

BUILDING BETTER RESILIENCE: NOTE ON AVOIDING MALADAPTATION



Copyright © 2024 Inter-American Investment Corporation ("IDB Invest"). This work is subject to a Creative Commons license CC BY 3.0 IGO (<https://creativecommons.org/licenses/by-sa/3.0/igo/deed.en>). The terms and conditions indicated in the URL Link must be met and the respective recognition must be granted to IDB Invest.

Further to section 8 of the above license, any mediation relating to disputes arising under such license shall be conducted in accordance with the WIPO Mediation Rules, as in effect at the time of the dispute. Any dispute related to the use of the works of IDB Invest that cannot be settled amicably shall be submitted to arbitration pursuant to the United Nations Commission on International Trade Law (UNCITRAL) rules, as in effect at the time of the dispute. The use of IDB Invest's name for any purpose other than for attribution, and the use of IDB Invest's logo shall be subject to a separate written license agreement between IDB Invest and the user and is not authorized as part of this license.

Note that the URL link includes terms and conditions that are an integral part of this license.

Author: Clara Bütow

With contributions by: Juan Carlos Paez Zamora, Camila Rodriguez Taylor, Mauricio Ayala Roa, Adriana Maria Valencia Jaramillo, Angela Miller.

Edited by: Nora Lambrecht and Andreas Smith Jorgensen

Table of Contents

04 Abstract

05 Introduction and objectives

05 *Adaptation and maladaptation in context*

06 *Definition of maladaptation*

08 *Relevant publications, policies and guidelines*

09 *How to use this document*

10 Understanding maladaptation

10 *The concept of maladaptation*

11 *Dimensions of maladaptation*

12 *Types of maladaptation*

13 *Maladaptation examples based on a literature review*

16 *(Mal)adaptation as a spectrum*

17 Drivers of maladaptation

24 Preventing maladaptation

24 *Towards a framework for effective adaptation outcomes*

25 *Checklist: Guiding questions for preventing maladaptation*

30 Conclusions

31 Bibliography

35 Annex: Avoiding maladaptation in the infrastructure sector



Abstract

To address increasing climate risks and vulnerabilities, climate adaptation is becoming a growing priority in development projects. The IDB Group, including its private sector arm IDB Invest, has committed to aligning its financial flows with the mitigation and adaptation goals of the Paris Agreement while scaling up climate adaptation finance. Through increased climate adaptation ambitions, IDB Invest and the IDB Group contribute to building climate resilience in Latin America and the Caribbean.

While climate adaptation pursues the reduction of risk and vulnerability to climate change impacts, such measures may also produce unintended consequences that may increase or shift current or future vulnerabilities or undermine sustainable development pathways. This is called maladaptation.

This document serves as guidance to enhance the efficiency of climate resilience and adaptation-related activities and avoid undesired outcomes. It introduces the concept, dimensions, and types of maladaptation; explores maladaptation drivers and ways to mitigate them; presents a framework to prevent maladaptation; and provides a checklist with potential guiding questions for project teams. Project teams and environmental and social specialists can leverage this guidance to assess and improve the design and implementation of climate-related projects, reducing associated social and environmental risks.



A person wearing a blue striped shirt is holding a black pen over a black tray filled with small green seedlings. The background is a blurred field of similar seedlings.

Introduction and objectives

Adaptation and maladaptation in context

In an age of accelerating climate change, development projects must go beyond delivering positive environmental and social impacts. Through its [Paris Alignment commitment](#) the Inter-American Development Bank (IDB) Group demonstrates its dedication to fully align new operations with the Paris Agreement goals, in order to keep global warming well below 2°C above pre-industrial levels and pursue efforts to limit temperature rise to 1.5°C and to enhance adaptive capacity, strengthening resilience and reducing vulnerability to climate change. By integrating climate-related dimensions into investment decisions and client relationships, the IDB Group seeks to combat climate change and enhance climate resilience in Latin America and the Caribbean as outlined in its [Institutional Strategy](#). Accordingly, IDB Invest, the private sector arm of the IDB Group, is intensifying efforts to build resilience and [scale up adaptation finance in the private sector](#).

This document supports IDB Invest in its [Paris Alignment Implementation Approach \(PAIA\)](#), developed by the IDB Group as a methodological tool to align operations and projects with the goals of the Paris Agreement. It also complements and builds upon the [IDB Invest Environmental and Social Sustainability Policy \(ESSP\)](#). As climate change increasingly affects communities, preparing for intensified impacts and extreme events is paramount for future prosperity and wellbeing. Global leaders and scientists agree that climate adaptation must become a priority to prevent the worst damages especially in climate-vulnerable regions. Defined by the Intergovernmental Panel on Climate Change (IPCC) as “the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities”¹, **adaptation** includes measures ranging from hard infrastructure and technology and nature-based solutions to social and economic policies to reduce vulnerability.



Definition of maladaptation

“**Maladaptation** refers to climate adaptation actions that increase current or future climate vulnerabilities within the boundaries of an operation, shift vulnerabilities from within the boundaries of an operation to an external or surrounding system (causing adverse effects on social, environmental, economic, or physical aspects of the system), or undermine sustainable development. Maladaptation occurs when an adaptation action undermines the coping capacities of existing systems, diminishes the capabilities of future generations to respond to climate vulnerabilities, or places a disproportionate burden for climate action on present-day or future external actors.”

IDB Group (2023): Technical Guidance for aligning IDB Group's Operations to the Paris Agreement. Water and Sanitation.

Examples include rainwater harvesting in agriculture to cope with unreliable precipitation patterns, preparing hospitals for intense flooding, or relocating assets due to sea level rise. If done well, adaptation should protect human well-being under changing climate conditions, preserve biodiversity and ecosystem functioning, prevent billions in economic losses, and save lives otherwise lost due to climate disasters and extremes.

Although there is still a significant gap in adaptation finance, the number of adaptation policies and programs has increased rapidly in recent years. However, despite good intentions, not all adaptation efforts have been a success. Some programs, policies and projects have led to mixed, unintended, or undesired outcomes, referred to as **maladaptation** - a phenomenon where development efforts exacerbate or shift existing vulnerabilities, undermine livelihoods, or create new risks.

Poorly designed adaptation strategies not only waste time and resources; they can also increase climate exposure and exacerbate vulnerability. Through maladaptation, people or assets can become even more likely to suffer negative climate effects.² Maladaptation jeopardizes project effectiveness and threatens the achievement of the Sustainable Development Goals (SDGs), potentially reversing decades of development gains or undermining future sustainable development by creating compounding risks.²⁻⁷

In dealing with climate risks, following the “no harm” principle requires preventing and avoiding maladaptation. Currently, most cases of maladaptation are only recognized ex post, once the damage has already occurred and intervention possibilities are very limited.^{8,9} Identifying maladaptation risks before investment decisions, throughout the project design and implementation phase, as well as after completion is essential for effective adaptation initiatives that minimize the risk for unintended, maladaptive outcomes.⁴

The [IDB Invest ESSP](#) highlights the importance of sustainable climate action and resilience for IDB Invest operations:



IDB Invest acknowledges the threat posed by climate change, especially to vulnerable populations, and the urgent need for both mitigation and adaptation across the region. IDB Invest considers climate change mitigation and adaptation to be a strategic priority for its investment and technical assistance activities in the region. (...) IDB Invest is committed to helping clients measure and manage both physical and transition climate-related risks in their operations, investment decisions and project development” (Paragraph 10).

Furthermore, climate-related risk assessments and risk management strategies (Paragraph 11) as well as emergency preparedness and response activities (Paragraph 12) are required from clients. Finally, IDB Invest confirms its focus on climate-related opportunities for investments and technical assistance (Paragraph 13).

