lao PDR, the Luang Prabang Living Land Farm, spreading over 200 km^2, has melded traditional organic rice-growing techniques with new farming methods, such as innovative grain selection. This has allowed the farm to plant and harvest during both the wet and dry seasons, thus increasing revenue. The farm has also diversified its revenue base by integrating ecotourism cantered on traditional rice farming, allowing it to support local community projects such as English classes for school children.[49]
6. **Health.** Nature offers invaluable health services such as filtering air pollutants, ensuring access to clean drinking water, and decreasing the prevalence of infectious and respiratory disorders.[50] Natural settings also promote physical activity and are associated with better mental health outcomes. Furthermore, research indicates that land conversions, which result in closer proximity between wildlife, livestock, and humans, can increase disease transmission rates.[51] Consequently, preserving forests can mitigate such disease spill overs by maintaining distinct habitats for wildlife away from urban centres.[52]

Principles of NbS[53]

At a glance, NbS might seem like a broad term for activities that utilise nature to achieve specific outcomes. However, it is more nuanced than that. NbS aims to address societal challenges while benefiting both biodiversity and human well-being. The International Union for Conservation of Nature (IUCN) defines societal challenges as those that have significant and demonstrable impacts on society. These include climate adaptation, disaster risk reduction, economic and social development, human health, food security, water security, environmental degradation, and biodiversity loss. It is vital to understand this distinction as inappropriate use of NbS can result in unintended negative consequences or maladaptation. For instance, planting an area with a monoculture tree for carbon mitigation can decrease the ecosystem's diversity, undermining its resilience and ability to provide ecosystem services.

To ensure effective and responsible use of NbS, the International Union for Conservation of Nature has outlined eight guiding principles[54]:

1. **NbS embraces nature conservation norms and principles**. While NbS upholds conservation values and principles, it is not a substitute for nature conservation—a separate global priority. Not all conservation efforts qualify as NbS. Though many NbS initiatives focus on biodiversity conservation, not all directly address it.

2. **NbS can be implemented alone or in an integrated manner with other solutions to societal challenges**. These solutions might offer comprehensive ecosystem services independently or complementing other initiatives, such as the integration of green-grey infrastructure through a mixture of mangroves and seawalls to reduce coastline erosion.
3. **NbS are determined by site-specific natural and cultural contexts that include traditional, local, and scientific knowledge**. Implementing NbS requires a deep understanding of the specific ecosystem, which includes knowledge from those connected to the ecosystem.
4. **NbS produces societal benefits in a fair and equitable way in a manner that promotes transparency and broad participation**. While NbS can benefit distant governments and communities, it might also restrict opportunities for nearby inhabitants. It is essential that benefits reach all, from local residents to national entities. Solutions should account for local values tied to the ecosystem and explore compensatory mechanisms, such as PES schemes.
5. **NbS maintains the biological and cultural diversity, and the ability of ecosystems to evolve over time.** To ensure sustainability and resilience against future climate changes, NbS should support and maintain both biological and cultural diversity, aligning with the temporal dynamics and complexity of ecosystems.
6. **NbS is applied at a landscape scale.** NbS often spans vast areas encompassing various ecosystems, such as forests, coasts, and farmlands. It is important to consider the broader landscape context when rolling out NbS.
7. **NbS recognise and address the trade-offs between generating immediate economic benefits for development and preserving future options for the full range of ecosystem services.** Simplifying an ecosystem for a single benefit, like turning diverse woodlands into monoculture plantations, can be counterproductive. Recognising and weighing trade-offs, along with the various purposes of an ecosystem, is crucial.
8. **NbS is an integral part of the overall design of policies, measures, or actions, to address a specific challenge.** This integration facilitates large-scale NbS projects and allows for adaptive management when necessary.

NbS also play a vital role in contributing to meeting the Global Biodiversity Framework (GBF) and the UN Sustainability Development Goals (SDG). NbS contributes significantly to the realisation of the ultimate 2050 vision and mission of GBF and the objectives of the Convention on Biological Diversity (CBD). It also meets SDG goal 3 (good health and well-being), 6 (clean water and sanitation), 11 (sustainable cities and communities), 13 (climate action), 14 (life below water), and 15 (life on land).

CASE STUDY: Payment for Ecosystem Services (PES)

PES is an innovative approach where those who benefit from ecosystem services—like carbon sequestration and climate resilience—financially compensate the land stewards providing these services. By doing so, PES promotes the conservation of natural ecosystems through eco-friendly

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A notable example of PES success is seen in Vietnam's Lam Dong forest conservation initiative. Through a PES program, over 3,000 forest-dwelling households are compensated for protecting 104,000 hectares of forest. Each household receives US$500 annually, marking a significant 400% increase in their income. The recognised ecosystem services of this forest range from water regulation in the Dong Nai river basin to soil protection and maintaining the scenic landscape. Beneficiaries, or "buyers" of these services, encompass hydropower plants, water supply organisations, and a tourism company. Several PES proponents suggest that, if applied nationwide, PES revenue could potentially soar to US$1 billion.

Source:
WWF, Payments For Ecosystem Services As A Major Conservation Tool
Ecosystem Marketplace, Vietnam Leads Southeast Asia in Payments for Ecosystem Services

CASE STUDY: Integrating Green and Gray Infrastructure as a Next-Gen Solution

Traditional built or "grey" infrastructure, like dams and seawalls, may not be enough to combat the escalating challenges posed by climate hazards, water shortages, and poverty.

Green infrastructure, which strategically preserves, enhances, or restores natural systems in tandem with conventional grey infrastructure, improves the resilience and adaptability of our infrastructure systems. This is crucial, especially in the face of present-day environmental challenges.

SERVICE	GREY INFRASTRUCTURE COMPONENTS	EXAMPLES OF GREEN INFRASTRUCTURE COMPONENTS AND THEIR FUNCTION
Water supply and sanitation	Reservoirs, treatment plants, pipe network	Watersheds: Improve source water quality, thereby reducing treatment requirements Wetlands: Filter wastewater effluent, thereby reducing wastewater treatment requirements
Hydropower	Reservoirs and power plants	Watersheds: Reduce sediment inflow and extend life of reservoirs and power plants
Coastal flood protection	Embankments, groynes, sluice gates	Mangrove forests: Decrease wave energy and storm surges, thereby reducing embankment requirements
Urban flood management	Storm drains, pumps, outfalls	Urban flood retention areas: Store stormwater, thereby reducing embankment requirements
River flood management	Embankments, sluice gates, pump stations	River floodplains: Store flood waters, thereby reducing embankment requirements
Agriculture irrigation and drainage	Barrages/dams, irrigation, and drainage canals	Agricultural soils: Increase soil water storage capacity and reduce irrigation requirements

Green infrastructure offers more than just technical advantages. It also brings about societal and economic benefits. While traditional grey infrastructure is often managed by the government or private organisations, green infrastructure is often under the care of local communities. It is most effective when tailored to the needs of these local stakeholders, presenting opportunities to uplift vulnerable populations.

An example of the cost-effectiveness of green infrastructure is evident in New York City, which saved US$1.5 billion by integrating green and grey systems to ensure a reliable water supply. However, the financial viability of such projects can vary based on local conditions, and thus should be thoroughly evaluated during technical assessments. Beyond just the monetary aspects, it is also essential to consider the broader benefits of green infrastructure to appreciate its full value.

The Vietnam Mekong Delta offers a shining example of how green and grey infrastructure can work hand-in-hand. Its strategy for coastal protection includes a mangrove belt outside the sea dike, serving as a first line of defence, followed by a more expansive mangrove stretch inland. This approach not only shields the area from coastal flooding, erosion, and saltwater intrusion but also enhances aquaculture and supports mangrove ecosystems, boosting the livelihoods of local communities.

Source: Integrating Green and Grey, Creating Next Generation Infrastructure, World Bank Group and World Resources Institute

Increasing reception of NbS

The intertwining challenges of climate hazards, biodiversity loss, and social inequality have catapulted NbS to the forefront of international climate discussions. Institutions such as the UN Framework Convention on Climate Change (UNFCCC) and the UN Convention on Biological Diversity[55] increasingly spotlight NbS as a viable solution. Consequently, we are observing a surge in the integration of NbS in NAPs and global climate policies. For instance, Timor-Leste has adopted NbS as a cornerstone of its NAP,[56] and Vietnam underscores NbS's pivotal role in its adaptation strategy.

The private sector, too, is increasing support for NbS. A testament to this shift is Business for Nature, a coalition comprising over 330 organisations—including stalwarts like the World Economic Forum and the World Business Council for Sustainable Development. This coalition underscores the business case for embracing NbS, with over 330 companies from 56 countries pledging to combat nature loss and restore natural ecosystems.[57] In Southeast Asia, the SCeNe Coalition exemplifies a similar endeavour, accelerating the adoption of NbS to tap into climate finance via carbon credits. However, most private sector interest in NbS thus far has primarily been on the carbon sequestration potential that can provide carbon credits.

Furthermore, this increasing reception has not yet translated to action to the scale required for either climate adaptation and/or mitigation.

This inadequacy in action can be attributed to the insufficient financial backing for NbS. Currently, only US$154 billion annually is directed toward NbS, falling short of the needed US$384 billion per year required by 2025.[58] Notably, the public sector provides 83% of this NbS funding. Given governmental fiscal constraints, it is imperative for the private sector to amplify its commitment and substantially increase its NbS investments.[59]

Click or scan QR Code to

Climate change is upon us, affecting not just the global landscape, but also local communities like Penang Island with its rich heritage, vibrant populace, and natural ecosystems.

Dive deeper with Hamdan Abdul Majeed, Managing Director of Think City, as he discusses Penang's urban greening initiatives and the Nature-based Climate Adaptation Programme for Urban Areas of Penang Island.

This video was produced by BBC StoryWorks for Think City as part of the Transforming Cities series.

At COP27, the UNFCCC Climate Champions called for a massive US$1 trillion investment in NbS for urban communities by 2030.[60]

The economic value of NbS

NbS offers a promising approach for climate adaptation and resilience. A meta-analysis of 69 studies across five habitats globally found that coastal habitats can reduce wave heights by an impressive 35% to 71% on average.[61] Further evidence indicates that NbS can diminish the severity of climate and weather hazards by a notable 26%.

These solutions also play a critical role in offsetting the economic costs of climate change. By 2030, climate change-related costs in developing countries are projected to range between US$402 billion and US$805 billion annually. By 2050, these costs could escalate to a staggering US$1.2 trillion to US$2.4 trillion, without taking into consideration the impact from Southeast Asia. [62] Implementing NbS to achieve a 26% reduction in climate and weather-related hazards could save these nations upwards of US$104 billion in 2030, and US$393 billion by 2050.[63]

Beyond these benefits, NbS often proves to be more cost-effective than traditional engineered/grey infrastructure solutions. It is not only affordable but also versatile in protecting against various climate threats. Returns over time are known to increase exponentially.[64] Unlike grey infrastructure, which offers localised benefits, NbS provides long-term benefits that span vast regions. Additionally, due to their reliance on natural regenerative processes, NbS often require less upkeep than their conventional counterparts.[65]

Challenges in implementing NbS

While there is mounting evidence that NbS can address the multifaceted challenges of climate change, there are several possible reasons why it has not been implemented at scale to achieve our climate goals.

- Traditional engineering solutions tend to deliver foreseeable and immediate results, making them more predictable. For instance, the protective role of a seawall is fairly straightforward, considering the geographical area it protects and its projected lifespan. Conversely, the benefits of a mangrove forest are nuanced, relying on several factors such as species type, maturity, and local involvement to maintain the mangroves. However, beyond just flood protection, mangroves enhance water security, boost local economies, and offer recreational spaces. But these advantages, being influenced by various socio-economic and ecological factors, make it complex to determine the comprehensive impact of an NbS.[66]
- Climate resilience of NbS is another concern. Ecosystems can be vulnerable to changing climate dynamics. Forests, for example, may face more frequent fires, impairing their self-recovery. Salt marshes, on the other hand, are at risk of inundation due to rising sea levels.[67] Although there are interventions to minimise these vulnerabilities, they nevertheless cast doubts over the efficacy and sustainability of NbS.
- Implementing NbS demands a broader consensus. They often span vast landscapes, needing the endorsement of multiple stakeholders like local communities, landowners, and both public and private sectors. In contrast, traditional engineered projects often involve fewer participants and typically require less land use.[68]
- Ongoing NbS projects conducted by the International Federation of Red Cross (IFRC) had identified challenges in the time, scalability and expertise needed for managing and monitoring NbS projects, there is also the challenge in identifying “champions” for NbS. The current social and market standards are still geared towards productivity and profitability.

However, the tide is turning. Advanced technologies and tools such as AI modelling are now offering more precise measurements of NbS’s diverse benefits. Globally, innovative pilot projects are discovering ways to enhance the resilience of NbS, from integrating grey into green infrastructure, and devising natural fortifications. Furthermore, there is a swelling wave of support for NbS among governmental bodies, non-governmental organisations (NGOs), and financial institutions. Initiatives like the World Bank’s Wealth Accounting and the Valuation of Ecosystem Services are driving the adoption of NbS across crucial sectors, including disaster management.[69]

CASE STUDY: Climate-Resilient NbS in Demak, Indonesia

NbS solutions are vulnerable to climate-induced hazards. For example, although mangroves play a pivotal role in mitigating coastal erosion and cushioning the effects of storm surges, they remain vulnerable especially in their early growth stages. Demak, a coastal town in Indonesia, encountered such challenges with several unsuccessful mangrove replanting efforts due to the deep and turbulent waters which were unsuitable for young mangrove saplings.

In response, the local community, together with Wetlands International and the Indonesian Government, constructed wave-dampening structures using bamboo poles, facilitating sediment accumulation. These sediments not only supported the natural regeneration of mangroves by catching seeds shed by mature trees, but also promoted the biodiversity of the mangrove ecosystem. Unlike many conventional replanting initiatives that primarily use a limited set of species, the Demak initiative witnessed the sprouting of at least 12 distinct mangrove species. This biodiversity inherently strengthens the forest's resilience against climate change.

Source: Mangrove restoration gives hope to Indonesia's sinking shores, UN Environment Programme

CASE STUDY: Green Grey Infrastructure in Concepcion, Philippines

Challenge
The Municipality of Concepcion is in the northern part of Panay Island, the sixth-largest and fourth-most populous island in the Philippines, formed by more than 25 island villages. This coastal area is exposed to the effects of climate change, from more intense dry seasons to extreme storms and typhoons, affecting the livelihoods of local communities.

Intervention
Green-Grey Infrastructure Initiative is the collaborative effort between The Global Mangrove Alliance and Conservation International, to use NbS along with grey infrastructure to increase the resilience of 11 island villages.

The Green Grey Infrastructure initiative has focused on three key objectives: (1) Rebuild coastal sediment by replanting mangroves; (2) Halt the ongoing beach erosion and (3) Reduce the effects of extreme weather events on residents.

The project conducts assessment and designs the infrastructure, using a combination of wave attenuation fences, sediment trapping fences, low-crest semi-permeable breakwater as grey solutions, and mangrove restoration and the establishment of a community-based marine protected area (MPA) as green solutions.

