Why Climate Mitigation and Adaptation Must Work in Tandem

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Executive Summary

The effects of climate change become more visible with each passing season—and with global warming now on a trajectory to exceed 2°C, the conditions under which adaptation solutions remain effective are approaching their limits. In this context, the need to coordinate adaptation and mitigation solutions is more urgent than ever. This report explores why integrated approaches matter, how multifunctional solutions can help expand climate resilience, and what actions public and private sector actors can take to scale impact quickly.

Mitigation and adaptation need to work in tandem, and neither can succeed alone. As climate impacts intensify, it is no longer sensible to treat adaptation and mitigation as parallel or separate efforts. Adaptation strategies can reduce losses, but their effectiveness diminishes rapidly beyond certain warming thresholds. Without extensive mitigation efforts, these limits come faster, leaving communities more vulnerable and investments less effective. Advancing both mitigation and adaptation together is not just more efficient—it is essential for protecting people, infrastructure, and economies.

Multifunctional solutions can help accelerate climate progress and unlock economic returns. Many adaptation strategies, such as nature-based solutions—actions taken to protect, sustainably manage, and restore natural or modified ecosystems in ways that address societal challenges effectively and adaptively while also providing human well-being and biodiversity benefits—or resilient energy systems, can deliver powerful mitigation co-benefits to accelerate climate progress. Such integrated solutions help overcome institutional silos, maximize effective use of limited resources, deliver climate resilience, reduce emissions, create revenue streams, and boost ROI.

Examples on the ground show the effectiveness of multifunctional solutions. Governments and businesses are already demonstrating how integrated climate responses can succeed. For example, mangrove restoration in the Philippines has reduced flood risk at a fraction of the cost of seawalls while simultaneously sequestering carbon. Projects in Thailand, the UAE, and Indonesia show how climate-smart design can enhance livability, economic performance, and positive environmental outcomes. Hybrid renewable systems in off-grid areas of the Philippines have cut energy costs and improved resilience.

Both public and private sectors have roles to play in scaling multifunctional solutions. Businesses can integrate climate risks and opportunities into their strategy, invest in dual-benefit technologies, and collaborate across value chains. Governments can align adaptation and mitigation in national plans, direct public finance toward integrated solutions, and enable inclusive, long-term planning. Together, businesses and governments can unlock capital, innovation, and delivery capacity at scale, moving from fragmentation to systemic impact.

Adaptation and Mitigation Must Work in Tandem Before Limits Close In

Global climate risks are rising, and the window for effective response is narrowing. A review of current emissions trajectories and policy commitments suggests that the long-stated goal of limiting global warming to 1.5°C may be out of reach. Instead, we are heading toward a 2.1°C to 3.6°C rise in temperature by the end of the century.[1] Although it may look incremental on paper, this shift has profound implications. Each additional tenth of a degree brings more severe, more frequent, and more widespread climate disruption and risks.

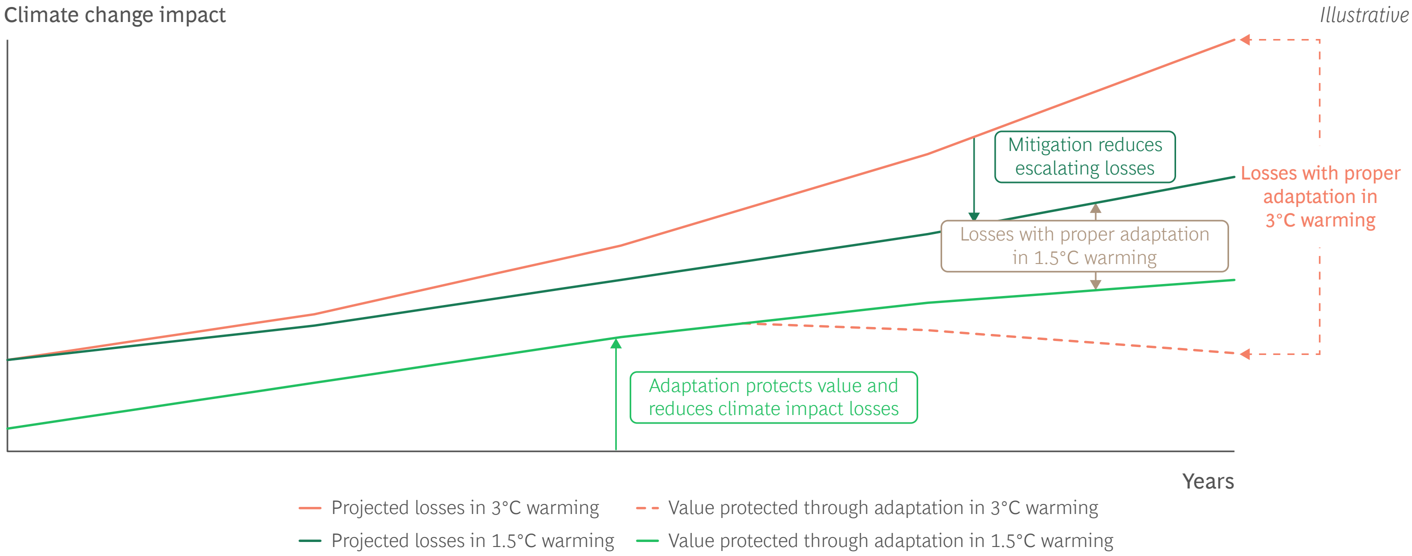
At these warming levels, the physical and economic toll compounds quickly. Global GDP could **decline by as much as 30%** under a 3°C scenario. Sea levels could rise by up to 1.8 meters, with flood damage potentially reaching $27 trillion annually.[2] These risks are no longer distant projections; they are already materializing in many regions. As the disruptions expand, one breakdown can set off another, amplifying risks across regions and sectors. The resulting social and economic shocks tend to fall disproportionately on vulnerable populations.

Adaptation and mitigation must work in tandem to intervene in this cascade. Adaptation reduces potential losses by enhancing the capacity of systems to withstand climate shocks. Mitigation solutions reduce the maximum extent of damage and prevent future losses from escalating in the medium to long term. Advancing both mitigation and adaptation concurrently could minimize the cost of climate change. (See **Exhibit 1**.)

1. Climate Action Tracker, "Warming Projections Global Update," November 2024.
2. Grandey et al., "Fusion of Probabilistic Projections of Sea-Level Rise," *Earth's Future*, December 2024; S Jevrejeva et al., "Flood damage costs under the sea level rise with warming of 1.5°C and 2°C", *Environmental Research Letters*, July 2018.

EXHIBIT 1

Mitigation and Adaptation Must Work in Tandem to Minimize the Cost of Climate Change Impact



Sources: CEPR; BCG analysis.

Adaptation solutions are vital but not boundless. They can make cities more liveable, infrastructure more durable, and communities more resilient. But adaptation has its limits—and with every year of delay in mitigation efforts, we move closer to those limits. In fact, emerging research suggests that adaptation effectiveness diminishes significantly with each degree of additional warming.

In a scenario involving an increase of 1.5°C, some current water-related adaptation solutions can reduce approximately 90% of potential losses. At 2°C, however, that number drops to 69%; and at 3° to 4°C, today's adaptation tools can manage less than half of projected risks. (See **Exhibit 2**.) Moreover, the economic return on those adaptation investments declines. For example, a seawall that delivers a 3:1 benefit-cost ratio at 1.5°C warming may fall below the breakeven point at 3°C.

In other words, rising temperatures push us ever closer to *hard limits* on adaptation effectiveness—ecological thresholds beyond which no technical adaptation solution, regardless of how well-funded or well-designed it is, can fully prevent loss and damage. For example, seawalls cannot protect low-lying islands against multimeter sea-level rise, and no cooling strategy will allow humans to work outside at wet-bulb temperatures above 35°C.[3] Put simply, the hard limits imposed by these ecological and biophysical thresholds overwhelm countermeasures that current technology can provide. (See **Exhibit 3**.)

Running up against hard limits carries significant social and economic costs and will leave societies worse off. In places like Fiji, for example, rising sea levels have already forced entire coastal villages to relocate to higher ground. Such relocation reduces physical exposure to flooding, but it also causes economic disruption, cuts cultural ties to ancestral lands, and requires substantial public expenditure.[4] (See "**Adaptation Limits in Southeast Asia**.")