Climate change is a risk multiplier that can exacerbate environmental and social risks both to the project or investment and to local communities. Assessing and addressing environmental and social risks holistically, understanding local contexts, and actively integrating activities to reduce climate-related vulnerability in the short and long term, will reduce risks of unwanted outcomes and maladaptation, and positively impact long-term sustainability of IDB Invest projects and technical assistance.

Relevant publications, policies and guidelines

There are several publications, policies and guidelines published by IDB Invest, the IDB Group, and other Multilateral Development Banks (MDBs) that are relevant to maladaptation. Among them are the following:



- [IDB Invest Environmental and Social Sustainability Policy \(ESSP\):](#)

The ESSP has the purpose to enhance the environmental and social sustainability of investment projects financed by IDB Invest through applying robust

environmental and social risk management standards. It also consolidates the institution's commitment to sustainable development.

- [IDB Invest Implementation Manual, Environmental and Social Sustainability Policy:](#)

The manual is based on the ESSP and describes each of the policies and standards with their respective objectives, principles and requirements that apply to IDB Invest and its private sector clients.

- [International Finance Corporation \(IFC\) Performance Standards:](#)

The IFC performance standards are an integral part of environmental and social risk management and are applied within IDB Invest as part of the ESSP.

- [IDB Group Paris Alignment Implementation Approach \(PAIA\):](#)

The PAIA describes the methodology, principles and technical guidance for assessments, client dialogues and technical design of transactions. Sector guidance documents complementing the approach are available for eight sectors.

- [Joint MDB Methodological Principles for Assessment of Paris Agreement Alignment:](#)

These principles provide guidance according to the type of financial instrument: [General Corporate Purpose Financing](#), [Policy-based Lending Operations](#), Direct Investment Lending Operations, and [Intermediated financing](#).

- [Scaling Adaptation Finance in the Private Sector:](#)

This IDB Invest publication outlines opportunities for private sector clients and investors to avoid future losses and damages due to climate-related risks and vulnerability. It also presents solutions to build resilience through a number of adaptation actions.



- [Climate Risk and Ports: A Practical Guide on Strengthening Resilience](#)

This IDB Invest guide helps port developers and operators create an action plan to build resilience and reduce the adverse consequences of climate-related events in and around port facilities. It provides information and analysis to better understand the climate context of a project, develop a risk assessment, formulate adaptation measures, and establish monitoring and evaluation procedures.



How to use this document

This document serves as guidance to better understand adaptation complexities, reduce the risk of maladaptation, and navigate possibilities to safeguard adaptation strategies. Introducing the concept of maladaptation, this document consolidates scientific knowledge on maladaptation drivers. Furthermore, it examines the factors to pay close attention to, proposing ways in which maladaptive risks can be reduced for each of its drivers. Due to adaptation being highly context-specific, not all features of maladaptation nor strategies to avoid it might apply to all projects.

By building upon the IDB Invest ESSP and other references mentioned above, the document provides a point of reference for assessing maladaptation risks. Environmental and social officers as well as project teams can use it to engage clients on adopting effective adaptation practices and avoiding maladaptation. Thereby, they can enhance the design and implementation of climate resilience aspects in projects, contributing, by these means, to the reduction of social and environmental risks.

A photograph of a man in a striped shirt and dark shorts riding a bicycle through a flooded street. A young child is sitting on his back, holding onto him. The water is murky and reflects the surrounding environment. In the background, other people and vehicles are visible, though out of focus.

Understanding maladaptation

The concept of maladaptation

The IPCC describes maladaptive actions as “actions that may lead to increased risk of adverse climate-related outcomes, including via increased greenhouse gas (GHG) emissions, increased vulnerability to climate change, or diminished welfare, now or in the future”.¹ Leading to new, shifted or increased risks or vulnerabilities, maladaptation poses a threat to current and future sustainable development, and could result in a waste of valuable financing, resources and time for urgently needed climate action and development.^{4,9,10} The IDB Group definition for maladaptation is closely linked to this IPCC conceptualization, highlighting, in particular, temporal and cross-regional risks, as well as the potential harm to existing systems and communities caused by maladaptive actions.

Scientific evidence shows that maladaptation disproportionately affects poor and disadvantaged people and communities by transferring risks and impacts to these already neglected populations.^{3,11} The majority of maladaptation cases referred to in scientific literature have been recorded in Global South countries^{3,12}, demonstrating a link between failed “development-as-usual” approaches and adaptation efforts.⁶

Although there are not many studies on maladaptation in the private sector, private adaptation finance is increasing, especially in relation to resource efficiency, water management, land degradation and other climate-related risks to business success. Private sector engagement in adaptation can be a way to simultaneously manage climate risks and increase corporate productivity and profitability.¹³ However, some private sector adaptation initiatives may lack efficient checks and balances, environmental impact assessments or safeguard systems that account for maladaptive risk, which confirms the relevance of maladaptation prevention within private-sector adaptation initiatives.¹⁴ The following box introduces the various dimensions of maladaptation in private, public and hybrid adaptation initiatives.

¹ See the introductory part of this document.

Dimensions of maladaptation

Complex system dynamics make it challenging to predict and track the impacts of adaptation measures. Here are common dimensions of maladaptation to identify unintended consequences:

1. Multiple drivers:

Maladaptation should be seen as one of many ongoing processes. A project with initial success might lead to maladaptive outcomes later. A multitude of socioeconomic, cultural, and environmental pressures often interact and evolve. Therefore, a variety of factors aside from climate influence the efficiency of climate adaptation.^{2,4,15} For example, relocation away from potentially hazardous shorelines may cut off fishers from their primary livelihood source and create new sources of vulnerability. The risk for maladaptation is especially high if adaptation projects take a climate-centered approach that neglects social aspects, economic dynamics, and governance issues.

2. Temporal scales:

Adaptation outcomes can vary across the short, medium, and long term. For example, infrastructure adaptation may improve the local economy in a climate risk prone region, enabling prosperity gains and incentivizing immigration in the short to medium term. However, a growing population and accumulation of assets in a hazardous area, caused by the perception of increased safety, can become problematic as soon as adaptation measures fail to withstand the intensity of climate impacts under more extreme warming pathways. Similarly, coastal tourism development that destroys natural buffers like coral reefs, sand dunes or mangroves should be considered maladaptive since it harms ecosystems and reduces climate resilience. Offset strategies that aim to balance harm elsewhere still increase risks in the project area.

Biodiversity offsets can undermine the complexity and multidimensional value of biodiversity, which is not easily replaceable, discouraging intrinsic nature protection.

3. Spatial scales:

While adaptation projects often target specific locations, effects can go beyond that area. Water management, like with transboundary rivers, can exemplify this. Upstream communities adapting to droughts by using more water can exacerbate scarcity downstream. Maladaptation can also lead to habitat loss, disrupted social networks, and livelihood disruptions beyond the targeted region.^{4,16}

4. Intentionality:

Maladaptation encompasses both 'unsuccessful' projects, and seemingly successful projects with unintended negative consequences. It also applies to projects that deliberately ignore longer term threats, or fail to consider the full range of potential consequences from the planned interventions.¹⁶

In conclusion, maladaptation can happen any time after the adaptive action is completed. It can spread beyond the original project area and happen despite the best intentions. Due to the detrimental effects of maladaptation, decision-makers who finance, green-light, design, implement, or evaluate adaptation projects carry an inherent responsibility to prevent maladaptation.



Types of maladaptation

Adaptation is not a one-size-fits-all-solution. Projects may succeed for some social groups, locations, or timeframes, but become maladaptive for others. This adaptation-maladaptation continuum will be explored further later. The forms that maladaptation can take can be categorized into three types: rebounding vulnerability, shifting vulnerability or eroding sustainable development.