Impact

- A total of 110,363 seedlings of native species have been planted covering an area of 11 hectares of mangrove rehabilitation.
- Established a 769.7-hectare community-based marine protected area (CB-MPA) which included capacity building and training.
- The additional two livelihood projects were included: the production of coconut-based products and the production of virgin coconut oil to reduce community heavy reliance on fishing.
- Established a Barangay Emergency Response Centre and emergency response plan.

Source: The Global Mangrove Alliance, Green-Grey Infrastructure in the Philippines

Leveraging the latest solution: Climate AI

AI has is now more than just a buzzword, and has a prominent place in some of the world's biggest platforms and forums. AI has now moved beyond being a mere concept to deliver real-world applications that are rapidly transforming industries.

AI is described as any technique that allows computers to replicate human intelligence, using logic, if-then rules, decision trees, and machine learning (ML). Notably, ML is a subset of AI that incorporates statistical techniques, enabling machines to enhance their performance on tasks through experience.

The realm of climate action, too, has been enriched by the capabilities of AI. There is a growing acknowledgement that integrating AI with climate analytics offers a formidable tool in the fight against climate change. In fact, of the organisations sampled globally, over 40% recognised the potential of harnessing AI for their climate-related endeavours.[70]

AI holds diverse applications in addressing climate concerns, spanning mitigation, A&R, and enablers:[71]

- **A&R:** AI refines the projection of long-term, regionalised climate effects and extreme events, while also enhancing the management of vulnerability and exposure.
- **Mitigation:** AI can help quantify emissions at both micro and macro levels, effectively helping decision-makers in managing efforts to reduce emissions and GHG effects and facilitate the removal of existing atmospheric emissions.
- **Enablers:** AI strengthens the pillars of climate research and modelling, augments financial analytics, and fosters education and behavioural change.

Click or scan QR Code to watch:

Understand how AI can help us to adapt to climate change, as explained by Hamid Maher, BCG Managing Director and Partner.

Within the subset of A&R, perhaps Climate AI's most invaluable contribution is its capacity to translate vast data streams into actionable insights. This data-driven clarity empowers swifter, more informed decision-making, pushing us closer to our climate resilience goals.

Climate AI's unique capacity to address the multi-faceted challenges of the climate crisis

The climate crisis is not a single issue, but a multifaceted challenge with profound economic, social, and environmental repercussions. While there is a wealth of data on this topic, much of it remains dispersed across different entities, and often in formats that are not easily accessible or interpretable for those who need it most.

Here is where AI proves itself useful as a transformative tool with the ability to translate and distil complex data sets into information vital for decision-makers. For instance, AI amplifies the precision of climate risk assessments. Through ML algorithms, it analyses large data sets and historical patterns, offering more accurate forecasts of potential climate risks.

Furthermore, AI equips decision-makers with the capability for scenario planning, simulating diverse scenarios based on specific parameters. Given the fluid nature of the climate crisis, and the fact that the outcomes largely depend on our actions today, it is vital to explore a range of possible future scenarios. This ensures our A&R strategies remain robust and relevant. Such models might explore various representative concentration pathways (RCPs) for specific years or predict global temperature changes over different periods. For instance, we have been modelling scenarios based on a 1.5°C temperature rise from pre-

industrial levels, however newer research suggests we might be edging closer to a 2.0°C increase or even higher. AI would then be able to analyse the impact for these various temperature scenarios.

For nations with limited resources, especially many in Southeast Asia, AI's capabilities are even more important. By providing more granular insights, it enables decision-makers to prioritise their resources effectively. For instance, while many data sources might offer national-level insights, AI can process data inputs further, generating insights right down to the municipal level to provide a more targeted and efficient approach to tackling the climate crisis.

Climate AI reduces uncertainty by quantifying the cost of inaction

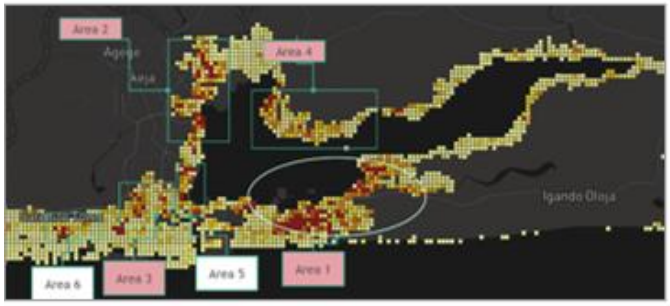
The impacts of climate change are largely "invisible" as they rest on predictions of events yet to occur, often projected decades or even centuries ahead. The outcomes of adaptation efforts, such as avoided economic, social, and environmental losses, are more difficult to quantify than those of mitigation, which can be directly measured (e.g., in metric tons of CO2). While mitigation strategies can be consistent with global standards, adaptation efforts must be tailored to local contexts and outcomes depending on the solution. Furthermore, NbS adaptation measures provide multipronged solutions which may be complex to measure, compared to linear adaptation approaches. For instance, mangrove planting might shield certain communities, contribute to carbon mitigation, boost local livelihoods, and conserve biodiversity. Each benefit requires a distinct metric of measurement. In contrast, a seawall might solely offer adaptation benefits by protecting against rising sea levels but lack secondary benefits.

Climate AI solves these issues by creating models that are able to synthesise and quantify inaction costs. It can simulate future scenarios, integrating complex outcome metrics across various dimensions. AI is then able to determine the potential return on investment (ROI) of an A&R initiative by juxtaposing projected costs of inaction against the total expense of the initiative—helping to inform decision-makers of the bankability of projects. These models are also adaptable and able to accommodate updated parameters to ensure their relevance and resonance with various stakeholders (e.g., detailed socio-economic impact for city authorities).

This adaptability allows for value-based prioritisation among multiple A&R strategies. AI can perform simulations for an array of solutions, producing a unified reference point, be it ROI or the number of people protected. Notably, AI can also forecast the long-term effects of A&R solutions. Such projections enable decision-makers to strategise not only which solutions to employ, but also the optimal timing for their deployment. This ensures efficient allocation of funds and resources both immediately and in the years to come.

A prominent application of AI in the A&R sector is climate risk assessment. AI-powered assessments can identify high-risk areas and quantify the impact of climate hazards. By processing vast amounts of climate data, AI can deduce hazard exposure and vulnerability across economic, social, and environmental spheres. [Exhibit 4.2.]

Exhibit 4.2: Illustrative map and quantified impact, generated by a climate risk assessment

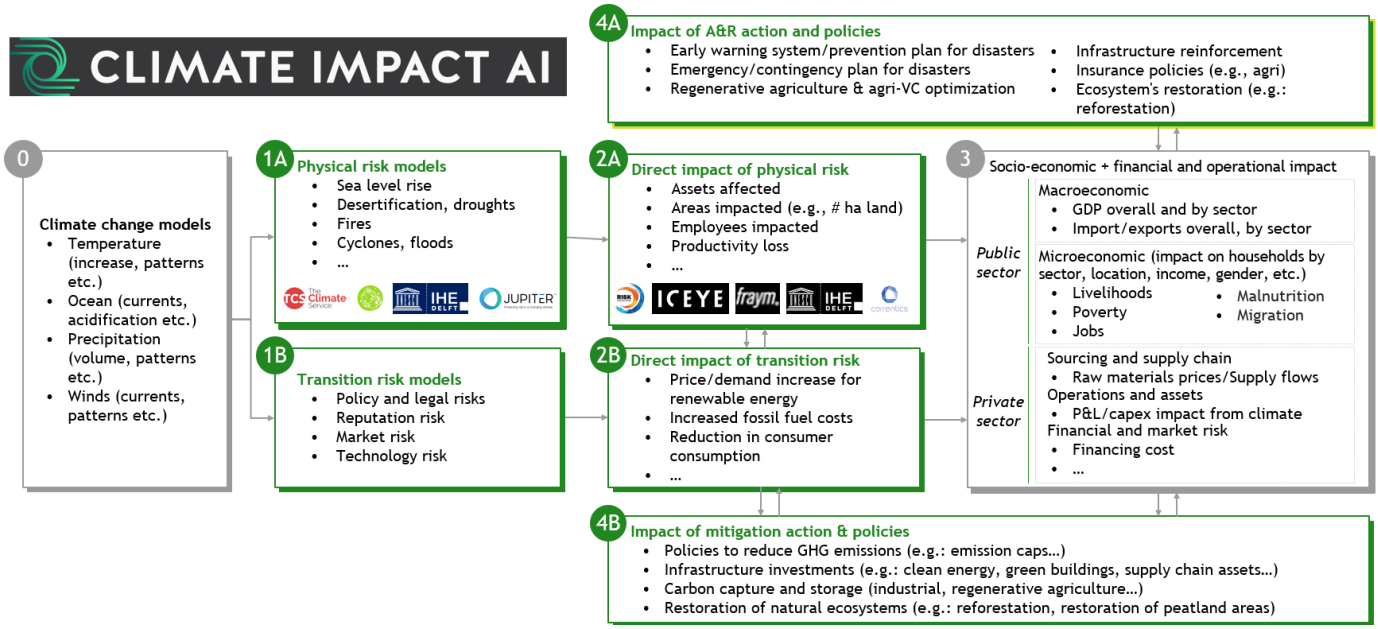


Most exposed LGAs	Population exposed	Capital Cost[1] exposed	GDP exposed
Area 1	91K	$1.9Bn	$2.6Bn
Area 2	144K	$517Mn	$721Mn
Area 3	116K	$426Mn	$580Mn

Illustrative map and quantified impact generated by climate risk assessment
LGAs: Local government areas

Providing visual representations of the exposure and vulnerabilities, coupled with quantitative analyses, offers a reliable framework for decision-makers. As these assessments can be conducted to the level of local municipalities, these models enable stakeholders to identify which areas require urgent intervention, facilitating effective resource allocation.

The BCG Climate Impact AI platform provides a tool and framework to assess physical and transition risks, the cost of inaction, and calculate the ROI of solutions



Note: Logos represent examples of organisations involved in the mentioned practice areas

Click or scan QR Code to watch:

How Southeast Asia can build climate resilience with the help of AI, as explained by Dave Sivaprasad, BCG Managing Director and Partner

CASE STUDY: Using Climate Risk Modelling for Data-Driven Decision-Making in a Southeast Asia Coast Region City

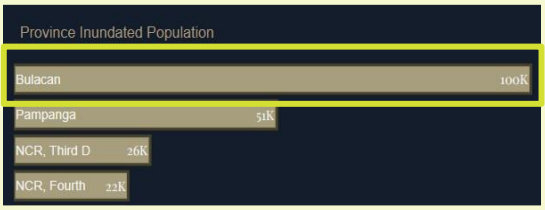
Challenge:

This Southeast Asia country is highly exposed to climate hazards. It is ranked #1 on the World Risk Index as the nation most at risk of disasters. The effects of climate change on the country are evident: sea levels are rising at an alarming rate of +13mm/year, 4x the global average. Since the 1970s, tropical cyclones have intensified by 12%, and the occurrence of Category 4 and 5 storms has more than doubled. Additionally, extreme rainfall events are becoming more common, with more days recording over 300mm of rain and a 25% rise in average one-day precipitation.

These climatic changes have profound implications for the country's social, economic, and natural systems:

1. Social impacts:
   - 74% of the population is exposed to climate hazards
   - Water access is becoming increasingly uncertain
2. Economic impacts:
   - Projected loss of 6% GDP annually by 2100
   - Anticipated declines in crop yield and fish catches by 25% and 40% respectively by 2050
   - Climate hazards have resulted in damages exceeding US$10 billion over the past decade
3. Natural impacts:
   - Over 70% of coral reefs are classified as high risk or worse
   - Mangrove populations have diminished by 80% over the past 75 years
   - Predicted biodiversity loss of 60% by 2050

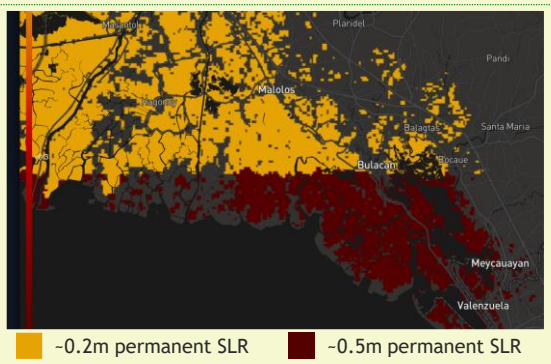
Intervention #1
Evaluate the implications of permanent sea level rise on the population. Identify the most affected segments and locations to enable collaborative decision-making between national and local governments, ensuring the prioritisation of vulnerable population groups.



100k of the region population are exposed, potentially displaced as permanent SLR up to 0.5m

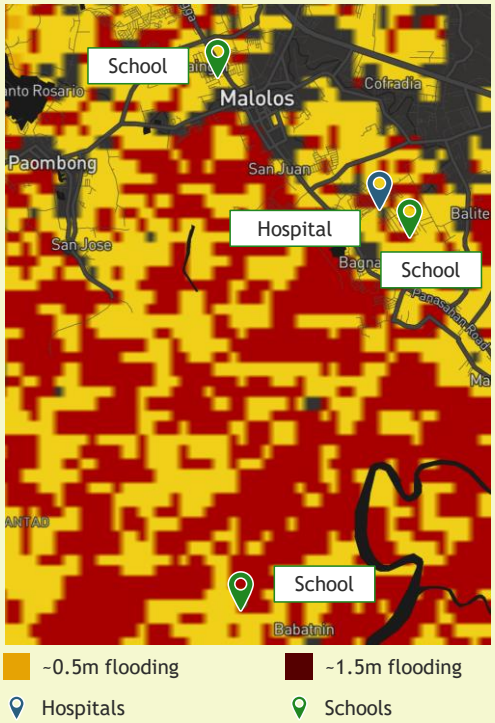
Index	% of flooded population
People in poverty	16%

16% of total population exposed are people in poverty, who are 2x more likely to be affected as they may not have the resources to adapt



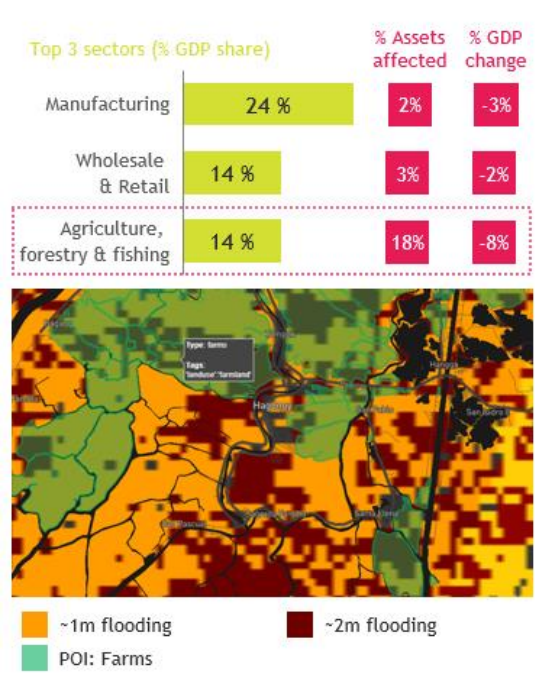
78% exposed people come from only 4 (of 21) municipalities

Intervention #2
Examine the potential impacts on vital infrastructure, laying the groundwork for an appropriate adaptation response such as early warning systems, flood-proofing buildings, and relocation. For new infrastructure, local government units can use the information to determine areas for development vs. areas to declare as no-build zones.