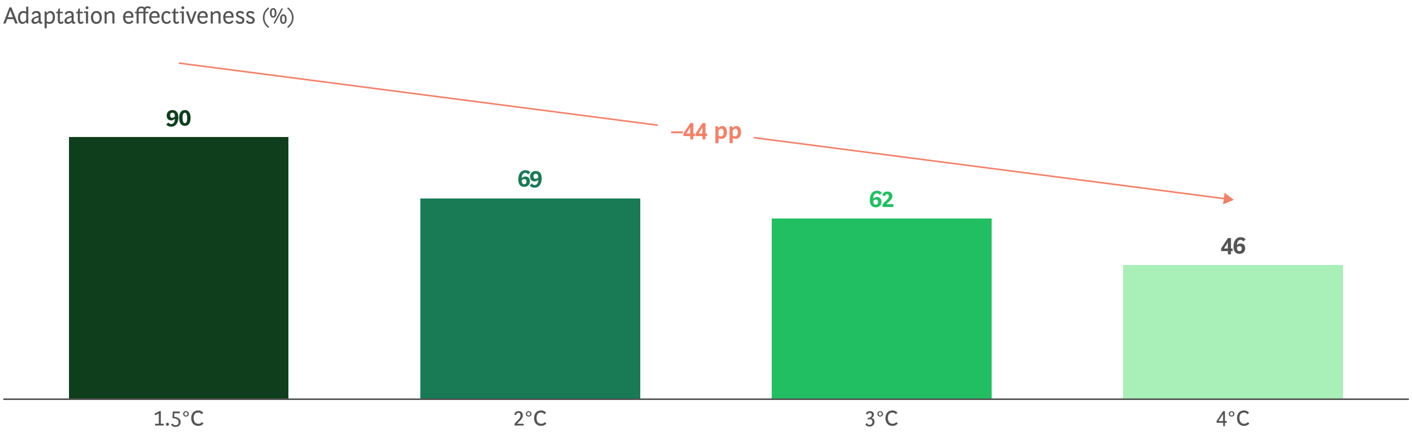
Adaptation solutions also face *soft limits*—barriers to implementation that can be overcome through policy reform, innovation, or institutional strengthening. Example of soft limits include the following:

- Social and cultural limits due to prevailing norms and values
- Economic and financial constraints that reduce the range, quality, or timeliness of adaptation boundaries
- Technological barriers, such as limits in innovation, access, and applicability of technologies in specific geographies
- Institutional and governance constraints, such as fragmentation, weak coordination, and limited enforcement

3. IPCC Sixth Assessment Report, August 2021.
4. Charan et al., "Customary Land and Climate Change Induced Relocation—A Case Study of Vunidogoloa Village, Vanua Levu, Fiji," *Climate Change Management* (2017).

EXHIBIT 2

The Effectiveness of Adaptation Solutions Diminishes Significantly as Temperature Increases



Sources: IPCC, Sixth Assessment Report (AR6); Lissner et al., "Effectiveness of water-related adaptation decreases with increasing warming", *One Earth* (2024); BCG analysis.
Note: Adaptation effectiveness of 100% would mean that the adaptation solution could recover all of the potential losses from climate hazards. pp = percentage points.

EXHIBIT 3

Adaptation Solutions Have Limits That Erode with Rising Temperatures

Non-exhaustive

Climate risk	Existing adaptation solutions	Adaptation solution limit
Urban extreme heat waves	• Urban greening/shade corridors • Heat-health early-warning systems • District cooling and passive building design	• Beyond ~2°C, lethal heat days can triple, beyond the capacity of cooling measures • At wet-bulb temperatures of ~35°C or higher, most measures are not effective
Coastal flooding and storm surges	• Seawalls, storm-surge barriers • Mangrove/marsh buffers • Infrastructure elevation	• For sea level rise of 1 meter or more, seawall costs increase significantly • Beyond 2 meters, no infrastructure can prevent permanent inundation
Coral bleaching and ocean acidification	• Shading structures and reef shelters • Assisted gene flow/heat-resistant corals • Reduction in pollution, overfishing	• At 1.5°C or more, warming can trigger annual mass bleaching • At 2°C, virtually all tropical reefs face functional collapse
Wildfires	• Fuel-load management and prescribed burns • Defensible space and fire-resistant buildings • Early detection and rapid response teams	• Warming beyond 2°C will double fire-weather days • Fire suppression costs are estimated to rise by 40% to 80% by 2050–2100 at the current rate of global warming

Sources: IPCC Sixth Assessment Report (AR6) – WGII (2022); IPCC Special Report on Global Warming of 1.5°C (2018); UNEP Adaptation Gap Report (2023);

Adaptation Limits in Southeast Asia

Parts of Southeast Asia's megacities and deltas are on track to fall below the average annual flood line by 2050 even if they reduce emissions moderately before then, meaning that they could face chronic inundation. In fact, land occupied by nearly one-fifth of Thailand's population and one-quarter of Vietnam's could lie below high-tide levels by 2100 despite ambitious mitigation efforts.[5] This represents a physical endpoint—or hard limit—in which traditional adaptations (such as higher seawalls and more widespread drainage systems) can no longer keep pace with coastal erosion and flooding, which will swallow homes faster than communities can defend or rebuild them.

Hard limits usually unfold after a gradual erosion of adaptive capacity over time. Failures of governance and societal commitment often exacerbate ecological tipping points and technological constraints, hastening the moment when adaptation options run out. For this reason, hard limits in Southeast Asia rarely emerge in isolation. Rather, they are the culmination of compounding stresses on natural and human systems.

By contrast, societies may reach soft limits even when technical solutions exist—because real-world barriers prevent implementation of those solutions. Financial constraints are a prime example: many local governments and communities lack access to capital or funding to invest in protective infrastructure, advanced technology, or capacity building. As a result, they may delay or underutilize feasible measures—from building seawalls to adopting drought-resistant agriculture—increasing the likelihood that manageable risks will escalate over time. A community may understand how to reinforce its shoreline—by planting mangrove, for example—but be unable to act due to budget limitations or land tenure issues.

Social and cultural factors—ranging from communities' understandable reluctance to relocate from ancestral lands to knowledge gaps that slow the adoption of climate-resilient practices—may also impede adaptation. These soft limits can compound over time. For example, underinvestment in resilience may lead to repeated disaster losses, which then drain local economies and further reduce their capacity to adapt. In Southeast Asia's agricultural heartlands, for instance, smallholder farmers are trying to adapt, but a lack of credit and policy support are preventing them from scaling their responses. This results in avoidable crop losses that undermine livelihoods and food security, which in turn shrink the resources available for future adaptation.[6]

To make matters worse, a soft limit left unaddressed today may evolve into a hard limit over time. In Southeast Asia's densely populated deltas and coastal zones, for example, delays in implementing protective measures—due to funding constraints or governance challenges—could allow sea-level rise and land subsidence to progress to a point at which adaptation options are significantly more constrained. Areas that were once inhabitable may face chronic inundation, making relocation the most viable option.[7] Clearly, the boundary between manageable risk and irreversible loss is shaped not only by physical thresholds, but also by the speed and effectiveness of our responses.

Another reality is that stress or failure in one domain can cascade into others, heightening overall vulnerability. For example, a drought in the Mekong River Basin is not just a local agricultural problem; it can simultaneously diminish hydropower generation, disrupt fisheries, and spur internal migration. Or consider what happened during the 2011 floods in Thailand, when insufficient flood protections around Bangkok led to the inundation of industrial estates. That disaster cost Japanese firms up to $15 billion in insured losses and disrupted global automotive and electronics supply chains.

These examples show how deficiencies in local adaptation can escalate into regional and even global economic trouble. In essence, failing to manage soft limits in one system can push another system over a hard threshold, creating cascading risks that extend across borders and sectors.

5. Kulp & Strauss, "New elevation data triple estimates of global vulnerability to sea-level rise and coastal flooding," *Nature Communications* (October 2019).
6. O'Neill et al., "Key Risks Across Sectors and Regions," 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 (2022).
7. Ibid.

Insurability as an Indication of Adaptation Limits

Insurance provides a valuable lens for assessing how the private market perceives and prices climate risks. When climate risk events become too frequent, severe, or uncertain, insurers may withdraw coverage or raise premiums sharply, signaling that the market's appetite or tolerance for risk has reached its limit.