1. Rebounding vulnerability

When an adaptation action increases vulnerability for a specific group, rather than decreasing it, rebounding vulnerability occurs. Vulnerability “rebounds” in the same or a new form, such as increased exposure or limited adaptive capacity. This hinders future adaptation and sustainable development progress.^{2,17}

Coastal dams and seawalls intended to protect communities from storms that can create a “bathtub effect” are an example. While they block ocean surges, they can trap inland flooding from rivers or heavy rain, causing flooding by preventing water from reaching the ocean – just like a full bathtub with no drain.

Disaster risk insurance can also lead to rebounding vulnerability. If it simply allows communities to rebuild after disasters without encouraging adaptation, it may lock them into a cycle of repeated losses with ever-increasing premiums.¹⁸

2. Shifting vulnerability

When an adaptation strategy reduces vulnerability for one group (potentially enhancing their climate resilience) but increases vulnerability for another, a shifting of vulnerability occurs. Overall vulnerability is not reduced but simply redistributed.^{2,17} This can exacerbate existing inequalities, particularly when marginalized communities are overlooked in planning.¹⁹ Adaptation strategies focused mainly on economic benefits are more likely to lead to such socioeconomically exclusionary outcomes.^{20,21}

3. Eroding sustainable development

Adaptation actions can result in negative effects that erode sustainable development. This can include social and cultural disruptions such as loss of traditional knowledge or practices, generation of social tensions in response to adaptation outcomes, lock-in effects by using infrastructure or technologies that become obsolete or unsustainable under more extreme climate change. Other undesired effects include increases in GHG emissions, environmental damage, or impacts on the wider public without singling out affected actors.^{17,22} This form of maladaptation very directly links to the [IDB Invest Environmental and Social Sustainability Policy \(ESSP\)](#) and the [IFC Performance Standards](#) as those standards aim to promote environmental and social risk management as well as sustainable development at large.

Maladaptation examples based on a literature review

1. Green Gentrification

Green gentrification favors wealthy urban residents in urban greening projects.¹⁹ Various studies in the United States link adaptation efforts to rising property values and neighborhood changes: green spaces bring livelihood benefits that can lead to higher property prices pushing out less privileged residents that are already more at risk to experience severe climate impacts.²³⁻²⁵ Consequently, in cases of green gentrification, adaptation may yield exclusionary outcomes and may increase inequality gaps between groups.

The example depicts that relocation may be labelled as an adaptation strategy and as necessary land use conversion but may risk exclusionary outcomes. The vulnerability of affected citizens may increase, especially in informal settlements with few legal protections that are easier to evict and less costly to expropriate.²⁷ Such maladaptation risks link directly to what IFC performance standard 5: Land Acquisition and Involuntary Resettlement seeks to avoid.

A similar example from Medellín, Colombia, was the construction of a 'Metropolitan Green Belt', a measure planned to relocate thousands of poor residents from areas at the risk of landslides or flooding. An analysis of the project demonstrated that whilst defining the location of thousands of low-income residents as non-recoverable areas with high risks of flooding and landslides, higher-income neighborhoods with similar environmental and geographic characteristics were not classified in the same category. The affected communities claim that the way in which the hazardous risk category was defined was biased and, thus, a form to legitimize eviction of less socioeconomically advantaged people from those areas.²⁷

2. Exclusionary flood management and eviction in the name of adaptation

According to a study, a 75 km-long floodplain restoration project which was proposed as a flood management strategy in the eastern periphery of São Paulo, Brazil, by its municipal government may have led to exclusionary outcomes. Despite offering flood resilience gains, the adaptation strategy included the removal of 7500 low-income families living in informal settlements in the project area.²⁶

3. *Elite control through climate risk framing*

Similarly to exclusionary policies, there are examples where climate adaptation framing may have been instrumentalized. Aiming at controlling flooding and develop the local economy in Indonesia's capital Jakarta due to rising sea levels and increasingly intense precipitation, the government has developed the 'Great Garuda' megaproject which foresees the building of a giant seawall, 17 new islets and new waterfront economic center. However, scientists, land activists and residents claim that the project fails to address root causes of flooding as well as vulnerability drivers, evicts traditional and poor communities, and prioritizes interests of political elites and business. They also argue that the \$US40 billion investment would be better spent on strategies that address root causes of vulnerability. Research describes how the Great Garuda project took advantage of climate discourse in that regard. Due to a lack of participation and vulnerability considerations, the project would very likely produce socioeconomic and ecological maladaptation, including forced eviction and a loss of traditional livelihoods, as well as a high risk of creating a septic lagoon of trapped freshwater polluted by insufficiently sanitized sewage water.²⁸

4. *Transfer of risk from MSMEs to neighboring districts*

In Mumbai, India, many Micro Small and Medium Enterprises (MSMEs) are suffering extensive losses from recurring heavy rain and flooding. With limited public flood management action and insufficient infrastructure, the MSMEs have started implementing their own short-term flood management strategies that include temporary barriers or using pumps for floodwater drainage. However, many of the strategies failed during

heavy rain periods and led to maladaptive outcomes because water pumped out of industrial estates was released into adjoining drainage channels. Climate-related financial losses for the MSMEs increased and the situation worsened for neighboring districts affected by the maladaptive strategies.²⁹

5. *Safe development paradox*

The safe development paradox describes a situation where an attempt to make hazardous areas safer in fact increases the potential for catastrophic damage and losses. If an area is perceived as safe, it attracts in-migration and economic development and, thus, raises the overall number of people and assets affected in case of severe disasters.^{4,30} The paradox is a common outcome in policies that target least-developed and most-vulnerable regions and highlights the importance of capacity building amongst the population, raising risk awareness and practicing long-term approaches in adaptation.

To illustrate, a climate-resilient development initiative invested in infrastructure in a least developed region in Bangladesh. Whilst this is likely to reap economic benefits in the short term, climate projections show that investment area would be permanently impacted by sea-level rise and other climate impacts in 2050.⁴ Therefore, the overall outcome of the investment strategy might cause even more losses due to the perceived safety it produces in the short run. In cases where risk perceptions demonstrate an area would become inhabitable due to climate impacts to an extent that goes beyond adaptive possibilities, development for short term gains may cause more harm than benefit in the mid to long term. Managed retreat or resettlement might be a more sustainable and climate-resilient option. In the case of Hurricane Katrina in the United States, previous development and



hazard reduction policies were effective to deal with everyday impacts and made the area appear safer and more attractive, thereby causing urban growth in New Orleans. However, the measures were insufficient to protect against more intense extremes. The in-migration meant increased losses and people affected by the severe hurricane.³⁰

6. *Agricultural adaptation lock-ins at the household and community level*

In northern Ghana, a study focused on household-level adaptation in villages found that farmers facing crop yield losses due to severe droughts, heat, and unpredictable precipitation patterns, diversified their income streams to strategies with even more intense water needs, thereby exacerbating water scarcity and their own climate vulnerability. Some even began selling livestock, shifting to wage labor or limiting their food intake. Many of the strategies to cope and adapt thus delivered maladaptive outcomes and lock-ins that shift or rebound vulnerability, and potentially worsen the situation in the future through eradicating sustainable development pathways and trapping people in poverty.^{3,31}