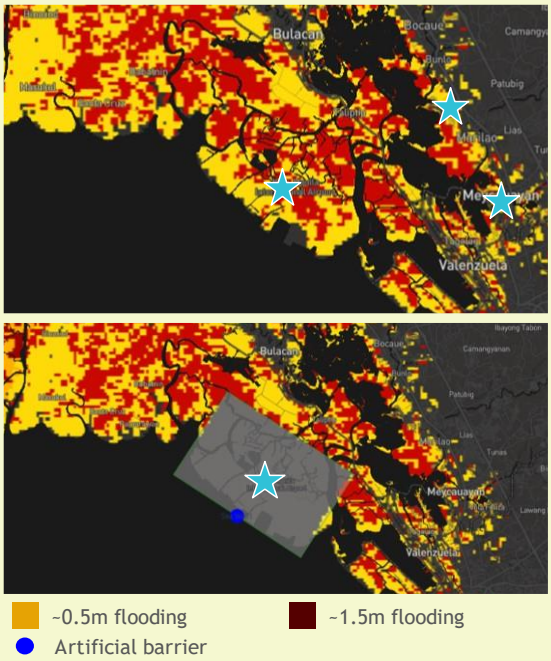
Sea-level rise could impact access to services such as healthcare and education which are critical to communities. 2% of hospitals and 3% of schools in the whole province could be exposed to SLR.

Intervention #3
Calculate the potential costs of inaction for the region's key sectors. This will guide the prioritisation of A&R strategies.



- Agriculture, forestry, & fishing sector are most affected by SLR in the city, with 18% of assets potentially inundated:
- Cost of inaction: US$3.2 billion, equivalent to up to 8% decrease in overall GDP of the city due to decline in sector output
- Risk of food insecurity due to disruption in fish and rice production; the city contributes to food supply within the province and in nearby regions

Intervention #4
Identify areas in the region that may attract private-sector attention, fostering plans for potential public-private partnerships.



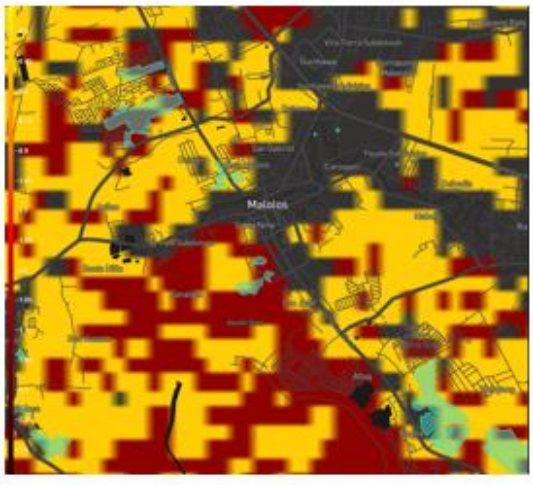
In most severely hit municipalities, flooding could rise up to two meters during extreme events. These areas have growing private sector presence that could be affected.

- Leading conglomerate building aerocity, water supply
- Real-estate company building commercial and residential properties
- Fast-moving consumer goods (FMCG) players with existing manufacturing plants

Funding solutions could be costly. Hence, it is important to explore alternative sources of funding (e.g., private sector)

Intervention #5
Assess the impact on the region's natural ecosystems to secure international support and funding for NbS such as Green Climate Fund and CARA

POI	Flooded	Units	Percent
Wetlands	39	km2	49%



Wetlands are critical to the region's ecosystem for the following reasons:

- Rich in biodiversity
- Provide protection to communities (buffer against sea level rise)
- Improve water quality

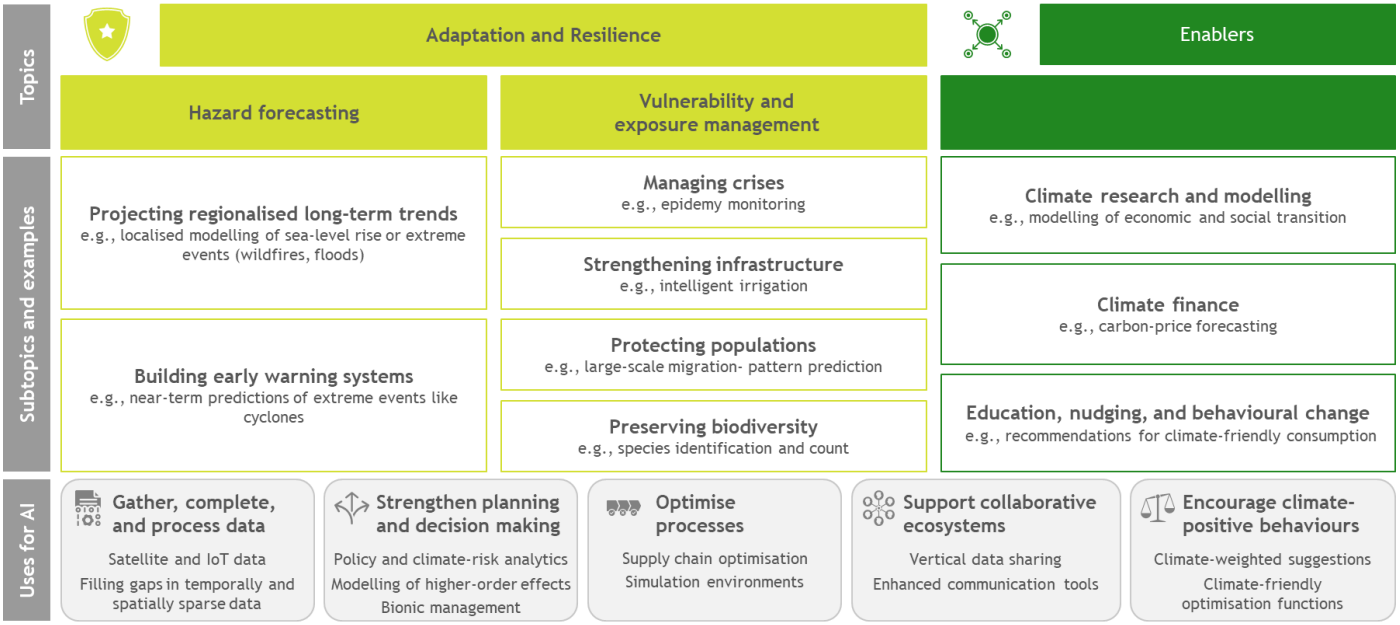
For the whole region, ~50% of wetlands are exposed to sea level rise, which poses a potential risk of damage.

In this area for example, all wetlands are observed to be affected by flooding.

Source: BCG project

Beyond climate risk assessments, there are several more applications for hazard forecasting, and vulnerability and exposure management that can be implemented for A&R. [Exhibit 4.3.]

Exhibit 4.3: Use cases for hazard forecasting and vulnerability and exposure management



Note: IoT = Internet of Things.
Source: BCG project experience; Climate Change AI (CCAI) "Tackling Climate Change with Machine Learning"; Global Partnership on AI (GPAI) "Climate Change and AI: Recommendations for Government Action."

1. **Projecting regionalised long-term trends**
   Climate AI produces precise projections of long-term regional trends, such as crop and fishing yields. This clarity enables planners to devise long-term strategies, guiding investments to support local livelihoods and promote continuous economic growth.

2. **Building early warning systems**
   Through AI modelling and analysis of extensive data sources like satellite imagery, we can forecast individual extreme weather events. This prediction allows policymakers to draft plans that either prevent or mitigate the impacts of such events.

3. **Managing crisis**
   AI's natural language processing can be used to streamline operations, effectively gathering and synthesising information from multiple sources. This equips decision-makers to make better informed decisions during times of crisis.

4. **Strengthening infrastructure**
   AI can be used to strengthen existing infrastructure. This includes predictive maintenance of structures, monitoring water quality and air pollution levels, and even supporting in risk identification during design projects.

5. **Facilitating climate migration**
   AI can predict large-scale migration patterns to boost the resilience of communities. It can also monitor potential resource scarcity and optimise social welfare allocations.

6. **Preserving biodiversity**
   Implement AI analysis to understand multiple pathways of climate driven impacts on ecosystems and biodiversity to reduce detrimental effects of increasing extreme weather patterns.

Across the region's six themes, there are several solutions that harness the power of nature and AI. Some examples include:[72]

Theme	Nature-based solutions	Analytics and AI
Infrastructure	• **Coastal flood defence.** Coastal defences such as coral and oyster reefs, coastal forests, wetlands, mangroves, seagrass, and barrier islands can mitigate the impacts of coastal flooding and storms. • **Inland flood defence**. Bioswales, rain gardens, and both detention and retention ponds serve as natural solutions to decrease the impact of inland flooding. • **Promoting green household solutions.** The use of green infrastructure in households, like home gardens, can enhance community resilience. • **Restoring degraded mangroves and coastlines**. Managed realignment of coastlines and the restoration and protection of vital coastal habitats, including mangroves, saltmarshes, coral reefs, and oyster reefs.	• **Advanced monitoring systems.** Develop enhanced systems to monitor climate data and assess the vulnerability of settlements to the effects of climate change. • **Infrastructure resilience assessments.** Conduct risk assessments to map and pinpoint high-risk infrastructure areas and vulnerable settlements.
Trade	• **Strengthen natural protection of shoreline from erosion**, and wave impact on supply chain facilities by growing salt marshes and mudflats. • **Creating rich revetments as an alternative to flood walls** to guard against coastal flooding that affect supply chain facilities and function and improve marine biodiversity.	• **Enhanced traffic information**. Offer real-time travel updates by integrating weather data with travel information, allowing travellers to be aware of travel conditions. • **Climate-resilient trade planning.** Incorporate climate risks into the planning of trade hubs, strategically determining logistic nodes while considering both climate threats and conventional factors.

Theme	Nature-based solutions	Analytics and AI
	• **Building coral reefs to prevent shoreline erosion** and waves from affecting coastal industries at the same time to promote marine biodiversity that a sustainable fishing industry • Introduce floating and hanging structures to boost the population of filter feeders to **restore the marine biodiversity affected by container ships**. • **Climate-proofing traded goods through NbS approaches** such as managing water for agriculture or ambient temperature in manufacturing facilities will enable this important supply chain hub to continue providing global trade benefits.	
Natural ecosystems	• **Ecosystem connectivity**. Increase the connectivity of terrestrial and aquatic habitats by establishing connection corridors between various ecosystems. • **Forest regeneration**. Implement assisted natural regeneration techniques, diverse selection of natural local trees and plants that are climate resilient for more efficient forest restoration. • **Coral reef restoration**. Engage in locally led coral reef restoration efforts. Inclusive restoration efforts create opportunities for the community to be part of the management of their natural resources. • **Coastal ecosystem rehabilitation**. Prioritise the naturalisation of modified coastlines and the restoration and protection of natural, untouched coastal habitats,	• **Ecosystem health monitoring**. Launch vulnerability assessment and monitoring programs to detect indicators of climate change in specific ecosystems, prompting timely interventions. • **In-depth environmental research.** Drive scientific research to improve projections of the repercussions of inaction. This includes understanding the cause-effect dynamics between environmental factors and biodiversity trends in areas like nature conservation, forestry, and fisheries.

Theme	Nature-based solutions	Analytics and AI
	such as mangroves, saltmarshes, coral reefs, and oyster reefs.	
Water	• **Riparian buffers**. Vegetative zones adjacent to water bodies designed to safeguard water quality.	• **Water resource management.** Deploy systems and practices for meticulous accounting and management of water resources, like dams and storage tanks, tailoring solutions for localised adaptation. • **Water source profiling**. Catalogue and evaluate watersheds and river basins for enhanced monitoring and management.
Agriculture	• **Fungal symbionts to help alleviate climate induced stress**. Use of beneficial fungi to increase plant resilience, nutrient absorption, and resistance to diseases. • **Integrated pest management**. Adopt pest control methods that curb pesticide usage and leverage natural predators and biological controls. • Land contouring. Implement contour farming techniques to reduce soil erosion and optimise water use.	• **Localised warning systems**. Design region-specific early warning systems factoring in local climate trends and risks specific to various crops. • **Enhanced weather monitoring**. Augment weather monitoring frameworks to furnish farmers with timely and precise climte data.

Theme	Nature-based solutions	Analytics and AI
Health	• **Façade solutions for heat management.** Introduce vegetation on building rooftops or implement roof ponds for cooling. • **Urban heat abatement**. Incorporate urban greenery elements like street trees, green roofs, and green walls to mitigate heat. • **Vector-borne disease control with bioagents**. Utilise biocontrol agents to curb disease vectors and apply saturation treatments for pathogens. • **Prevention of the spread of zoonotic diseases by keeping human and wildlife habitation spaces separated.** This can be designed with urban forests and providing connectivity with corridors of fragmented green lungs within cities and connecting to larger natural spaces outside city boundaries.	• **Disease surveillance and alerts.** Standardise disease case definitions, ensure adequate testing capabilities, and develop robust alert systems. • **Heat monitoring and alerts**. Define heat thresholds and craft monitoring and alert mechanisms. • Monitoring mental health post-extreme weather. Design and roll out standardised tools to assess mental health impacts after major weather events, coupled with baseline data collection to identify when interventions are necessary.

Limitations of Climate AI

While AI offers immense potential in the realm of climate change, it is essential to acknowledge the existence of notable limitations.

- The effectiveness of Climate AI is contingent on the availability and quality of data. However, the inherent uncertainty and variability in climate data can pose challenges and introduce inaccuracies into AI models, thereby impacting the precision and reliability of climate predictions and recommendations.
- The substantial computational resources required by many AI algorithms, particularly deep learning models, may prove prohibitive for regions or organisations with limited access to advanced computing infrastructure. In addition, the challenge of limited interoperability between technology platforms, driven by providers' proprietary interests, restricts users, especially the public sector, in sharing intelligence and tailoring solutions to local contexts.
- While AI can be incredibly sophisticated and nuanced, these models still lack the human ability to interpret and contextualise data. AI may identify a correlation between two climate variables but lacks understanding of the underlying causes or broader implications of that correlation. At the same time, many AI/ML systems remain a “black box” where it is difficult to discern the algorithmic process that led to a given output, which can subsequently cause trust and transparency issues for some users.

However, despite these challenges, rapid progress is being made in data collection and validation, equitable access to computing resources, and continuous enhancement of AI models coupled with human expertise, critical thinking, and creativity. Such measures can both accelerate and facilitate the responsible and effective integration of AI into A&R development.