For example, insurers have withdrawn from wildfire- and hurricane-prone markets in California and Florida, citing rising claims from policyholders that make coverage unaffordable.[8] Crop insurance programs in the US Midwest and in South Asia are also under strain as highly unpredictable rainfall patterns and variations in yield undermine the actuarial basis for affordable coverage.[9]

Interpreting insurability requires careful consideration of multiple market dynamics. Premiums and coverage availability are influenced by insurers' risk appetite, prevailing market cycles, reinsurance capacity, and the maturity of the local insurance ecosystem. Ultimately, declining insurability is evidence not that a region has crashed into hard adaptation limits, but rather that financial risk-sharing systems are reaching their tolerance threshold under current market conditions.

As such, these instances offer practical, though partial, signals of when and where climate risks are becoming too uncertain or uneconomical for private markets to bear, highlighting the need for public intervention, blended finance, or the adoption of systemic resilience measures to restore balance.

8. World Economic Forum, "How wildfire risk and extreme heat is changing the insurance industry" (2023); NBC News, "Hurricane risk in Florida is escalating. Home insurance is harder to get" (2025).
9. SOA Research Institute, "Projected Changes in Insurability and Affordability of Insurance Coverages Due to Climate Change" (2021); Eco-Business, "India's farm insurance proves costly for most vulnerable" (2025).

A New Imperative: Integration Instead of Parallel Tracks

Many organizations still treat adaptation and mitigation as separate domains, often led by different agencies, funded from different streams, and planned on separate timelines. But that divide is increasingly unworkable. In practice, mitigation and adaptation are interdependent levers, and neither is fully effective without the other.

Mitigation decisions directly influence a region's nearness to temperature thresholds that determine whether adaptation efforts succeed or fail. Likewise, many adaptation strategies, such as nature-based solutions, energy resilience infrastructure, and regenerative systems, can yield measurable climate mitigation benefits. Solutions that deliver on both fronts are no longer optional. They are essential.

If we act now, we can preserve our options. We can maintain a broad portfolio of financially viable, technically feasible, and socially inclusive adaptation strategies. But every delay in reducing emissions compresses that space, forcing harder tradeoffs, leaving more people at risk, and pushing some systems toward the edge of what can be protected.

The next frontier involves designing and delivering scalable multifunctional solutions—interventions that simultaneously address adaptation and mitigation and provide other benefits in a systemic rather than fragmentary way. By doing so, they avoid some painful tradeoffs, optimize resource use, and generate broader public value. (See **Exhibit 4**.)

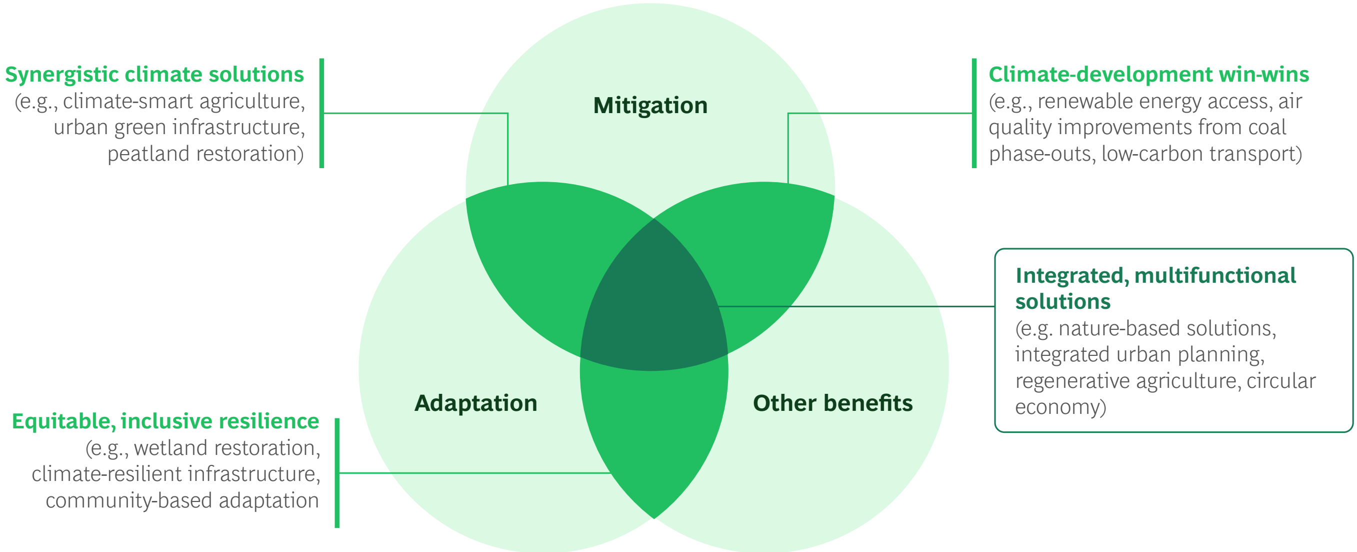
Multifunctional approaches offer a way to deliver greater impact per investment, addressing climate risks and immediate vulnerabilities while also delivering value across ecological, economic, and social dimensions. Example include enhancing biodiversity, improving water quality, supporting fisheries, and enabling eco-tourism. In addition, these approaches can help reshape institutions, infrastructure, and natural systems to adapt to growing climate stress.

Similarly, decentralized renewable energy systems present a scalable and impactful engineered solution, particularly in off-grid and disaster-prone areas. By replacing diesel generators, these systems enhance energy resilience, reduce emissions, and ensure that vulnerable communities have access to affordable, reliable power. Like nature-based options, these systems can unlock multiple benefits simultaneously, strengthening both climate outcomes and development priorities.

Detailed cost-benefit analyses conducted by BCG and others show that multifunctional solutions are more resilient, more cost-effective, and better able to deliver long-term value across economic, environmental, and social dimensions than single-function alternatives such as seawalls. Consider the following cost-benefit analyses of multifunctional solutions involving mangrove restoration and hybrid solar systems in Southeast Asia.

EXHIBIT 4

Multifunctional Solutions That Offer Mitigation, Adaptation, and Other Benefits Can Help Widen Adaptation Space



Source: BCG analysis.

Case Study

Cost-Benefit Analysis of Mangroves for Coastal Protection

Mangroves are a prime example of a multifunctional, nature-based solution that delivers both protective and productive value, reducing coastal erosion and storm surge while also supporting fisheries, carbon storage, and local livelihoods. Two cost-benefit analyses of mangroves in Southeast Asia illustrate this.

Ecosystem-Based Adaptation via Mangroves in Barangay Silonay, Philippines

Barangay Silonay, a small coastal village with approximately 1,400 inhabitants in Calapan City, faces increasing exposure to typhoons, storm surges, and sea-level rise. Under business-as-usual projections, a sea-level rise of 1 to 3 meters could inundate up to 25% of Calapan's land area, placing lives, infrastructure, and livelihoods at significant risk.

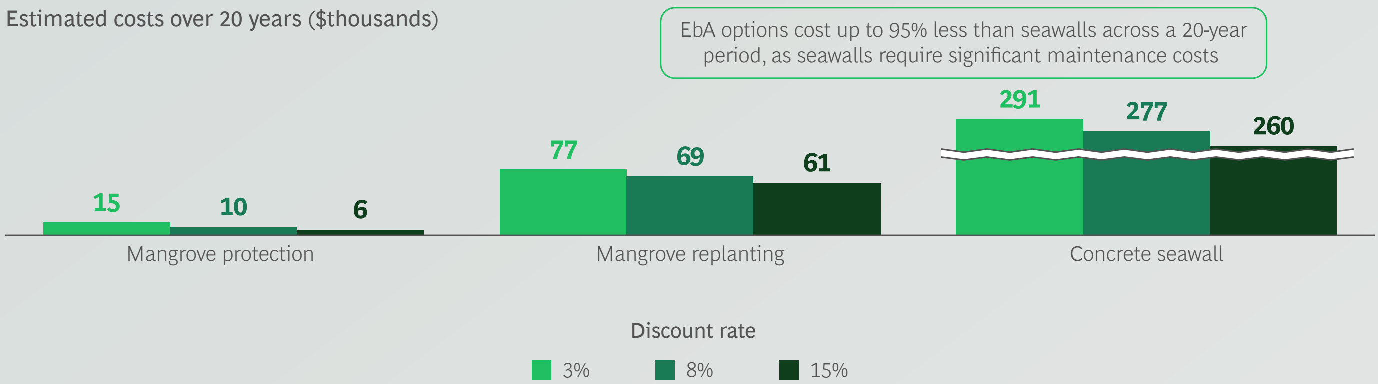
Strategies Assessed

To assess the cost-effectiveness of different possible responses, Conservation International compared three coastal adaptation strategies, two of which involved ecosystem-based adaptation (EbA), a strategy for adapting to climate change by harnessing nature-based solutions and ecosystem services:

- EbA via mangrove protection
- EbA via mangrove replanting
- Conventional gray infrastructure in the form of a concrete seawall

Key Findings

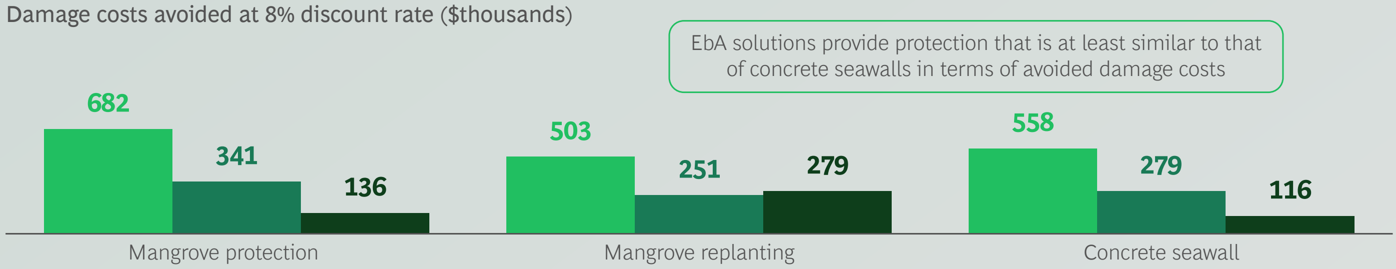
EbA options cost up to 95% less than seawalls over a 20-year period, with lower capital and ongoing maintenance requirements.



Sources: IUCN, "Cost and Benefits of Ecosystem Based Adaptation" (2016); BCG analysis.
Note: Discount rate is used to account for the weighted average cost of capital in calculating a project's net present value. EbA = ecosystem-based adaptation.

In terms of avoided flood damage, EbA options provide protection levels similar to those offered by concrete seawalls.

Damage costs avoided at 8% discount rate ($thousands)



Sources: IUCN, "Cost and Benefits of Ecosystem Based Adaptation" (2016); BCG analysis.
Note: EbA = ecosystem-based adaptation.
[1]**Avoided** damage as a percentage of total calculated damage is estimated to range from 10% to 25% for EbA options and from 25% to 50% for concrete seawalls. The exact percentage will depend in part on the design of the seawall.

Ultimately, the benefit-cost ratio (BCR) of EbA strategies in Barangay Silonay was 4 to 30 times as high as that of seawalls. At a discount rate of 8% and with avoided damage of 25%, mangrove protection achieved a BCR of 35, compared to a BCR of 1 to 2 for seawalls.

Benefit-cost ratio for avoided damages at 8% discount rate

Sources: IUCN, "Cost and Benefits of Ecosystem Based Adaptation" (2016); BCG analysis.
Note: EbA = ecosystem-based adaptation.
[1]**Avoided** damage as a percentage of total calculated damage is estimated to range from 10% to 25% for EbA options and from 25% to 50% for concrete seawalls. The exact percentage will depend in part on the design of the seawall.

Value of Mangrove Ecosystem Services in Indonesia

This Philippines study demonstrates how EbA strategies such as mangrove restoration offer robust coastal flood protection and mitigation in the form of carbon sequestration while generating multiple co-benefits for biodiversity, fisheries, and livelihoods. In contrast to traditional hard infrastructure, these nature-based approaches are regenerative, low-maintenance, and compatible with community use—and they cost much less.

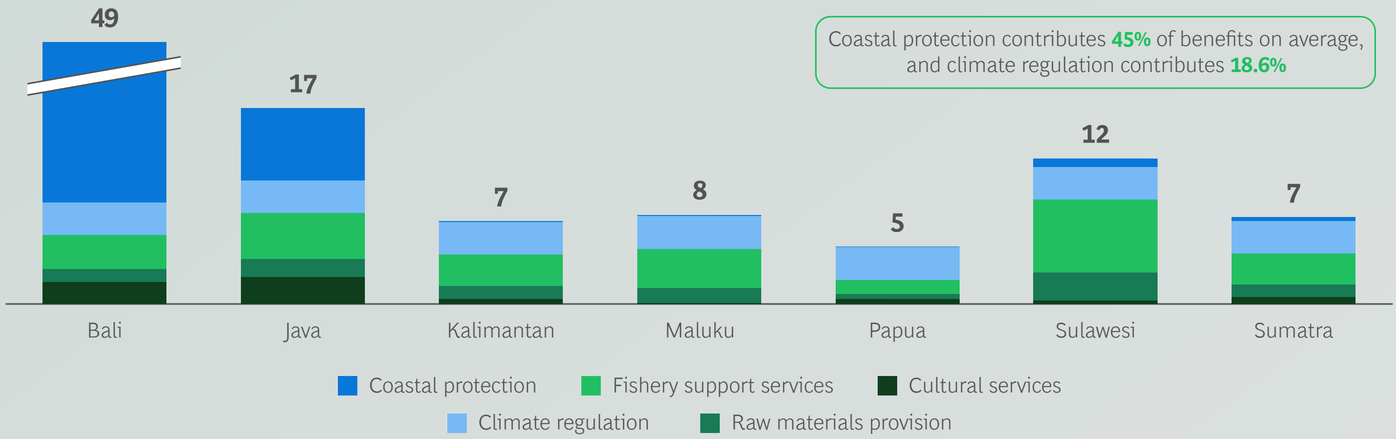
Another cost-benefit analysis involving mangroves focused on Indonesia, which is home to the largest area of mangroves globally, spanning more than three million hectares. These ecosystems provide critical services—including shoreline stabilization, carbon sequestration, and fisheries support—yet many have been degraded as a result of land conversion and insufficient protection.

To assess the economic case for restoration, the World Bank analyzed the value of mangrove ecosystem services across Indonesia's regions, balancing these benefits against restoration and land-use opportunity costs over a 30-year period at a 5.5% discount rate.

Potential Benefits

Mangroves deliver a wide range of benefits simultaneously:

- Coastal protection accounts for about 45% of the total economic value per hectare.
- Climate mitigation (primarily through carbon storage) contributes on average about 18.6% of total economic value per hectare.
- Additional co-benefits include fisheries support, raw material provision, and cultural services—especially where mangroves and associated fauna are closely intertwined with indigenous beliefs and practices.



Sources: World Bank, "The Economics of Large-scale Mangrove Conservation and Restoration in Indonesia" (2022); BCG analysis.

Key Findings

Estimated costs for mangrove restoration–including planting, infrastructure, and maintenance–were approximately $3,900 per hectare, with opportunity costs (in the form of forgone agricultural land use, for example) averaging $3,400 per hectare.

The BCR for mangrove conservation and restoration thus exceeds 1, demonstrating a clear net economic gain. In high-exposure coastal areas such as East Kalimantan and Jayapura, the BCR exceeds 5, making mangrove restoration among the most cost-effective natural infrastructure investments available.

These findings reinforce the case for scaling nature-based solutions. When strategically sited, mangrove conservation and restoration in countries like Indonesia can deliver economically beneficial mitigation and adaptation solutions.

Sources: IUCN, "Cost and Benefits of Ecosystem Based Adaptation" (2016); World Bank, "The Economics of Large-scale Mangrove Conservation and Restoration in Indonesia" (2022); BCG analysis.

Case Study

Cost-Benefit Analysis of Hybrid Solar Systems for Off-Grid Energy Resilience

Engineered solutions can bring multifunctional benefits that maximize their benefit-cost ratios. One example is the use of hybrid solar systems for off-grid energy resilience.

Roughly one million households in the Philippines , many in off-grid island regions, lack reliable electricity. These communities rely heavily on diesel-powered microgrids that are expensive to operate, vulnerable to fuel supply disruptions, and exposed to climate-related shocks such as typhoons. An estimated 67% of these microgrids operating under the national utility cannot provide 24-7 power.