7. *Biodiversity loss and ecosystem damages*

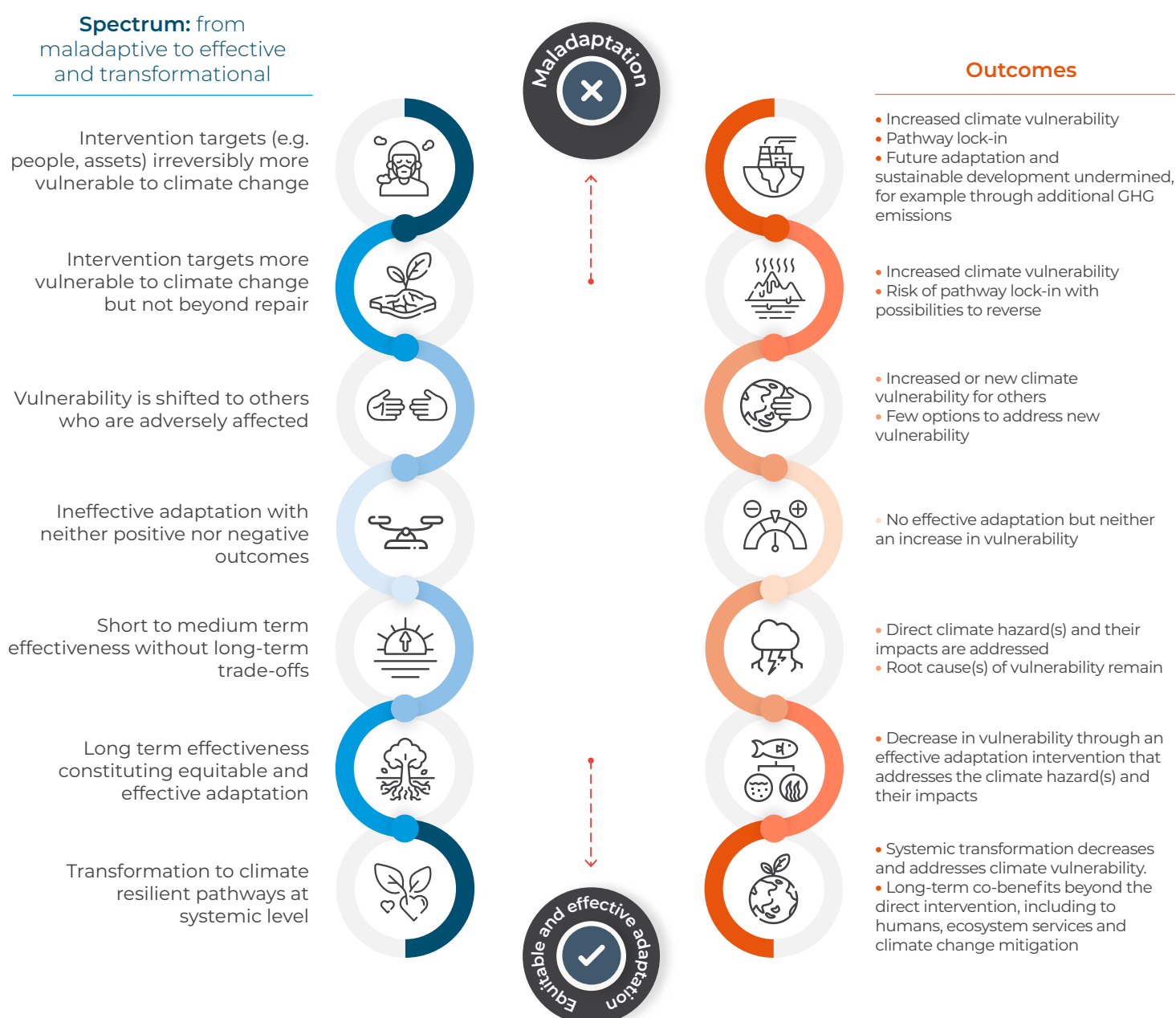
A private sector project framed as a forest-based climate change initiative, claiming to reforest a degraded area in Cambodia, has instead led to a range of maladaptive outcomes: according to a study, much of the project area was natural forest cut for the intervention, and then converted into much less biodiverse acacia plantations. This reduced ecosystem functions, destroyed wildlife habitat, and stripped local communities of forest-based livelihood opportunities. Forced exclusion from protected areas undermined locally organized forest protection.^{3,7}

A study regarding a project from Comoros depicts the negative environmental externalities coastal defense structures can create. Seawalls built on Grande Comore with the hope of protecting against erosion, storms and sea level rise have in fact contributed to further erosion and ecosystem degradation. The authors of the study link this mainly to poor design and construction, lack of knowledge on seawall risks and disadvantages, lack of capacity, resources and awareness of alternative strategies, and call for more site-specific management.^{16,32}

(Mal)adaptation as a spectrum

Adaptation success and maladaptation are not dichotomous. They present a spectrum, with outcomes ranging from transformative (leading to climate-resilient communities) to maladaptive (increasing vulnerability and thereby risk to people, ecosystems and assets). Most fall somewhere in between, with mixed consequences for climate risk reduction and distribution across different groups, locations, and times. These outcomes depend on context and can change over time. Viewing adaptation as a spectrum acknowledges that interventions can have both positive and negative effects, and helps identify and address maladaptation to move towards more resilient adaptation pathways.^{2,22}

Figure 1. A spectrum ranging from maladaptation to effective and transformational adaptation.²





Drivers of maladaptation

Adaptation failure can be linked to individual factors but is often a combination of multiple drivers and contextual situations that hinder adaptation success. To move towards effective adaptation outcomes, it is critical to understand the drivers that lead to maladaptation in the first place. The following section describes common maladaptation drivers and suggests strategies to minimize maladaptive risks for each of them below.

They include:

01. *Poor planning and implementation.*
02. *Focus on technological fixes.*
03. *Failure to address the root causes of vulnerability.*
04. *Inequitable project design and lack of stakeholder consultation.*
05. *Inherent power dimensions of adaptation decision-making.*
06. *Blurry distinction and competing interests between adaptation and development.*
07. *Evaluation systems and the quantification of non-quantifiable variables.*
08. *Short-term project cycles.*
09. *Limits to adaptation.*

01. *Poor planning and implementation*

Poor planning and design of adaptation strategies is often described as the primary cause of maladaptation.² Maladaptation can also happen due to poor project implementation or misalignment with the actual challenge and context addressed. The flaws in design and implementation can include a lack of awareness for vulnerability drivers, emphasizing the wrong actors, lack of contextual understanding, and producing lock-in effects through adaptation interventions.²



Lesson: Adaptation planning should consider potential short, mid and long-term effects, addressing root causes of vulnerability and building on thorough contextual understanding. Furthermore, participatory approaches lead to more equitable and sustainable outcomes.



02. Focus on technological fixes

Maladaptation is often linked to adaptation strategies that focus on technological fixes without contextual and social, economic, or cultural components. Such strategies are constrained by short-sighted goals and a narrow understanding of vulnerability. This leads to a limitation in the methods, engagements and scope considered and chosen for the project.¹⁶ Some engineered solutions can lock in undesirable development pathways, for example through the "safe development paradox" ([see here](#)).



Lesson: While conceiving adaptation measures, there is a need for deep contextual understanding, local knowledge, and socioeconomic considerations. In most cases, adaptation solutions that focus on purely technical solutions have a higher risk of becoming maladaptive. Meaningful stakeholder consultation, intersectional approaches and equitable processes are critical for adaptation success.

03. Failure to address the root causes of vulnerability

In many cases, maladaptation is caused by a shallow understanding of root causes of vulnerability, namely the factors that make people susceptible to being harmed by climate change.^{7,33} Vulnerability, created by physical and ecological contexts as well as sociocultural and economic factors, includes dimensions like race, religion, ethnicity, gender, poverty, political preferences, cultural norms and more.² Many times, already disadvantaged and marginalized groups face disproportional vulnerability to climate change.