Interrelationships and interaction between risks

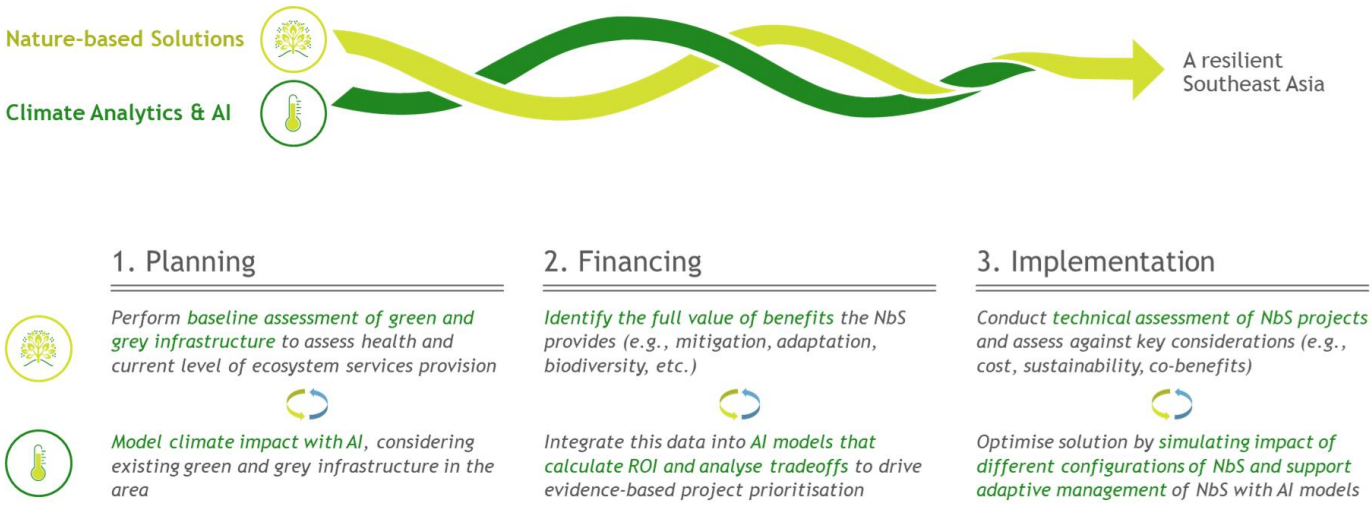
In the context of Southeast Asia's efforts to adapt to climate change, it is crucial to emphasise the importance of understanding how different risk factors are connected. There are multiple feedbacks between individual risks that can potentially create cascades, amplifying systemic risks and impacts far beyond the level of individual ones.[74] Recognising these interactions and relations is essential for decision-makers, as they can reveal both opportunities and challenges for solutions with multi-faceted impacts across multiple risks.

By examining the complex connections between climate-related issues, we can uncover the potential chain reactions and beneficial interactions that shape our adaptation strategies. For example, climate change will combine with pre-existing socioeconomic and ecological conditions to generate direct effects both on the structure of ecosystems and on certain natural processes such as the hydrologic cycle.[75] Understanding how these risks are linked or affect each other empowers decision-makers to create more comprehensive and effective strategies for dealing with climate change. This approach not only allows us to address multiple vulnerabilities at once but also strengthens the resilience of communities, ecosystems, and economies as they face the evolving challenges of a changing climate.

Harnessing the combined power of nature and AI for Southeast Asia

While nature and AI are formidable solutions, we believe that the fusion of these two forces holds great potential to bring about transformative change for the region. Together, nature and AI complement each other to unlock synergies throughout the A&R process. [Exhibit 4.4.]

Exhibit 4.4: NbS and Climate AI complement each other to drive successful A&R solutions



The profound synergy of this partnership is best captured through two case studies from Kenya and Sri Lanka.

CASE STUDY: Climate-Resilient NbS in Tana River Basin, Kenya

Challenge:

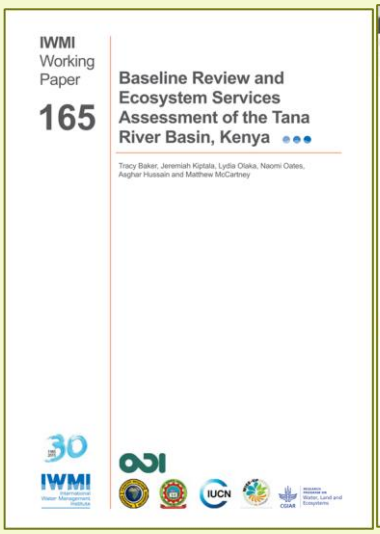
The local river basin faces multiple competing demands, including irrigation, fishing, hydropower, and cattle grazing. With climate changes on the horizon, the impact on river flows and the efficiency of dams and irrigation systems remain uncertain.

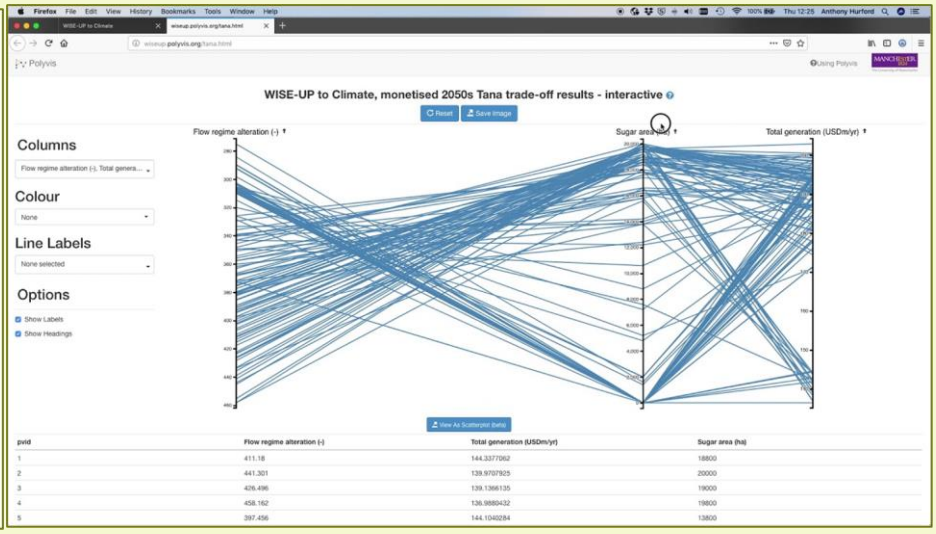
Intervention:

The International Water Management Institute (IMWI) performed a baseline assessment to elucidate the relationship between river flows and vital ecosystem services, such as fisheries and livestock grazing. For example, a key insight from the investigation revealed that the economic contribution of floodplain grazing was found to be US$140 million annually. To look deeper into the matter, the WISE-UP modelling technique was employed to simulate the outcomes of various combinations of green and grey infrastructure. This helped identify trade-offs between different ecosystem services. This model casted projections on future river flows, exploring a range of climate scenarios while factoring in both upstream and downstream requirements.

Impact:

The findings underscored the economic advantages of green infrastructure, which were estimated to exceed US$300 million annually, while concurrently improving dam performance in the context of climate change. The model further demonstrated that bolstering natural infrastructure in the upper catchment would not only optimise dam performance, but also preserve these benefits amid evolving climate challenges.





Caption

Left: IMWI Working Paper Right: Interface of WISE-UP model comparing trade-offs

Source: IUCN Water Programme, IUCN Global Standard for Nature-based Solutions, WISE-UP to Climate: Interactive Trade-off Analysis

CASE STUDY: A Combination Approach of Green-Grey Infrastructure to Protect Colombo from Flooding was Optimised with the use of Computer Modelling

Location: Colombo Metropolitan Region, Sri Lanka

Challenge:

Colombo, Sri Lanka's commercial and financial hub, has experienced increased flooding due to climate change-induced sea level rise and the detrimental effects of urbanisation, which include the degradation and conversion of vital wetlands. While wetlands are crucial for storing rainfall, their water retention capacity has decreased by 40%.

Intervention:

The World Bank has endorsed a hybrid infrastructure initiative. This project combined grey infrastructure elements such as tunnels, pumping stations, canals, and flood gates, with green strategies, earmarking 2,000 hectares of wetlands specifically for water storage in Colombo. Computer modelling was then employed to evaluate the merits of urban development versus wetland conservation across hundreds of scenarios. These scenarios spanned diverse economic growth trajectories and potential climate change outcomes. Specifically, the modelling assessed the impact and value proposition of transforming wetlands into lakes—a common practice in Colombo. The model findings posited that retaining wetlands was a superior strategy from an economic welfare standpoint, which in turn informed the project's direction, mitigating uncertainty in expected returns.

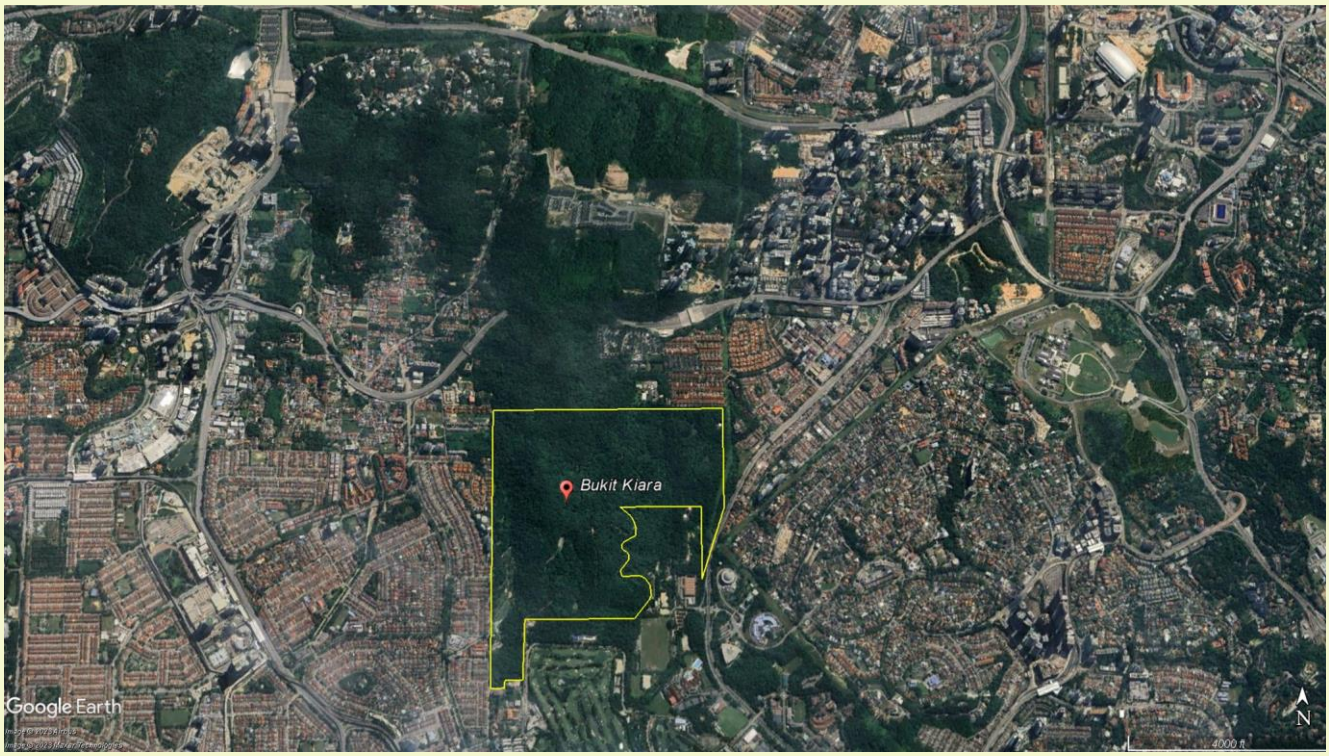
Impact:

Enhanced flood defence measures now safeguard 232,000 residents. Additionally, three public areas, including Colombo's premier urban wetland park in Beddagana, were upgraded. Beyond water storage, these spaces now double as recreational hubs and present eco-tourism prospects.

Source: Working with nature to protect people, IFRC and WWF report

CASE STUDY: Bukit Kiara Federal Park a Sanctuary for Eco-System Services

Location: Bukit Kiara Federal Park, Kuala Lumpur, Malaysia



Intervention:

Community-led participation is instrumental in driving a bottom-up approach to NbS. A good example of this is the 25-year campaign for protection led by a community-based organisation, the Friends of Bukit Kiara (FoBK) and the TTDI Residents Association in Kuala Lumpur, Malaysia. The community has successfully protected a green lung, Bukit Kiara Federal Park (BK), which was under threat of conversion and has already started seeing multiple benefits flowing from this project.

It has protected a river system which is of the highest water body class with rich freshwater aquatic life like shrimps, otters, and river crabs. These are all good biological indicators of water quality. BK attracts many people who come to walk at the tarmac circuit, to hike in the jungle trails and to partake in mountain biking. Bird watchers congregate most afternoons trying to spot the more unusual species of birds whereas the hashers are on the trails in the evenings.

BK also provides key ecological functions and services related to flood mitigation. During the 1 in a 100-year storm in Malaysia in December 2021 leading to the worst case flooding the nation has seen, the surrounding leafy neighbourhood of TTDI adjacent to the green lung was spared any major issue despite the fact that the storm drains built as part of the infrastructure of the township in the 1980s collapsed in part due to the ferocity of the water flows. There is no doubt that if not for BK providing the natural absorption capacity for the rains this whole neighbourhood would been submerged.

Impact:

This site is increasingly used as a model community led project emphasising both nature-based solutions and environmental education for sustainable outcomes.

Source: The Friends of Bukit Kiara www.fobk.org, FoBK Booklet "BUKIT KIARA A Sanctuary in the City", Google Earth

CHAPTER 5: Nature, AI, and collaboration: A climate resilience playbook

Combining the power of nature, AI, and collaboration presents a promising avenue for A&R initiatives in Southeast Asia. The SEACAR Alliance's goal is to support A&R stakeholders to convert this knowledge into actionable A&R strategies for the region.

In this chapter, we present a playbook designed to guide the execution of A&R projects in urban Southeast Asia, anchored around three key enablers highlighted in the earlier chapters:

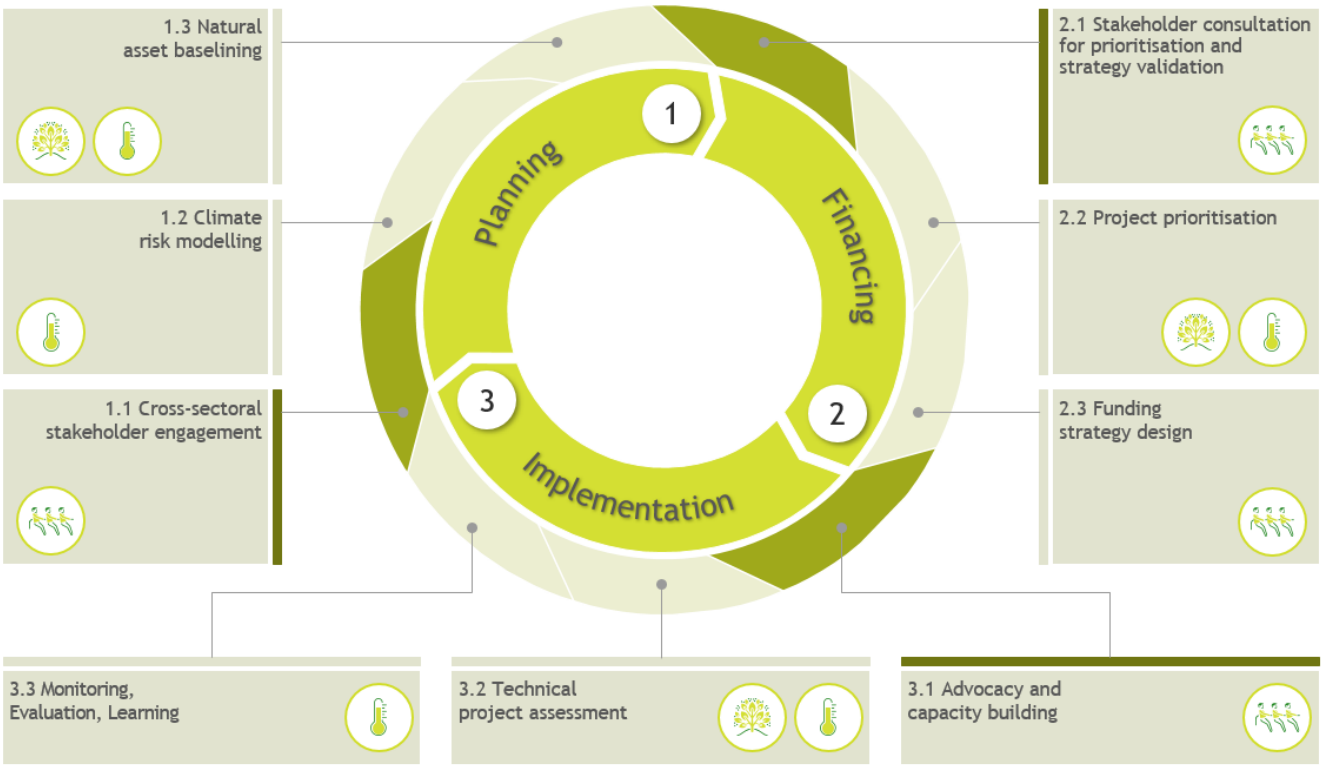
1. **Collaboration.** At the heart of every successful A&R endeavour lies collaborative effort. Whether it is inter-country coordination or cross-sectoral integration, the insights and contributions from various stakeholders are needed. Their involvement ensures the selection of appropriate solutions, the funding of large-scale A&R initiatives, and the sustainability of adopted measures.
2. **Nature.** NbS offers a wealth of advantages. Beyond A&R, it also fosters carbon mitigation, biodiversity conservation, and the creation of sustainable livelihoods, as well as providing cross-cutting solutions for all six themes we are exploring.
3. **AI.** Integrating climate analytics and AI into the mix accelerates project implementation. By curtailing uncertainties and enhancing decision-making processes, they become instrumental in the successful deployment of A&R solutions.