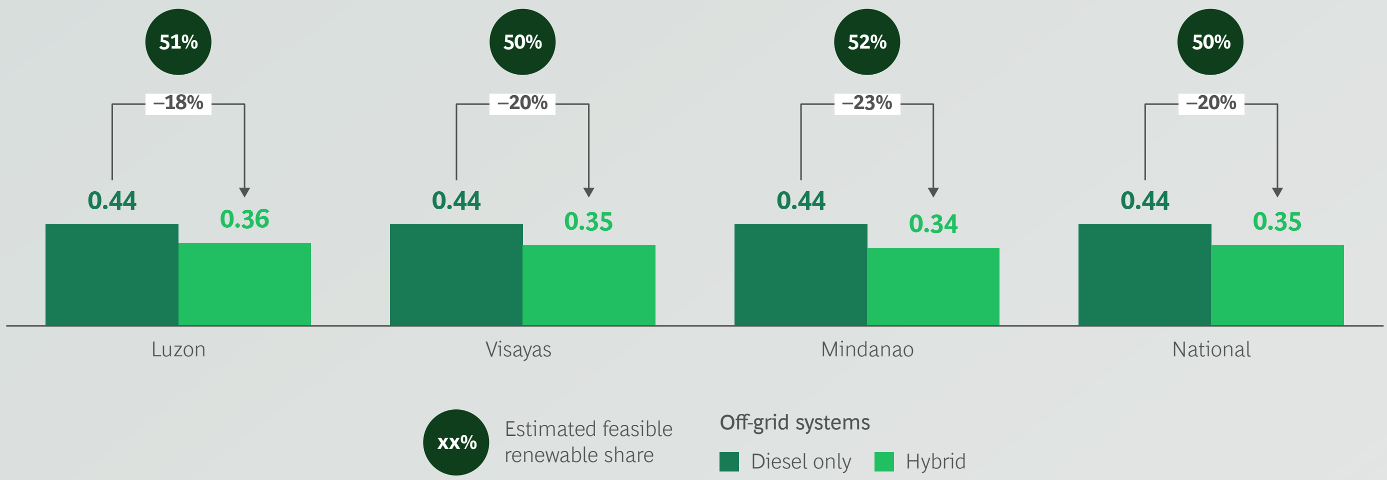
Systems Assessed

To assess alternatives, researchers Ocon & Bertheau (2019) evaluated transitioning to hybrid solar photovoltaic (PV) battery–diesel systems to improve affordability, resilience, and sustainability. In addition, researchers Castro et al. (2023) assessed the potential of these hybrid systems in combination with additional adaptation measures such as insurance and storm-hardening. The researchers assessed four system types:

- **Diesel-Only**. Diesel generators fully supply energy.
- **Hybrid Nonhardened**. Solar PV and battery storage are exposed to typhoon risk.
- **Hybrid Insured**. Annual insurance premiums cover damage to nonhardened systems.
- **Hybrid Storm-Hardened**. Renewable systems with higher upfront and operations and maintenance costs are build to withstand extreme weather events.

Key Findings

Across the three major island groups—Luzon, Visayas, and Mindanao—hybrid systems with a 50% renewable energy share reduced the levelized cost of electricity (LCOE) by 18% to 23% compared to diesel-only grids.



Sources: Ocon & Bertheau, "Energy Transition from Diesel-based to Solar Photovoltaics-Battery-Diesel Hybrid System-based Island Grids in the Philippines – Techno-Economic Potential and Policy Implication on Missionary Electrification" *Journal of Sustainable Development of Energy, Water and Environment Systems* (March 2019); BCG analysis.

Even under scenarios with base-case costs or elevated battery costs, hybrid systems achieved LCOE reductions of 18% to 20%, making them viable in the near-term. If battery energy storage system costs continue to fall, potential savings could increase significantly, with a reduction of up to 28% in LCOE possible if battery energy storage system costs drop by 50%.

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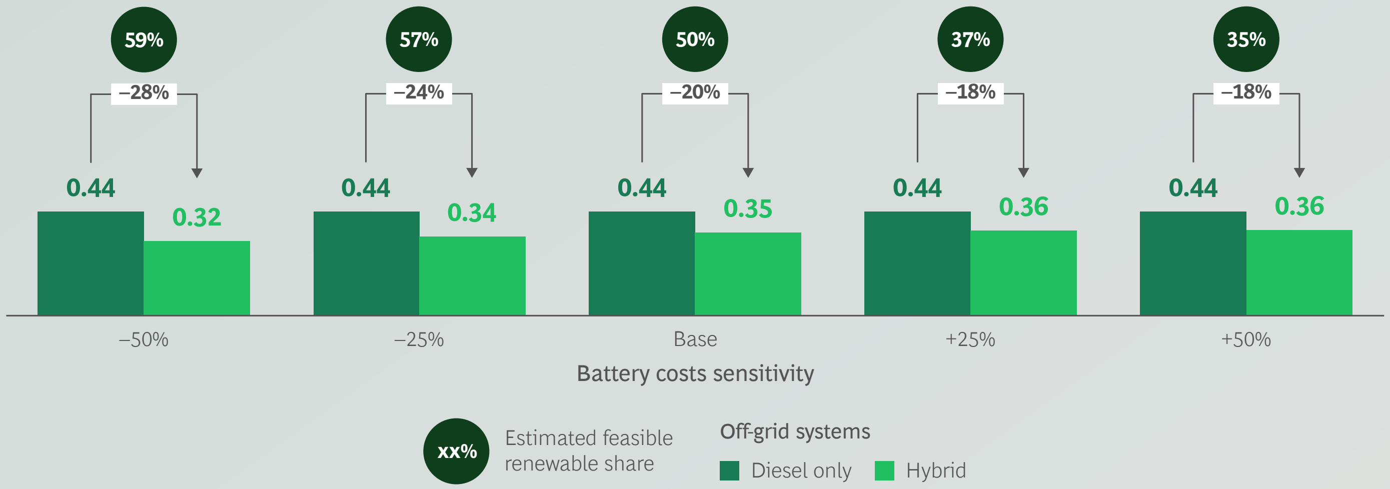
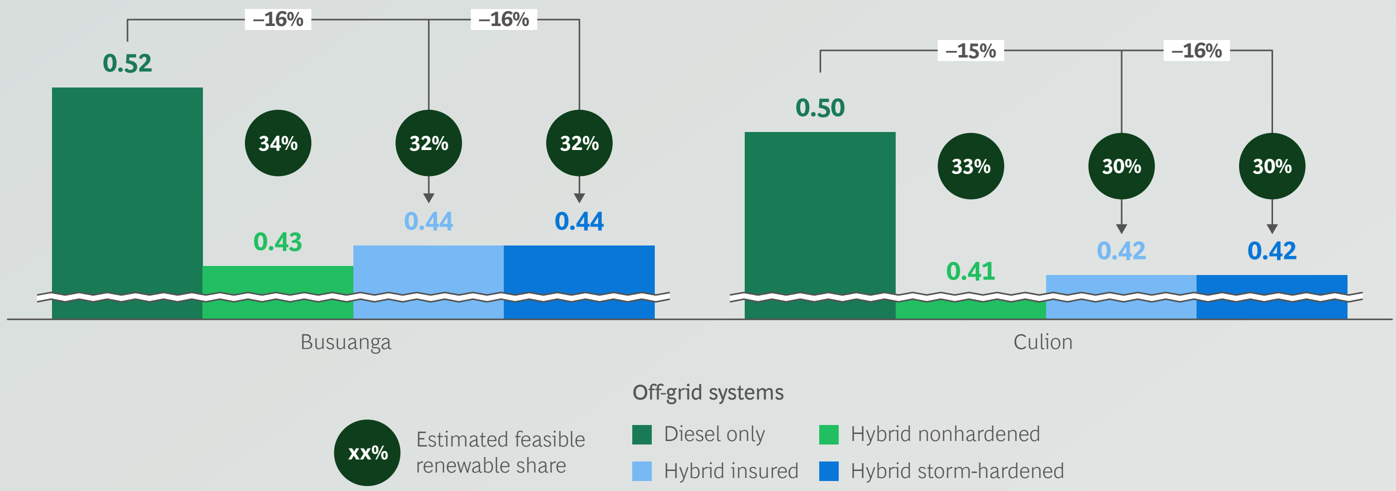


Sources: Ocon & Bertheau, "Energy Transition from Diesel-based to Solar Photovoltaics-Battery-Diesel Hybrid System-based Island Grids in the Philippines – Techno-Economic Potential and Policy Implication on Missionary Electrification," *Journal of Sustainable Development of Energy, Water and Environment Systems* (March 2019); Salac et al., "Off-Grid Electrification Using Renewable Energy in the Philippines: A Comprehensive Review," Smart Cities (April 2024); Castro et al., "Storm hardening and insuring energy systems in typhoon-prone regions: A techno-economic analysis of hybrid renewable energy systems in the Philippines' Busuanga island cluster," *Energy Strategy Reviews* (November 2023); BCG analysis.