Understanding the root causes of vulnerability is key to addressing the ways in which natural hazards may affect certain populations. If those factors are ignored, adaptation practices can redistribute vulnerabilities and increase risks especially for already marginalized people.^{3,12} A comprehensive contextual understanding of the location and beneficiaries, including system dynamics, helps to align the project design with the causes of vulnerability in mind and lead to more effective and sustainable project outcomes.^{2,15}



Lesson: Adaptation strategies should be designed with a multidisciplinary approach, bearing in mind the various and often interlinked sources of vulnerability including from environmental, economic, sociocultural, physical and climate factors. Maladaptive risk can be reduced by including adaptive measures that address the root causes of vulnerability.



04. *Inequitable project design and lack of stakeholder consultation*

A lack of equity and stakeholder participation in the design and implementation of adaptation strategies is another common driver of maladaptation.³³ Failing to properly involve community members and stakeholders, especially formerly excluded ones, in the decision-making process, can lead to neglected needs, misaligned interventions and maladaptive outcomes. It is important to translate stakeholder inclusion into meaningful engagements that influence project design and thereafter are followed through its implementation. Experience shows that if the preferences identified in stakeholder consultation meetings are not considered as important as the inputs provided by experts and elites, the project may have exclusionary outcomes.²⁷



Lesson: Projects need to assess community needs, discuss proposed actions, and include stakeholders in their design and implementation. Projects should ensure representation, bridge potential knowledge gaps, and make consultations accessible to individuals with limited capacity, for example by providing compensation allowances, care alternatives (e.g. childcare), language translation, transport and disability assistance. Furthermore, the timing in the season (e.g. farmers), week (e.g. day workers, tourism), or day (e.g. care work) might impact who is able to attend stakeholder consultations.

05. *Inherent power dimensions of adaptation decision-making*

Decision-making in adaptation has inherent power dimensions. They shape who decides which groups will be supported in adapting to climate change as well as where and how. More powerful groups often define whose interests, needs, and values are considered, which preferences people have in terms of climate priorities, and which trade-offs or losses are deemed acceptable.³⁴⁻³⁶

Neglecting the power dimensions inherent in adaptation decisions usually comes at the benefit of elites and leads to an exclusion of less privileged voices and higher maladaptation risks. Even in approaches labelled as participatory pitfalls can prevent equitable decision-making. This may happen through domination of a certain group, worldview or knowledge type, prioritizing technical expertise, or relying on quantifiable data only.³⁴



Lesson: Organizations that finance, design, or implement adaptation initiatives can shape

decision making processes. Providing conditions so that all voices are heard and considered, especially of less dominant, marginalized or previously excluded actors can make a significant difference in participatory outcomes. This may include providing special participation opportunities for women or minorities so they can voice opinions more freely.

06. *Blurry distinction and competing interests between adaptation and development*

As climate adaptation finance increases and adaptation plans gain priority on global and local agendas, a growing number of development actors is discovering adaptation as a pathway to increase finance for their respective interests. In such way, some actors are attempting to retrofit the adaptation framing into existing development agendas, and use this labelling to access novel financing streams.³³ However, mandates to mainstream adaptation into development-as-usual programs can risk maladaptive outcomes if initiatives take place without deeper understanding of climate-specific risks, vulnerabilities and needs and instead reproduce development-as-usual and technocratic patterns.^{19,34}

The blurred lines between climate adaptation and development influence the selection, perception, and financing of projects, which can create new trade-offs between adaptation and development rather than an appreciation of both as complementary and equally needed. Limited resources and capacity generally result in prioritizing projects with greater short-term gains over mid- to long-term adaptive planning.¹⁶



Lesson: Whilst there are many parallels between adaptation and development, they should

be regarded as complementary rather than competing. Although adaptation measures that address socioeconomic vulnerabilities can be similar to development initiatives, they require climate-specific and holistic considerations to build for long-term climate resilience. Maladaptation risks include outcomes that erode sustainable development.



07. *Evaluation systems and the quantification of non-quantifiable variables*

Another driver of maladaptation lays in project monitoring and evaluation (M&E). This links to how adaptation effectiveness is measured and tracked, and how adaptation success or failure is determined. The framing of adaptation M&E significantly changes the selection, implementation and outcomes of adaptation measures.^{22,33,37,38} Usually defined by the financing or managing organization, the choice of M&E systems can have far-reaching consequences. Many funding agencies rely on generalizable metrics which usually means quantifying non-quantifiable variables like justice, equity, resiliency, and vulnerability. The simplification inherent to the process of transcribing qualitative information into quantifiable indicators compromises accuracy, descriptive evidence, complexity, and contextual information. This incomplete picture can create a bias at the advantage of technocratic and short-sighted adaptation strategies, and evaluation systems relying on ticked boxes rather than an analysis of more systemic factors.^{9,16,37} Due to budget constraints, mal-designed evaluation methodologies and funding dynamics that make it difficult to admit or respond to mistakes. This can go as far as assessments lacking any meaningful evaluation, or project reporting containing falsified missing information, or having obscured safeguard violations.^{7,16}



Lesson: Monitoring and evaluation (M&E) systems can play a big role in detecting maladaptive risks early on. If well designed, they can enable better decision-making, immediate adjustments, and response mechanisms. However, M&E frameworks need to be carefully designed to avoid oversimplification of qualitative variables or promote biases through their assessment methodology. Meaningful evaluation systems can display contextual factors, show mistakes or undesired outcomes, and yield to efficient and effective responses.

08. *Short-term project cycles*

Most adaptation projects aim to complete the implementation of all project activities within a limited number of years. The time horizon of adaptation programs can lead to insufficient long-term considerations beyond the project phases. As described earlier, there are several maladaptive outcomes that may only become visible in the mid to long-term, sometimes years or decades after the adaptation measure has been implemented. Accounting for maladaptive outcomes in the long run requires that finance and governance constraints be overcome.



Lesson: The lack of mid and long-term M&E of adaptation actions generates an additional risk, as many impacts (positive and negative) can only be fully assessed after long time spans. Adaptation initiatives should invest in long-term evaluation mechanisms, including budgeting funds for potential interventions, as well as defining long-term accountabilities among project partners. Furthermore, adaptation methodologies should include long-term projections, risks, and opportunities for transformative adaptation strategies.



09. *Limits to adaptation*

Adaptation limits are both soft and hard thresholds beyond which climate adaptation strategies lose effectiveness. Climate change itself is a key risk to long-term adaptation success: under higher warming scenarios, more intense climate impacts increase the threat of chronic and sudden constraints on society, thereby making formerly successful adaptation strategies inefficient, sometimes even leading to safe development paradoxes. Additional climate change is amongst the most serious risks to effective adaptation, and rapid mitigation of GHG emissions is paramount for long-term benefits.^{3,9,39}

Adaptation limits also relate to socioeconomic and ecological determinants. The undermined adaptive capacity faced by people in vulnerable situations, e.g. women, youth, elderly, minorities, refugees and indigenous people, presents a socioeconomic example.^{3,11} In addition, limits to adaptation can be exacerbated by a lack of resources, insufficient capacity, technology failure and ineffective governance structures.