This playbook is designed for city planners, community leaders, investors, private entities, and any individual or group keen on championing A&R initiatives in Southeast Asia.

Outlined in our framework are three essential phases in A&R project deployment: planning, financing, and implementation. However, the journey does not end at implementation. A cyclical, adaptive-learning approach is paramount. It mandates project owners to consistently monitor outcomes, maintain stakeholder engagement, and make requisite adjustments as situations evolve. [Exhibit 5.1.]

Exhibit 5.1: The SEACAR framework for deploying NbS and Climate AI

The SEACAR Framework for deploying NbS and Climate AI to advance A&R in SEA Cities



At every step of the project delivery cycle, the importance of collaboration, nature, and AI cannot be overemphasised. Project owners must secure the required expertise and resources needed for successful project delivery.

The case studies featured in this playbook are a combination of publicly available examples, and insights gained from projects spearheaded by the SEACAR founding partners.

Planning

1.1 Cross-sectoral stakeholder engagement

Initiating a successful A&R project begins with identifying the stakeholders essential for establishing the A&R baseline within your targeted intervention area. Engaging these stakeholders not only ensures project buy-in but also strengthens the project's sustainability. Key participants hail from various sectors, such as:

- **Local government units**

  While broad datasets from national governments and global organisations are often available, A&R solutions require a localised approach. Local government units are pivotal in furnishing detailed, area-specific data, which might include historical economic, social, and environmental impacts of climate events. These units can validate data, offer qualitative insights, and share resources like city plans, maps, and urban planning records. Engaging with local government units also offers clarity on their current A&R strategies, highlighting potential risks or opportunities.

- **Academia**

  Universities provide another source of research and insights pertinent to A&R endeavour. For example, Malaysia's University Kebangsaan Malaysia (UKM) is part of CORDEX or Coordinated Regional Climate Downscaling Experiment. UKM is working on assisting with the downscaling for Southeast Asia. Such institutions not only offer findings but might have also developed helpful tools for climate assessment. Leveraging these academic tools and insights can immensely strengthen the A&R project's design and plan.

- **Local communities**

  Local communities are at the heart of locally led adaptation (LLA). Project owners must actively involve community leaders and members through engagements such as interviews, workshops, and dialogues, capitalising on the collective knowledge of the community. Entrusting local stakeholders with a pivotal role in the early planning stages empowers them, ensuring the A&R project resonates with their needs and aspirations. Such grassroots involvement is critical in maximising the project's longevity and impact.

DEEP-DIVE: Principles for Locally Led Adaptation

These eight principles were developed by the Global Commission on Adaptation and launched at the 2021 Climate Adaptation Summit.

1. Devolving decision-making to the lowest appropriate level: Empower local institutions and communities with direct access to financial resources and the authority to determine how adaptation actions are planned, executed, monitored, and assessed for success.

2. Addressing structural inequalities faced by women, youth, children, disabled, displaced, Indigenous Peoples and marginalised ethnic groups: Recognise and address the gender, economic, and political disparities that amplify vulnerabilities. This includes actively involving vulnerable and marginalised populations in shaping and directing adaptation strategies.

3. Providing patient and predictable funding that can be accessed more easily: Advocate for streamlined access to funds, supporting the long-term development of local governance, capacities, and institutions. Reliable, long-term funding ensures communities are better equipped to enact effective adaptation measures.

4. Investing in local capabilities to leave an institutional legacy: Strengthen the capabilities of local institutions so they can identify climate risks, devise solutions, and manage adaptation initiatives in the long run, independent of project-based donor contributions.

5. Building a robust understanding of climate risk and uncertainty: Inform adaptation decisions through a combination of local, traditional, indigenous, generational, and scientific insights. This comprehensive knowledge base fosters resilience across varied future climate scenarios.

6. Flexible programming and learning: Promote adaptive management to navigate the unpredictable nature of adaptation. This involves robust monitoring, dynamic learning systems, flexible financial structures, and adaptable programming.

7. Ensuring transparency and accountability: Prioritise clarity and accountability in all processes, from financing to designing, and executing programs, ensuring local stakeholders are well-informed and engaged throughout.

8. Collaborative action and investment: Champion collaboration across sectors, initiatives, and levels. By coordinating various funding sources (humanitarian assistance, development, disaster risk reduction, green recovery funds, and more), it is possible to minimise redundancy, optimise efficiencies, and share best practices.

Source: Global Commission on Adaptation

CASE STUDY: Climate and Resilience Baseline study in Kuala Kangsar

Location: Kuala Kangsar, Perak, Malaysia

Challenge: Climate risk modelling was undertaken for Kuala Kangsar, drawing on data from diverse sources that might not fully reflect the unique conditions of respective Mukims (a type of administrative subdivision in Malaysia). For accuracy and reliability, these modelling results required validation through discussions and engagement sessions with local government units and communities in the Mukims.

Intervention: Focus group discussions with local government units were organised to cross-check and verify the data. Public engagement sessions were conducted to gather detailed, localised insights, such as identifying flood-prone areas, temporary evacuation centres, and assessing the efficacy of the current early warning system.

Impact: Data collected better paved the way for suitable climate adaptation strategies tailored to local needs. Collaboration with government officials meant their expertise and insights were incorporated into policymaking processes, enhancing the strength and relevance of climate-resilience initiatives. Engaging directly with local residents unlocked grassroots perspectives, offering a richer understanding of localised challenges and vulnerabilities.

Public engagement session at Mukim Chegar Galah in Kuala Kangsar. Community representatives providing their responses regarding climate impacts and adaptation.

Public engagement session at Mukim Sayong in Kuala Kangsar. Think City officer summarising participants' feedback.

The above project was implemented by Think City with support from Yayasan Hasanah and Ministry of Finance of Malaysia.

1.2 Climate risk modelling

Leveraging the data and insights collected in the previous step, project owners are better positioned to develop AI models that will simulate various climate scenarios, offering insights into potential impacts from climate hazards.

The BCG Climate Risk Index incorporates five core dimensions to determine the most vulnerable areas:

- Flood intensity
- Capital cost associated with infrastructure damage
- Impact on GDP
- Population affected by flooding
- Percentage of vulnerable population impacted

These dimensions can be adapted and incorporated into the model based on the specific climate hazards prevalent in the target area for intervention.

Additionally, climate risk models shed light on the cost of inaction, emphasising the need for urgency and prioritisation of A&R projects. The cost of inaction can be assessed cross three dimensions:

- **Social.** Impacts on the general population and especially vulnerable groups, such as women, children, and the economically disadvantaged. These impacts also include access to vital resources like water, food security, and essential community infrastructures, including the number and location of health and education centres at risk.
- **Economic.** Damages to critical infrastructure, including transportation, communication, and power systems, along with the potential impact on GDP.
- **Natural.** Potential harm to natural ecosystems, identified through metrics like the number of hectares of mangroves or forests at risk.

CASE STUDY: Using Climate AI to Offer Data-Driven Recommendations on Sea-Level Rise in a Southeast Asia Coast Region

Challenge:

This Southeast Asian country is highly exposed to climate risks:

- Sea-level rise: Increasing at a rate 4x faster than the global average
- Tropical cyclones: The frequency of severe Category 4 and 5 storms has more than doubled
- Rainfall: Average one-day precipitation levels have surged by 25%

Intervention:

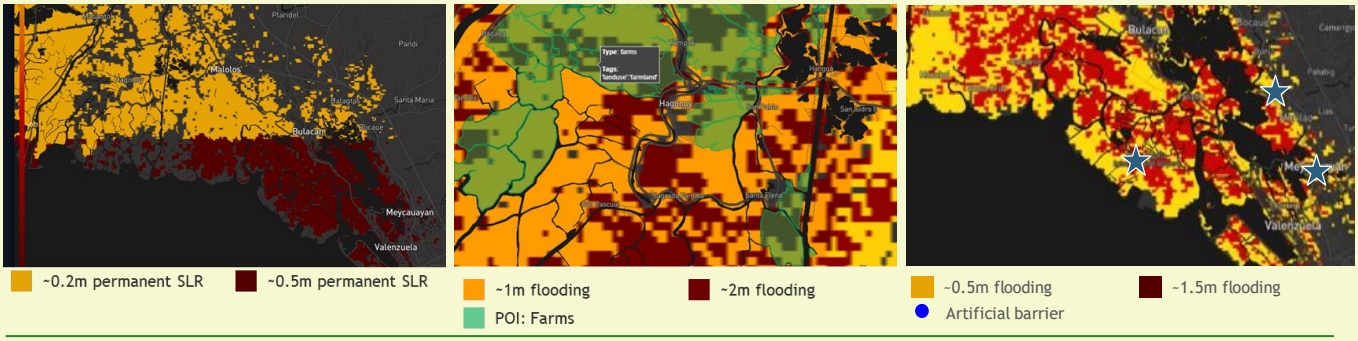
Climate AI and analytics were used to quantify the potential social, economic, and natural impacts of sea level rise.

Impact:

The quantified cost of inaction:

- Social impact: 78% of the vulnerable population resides in just four of 21 municipalities
- Economic impact: Potential toll on GDP estimated at US$3 billion
- Natural impact: 50% of wetlands are at risk

This analysis led to data-driven recommendations for A&R action, which included identification of high-priority intervention areas, private entities with vulnerable critical assets for potential partnership and funding and highlighting international funding opportunities.



Images from left to right: 1) Modelling of sea-level rise, 2) Mapping of flooding scenarios vs. farmlands, 3) Mapping of flooding scenarios vs. private sector critical infrastructure

a. This does not include indirect impacts (reduced ecosystem services)

Project sponsors: Foreign Commonwealth & Development Office, BCG

CASE STUDY: Using Remote Sensing and Thermal Imaging to Gauge Heat Stress in Urban Penang

Location: George Town and Bayan Lepas, Penang, Malaysia

Challenge:

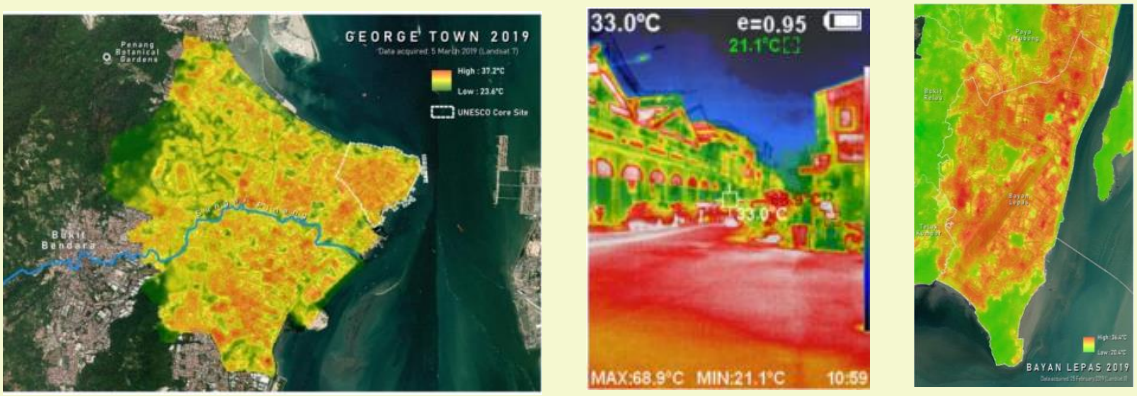
Urban areas in Penang Island are grappling with rising temperatures and increased extreme weather events, resulting in frequent flooding. Such climate change poses immediate health risks, from heat-stress related illnesses and flood-induced injuries to mental health impacts. To design effective climate adaptation strategies, there is a need to understand which areas within George Town and Bayan Lepas are most susceptible to rising temperatures.

Intervention:

To understand which areas are most exposed to rising temperatures, remote sensing (Landsat 8) and thermal imagery were used to determine surface temperatures in George Town and Bayan Lepas. Surface temperatures of urban areas are observed to be approximately 8°C higher than their neighbouring natural or rural counterparts, a phenomenon attributed to the urban heat island effect.

Impact:

The climate risk assessment guided the way for proposed interventions to focus on NbS. These solutions aimed to lower surface temperatures, mitigate stormwater runoff, increase community resilience, and enhance institutional capacities.



(Left) Land surface temperature of George Town in 2019.
(Centre) A thermal image capturing the relatively high surface temperatures of a street within the George Town World Heritage Site.
(Right) Land surface temperature of Bayan Lepas in 2019.

The above project was initiated by Think City, in collaboration with the United Nations Human Settlements Programme (UN-Habitat), Ministry of Natural Resources, Environment and Climate Change, Penang State Government, City Council of Penang Island, Department of Irrigation and Drainage, and Yayasan Hasanah. The project was subsequently supported by the Adaptation Fund for implementation.