Even with insurance and storm-hardening costs factored in, the overall LCEO of hybrid renewable systems is still 15% to 16% lower than diesel-only grid systems.



Sources: Castro et al., "Storm hardening and insuring energy systems in typhoon-prone regions: A techno-economic analysis of hybrid renewable energy systems in the Philippines' Busuanga island cluster," *Energy Strategy Reviews* (November 2023); BCG analysis.

These decentralized renewable systems function as a climate mitigation solution by reducing emissions from diesel power, and they function as a critical adaptation strategy by making the energy supply more secure even as climate risks intensify.

Designing for Systems, Not Silos

When designing multifunctional solutions, organizations need to take a systems approach to avoid unintended negative consequences that might occur if the focus were too narrow or siloed. This means looking beyond the project level and accounting for the full landscape of interdependencies, institutional dynamics, market incentives, local community priorities, and ecological thresholds.

Successful approaches tend to share several defining characteristics. They are locally led, grounded in the best available climate data and science, and designed to address interconnected risks across upstream, downstream, and adjacent systems. They build on proven models, are contextualized to local realities, and embed broader considerations such as equity, long-term sustainability, and institutional capacity. The policy and financing environment must be favorable, too.

Delivering these solutions at scale requires smart thinking and strong deployment systems. For example, ecosystem-based watershed management must balance water retention, carbon storage, and agricultural productivity. Urban green infrastructure should ensure equitable access while managing the risk of *green gentrification* —when eco-friendly improvements such as added green space drive up property values and force lower-income residents to leave. Even decentralized energy systems must account for upstream issues such as battery sourcing and downstream concerns such as waste management and long-term affordability.

Taking this systems approach is challenging, but there are instructive precedents for doing it well. One example is the Digital Urban Climate Twin (DUCT) platform in Singapore—the world's first digital twin of a country. DUCT combines real-time data on infrastructure, mobility, land use, and environmental conditions, enabling robust analysis of different what-if policy pathways. DUCT assessed the Singapore Green Plan 2030 by modeling over 300 climate action scenarios, including green urban infrastructure, building energy efficiency, increased electric vehicle adoption, and renewable energy supply.

Another example is the Integrated River Basin Management (IRBM) project—a five-year initiative by the Global Environment Facility, the UN Development Program, and the Association of Southeast Asian Nations to reduce pollution, secure freshwater flows, and strengthen resilience through coordinated river basin governance. The IRBM project is unique in tailoring solutions for locale-specific hydrological conditions and contexts, integrating policy development to support project pilots, and providing skills training on the systems approach to empower local communities and ensure stakeholder engagement for long-term implementation.

These initiatives are vital because, without proper systemic design, adaptation initiatives can lead to maladaptation that hurts long-term resilience. (See **Exhibit 5**.)

A systems approach ensures that planners develop resilient adaptation strategies rather than brittle ones, that they identify tradeoffs early and manage them responsibly, and that they distribute benefits fairly rather than concentrating them among a few. Ultimately, having an integrated, forward-looking design is crucial to the success of adaptation efforts.

EXHIBIT 5

Poorly Designed Interventions Can Lead to Maladaptation That Triggers or Tightens Adaptation Limits

Adaptation effectiveness: Maladaptation → Effective adaptation

Result of adaptation	**Target population is irreversibly more vulnerable to climate change**	**Target population is more vulnerable to climate change, but still fixable**	**Others are adversely affected by the adaptation solution**	**Ineffective adaptation**	**Short- and/or medium-term effectiveness, with no long-term negative consequences**	**Long-term positive impact**	**Transformation to a climate-resilient pathway**
Impact on adaptation limit	Triggers or reinforces hard limits	Tightens soft limits, requires targeted correction to avoid escalating to hard limit	Creates new soft limits for other populations or systems through risk externalization	Reinforces or prolongs soft limits by keeping systems locked in vulnerability	Stabilizes or delays approach to soft limits	Expands the soft-limit boundary to protect more value before hard limits are reached	Redefines limit boundaries, potentially rendering previous limits obsolete
Example	Building coastal infrastructure that blocks ecosystem migration and leads to irreversible habitat loss	Rebuilding informal settlements in high-risk coastal zones after a disaster, without upgrading infrastructure	Constructing a flood protection wall that diverts water toward unprotected neighboring communities	Adopting poorly designed insurance schemes that do not address underlying risk	Building temporary flood barriers that buy time while planners engage in long-term flood management planning	Introducing integrated water resource management to enhance water security across dry seasons	Embedding adaptation into urban development strategy to redesign how people live

Sources: Schipper, "Maladaptation: When Adaptation to Climate Change Goes Very Wrong," *One Earth* (October 2020); BCG analysis.

From Concept to Impact: Multifunctional Solutions in Action

Pioneering governments, businesses, and communities across sectors and geographies are already demonstrating that integrated approaches to adaptation and mitigation can deliver tangible, scalable benefits. These early movers are redefining what climate action looks like. They are not just managing risk, but also building resilience, strengthening livelihoods, and unlocking new value in the process.

Their experiences offer a proof of concept and a roadmap for others to follow. The following case studies illustrate the implementation of integrated strategies in real-world contexts, from cities confronting rising seas to global food manufacturers rethinking and retooling food supply chains.

Case Study

Benjakitti Forest Park—Bangkok, Thailand

Climate Risks: Urban Flood Risk, Heat Stress, and Degraded Land Use

Bangkok's Khlong Toei district, once home to a 52-hectare tobacco factory, faced a convergence of environmental risks: severe flooding, intense heat, and poor air quality, compounded by a lack of green space—just 3 square meters per person, among the lowest in Southeast Asia.

Monsoon rains routinely overwhelmed the city's drainage system, due to a combination of surface impermeability and climate-driven extreme rainfall. At the same time, the urban heat island effect pushed local temperatures 2° to 3 °C higher than in surrounding rural areas, exacerbating public health risks and increasing energy demand for cooling.

Solution: Nature-Engineered Cooling and Flood Resilience

To address these compounding challenges, the Bangkok Metropolitan Administration transformed 41 hectares of degraded industrial land into Benjakitti Forest Park–a multifunctional urban green space integrating stormwater sponge systems, tree canopies, and public amenities.

Designed by a coalition including Turenscape and Thai forestry experts, the project aimed to provide ecological resilience, climate mitigation, and social value through green infrastructure at scale.

Key interventions include the following:

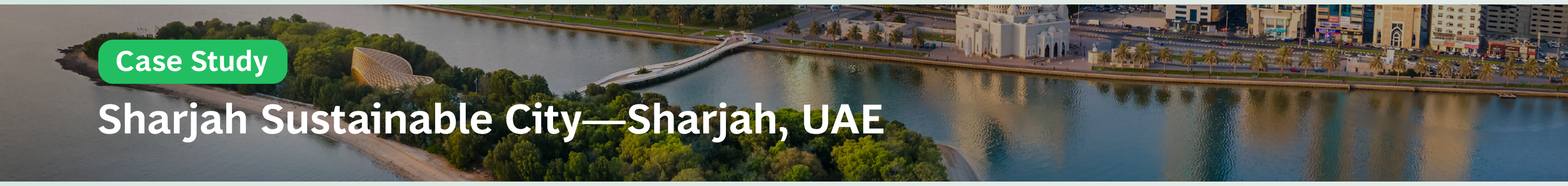
- The Bangkok Metropolitan Administration constructed multitiered wetland retention cells with the capacity to hold over 128,000 cubic meters of floodwater, helping mitigate peak runoff and improve water quality.
- It developed 1.6 kilometers of elevated skywalks, boardwalks, and cycle paths through native tree canopies, enhancing urban mobility and shading.
- It restored native vegetation to support urban biodiversity, climate resilience, and public health outcomes.

Impact: Better Flood Management, Improved Urban Comfort and Biodiversity, and Reduced Urban Emissions

- The park retained all runoff during major rainfall events in 2022 and 2024 when neighboring districts experienced inundation.
- Ambient temperatures within the park dropped by 1.5°C to 2.2°C during the hot season due to increased vegetation and water bodies.
- It reestablished native plant zones and attracted over 40 documented bird and pollinator species to the urban core.
- It provides mitigation benefits through tree planting and reduced energy use for stormwater pumping.