Severe glacier retreat, biodiversity loss, Amazon Forest dieback and ocean acidification are examples of ecological determinants. Their impacts on affected communities can become so severe and disruptive that effective adaptation pathways are no longer feasible. Consequences range from crop failures to loss of livelihoods and severe impacts on health.^{3,39}

It is worth noting that despite the limits, adaptation can provide immense benefits to society, the economy and biodiversity, preventing losses and protecting lives compared to the counterfactual. Transformative adaptation has the potential to expand adaptive possibilities, providing additional options after reaching first adaptation limits, and preventing maladaptive outcomes.^{3,39,40}



Lesson: Adaptation and mitigation must go hand in hand to prevent the worst losses and damages from climate impacts. A rapid reduction of GHG emissions, a fast energy transition and a green economy are key to staying on warming pathways below 1.5°C. Under lower emission scenarios, adaptation will be much more effective and less likely undermined by more intense, frequent and extreme climate effects. Socioeconomic determinants and environmental degradation can pose further limits to adaptation. Hence, it is critical to focus on designing adaptation solutions that strengthen rather than harm the systems that success relies upon.



Preventing maladaptation

Towards a framework for effective adaptation outcomes

The following section proposes steps to assess maladaptation-adaptation-related outcomes at multiple points in adaptive processes. This can help project teams anticipate, identify and manage maladaptive risk and effective adaptation opportunities, thereby improving investment choices and leading to more successful adaptation outcomes.

Assessing whether a strategy is leading to (a) an improvement, (b) no effect, or (c) a worsening in the respective dimension²², the framework 'Navigating the Adaptation–Maladaptation continuum' (NAM framework) developed by Reckien et. al (2023) provides an assessment methodology of adaptation strategies against the following six key dimensions:

01. *Ecosystems and ecosystem services*
02. *Climate systems (GHG emissions)*
03. *Social system (transformational potential),*
04. *Equity-related outcomes on low-income populations*
05. *Equity-related outcomes on women/girls*
06. *Equity-related outcomes on marginalized ethnic groups.*

For each of the categories, the NAM framework ranks the outcomes using a scoring scale from one (1) to four (4) depending on whether the outcome is negative (score 1), neutral (score 2), slightly positive (score 3) or larger and transformative positive (score 4). Responses are then aggregated for all dimensions, considering the range and average score, to reflect the likelihood of the adaptation option to produce effective adaptation and avoid maladaptation. Dimensions with lower scores indicate a need for adaptive management in order to prevent negative outcomes.²²

The use of the NAM framework can help detect the potential effects of current and future adaptation strategies pursued by actors across the portfolio. It can serve as an indicative list that can be tailored to project characteristics and to guide client engagement. The framework is the basis of the more exhaustive checklist provided further on in this document. Since the spectrum from effective adaptation to maladaptation has various drivers and degrees of uncertainty, the framework and the checklist can help to holistically examine projects and screen them for potential impacts across dimensions.

Continued project supervision and evaluation before, during and after adaptation projects

As aforementioned, long-term adaptation success requires evaluations at various points in time. To minimize maladaptive risks, ex-ante approaches have gained support in research and practice. Also, projects require continuous supervision to detect unwanted side effects, respond to unexpected challenges and identify and promote synergies for gained effectiveness. As some maladaptive outcomes only become clear after the completion of adaptation measures, availability of funds and capacity to respond and improve such delayed negative consequences are desirable. In summary, an assessment such as the checklist is ideally applied before, during and at the end of a given adaptation initiative, as well as a few years down the line. Such a comprehensive process allows for adaptive management adjustments and can thereby improve overall adaptation success.^{3, 4, 8, 9, 22}

Checklist: Guiding questions for preventing maladaptation



The following checklist serves as an orientation for project assessment through a (mal) adaptation lens. It thereby provides a point of departure to detect risks, opportunities and long-term effects. Due to the context-specificity, there may be some projects where not all questions are applicable or can be answered. Nonetheless, the checklist may be useful to analyze similar issues, and better understand how to mitigate maladaptation drivers. The checklist has been developed from the aforementioned NAM framework, complemented by up to three guiding questions per category, as well as one additional section (*Part 3*) examining the process, feasibility and long-term effects of the project.

Part 1 *System dynamics*

1. *Ecosystems and ecosystem services*

Whilst some adaptation initiatives focus specifically on applying ecosystem-based strategies, others undermine ecosystems through negative environmental side-effects. In this category, the potential impact of a project on ecosystems is evaluated, ranging from destructive to actively improving biodiversity, ecosystem health and natural resilience.^{22, 37}

1.1. Does the project invest in ecosystem conservation, management, and restoration of ecosystems?

1.2. Does the project enhance ecosystem services, including regulating, supporting, cultural and/or provisioning ecosystem services?

1.3. Does the project reduce or reverse land use conversion from natural landscapes to built infrastructure, from impermeable to permeable surfaces, or from grey to hybrid and nature-based solutions?

2. *Climate systems (co-benefits and trade-offs)*

Adaptation interventions that rely on fossil energy, produce emissions or undermine the absorption and storage of GHGs, pose a trade-off from a climate systems perspective. Projects should instead look for co-benefits between adaptation, mitigation and the Sustainable Development Goals (SDGs).⁴¹

2.1. Does the project, its activities or consequences avoid an increase in GHG emissions?

2.2. Are there synergies or co-benefits between the adaptation measure, climate mitigation and the SDGs?

2.3. Does the project avoid a dependency on intense or increased energy consumption, resource depletion or land use conversion?

3. *Social system (transformational potential)*

Effective adaptation requires sufficient understanding and addressing of the vulnerability context and social inequities. Projects should account for gendered risk experiences, the differentiated vulnerability of poor and marginalized populations, children, elderly, people with disabilities, refugees and people on the move, or groups facing discrimination and social exclusion. Rather than framing

affected populations as victims, projects should recognize local change agents, integrating local and traditional knowledge and cultural heritage. The social system dimension of adaptation can include the transformative potential of a project (projects that contribute to sustainable, effective systems change), (merely) incremental effects (projects that tackle and reduce the source of a risk but do not go beyond that), but also those that negatively impact social systems (projects that undermine social cohesion, future sustainable development, or produce an increase in inequalities).^{2,3,10,16,19}

3.1. Is the context well understood, in a way that the project identifies, addresses, and decreases root causes of vulnerability?

3.2. Are there social tipping points that could be affected by the adaptation measure, and does the project safeguard against negative social feedback?

3.3. Does the project support long-term systemic changes which enhance sustainable and climate-resilient development, or does it produce incremental effects that address risk and vulnerability sources?

Part 2 *Justice and equity*

4. Equity-related outcomes on low-income populations, women and girls, and marginalized ethnic groups

Effective adaptation projects have the potential to increase justice and equity in project areas, thereby building resilience especially for most vulnerable populations. Maladaptive projects, on the other hand, can redistribute vulnerability or make people worse off than before the adaptation intervention, thereby worsening justice and equity for local populations. Paying attention to the distributional effects of adaptation and putting equitable solutions at the core of adaptation planning and implementation is thus a key factor for more effective outcomes.^{3,19,26,37} Dimensions four, five and six from the NAM framework are joined together here, as in most cases similar questions can be asked for low-income populations (NAM dimension 4), women and girls (NAM dimension 5) and marginalized ethnic groups (NAM dimension 5).

4.1. Does the project serve (a) lower-income communities and people living in poverty or informal areas, (b) women and girls and (c) marginalized ethnic groups and people facing discrimination and exclusion, by reducing their vulnerability and supporting their resilience and wellbeing?

4.2. Does the adaptation strategy go beyond technically feasible, cost-effective measures to actively pursue fairness and justice for (a) lower-income communities and people living in poverty or informal areas, (b) women and girls and (c) marginalized ethnic groups and people facing discrimination and exclusion?

4.3. Are adaptation benefits and burdens distributed evenly, putting the most vulnerable first, and can this be shown through a comprehensive vulnerability assessment?