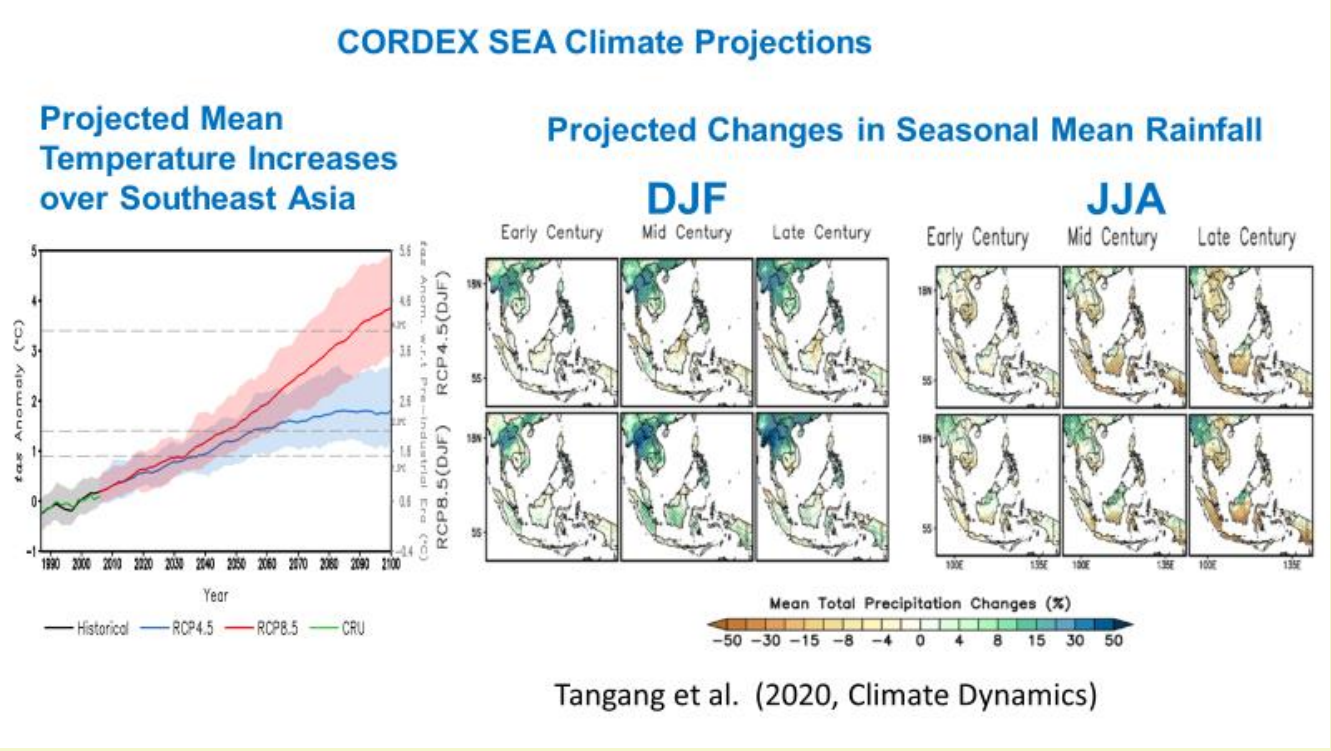
The project's proposal won the Climathon Global Cities Award, having been shortlisted alongside proposals from Miami, Karthoum, Dublin and Salvador. It also won the Award of the Kingdom of Saudi Arabia for Environmental Management in the Islamic World.

CASE STUDY: Coordinated Regional Climate Downscaling Experiment (CORDEX)

CORDEX is a valuable resource for A&R practitioners to obtain the necessary high-resolution data needed for their projects. Typically, global climate models provide reliable information at scales of 1,000 by 1,000 kilometres. These scales can cover diverse landscapes, each with unique exposures and vulnerabilities to climate risks. Regional Climate Downscaling (RCD) is essential for obtaining information on "high-resolution" climate scenarios at regional, smaller, and targeted scales. Such granularity is vital for designing A&R strategies tailored to specific, targeted areas.

The World Climate Research Program, established by CORDEX, is a collaborative platform bringing together researchers, data scientists, and experts. Their collective aim is to advance RCD efforts, enhancing the efficacy and precision of A&R solutions worldwide.

Specifically for Southeast Asia, the goal is to create high-resolution climate change scenarios (25km x 25km), which will be made accessible to all. To learn more about Southeast Asia RCD efforts, visit: https://cordex.org/domains/region-14-south-east-asia-sea/



1.3 Baseline assessment of the natural landscape

Assessing the current landscape of the target intervention area is crucial and should go hand-in-hand with the climate risk assessment. This approach helps with identifying the most optimal location for intervention and ensures seamless integration with existing green and grey infrastructures.

Key steps in this assessment include conducting a thorough inventory of natural assets, evaluating their health, and the ecosystem services they offer. Several mapping exercises must also be done:

- Mapping of natural and built infrastructure
- Mapping of permeable and non-permeable surfaces
- Mapping of historical natural ecosystems prior to urban development

This assessment will inform the development of a portfolio of the most suitable NbS according to the risks identified earlier. For each proposed solution, it is essential for the project owner to recognise the value of the natural assets involved and strategise how to integrate the solution into the existing fabric, be it natural or man-made, to ensure the greatest benefit.

Understanding the value of natural capital

Nature offers invaluable contributions to our economy through the ecosystem services it provides. WWF estimates the total value of natural capital to be at least US$125 trillion per year. These ecosystem services can be grouped into four main categories:

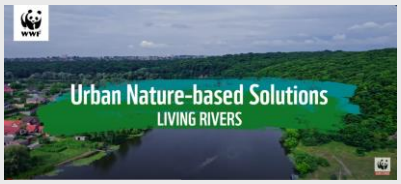
- **Supporting services.** Those services creating conditions necessary for the provision of all other ecosystem services, for example photosynthesis or soil formation.
- **Provisioning services**. All products coming from ecosystems, for example food, fibre, fuel, herbs and medicinal plants, genetic resources, and drinking water.
- **Regulating services**. The capacity of ecosystems to regulate important natural processes, for example regulation of climate, quality, and quantity of water, etc.
- **Cultural services.** Non-material benefits from ecosystems, for example the aesthetic and recreational value of landscapes.

There are established methodologies for valuing ecosystem services. The Natural Capital Project at Stanford University and The Economics of Environment and Biodiversity (TEEB) can be referred to.

In Malaysia, a soon-to-be published study has estimated the natural capital value of Protected Areas in Peninsular Malaysia to be RM9.97 billion (US$2.1 billion) per year. The report highlights that this is likely an underestimate as international tourism estimates were taken during the Covid-19 pandemic period, and some downstream water benefits were not included.

Source:
https://www.wwf.org.uk/what-we-do/valuing-nature#how-we-value-nature
https://wwf.panda.org/discover/knowledge_hub/where_we_work/black_sea_basin/danube_carpathian/our_solutions/green_economy/pes/
https://www.wwf.fr/sites/default/files/doc-2022-10/Paying_foresters_to_provide_ES.pdf

CASE STUDY: Bishan-Ang Mo Kio Park and Kallang River Restoration



Click or scan QR Code to watch:

The transformation of a concrete canal into a meandering river by Singapore Bishan-AMK Park

Location: Bishan-AMK Park, Singapore

Challenge:

Singapore has been experiencing several climate-related issues, including erratic rainfall patterns, urban heat island effect, floods, temperature rises, droughts, and erosion.

Intervention:

A once-concrete stormwater channel in the park was transformed into a three-kilometre winding river bordered by lush, vegetated banks. This transformation combined civil engineering with soil bio-engineering methodologies and biophilic design principles. A total of 10 diverse bio-engineering techniques were evaluated prior to implementation to ensure the best possible outcome. The project also utilised existing parkland and waterway without additional land-take, thereby bolstering the project's feasibility.

Impact:

Savings of US$57 million in capital expenditure were achieved in comparison to the original concrete storm drain. The revamped space also saw a 2.4-3.6x increase in socio-economic value. Furthermore, these enhancements resulted in socio-economic benefits aligned with the United Nations' SDGs estimated at a minimum of US$105 million per year.

Project Sponsors: Joint collaboration between PUB, Singapore's National Water Agency, and the National Parks Board

Source: WWF Urban Nature-based Solutions

Financing

2.1 Engaging stakeholders in prioritisation and funding strategy

NbS for A&R, while generally more cost-effective than traditional built infrastructure, still requires significant capital. For these solutions to be truly impactful in building A&R against a community's climate risks, robust funding is required.

The funding process encompasses two main steps:

- Prioritising projects from the portfolio formulated during the planning phase.
- Developing a funding strategy tailored to the local landscape and the prioritised projects. In both steps, stakeholder engagement is critical.

Engaging key decision-makers helps to identify their different priorities selecting and endorsing A&R initiatives. For instance, while private companies might emphasise the economic returns of an A&R initiative, government units could prioritise its social benefits, such as protecting vulnerable populations. Local communities should also be engaged to understand their specific circumstances and lived realities. Engagements should be broad and incorporate perspectives from those within different income levels, gender, age, and occupations.

Insights from these stakeholders will determine the types of data required for prioritisation, ensuring all relevant interests are considered. This might include data on project timelines, expected co-benefits, or potential adverse effects. To enhance decision-making accuracy, the data collected should be corroborated by the respective stakeholders.

Similarly, crafting a funding strategy hinges on stakeholder input. Project owners should engage potential funders to grasp their objectives and gauge their interest in supporting projects in a target municipality. Familiarity with funders' primary concerns can better align projects with funding sources. Local government insights can illuminate key policy incentives and regulatory levers that influence available climate financing. Additionally, contributions from academic institutions and civil society organisations can spotlight broader fundraising opportunities in the ecosystem.

2.2 Project prioritisation

Project owners need to synthesise insights from the various stakeholder engagements to formulate a comprehensive prioritisation framework. This framework will likely include various criteria, such as project cost, implementation ease and speed, potential co-benefits, required capabilities, possible negative repercussions, and others.

This framework will then be converted into an AI model to generate the impact of different solutions. This will allow project owners to weigh the trade-offs among the different options and discern distinct project patterns within the portfolio that will inform the overall funding strategy.

2.3 Designing a financing strategy

Once A&R projects are prioritised, the next step is aligning them with suitable funding sources.

The first step to designing a financing strategy is by thoroughly understanding the city's financial landscape. This involves examining current financing policies, as well as relevant legal, institutional, and operational frameworks applicable for A&R initiatives. Such an understanding can reveal policy levers instrumental in facilitating A&R financing.

Subsequently, a comprehensive list of prospective funders should be curated, encompassing public entities, development finance institutions (DFIs), climate funds and investments, public-private partnerships, and more. For each funder, project owners must understand the potential funding amounts and preconditions for eligibility.

By aligning the project types with available funders and their priorities, project owners can then begin to craft strategies tailored to each project and its corresponding funder. This alignment enables the harnessing of investments from multiple sources.

Finally, a clear financing roadmap is paramount. This roadmap should include the financing timeline and targets mapped against the requirements of priority projects and their corresponding implementation timelines.

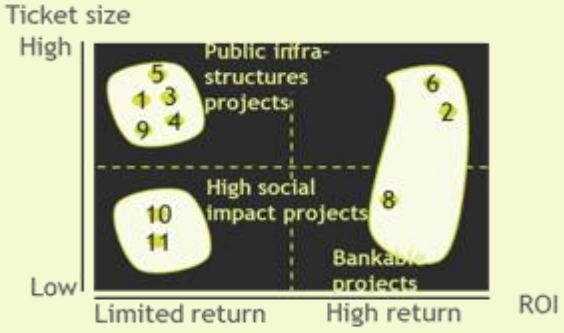
CASE STUDY: Crafting a Funding Approach for an Integrated A&R Plan in an African Mega-City

Challenge:

- The city faces multiple climate threats, with flooding, sea-level rise, storm surges, elevated temperatures, and intense rainfall being predominant. These challenges are intensified by the city's unique factors—high population density, large-impoverished population, its coastal location, and a low-lying topography.
- The city's adaptive capacity is often constrained by institutional weaknesses.
- Failure to act could result in a cost of US$27-34 billion by 2050 due to sea level rise and extreme temperatures, a figure surpassing 12x the state's 2021 budget.

Intervention:

- A stakeholder engagement plan was laid out over a span of six months.
  - Engagements ranged from individual discussions to public launches, specialised workshops, and investor roundtables.
  - The roster of stakeholders spanned government bodies, regulators, private investors, developmental and bilateral organisations, specialised funds, project partners, credit guarantee agencies, and technical experts.
- The A&R solutions were categorised according to their ROI and ticket size.
  - From a portfolio of 16 A&R solutions designed to mitigate the negative impacts of extreme heat, solutions varied from NbS to hybrid green-grey infrastructures, and traditional engineered infrastructures. Examples include:
    - NbS: Introducing climate-resilient trees in high-risk heat zones and implementing evaporative cooling systems such as large and small water bodies within the city.
    - Hybrid green-grey solutions: Incorporating green wall systems.
    - Traditional engineered solutions: Constructing a street grid optimised for wind ventilation, complete with shading structures.
  - A 2x2 matrix was developed to organise projects according to their ROI and ticket size (i.e., cost of the A&R project), with the ROI reflecting the social, economic, and environmental impacts, as well as the co-benefits of the A&R solution.
  - Using this matrix, three main project archetypes were identified to guide the funding strategy.



- A financing strategy was designed for the shortlisted solutions.
  - BCG developed a structured framework to provide a clear financing direction.

Explanation of how each strategic component comes together:

- High ROI projects: These are bankable and thus highly attractive for funders. Institutions such as DFIs, multilateral and bilateral banks, as well as corporates, are likely to be interested investors.
- High capital requirement but low ROI projects: These can be positioned as vital public infrastructure projects. Funders for such projects are not solely driven by direct financial returns. They place significant value on overarching impacts, including the social and natural consequences of projects.
- Low-ticket size and low ROI projects: These are suitable as social- impact projects. Their primary impacts lie not in tangible financial benefits, but in the less quantifiable realms, such as the protection of vulnerable groups.

Expected Impact:

Secure technical assistance and pre-feasibility funding for 2-3 of the prioritised projects.

Source: BCG case

Implementation

3.1	Engage, advocate, and build capacity among stakeholders

Much like the previous steps, effective implementation begins by actively engaging key stakeholders to foster support and build capacity. Embracing a co-creation governance model, which emphasises multi-stakeholder co-implementation, often yields better results than traditional, isolated approaches.

When crafting an engagement strategy, several fundamental questions arise:

- Who are the vital stakeholders for the co-implementation of the NbS?
- What role does each entity play?
- How can these entities best collaborate?

For instance, initiating a dialogue with community leaders can provide insights into the details of a chosen A&R solution. Project owners stand to gain insights on matters such as the intervention area, preferences for certain natural assets, potential challenges in solution delivery, and more.

Local government engagement is paramount at this stage to explore incentives or policies that support the success and longevity of the A&R solution. In the context of urban greening, for instance, communities might receive rewards—be it monetary or in-kind—for maintaining the newly planted trees in their vicinity. Additionally, holding workshops with city authorities is a powerful tool to ensure there are synergies

between the community's disaster risk plans, the overarching A&R strategy, and the particular A&R solution being put into action.

Finally, it is essential to prepare a clear handover plan to identify the long-term owners of the project, whether they be city personnel or even newly formed bodies. Whomever they may be, it is crucial to provide capacity-building programmes, ensuring the long-term project owners possess the requisite skills and knowledge to maintain and enhance the A&R solution's effectiveness.

CASE STUDY: Online Survey and Consultations with Local Stakeholders of Vietnam's Central Truong Son Region

Location: Central Truong Son, situated within the longest mountain range spanning Vietnam and Lao PDR, boasts one of Asia's most expansive uninterrupted natural forests.