Benjakitti Forest Park demonstrates how urban planning for large-scale, multifunctional green infrastructure can deliver resilience and mitigation gains simultaneously–improving liveability, reducing emissions, and strengthening ecosystems in one of Southeast Asia's densest capitals.

Sources: Turenscape; Bangkok Metropolitan Administration Urban Resilience Plan; *Bangkok Post*; BCG analysis.



Case Study

Sharjah Sustainable City—Sharjah, UAE

Climate Risks: Energy, Water, and Waste Pressures in an Arid Urban Environment

Sharjah, like many other cities in the Middle East, faces converging climate and resource challenges. The UAE's hot-arid climate drives exceptionally high demand for air conditioning: cooling accounts for 70% of building energy use, which in turn contributes to some of the highest per capita CO_2 emissions in the world.

Sharjah's historic reliance on fossil fuel-based electricity and desalinated water has compounded these pressures. At the same time, rapid population growth and economic growth have strained the city's solid waste and wastewater systems. By 2020, over 77% of municipal waste was going to landfills, with recycling infrastructure underdeveloped.

Solution: Net-Zero-Energy, Circular Urban Design

Completed in 2023, Sharjah Sustainable City (SSC) represents a first-of-its-kind urban model for the UAE, integrating climate mitigation, adaptation, and circularity across all core systems. The project was led by Diamond Developers in partnership with the Sharjah Investment and Development Authority.

Key features include the following:

- 1,250 energy-efficient villas are equipped with individual rooftop solar PV, smart-grid connectivity, and EV charging infrastructure to reduce electricity demand and emissions.
- A closed-loop wastewater recycling system enables 100% reuse of wastewater for irrigation across the development.
- An onsite waste-to-energy facility supports circular waste management and emissions reduction.
- Over 30% of the development is devoted to green space, including food-producing greenhouses that boost urban cooling, biodiversity, and food security.

Impact: More Efficient Resource Use, Lower Carbon Intensity, and Improved Waste Management Along with Positive Economic Returns

- SSC villas recorded 50% lower greenhouse gas intensity than conventional homes, and grid electricity and water use were lower than the Dubai averages by 42% and 30%, respectively.
- The integrated waste-to-energy and wastewater systems permitted diversion of up to 90% of municipal solid waste from landfills.
- The project achieved strong commercial uptake, with sales transactions exceeding AED 2.5 billion ($680 million) within a year of launch.

SSC demonstrates how public–private collaboration can facilitate climate-smart urban planning anchored in net-zero design and circular systems to deliver long-term resilience and commercial returns, even in resource-stressed environments.

Sources: Rodriguez-Ubinas et al., "Sustainability Through Energy Conservation Building Codes: Comparative Analysis of Green Building Regulations in the Middle East," *WIT Transactions on Ecology and the Environment* (2020); Alnaqbi & Alami, "Sustainability and Renewable Energy in the UAE: A Case Study of Sharjah," *Energies* (October 2023); Sharjah Sustainable City; BCG analysis.

Case Study

Mars's Climate-Smart Rice Programs—US, Thailand, and South Asia

Climate Risks: Agricultural Emissions and Climate Risk Across Mars's Rice Supply Chain

Mars, one of the world's leading food manufacturers, sources significant volumes of rice for its global brands. But rice farming presents both environmental and supply chain challenges: it accounts for up to 10% of the world's methane emissions and more than 40% of global irrigation water use.

With climate change intensifying, Mars's rice supply is increasingly vulnerable to water scarcity, extreme weather, and soil degradation, especially in key producing regions such as the US, Thailand, India, and Pakistan. Recognizing this exposure, the company has committed to achieving a net-zero value chain by 2050, making climate-smart agriculture a strategic priority.

Solution: Climate-Smart Agriculture to Reduce Emissions, Enhance Resilience, and Boost Yields

Mars has invested in several climate-smart rice initiatives, deploying a combination of water-saving technologies, digital tools, and initiatives to build farmer capacity. These interventions were designed to deliver both mitigation and adaptation benefits, while improving farmer livelihoods.

Key initiatives include the following:

- Mars introduced alternate wetting and drying (AWD) practices to a family of farmers in Arkansas to reduce water use and methane emissions.
- It launched the Sustainable Aromatic Rice Initiative (SARI) in Thailand, training 1,450 smallholder farmers (70% women) in water management, digital tracking, and yield optimization.
- in partnership with Helvetas, Mars encouraged farmers in India and Pakistan to adopt the Sustainable Rice Platform standard, including AWD, drip irrigation, and laser leveling.

Impact: Reduced Emissions, Increased Yields, Lower Water Use, and Improved Income

- In the US, AWD adoption cut water use by 60% and reduced greenhouse gas emissions by up to 60% among participating farmers.
- In Thailand, SARI boosted rice yields by 43% in Roi Et and by 10% in Central Plains, while reducing water use by 56% and 41%, respectively.
- In South Asia, WAPRO reduced water consumption by about 21% in Pakistan and about 30% in India, with farmers reporting income increases of up to $56 per hectare per cropping season.

Mars's climate-smart rice initiatives highlight how companies that drive innovation with multifunctional benefits can strengthen supply chain resilience, reduce resource costs, and lower supply chain emissions while supporting local livelihoods.

Sources: Mars; Sustainable Rice Platform; BCG analysis.

Case Study

Building with Nature—Demak, Central Java, Indonesia

Climate Risks: Eroding Coastlines and Threatened Livelihoods

Coastal erosion and flooding along Java's northern coastline endanger the lives and livelihoods of over 30 million people. Mangrove deforestation, unsustainable coastal infrastructure, and groundwater extraction are driving these risks.

Sea-level rise projections in a business-as usual scenario indicate that Demak will experience up to 7 kilometers of inland flooding by 2100, threatening more than 70,000 residents and damaging 6,000 hectares of aquaculture ponds. Without intervention, livelihoods that depend on agriculture and aquaculture face income losses of 60% to 80%.

Solution: Nature-Based Infrastructure Integrated with Livelihood Empowerment

The Building with Nature initiative delivers an integrated response that combines permeable dams, mangrove regeneration, and sustainable aquaculture. Developed by a multistakeholder coalition whose members include Indonesian ministries, Wetlands International, EcoShape, TU Delft, Wageningen University, Blue Forests, UNDIP, and other local partners, the project aims to restore natural coastal defenses and stabilize communities through inclusive, multifunctional design.

Key interventions include the following:

- Construction of permeable brushwood dams will help trap sediment and stimulate natural mangrove regrowth.
- Promotion of eco-aquaculture techniques will encourage farmers to shift to practices that make space for mangrove restoration and support mangrove protection.
- Capacity-building and training for over 120 local farmers will enhance sustainable practices and economic resilience.

Impact: Ecosystem Restoration, Carbon Sequestration and Improved Livelihoods

- About 20 kilometers of shoreline are under restoration and 119 hectares of mangroves have been recovered, halting erosion in pilot villages.
- Aquaculture productivity and farmer incomes have tripled in pilot areas, with a threefold increase in milkfish yields and a sixfold increase in shrimp yields, reducing pressure to clear more mangrove areas.
- The restored mangroves sequester an estimated 4,000 tons if CO_2 equivalent annually (based on an estimate of average mangrove sequestration per hectare), delivering additional climate mitigation benefits.

The Building with Nature initiative showcases how public-private partnerships that invest in multifunctional nature-based infrastructure that also support livelihoods can achieve climate resilience and inclusive sustainable development, as well as providing climate mitigation.

Sources: Wetlands International; UNEP; Zeng et al., "Global potential and limits of mangrove blue carbon for climate change mitigation," *Current Biology* (2021); BCG analysis.

Case Study

Duke Energy’s Energy Resilience and Decarbonization Strategy

Climate Risks: Grid and Generation Infrastructure Vulnerability and Regulatory Pressure to Decarbonize

Duke Energy operates one of the largest regulated electricity utility systems in the US, serving over eight million customers across six southeastern states. This region faces increasingly frequent climate extremes—including hurricanes, floods, droughts, and heatwaves—that compound the stress on critical infrastructure such as power plants, substations, and transmission lines, many of which rely on water-based cooling systems.

The utility also faces rising regulatory and public pressure to decarbonize. Duke Energy is subject to state mandates in North Carolina and South Carolina to reduce electricity sector emissions. Its goal is to reduce carbon emissions by at least 50% by 2030 and to reach net zero by 2050.