4.4. Does the project avoid compromising the wellbeing or vulnerability of one group through the intervention?



Part 3

Process, feasibility and long-term effects

5. Equitable and inclusive adaptation processes

Communities, affected populations and marginalized groups need to be included in the design and implementation of adaptation projects. As no community is uniform, their diversity of needs, interests and opinions that should be reflected and discussed in adaptive decision making. Power dimensions within adaptation processes matter as well. If (a) elites control adaptation decision-making, (b) bureaucracy gatekeeps the less educated from participating, or (c) timing, location or a lack of invites prevents the access of marginalized groups in consultations, adaptation processes are prone to become inequitable and exclusive.^{2,10,15,37}



5.1. Has the project been conceived with input from communities and a diverse range of stakeholders, including (a) lower-income communities, (b) people living in poverty or informal areas, (c) women and girls, and (d) marginalized ethnic groups and people facing discrimination and exclusion?

5.2 Can project sponsors make sure that existing networks and coalitions with partners do not exclude marginalized and vulnerable people?

5.3. Are all relevant stakeholders (a) informed soon enough about the consultation processes, (b) able to financially afford their participation, (c) find alternatives for labor or care work responsibilities during the consultation times, (d) travel safely to and from the location where consultations take space, (e) able to follow the language and terminology of the consultation, and (f) able to, beyond their cultural factors, voice their full opinion without fear of negative consequences?

5.4. Is the project oriented towards achieving transparency, accountability, and representation through its processes?

6. Financial and operational feasibility and sustainability

Adaptation initiatives, just like any project, need to be realistic and feasible. Resources, capital and capacity need to be available over the whole project timeline, taking into account potential risks and opportunity costs.³⁷

6.1. Is adaptation success defined considering stakeholders, vulnerabilities, contextual factors, and potential long-term effects?

6.2 How is adaptation success measured, monitored, and evaluated?

6.3. Can necessary resources, financing, inputs, knowledge, data, human capacity be guaranteed over the whole project timeline?

6.4 Is the project economically, ecologically, and socially sustainable, explicitly looking at longer-term, cross-generational viability of adaptation actions?



7. Avoiding long-term negative consequences of lock-ins and path dependency effects

Due to budget constraints, financing cycles and economic pressures, many initiatives focus on the short run. Neglecting long term consequences in adaptation can lead to unexpected outcomes that only become visible down the line, including a lock-in with unsustainable infrastructure or technology, path dependency effects, or false risk perceptions.^{2, 8, 41}

7.1. Is the initiative flexible and adaptable?

7.2 Is there sufficient capacity to track and respond early-on to maladaptive effects so that path dependency and lock-in can be avoided?

7.3 Does the project provide an ongoing incentive for further adaptation?

7.4. Does the project support relative diversification of economic activities, or does it integrate potential changes in livelihoods that result from increased climate effects?

7.5. Does the project explicitly account for cross-scalar, long-term impacts of adaptation action, looking beyond its intended timeline to include possible secondary and tertiary effects?



Conclusions

Climate adaptation efforts have been increasing across regions and sectors, generating multiple benefits that go beyond building resilience to climate-related shocks and changes. Effective adaptation has the potential to reap several co-benefits including increased biodiversity and ecosystem resilience, climate mitigation, reduction of inequalities, equity and inclusion, health, wellbeing, economic prosperity and more. In an age of accelerating climate risks, adaptation has become essential to prevent the worst losses and damage, to save lives and secure livelihoods. However, adaptation actions have sometimes proven inadequate in their geographic scale and scope, failing to systematically and sufficiently address root causes of climate-related risk and vulnerability.²²

Maladaptation happens where well-intended adaptation initiatives backfire, rebounding or redistributing vulnerability or eroding future sustainable development opportunities. Adaptation outcomes are rarely clear-cut. Much rather, there is a continuum of adaptation outcomes ranging from maladaptation to effective adaptation. Maladaptation poses a serious risk to project success, and therefore it is in the interest of any adaptation initiative to understand what drives it, to learn from examples and engage with strategies that help to reduce maladaptive risks and increase the chances of positive and effective adaptation outcomes. Decision-makers that design, choose, finance or implement adaptation initiatives have a responsibility for project outcomes.²² Actors controlling project finance should beware of risking undesired, unsustainable and harmful outcomes by prioritizing short-term economic gain at the sacrifice of environmental quality and social safety.¹⁶

Without a doubt, adaptation works and is urgently needed to protect humans and nature from the worst, most costly, and damaging effects of the climate crisis. With the right strategies, mindful detection of maladaptation drivers, and adoption of system thinking and a multidisciplinary approach to address vulnerabilities, adaptation initiatives can become more sustainable and effective in the short and in the long term.



Bibliography

1. *IPCC*. Annex VII: Glossary. 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* (eds. Matthews, J. B. R. et al.) 2215–2256 (2021). doi:10.1017/9781009157896.022.2215.
2. *Schipper, E. L. F.* Maladaptation: When Adaptation to Climate Change Goes Very Wrong. *One Earth* 3, 409–414 (2020).
3. *Birkmann, J.* et al. Chapter 8: Poverty, Livelihoods and Sustainable Development. 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 (IPCC), 2022)*.
4. *Magnan, A. K.* et al. Addressing the risk of maladaptation to climate change. *Wiley Interdiscip. Rev. Clim. Chang.* 7, 646–665 (2016).
5. *Eriksen, S.* et al. Adaptation interventions and their effect on vulnerability in developing countries: Help, hindrance or irrelevance? *World Dev.* 141, 105383 (2021).
6. *Thomas, K. A. & Warner, B. P.* Weaponizing vulnerability to climate change. *Glob. Environ. Chang.* 57, 101928 (2019).
7. *Work, C., Rong, V., Song, D. & Scheidel, A.* Maladaptation and development as usual? Investigating climate change mitigation and adaptation projects in Cambodia. *Clim. Policy* 19, S47–S62 (2019).
8. *Magnan, A.* Avoiding maladaptation to climate change: towards guiding principles. *S.A.P.I.EN.S* 7, (2014).
9. *Schipper, E. L. F.* Catching maladaptation before it happens. *Nat. Clim. Chang.* 12, 2021–2022 (2022).
10. *Soanes, M.* et al. Principles for locally led adaptation A call to action. (2021).

11. Roy, J. et al. Sustainable Development, Poverty Eradication and Reducing Inequalities. in Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, 445–538 (2018). doi:10.1017/9781009157940.007.
12. Atteridge, A. & Remling, E. Is adaptation reducing vulnerability or redistributing it? WIREs Clim. Chang. 9, (2017).
13. Global Center on Adaptation. Economics and finance. The private sector. in State and Trends in Adaptation Report 2021 (2021). doi:10.5040/9781492596301.ch004.
14. Pauw, P. & Dzebo, A. Private finance for climate-change adaptation: challenges and opportunities for Kenya. vol. 6 <http://hdl.handle.net/10419/199786> (2016).
15. Dilling, L., Daly, M. E., Travis, W. R., Wilhelmi, O. V. & Klein, R. A. The dynamics of vulnerability: why adapting to climate variability will not always prepare us for climate change. Wiley Interdiscip. Rev. Clim. Chang. 6, 413–425 (2015).
16. Bertana, A., Clark, B., Benney, T. M. & Quackenbush, C. Beyond maladaptation: structural barriers to successful adaptation. Environ. Sociol. 8, 448–458 (2022).
17. Juhola, S., Glaas, E., Linnér, B. O. & Neset, T. S. Redefining maladaptation. Environ. Sci. Policy 55, 135–140 (2016).
18. O'Hare, P., White, I. & Connelly, A. Insurance as maladaptation: Resilience and the 'business as usual' paradox. Environ. Plan. C Gov. Policy 34, 1175–1193 (2016).
19. Dodman, D. et al. Chapter 6: 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 (IPCC), 2022).
20. Shi, L. et al. Roadmap towards justice in urban climate adaptation research. Nat. Clim. Chang. 6, 131–137 (2016).
21. Klein, J., Juhola, S. & Landauer, M. Local authorities and the engagement of private actors in climate change adaptation. Environ. Plan. C Polit. Sp. 35,.
22. Reckien, D. et al. Navigating the continuum between adaptation and maladaptation. Nat. Clim. Chang. (2023) doi:10.1038/s41558-023-01774-6.
23. Keenan, J. M., Hill, T. & Gumber, A. Climate gentrification: From theory to empiricism in Miami-Dade County, Florida. Environ. Res. Lett. 13, (2018).