Challenge:

The landscape's natural habitats are threatened by many human development activities such as legal and illegal land-use, illegal wildlife poaching and trade, and illegal logging for timber and non-timber products. With the help of WWF Vietnam, it is now a regenerative landscape offering protection to many plant and animal species. However, the landscape faces several more challenges in the face of climate change, including exposure to risks such as:

- Heavy rains causing floods, flash floods with deadly mud and rocks, landslides, and destruction of dykes, houses, crops, and roads.
- Abnormal extreme heat lasting for a long time during the dry season, resulting in low rainfall and humidity, severe drought, expanding desertification (the Central and Central Highlands are ranked second of the four areas at high risk of desertification in Vietnam), and wildfires.

Intervention:

An online survey was used to gather and analyse the concerns, opinions, and suggestions of various stakeholders on the proposed NbS. The survey informed further consultations and interviews with stakeholders, which were conducted face-to-face, online, or by phone call. The survey also raised awareness on NbS and encouraged increased adoption for climate change adaptation and mitigation, and biodiversity conservation. Over 60 stakeholders were engaged for this project, which included representatives from:

- WWF staff in Hanoi and specific project areas.
- Government officials and departments (e.g., Department of Agriculture and Rural Development, Departments of Natural Resources and Environment, etc.).
- Scientists/experts in relevant ministries, sectors, and other local officials.
- NGO representatives.
- Note: Gender was factored in the data collection and was disaggregated at certain points of the analysis.

Impact:

The suggestions and insights generated were leveraged to guide the implementation of selected NbS, including:

- Creating a green belt for wildfire prevention and control by creating a cultivation garden and planting indigenous trees based on traditional knowledge.
- Developing Ru Cha mangrove forest into an open conservation zone.
- Enriching forests and improving the livelihoods of ethnic minority communities by developing value chains of rattan, bamboo, and medicinal plants.

Source: WWF Vietnam

3.2 Technical assessment of priority A&R solutions

A comprehensive technical assessment is imperative to ensure the feasibility and effectiveness of priority A&R solutions. This review should integrate principles for implementing climate-smart solutions. For instance, when selecting tree species to optimise the cooling effect, choices should avoid endemic species, thereby ensuring a better fit for the local context and streamlining procurement and maintenance costs.

It's also crucial to identify potential synergies with current A&R interventions both within and outside the intended intervention area. As an example, introducing NbS upstream might reduce the need for built structures downstream. Evaluating such impacts is essential to lessen duplication and to enhance the overall effectiveness of A&R efforts in intervention.

Risk assessment is another key component at this stage. Project owners need a holistic understanding of the interplay among the economy, society, and ecosystems. AI could be deployed to assist in culminating the assessment into a robust risk management plan, ensuring that potential challenges in solution delivery are adequately addressed and mitigated.

CASE STUDY: Community-Based Mangrove Restoration

Location: Ayeyarwady Delta, Myanmar

Challenge:
Over the past two decades, Myanmar has lost over 60% of its mangrove forests due to illegal logging, land expansion, and unsustainable livelihood practices.

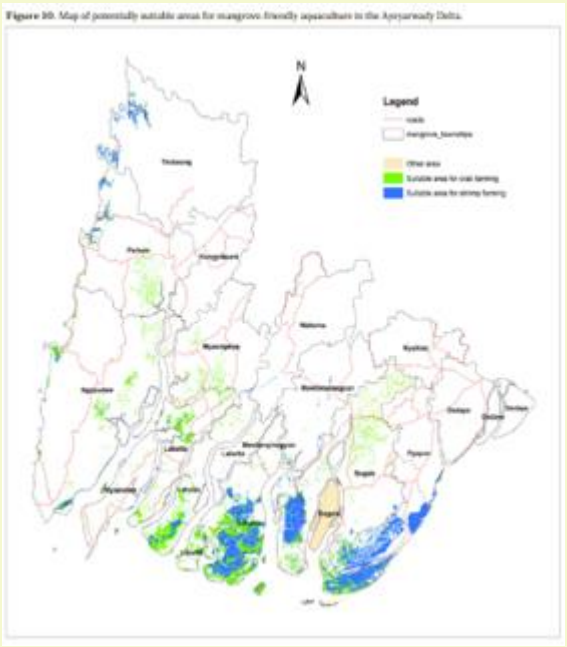
Intervention:
Local communities were offered training and workshops on mangrove-friendly aquaculture farming, learning about mud-crab and shrimp farming, as well as methods that do not require land conversion and can be seamlessly integrated into the mangrove ecosystem.

Technical assessments undertaken:

- Site suitability identification – To determine suitable areas for mangrove-friendly aquaculture, three conditions must be fulfilled, and a mapping exercise was carried out:
  - Mangrove land - Essential for sustainable aquaculture.
  - Height above sea level – Using Climate AI (specifically Climate Central's Digital Elevation Model), the elevation of mangrove land was analysed to ensure the ponds would receive adequate water supply.
  - Protected area considerations – Farming sites must be located outside of national parks or other protected areas.
- Investment requirements – This covered the financial aspects linked to pond construction, mangrove rehabilitation, and capacity development for local farmers:
  - Mixed planting was recommended to enhance diversity and productivity by maintaining multiple species and canopy layers in the ponds.
- Landscape impact:
  - A baseline valuation of pond areas was undertaken, detailing both monetary outcomes (such as net income in US$ millions) and non-monetary benefits, including carbon sequestration, creation of green jobs (measured in full-time equivalents), and species diversity (using the Shannon Index).
  - Modelled 2 green growth scenarios: 1) mangrove-friendly aquaculture, and 2) higher priority on crab-culture (more mangrove-friendly) while considering monetisation opportunities via carbon credits.
  - The ROI for each model was then calculated.

Risk analysis and inventory:

- Using the CSR Risk Check Tool by MVO Nederland, potential risks were identified across 4 domains:
  - Fair Business Practices
  - Human Rights and Ethics
  - Labour Rights
  - Environment



Caption: Map of suitable sites for mangrove-friendly aquaculture

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Impact:
10 communities are now sustainably managing ~1,500 hectares of mangrove forests. Support has also been provided to 8,265 individuals, enabling them to better adapt to the effects of climate change. This transformative journey has also resulted in economic results, with the value of coastal protection offered by these mangrove forests to be estimated at US$177.54 million.

Additionally, the community has benefitted from higher quality livestock thanks to sustainable practices. A cost benefit analysis comparing aquaculture without mangroves to that within mangroves further indicated more favourable economic outcomes for the latter (difference ranged from US$65 to US$250 per hectare per year).

Source: WWF Myanmar (https://www.wwf.org.mm/en/reports/?uNewsID=376718)
https://wwfasiapacific.exposure.co/working-with-local-communities

3.3 Establish monitoring, evaluation and learning mechanisms

NbS often deliver their benefits over time. Given that factors like climate patterns, potential hazards, and the efficacy of A&R solutions can change, it is essential to continuously learn and adapt to ensure the targeted outcomes are met. Effective monitoring, evaluation, and learning (MEL) mechanisms are key to this adaptability.

Begin by determining the success metrics for the A&R solution. The "Theory of Change" framework can provide clarity on how the proposed solution will achieve the intended A&R outcomes.[76] This requires defining specific metrics and assumptions at every level of the framework.

Next, use advanced analytics and AI to create a dashboard that captures the metrics pertinent to the A&R solution. This dashboard should be tailored to its audience, offering different views for different stakeholders. For instance, while the long-term project team might focus on data inputs, decision-makers would benefit from comparing projected outcomes against actual results.

Finally, it is essential to embed these MEL practices within the project team and among sponsors. This means clearly assigning roles and responsibilities to team members and relevant city authorities. In addition, establish a consistent review schedule for the A&R solution. Regular check-ins ensure that if the project deviates significantly from its intended outcomes, experts can step in with recommendations for course corrections.

CASE STUDY: Monitoring and Evaluation of Vietnam's National Adaptation Plan

Location: Vietnam

Challenge:

Vietnam ranks high on the list of countries most vulnerable to climate change impacts. The country has approved the NAP for 2021-2030, extending its vision to 2050. An essential component of this plan is a monitoring and evaluation system to track its implementation progress.

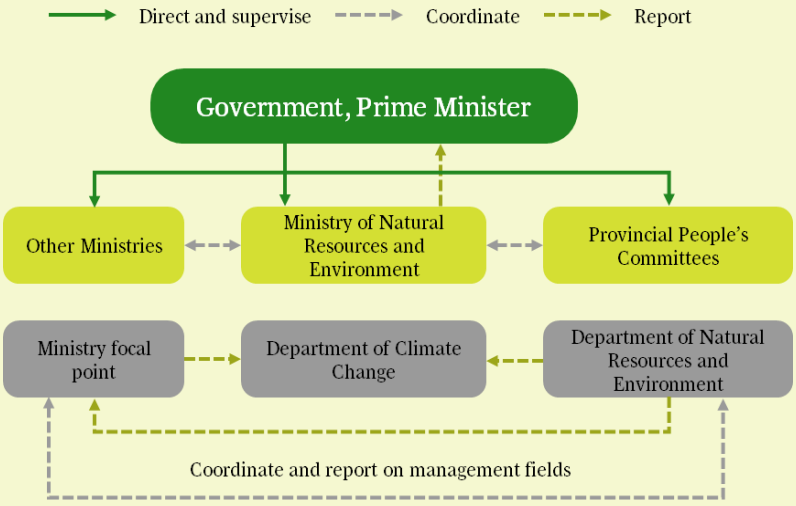
Intervention:

An organised structure was established, offering clearly defined roles and responsibilities for different stakeholders, including ministries, ministerial-level agencies, and provincial-level People's Committees. An online reporting dashboard was also introduced to upload monitoring and evaluation (M&E) results and assist key players in implementing the M&E system. Each ministry, as part of this system, is allocated an account to input its data into the dashboard.

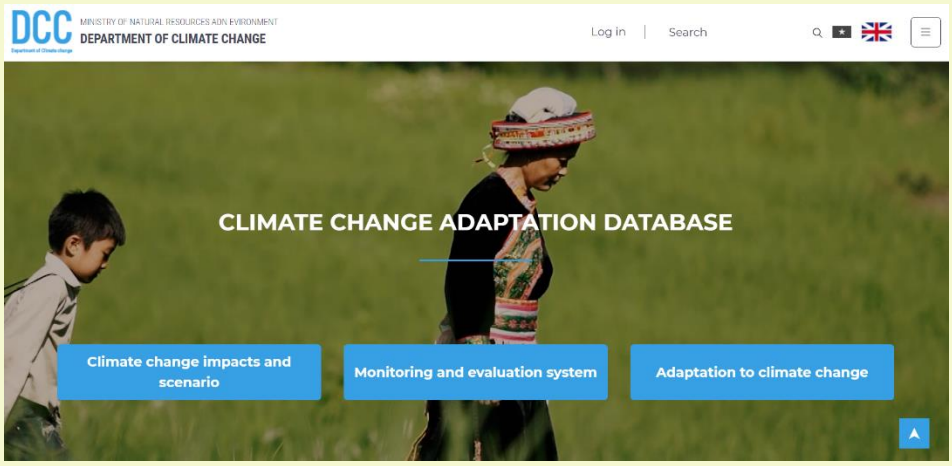
The Ministry of Natural Resources and Environment (MONRE) then consolidates this data to monitor performance metrics related to climate adaptation, the SDGs, and the Sendai Framework for Disaster Risk Reduction. To ensure a smooth transition and efficient operation of this M&E system, consultations and training workshops were conducted for capacity-building.

Impact:

The dashboard has effectively streamlined data collection for management staff, facilitating efficient report generation on adaptation activities. It also equips ministries, ministerial-level agencies, and provincial-level People's Committees with the ability to easily update information online.



Caption: Organisation supervision and coordination of the implementation of the M&E system



Caption: Homepage of Vietnam's Climate Change Adaptation Database, http://adaptation.dcc.gov.vn

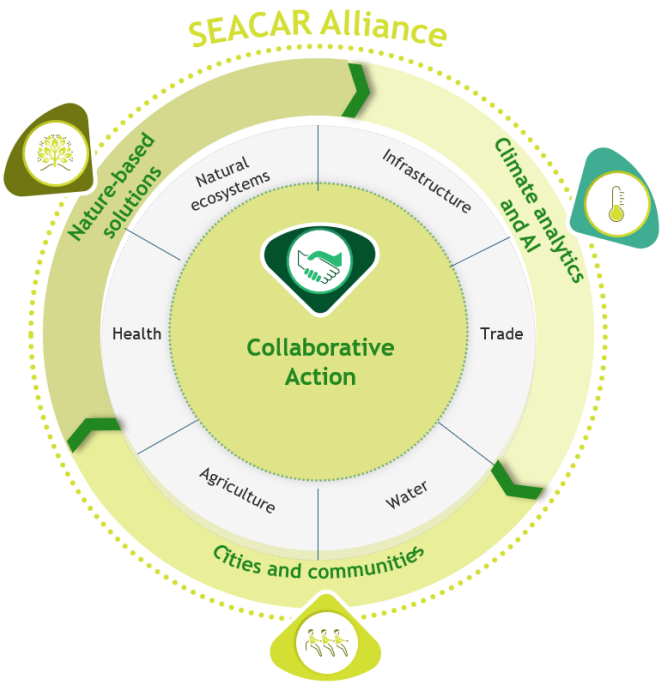
Source: Viet Nam's Approach to Monitoring & Evaluation (M&E) of the National Adaptation Plan, Department of Climate Change

Conclusion

In the face of undeniable and pressing climate challenges, there is no room for complacency in Southeast Asia. Actionable and meaningful A&R efforts are not just necessary, they are imperative for the region's future. The SEACAR Alliance believes that collaborative efforts, NbS, and Climate AI have the potential to propel Southeast Asia toward a climate-resilient future. These tools, aimed towards six pivotal and interlinked themes—natural ecosystems, infrastructure, trade, water, agriculture, and health—offer A&R practitioners a strategic playbook to combine and deploy both NbS and AI for the region's urban areas.

Moving forward, it is the collective spirit and united commitment of Southeast Asia that holds the promise of a resilient future. As residents of this vibrant region, we must embrace this journey together, forging a path defined by collaboration and purposeful action.

About the SEACAR Alliance



Vision

Centred on collaborative action, the Alliance aims to emphasise the importance of nature-based solutions, climate analytics, and AI in advancing the resilience of cities and communities across six key themes.

Pillars

SEACAR differentiates itself from other initiatives by highlighting the combined potential of nature and AI in addressing climate risks at a city scale. We believe that Southeast Asia is in a prime position to harness the power of nature, climate analytics, and AI to accelerate this endeavour. The actions we take in cities and communities will shape Southeast Asia's resilience in the upcoming decades.

Themes

The selected themes are sectors most impacted by climate hazards in the region:

- **Infrastructure** encompasses housing, educational and healthcare facilities, transportation, and more. Climate adversities can damage this infrastructure, impeding economic progress and leading to community displacements.
- **Trade**, a vital pillar of Southeast Asia's economy, faces threats from climate hazards that can disrupt trade routes, maritime channels, and global value chains.
- **Water**, vital for human survival, also serves as an economic resource in agriculture, manufacturing, and energy. Its quality and availability can be compromised by unpredictable rainfall, flooding, and other events.
- **Agriculture** is pivotal for food security and is a major GDP and livelihood source; climate hazards can result in diminished crop and livestock productivity.
- **Health** bears the brunt of climate adversities. This includes physical health concerns such as heat-related ailments and vector-borne diseases, mental health issues arising from displacements, and strains on health infrastructure.
- **Natural ecosystems** offer crucial services, including carbon sequestration, water regulation, and soil stabilisation. However, climate hazards can impair these ecosystems, limiting their capability to deliver these services.