Solution: Building Grid Resilience While Accelerating the Transition to Clean Energy

In response, Duke Energy has undertaken an integrated strategy to modernize its infrastructure, manage physical climate risks, and scale up low-carbon power generation, linking both adaptation and mitigation priorities.

Key initiatives include the following:

- An enterprise-wide climate-risk assessment across all electric and gas utilities aims to embed risk projections into transmission and generation planning.
- The utility has invested over $10 billion since 2022 in grid hardening and modernization, including putting lines underground, upgrading to higher-heat-rated components, and deploying self-healing grid technologies that use sensors and automated controls to restore service rapidly after disruptions.
- Duke is helping develop forward-looking decarbonization pathways such as green hydrogen, carbon capture and storage, and nuclear innovation to improve resilience and reduce emissions.

Impact: Enhanced Reliability, Improved Energy Security, and Reduced Emissions

- By deploying self-healing grid systems, Duke estimates that it avoided over 1.5 million customer outages across six states in 2023 and saved 3.5 million hours of downtime during hurricane season.
- The utility received $57 million from the US Department of Energy to rebuild key transmission lines incorporating climate-resilient design features, improving system reliability for over 14,000 customers.
- Duke is on track to cut emissions 50% by 2030 and achieve net zero by 2050, thanks to coordinated investments in grid reliability and clean energy integration.

Duke Energy’s approach exemplifies how energy providers can embed adaptation into decarbonization, delivering dual resilience and mitigation outcomes through systems-level infrastructure strategy. By adopting this approach, companies can also unlock blended finance opportunities from the public sector to de-risk these investments.

Sources: Duke Energy; BCG analysis.

As the preceding case studies show, the context for multifunctional solutions varies considerably. But successful initiatives share several key strategies:

- **Co-Benefit by Design.** Embed adaptation and mitigation goals together from the outset, rather than retrofitting one onto the other. For example, Bangkok's green flood abatement infrastructure enhances both urban livability and climate resilience, and nature-based agricultural practices in Southeast Asia improve yields and sequester carbon.

- **Cross-Sector Collaboration.** In implementing adaptation and mitigation solutions, use diverse partnerships comprising public agencies, private firms, communities, and NGOs. In the Mekong Delta, joint efforts by local governments and international development partners aligned water resilience projects with livelihood support and land-use reform.

- **Financial Innovation and De-Risking Mechanisms.** Unlock innovative finance, such as blended capital or insurance-backed guarantees. Coastal cities that paired engineering with ecosystem restoration secured financing from both public climate funds and private insurers.

- **Local Knowledge and Inclusive Governance.** Involve local communities, indigenous groups, and marginalized stakeholders to improve trust, adoption, and sustainability. Participatory land planning initiatives and community-led coastal restoration projects have benefited from combining traditional knowledge with technical design.

The Path Forward: Unlocking Integrated Action Across Public and Private Sectors

Although these case studies are promising, they represent only a fraction of what is needed to match the scale and urgency of the climate challenge. Accelerating the shift to multifunctional solutions will require coordinated action by the public and private sectors to mobilize the necessary capital, capabilities, and commitment.

Private Sector: Driving Innovation, Capital, and Delivery at Scale

For businesses, climate adaptation is becoming increasingly integral to managing risk, securing supply chains, and maintaining long-term competitiveness. As physical climate risks intensify and expectations from regulators and investors evolve, the private sector must advance multifunctional solutions that serve both decarbonization and resilience objectives. Several opportunities are emerging in the areas of strategy, investment, partnerships, and market signaling:

- **Future-proof operations by redesigning core operations with climate mitigation and adaptation in mind.** Businesses may consider assessing emissions and climate risks across their operations and supply chains, and adjusting production, sourcing, and logistics to be more climate-resilient and sustainable. For instance, agriculture players could deploy alternate wetting and drying techniques to reduce water consumption and limit methane emission from soil, enhancing yields while lowering climate impact.

- **Allocate capital for dual benefit by prioritize investment in solutions that serve both adaptation and mitigation goals.** Businesses can redirect capital toward solutions that deliver mitigation and adaptation simultaneously, such as creating nature-based flood buffers and replacing diesel generator sets (consisting of a generator and an engine) with renewable energy. For example, utility companies could invest in grid modernization to better integrate low-carbon power while maintaining vigilance against climate risk disruptions.

- **Promote innovative partnerships by collaborating to co-develop and scale integrated solutions.** Businesses can join forces with public institutions, NGOs, and startups to pilot and scale multifunctional solutions. For example, oil and gas companies might partner with conservation groups to create a nature-based water treatment system to filter wastewater and replenish aquifers.

- **De-risk through blended finance to unlock investment in multifunctional solutions in frontier markets and vulnerable sectors.** Businesses can work closely with development banks and public partners to co-invest in multifunctional solutions in frontier regions or sectors with a high level of climate vulnerability. For example, real estate companies might work with local governments or development banks to leverage funding to de-risk investments in nature-based coastal defence solutions and generate blue carbon credits.

- **Support transparent signals by enhancing climate risk disclosure and aligning with emerging climate disclosure frameworks.** Businesses can increase their openness with regard to climate risk disclosure (for example, to the International Sustainability Standards Board). Improving transparency around the physical and transition risks of planned solutions could bolster investor confidence and encourage collaboration on multifunctional solutions to address intensifying climate risks.

Public Sector: Enabling Scaled and Integrated Climate Action

Through regulation, planning, finance, and institutional design, public sector actors can help catalyze multifunctional solutions. To support scaled implementation, they can take action across five mutually reinforcing areas:

- **Pursue strategic integration by aligning climate planning across mitigation and adaptation frameworks.** Public actors can embed dual climate goals into national and subnational strategies, such as by ensuring consistency across national adaptation plans, nationally determined contributions, and development priorities. For example, countries updating their nationally determined contributions could incorporate adaptation co-bene its along with mitigation investments, such as nature-based solutions or climate-smart infrastructure.

- **Target investments to channel public finance toward integrated, high-impact solutions.** Public budgets and development funds can prioritize initiatives with clear economic multipliers. For example, they might focus on regenerative agriculture that amplify returns through higher yields, avoided losses, and carbon credits; green urban infrastructure that improves community health and biodiversity; and hybrid coastal protection measures that sequester carbon, strengthen resilience, and support local fishery and aquaculture economies.

- **Adopt policies and standards and set regulatory signals that reward integration and long-term resilience.** Public agencies can update infrastructure standards, zoning rules, and procurement guidelines to require climate risk assessments and favor integrated designs. For example, new infrastructure tenders might include scoring criteria for solutions that address both emissions and physical climate risk.

- **Build institutional capacity to strengthen public sector capability for cross-sectoral implementation.** Governments can invest in capacity building for agencies at all levels—equipping planners, regulators, and implementers to work across silos. This might involve training programs, digital tools such as climate data platforms, or establishing dedicated climate-planning units. For instance, setting up regional climate planning hubs or digital climate twin platforms could support joint decision making across ministries, utilities, and municipalities.

- **Foster inclusive governance by facilitating participation in and accountability for climate investments.** Public institutions can play a convening role by ensuring meaningful engagement of local communities, indigenous groups, and marginalized populations from an early stage in the process. Participatory design in water management and urban development projects can improve local ownership, reduce con lict, and enhance outcomes.

Acting Together at Pace and Scale

The momentum behind multifunctional solutions reflects a broader shift from reactive climate responses to integrated, forward-looking strategies. The opportunity now is to scale what is already working, expand where innovation is needed, and embed climate integration into core decision making across sectors.

This shift will require new forms of collaboration. Adaptation and mitigation are no longer challenges that governments or businesses can solve in isolation. System-scale solutions require shared commitment, coordinated delivery, and blended financing. That means moving from single-actor interventions to well-orchestrated public-private collaborations that align strategic ambition with operational capability and financing models.

Private actors can bring innovation, capital, and delivery expertise. Public institutions can shape supportive policies, de-risk early investment, and ensure that benefits are inclusive and align with long-term climate goals. Together, they can unlock a market for climate resilience that safeguards assets today, promotes a more resilient, low-carbon future, and creates value over the long term.

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Related Publications

"**The Cost of Inaction: A CEO Guide to Navigating Climate Risk**" (December 2024)

"**The Private Equity Opportunity in Climate Adaptation and Resilience**" (May 2025)

"**Why Investing in Climate Action Makes Good Economic Sense**" (March 2025)

"**Five Imperatives to Spur Investment in Climate Adaptation**" (September 2025)

For Further Contact

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