Our invitation to you

The Alliance believes that the most impactful solutions can only come from rich and collaborative action. Hence, we invite stakeholders from all walks to reach out and engage with the SEACAR Alliance. Potential avenues of engagement include:

- **Joint knowledge sharing** – Contribute experiences and insights to the Alliance's annual co-publication, and partake in interviews, workshops, and roundtables to elevate the A&R profile in Southeast Asia.

- **Provide topic leadership** – Lead in co-authoring or contributing extensively to selected topics for the annual co-publication, and champion dialogues and discussions with regional stakeholders.

- **Be a resource partner** – Assist the Secretariat with funding or manhours, back an A&R pilot project in the region and magnify SEACAR's influence by broadening its network or spotlighting it at key climate events.

Active participation with the Alliance offers myriad advantages. This includes access to a vast regional knowledge pool on climate A&R, collaborative data and idea exchanges with key regional stakeholders, and the opportunity to expand your network and platform across various sectors in Southeast Asia.

Help us chart a climate-resilient course for Southeast Asia.

ENDNOTES

1. Notre Dame Global Adaptation Initiative (2019). Available on: https://gain.nd.edu/about/ (Accessed on: 30 November 2023)

2 ADB. (2023) Climate Finance Landscapre in Asia and the Pacific [online] Available on: www.adb.org/publications/climate-finance-landscape-asia-pacific

3 E. L. Birch, M. Rodas, S. Geldin and A. Llyod (2023) State of Finance in Nature in Cities: Time to Assess. UNEP Report. Paris: United Nations.

4 WWF-IFRC. (2022) Working with Nature to Protect People

5. Bündnis Entwicklung Hilft / IFHV (2023): WeltRisikoBericht 2023. [online] Available on: https://www.ifhv.de/publications/world-risk-report

6. Oxford Economics. Global Economic Databank. [online] Available on: https://data.oxfordeconomics.com/. (Accessed on: 23 Sep 2023)

7 IMF Data. International Finances [online] Available on: https://www.imf.org/external/datamapper/NGDP_RPCH@WEO/WEOWORLD/SEQ (Accessed on: 30 Nov 2023)

8. Oxford Economics. Global Economics Databank. [online] Available on: https://data.oxfordeconomics.com/ (Accessed on: 23 Sep 2023)

9. International Labour Organization. (2023) World Employment and Social Outlook: Trends 2023 [online]. Available on: https://industrialrelationsnews.ioe-emp.org/industrial-relations-and-labour-law-february-2023/news/article/world-employment-and-social-outlook-trends-2023-an-ilo-report

10. ADB SEADS. (2022) Breaking the Waves: Kickstarting the Global Sustainable Blue Economy in Southeast Asia

11. Thorhaug, A., Gallagher, J. B., Kiswara, W., Prathep, A., Huang, X., Yap, T. K., ... & Berlyn, G. (2020). Coastal and estuarine blue carbon stocks in the greater Southeast Asia region: seagrasses and mangroves per nation and sum of total. Marine Pollution Bulletin, 160, 111168.

12 S.C. Kwan and D McCoy. (2023) Climate displacement & migration in South East Asia [online]. Available on: https://reliefweb.int/report/viet-nam/climate-displacement-migration-south-east-asia (Accessed on: 30 November 2023)

13. Renaud, F., Chardot, L., Hamel, P., Cremin, E., Ng, D. K., Balke, T., ... & Horton, B. P. (2021). Adaptation and Resilience in ASEAN: Managing Disaster Risks from Natural Hazards.

14. Nadarajah, H. (2023) Environmental Intelligence: The Ambitious New Global Biodiversity Framework: The View from Southeast Asia. [online] Available on: https://www.asiapacific.ca/publication/enviro-intelligence-ambitious-new-global-biodiversity-framework-southeast-asia (Accessed on: 30 November 2023)

15. Chow, W. (2015) How climate change will affect transboundary haze. [online] Available on: https://www.todayonline.com/commentary/how-climate-change-will-affect-transboundary-haze (Accessed on: 30 November 2023)

16. Osborne, Z. (2020), The great salt drought desiccating Vietnam's Mekong Delta. [online] Available on: https://www.aljazeera.com/features/2020/4/22/the-great-salt-drought-desiccating-vietnams-mekong-delta (Accessed on: 30 November 2023)

17. Kwan, S.C. and McCoy, D. (2023) Climate displacement & migration in South East Asia. [online] Available on: https://www.aljazeera.com/features/2020/4/22/the-great-salt-drought-desiccating-vietnams-mekong-delta (Accessed on: 30 November 2023)

18. Klein, R. J., Harris, K., Benzie, M., & Lager, F. (2023). The Global Transboundary Climate Risk Report 2023.

19. Oxford Economics. Global Economics Databank. [online] Available on: https://data.oxfordeconomics.com/ (Accessed on: 23 Sep 2023)

20. Philippine Climate Change Commission. (2018) National Adaptation Plan Global Support Program

21. Dotto, C., Shveda, K. and Robison, L. (2023) A 'once-in-200 years' heat wave caught Southeast Asia off guard. Climate change will make them more common [online] Available on: https://www.aljazeera.com/features/2020/4/22/the-great-salt-drought-desiccating-vietnams-mekong-delta (Accessed on: 30 November 2023)

22. Lotulung, G. (2023), Indonesia's Drowning Land [online] Available on: https://thediplomat.com/2023/02/the-drowning-land/ (Accessed on: 30 November 2023)

23 ASEAN Secretariat. (2022) ASEAN Statistical Year Book 2022. [online] Available on: https://www.aseanstats.org/wp-content/uploads/2023/04/ASYB_2022_423.pdf

24. Kyriakopoulou, D., Kyricou, G. and Pearson, N. (2023) How does climate change impact on international trade?

25. ISEAS – Yusof Ishak Institute. (2023) Rice Production and Food Security in Southeast Asia under Threat from El Niño

26. IPCC. (2021) The Sixth Assessment Report [online] Available on: https://www.ipcc.ch/assessment-report/ar6/

27. Dodman, D., B. Hayward, M. Pelling et.al. (2022) Cities, Settlements and Key Infrastructure. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

28. Z. Hirji (2023). Major Climate Disasters Cost the U.S. $165 Billion in 2022 [online] Available on: https://www.bloomberg.com/news/articles/2023-01-10/us-storms-heat-drought-racked-up-165-billion-of-damage-in-2022 (Accessed on: 25 November 2023)

29. C40 Cities (2022). Climate-related flooding and drought expected to impact millions of people and cost world's major cities $194 billion annually [online] Available on: https://www.c40.org/news/climate-related-flooding-drought-cities-billions/ (Accessed on 25 November 2023)

30. CDP. Cities at risk: dealing with the pressures of climate change [online] Available on: https://www.cdp.net/en/research/global-reports/cities-at-risk (Accessed on 22 November 2023)

31. Hallegatte, S., Rentschel, J. and Rozenberg, J. (2019) Lifelines: The Resilient Infrastructure Opportunity [online] Available on: http://hdl.handle.net/10986/31805 (Accessed on: 20 November 2023)

32. Glavovic, B.C., Chow, Y., … and Garschagen, M. (2022) Cross-Chapter Paper 2: Cities and Settlements by the Sea. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change

33. Hallegatte, S., Rentschel, J. and Rozenberg, J. (2019) Lifelines: The Resilient Infrastructure Opportunity [online] Available on: http://hdl.handle.net/10986/31805 (Accessed on: 20 November 2023)

34. Kutner, M. (2021) Cities on the Route to 2030

35. Bapna, Brandon, M.C., … and Chan, C. (2019) Adapt Now: A Global Call for Leadership on Climate Resilience

36. Ritchie, H. and Roser, M. (2019) Urbanization

37. Dahiya, B. (2014) Southeast Asia and Sustainable Urbanization; UN-Habitat (2022). ASEAN Sustainable Urbanization Report

39. ASEAN Publication. (2022) ASEAN Sustainable Urbanisation Report

40. ADB. (2023) Climate Finance Landscape of Asia and the Pacific

41. ADB. (2022) ADB Southeast Asia Innovation Hub: Catalyzing Green and Innovative Finance

42. Mandai Nature. (2022) Building a Sustainable Southeast Asia through Nature-based Solutions [online] Available on: https://www.mandainature.org/en/home/news-and-update/building-a-sustainable-southeast-asia-through-nature-based-solutions.html (Accessed on 15 November 2023)

43. Natural-based Solutions Evidence Platform [online] Available on; https://www.naturebasedsolutionsevidence.info/evidence-tool/ (Accessed on: 25 Octorber 2023)

44. Kikstra, J. S., Nicholls, Z. R., Smith, C. J., Lewis, J., Lamboll, R. D., Byers, E., ... & Riahi, K. (2022). The IPCC Sixth Assessment Report WGIII climate assessment of mitigation pathways: from emissions to global temperatures. Geoscientific Model Development, 15(24), 9075-9109.

45. WWF. Where do orangutans live? And eight other orangutan facts [online] Available on: https://www.worldwildlife.org/stories/where-do-orangutans-live-and-eight-other-orangutan-facts (Accessed on: 30 November 2023)

46. Yayasan Hasanah. Strengthening Capacity and Capability in Conservation [online] Available on: https://yayasanhasanah.org/impact-areas/environment (Accessed on 30 November 2023)

47. World Bank. (2021) Opening the door to Community Forest Access and Management in Indonesia [online] Available on: https://www.worldbank.org/en/news/feature/2021/10/21/opening-the-door-to-community-forest-access-and-management-in-indonesia (Accessed on 30 November 2023)

48. Bertule, M. and Hansen, L. R. (2022) Nature-based solutions to Emerging Water Management Challenges in the Asia-Pacific Region, UN Environment Programme and UN Climate Technology Centre & Network

49. Miralles-Wilhelm, F. (2021) Nature-based solutions in agriculture, Food and Agriculture Organization of the UN and The Nature Conservancy

50. MacKinnon, K., van Ham, C., Reilly, K. and Hopkins, J. (2019) Nature-based solutions and protected areas to improve urban biodiversity and health. In: Marselle M, Stadler J, Korn H, Irvine K, Bonn A (eds) Biodiversity and Health in the Face of Climate Change. Springer, Cham

51. de Wit, W., Freschi, A. and Trench, E. (2020) Covid-19 Urgent Call to Protect People and Nature

52. Doswald, N., Janzen, S., Nehren, U., Vervest, M. J., Sans, J., Edbauer, L., ... & Grey, C. (2021). Words into Action: Nature-based solutions for disaster risk reduction.

53. Barrow, E., Wit, P., Hawes, P., & Mainguy, G. (2012). IUCN commission on ecosystem management. SAPI EN Shar Knowl Prep Future, 57.

54. Cohen-Shacham, E., Andrade, A., Dalton, J., Dudley, N., Jones, M., Kumar, C., ... & Walters, G. (2019). Core principles for successfully implementing and upscaling Nature-based Solutions. Environmental Science & Policy, 98, 20-29.

55. Melanidis, M. S., & Hagerman, S. (2022). Competing narratives of nature-based solutions: Leveraging the power of nature or dangerous distraction?. Environmental Science & Policy, 132, 273-281.

56. Qi, J. (2021) How Timor-Leste Is Using the National Adaptation Plan (NAP) Process to Scale Up Ecosystem-Based Adaptation (EbA)

57. Makower, J. (2020) Trend: Companies warm to nature-based solutions [online]. Available on: https://www.greenbiz.com/article/trend-companies-warm-nature-based-solutions. (Accessed on: 30th November 2023)

58. Wendo, H. (2022) Financing Ecosystem Restoration and Biodiversity Conservation: Lessons and Opportunities from Climate Finance [online] Available on: https://www.opml.co.uk/blog/financing-ecosystem-restoration-biodiversity-conservation-lessons-opportunities-climate-finance (Accessed on: 30 November 2023)

59. United Nations Environment Programme (2022). State of Finance for Nature. Time to act: Doubling investment by 2025 and eliminating nature-negative finance flows. Nairobi. [online] Available on: https://wedocs.unep.org/20.500.11822/41333 (Accessed on: 30 November 2023)

60. COP27 Presidency. (2022) Sharm-El-Sheikh Adaptation Agenda

61. Narayan, S., Beck, M. W., … and Reguero, B. G. (2016) The Effectiveness, Costs and Coastal Protection Benefits of Natural and Nature-Based Defenses

62. Markandva, A. and González-Eguino, M. (2019), Integrated Assessment for Identifying Climate Finance Needs for Loss and Damage: A Critical Review; Mechler, R., … and Bouwer, L. (2019) Loss and Damage from Climate Change

63. WWF-IFRC. (2022) Report Working with Nature to Protect People

64. United Nations Office for Disaster Risk Reduction - Regional Office for Asia and Pacific. (2020) Ecosystem-Based Disaster Risk Reduction: Implementing Nature-based Solutions for Resilience

65. United Nations Office for Disaster Risk Reduction - Regional Office for Asia and Pacific. (2020) Ecosystem-Based Disaster Risk Reduction: Implementing Nature-based Solutions for Resilience

66. S. Nathalie, C. Alexandre, B. Pam, et.al. (2020) Understanding the value and limits of nature-based solutions to climate change and other global challenges

67. S. Nathalie, C. Alexandre, B. Pam, et.al. (2020) Understanding the value and limits of nature-based solutions to climate change and other global challenges

68. The Regeneration. (2022) The Tradeoffs Between Engineered and Nature-Based Solutions to Climate Change [online]. Available on: https://weekly.regeneration.works/p/the-tradeoffs-between-engineered

69. Browder, G., Ozment, S., Bescos, I. R., Gartner, T., & Lange, G. M. (2019). Integrating green and gray. World Bank and World Resources Institute: Washington, DC, USA.

70. BCG. (2022) BCG Climate AI survey

71. BCG. (2022) How AI can be a Powerful Tool in the Fight against Climate Change, AI for the Planet 2022

72. Change, I. C. (2014). Mitigation of climate change. Contribution of working group III to the fifth assessment report of the intergovernmental panel on climate change, 1454, 147.

74. Masson-Delmotte, V. P., Zhai, P., Pirani, S. L., Connors, C., Péan, S., Berger, N., ... & Scheel Monteiro, P. M. (2021). Ipcc, 2021: Summary for policymakers. in: Climate change 2021: The physical science basis. contribution of working group i to the sixth assessment report of the intergovernmental panel on climate change.

75. Pörtner, H., Roberts, D. C., Parmesan, C., Adams, H., Adelekan, I., Adler, C., ... & Caretta, M. A. (2023). IPCC 2022: Technical Summary, Working Group II Impacts, Adaptation and Vulnerability (Doctoral dissertation, Intergovernmental Panel on Climate Change)

76. Hendrickson, C. Y., & Henrysson, M. (2023). 4. Theories of Change and results-based management for the sustainable development agenda. Strategic Thinking, Design and the Theory of Change: A Framework for Designing Impactful and Transformational Social Interventions, 56

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