24. *Immergluck, D. & Balan, T.* Sustainable for whom? Green urban development, environmental gentrification, and the Atlanta Beltline. *Urban Geogr.* 39, 546–562 (2018).
25. *Gould, K. A. & Lewis, T. L.* From Green Gentrification to Resilience Gentrification: An Example from Brooklyn. *City Community* 17, 12–15 (2018).
26. *Henrique, K. P. & Tschakert, P.* Contested grounds: Adaptation to flooding and the politics of (in) visibility in São Paulo's eastern periphery. *Geoforum* 104, 181–192 (2019).
27. *Anguelovski, I.* et al. Equity Impacts of Urban Land Use Planning for Climate Adaptation: Critical Perspectives from the Global North and South. *J. Plan. Educ. Res.* 36, 333–348 (2016).
28. *Salim, W., Bettinger, K. & Fisher, M.* Maladaptation on the Waterfront: Jakarta's Growth Coalition and the Great Garuda. *Environ. Urban. ASIA* 10, 63–80 (2019).
29. *Schaer, C. & Pantakar, A.* Promoting private sector engagement in climate change adaptation and flood resilience—a case study of innovative approaches applied by MSMEs in Mumbai, India. in *Theory and Practice of Climate Adaptation. Climate Change Management* (eds. Alves, F., Leal Filho, W. & Azeiteiro, U.) (Springer International Publishing, 2018). doi:10.1007/978-3-319-72874-2_33.
30. *Burby, R. J.* Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing About Wise Governmental Decisions for Hazardous Areas. *Ann. Am. Acad. Pol. Soc. Sci.* 604, 171–191 (2006).
31. *Antwi-Agyei, P., Dougill, A. J., Stringer, L. C. & Codjoe, S. N. A.* Adaptation opportunities and maladaptive outcomes in climate vulnerability hotspots of northern Ghana. *Clim. Risk Manag.* 19, 83–93 (2018).
32. *Betzold, C. & Mohamed, I.* Seawalls as a response to coastal erosion and flooding: a case study from Grande Comore, Comoros (West Indian Ocean). *Reg. Environ. Chang.* 17, 1077–1087 (2017).
33. *Eriksen, S.* et al. Adaptation interventions and their effect on vulnerability in developing countries: help, hindrance or irrelevance? (2021).
34. *Scoville-Simonds, M., Jamali, H. & Hufty, M.* The Hazards of Mainstreaming: Climate change adaptation politics in three dimensions. *World Dev.* 125, 104683 (2020).
35. *Nagoda, S. & Nightingale, A. J.* Participation and Power in Climate Change Adaptation Policies: Vulnerability in Food Security Programs in Nepal. *World Dev.* 100, 85–93 (2017).
36. *Eriksen, S. H., Nightingale, A. J. & Eakin, H.* Reframing adaptation: The political nature of climate change adaptation. *Glob. Environ. Chang.* 35, 523–533 (2015).

37. *Singh, C.* et al. Interrogating 'effectiveness' in climate change adaptation: 11 guiding principles for adaptation research and practice. *Clim. Dev.* 14, 650–664 (2022).
38. *Berrang-Ford, L.* et al. A systematic global stocktake of evidence on human adaptation to climate change. *Nat. Clim. Chang.* 11, 989–1000 (2021).
39. *O'Neill, B.* et al. Chapter 16: Key Risks across Sectors and Regions Coordinating. in *Climate Change 2022: Impacts, Adaptation and Vulnerability* 2411–2538 (Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC), 2022). doi:doi:10.1017/9781009325844.025.
40. *Felgenhauer, T.* Addressing the limits to adaptation across four damage–response systems. *Environ. Sci. Policy* 50, 214–224 (2015).
41. *Barnett, J. & O'Neill, S.* Maladaptation. *Glob. Environ. Chang.* 20, 211–213 (2010).
42. *Stewart, M. G. & Deng, X.* Climate Impact Risks and Climate Adaptation Engineering for Built Infrastructure. *ASCE-ASME J. Risk Uncertain. Eng. Syst. Part A Civ. Eng.* 1, 1–12 (2015).
43. *Romero-Lankao, P. & Gnatz, D.* Risk Inequality and the Food-Energy-Water (FEW) Nexus: A Study of 43 City Adaptation Plans. *Front. Sociol.* 4, 1–14 (2019).
44. *Ranganathan, M. & Bratman, E.* From Urban Resilience to Abolitionist Climate Justice in Washington, DC. *Antipode* 53, 115–137 (2019).
45. *Schlosberg, D. & Collins, L. B.* From environmental to climate justice: Climate change and the discourse of environmental justice. *Wiley Interdiscip. Rev. Clim. Chang.* 5, 359–374 (2014).



Annex:

Avoiding maladaptation in the infrastructure sector

This section contains an example of the steps and measures to avoid maladaptation in an infrastructure project located in a region with high climate-related exposure and vulnerability. To provide environmental and social specialists as well as project teams with a practical way of how the proposed checklist could be applied, it follows the guiding steps and questions, outlining concrete steps to enhance adaptation success likelihood and avoid maladaptation.

Due to context-specificity, the success or failure of certain adaptation measures can depend on a multitude of factors (in)directly linked to the chosen adaptation strategy. Climate vulnerability is multidimensional and intersectional, which makes it complex to address. This example indicates how maladaptive risks can be kept to a minimum. However, further steps might be necessary depending on the specific project.

The need for climate adaptation in the infrastructure sector

Infrastructure adaptation is essential for climate-resilient development. Due to climate change, infrastructure in many places around the world is becoming more exposed to increasingly frequent and intense natural hazards which can have a detrimental effect on local and

global economies, human wellbeing, and safe, sustainable provision of basic services. Climate adaptation is paramount to prevent losses, damage and disruption of existing infrastructure systems, and needs to be part of the planning and design of new infrastructure projects.³

Maladaptive risk of infrastructure investments

Even though infrastructure can help to reduce the impacts of climate change,^{19,42} infrastructure development and adaptation may increase inequality in cities and settlements, for example through social, economic and cultural structures that increase marginalization and thereby contribute to climate vulnerability of already vulnerable populations at the benefit of privileged groups.^{19,27,43} Green gentrification mentioned in Box 2 is one example for such maladaptive outcomes. Effective adaptation in the infrastructure sector takes into account sociocultural and economic drivers of climate vulnerability and builds on inclusive and participatory processes. If done well, infrastructure adaptation can promote distributive and procedural justice and transform cities and settlements into more fair and resilient spaces.^{19,26,44,45}

Checklist illustration for an infrastructure project: Building a climate-resilient railway

For the sake of this hypothetical example, a possible investment in a new train track is considered. The track goes from city A, a coastal city, close to the river up to city B, which is 500 km inland in a mountainous landscape, connecting three more towns on the way. The train could boost the local economy and make travel much more accessible for 2 million people living in the 5 towns and cities as well as their surrounding areas. The shortest way to build the track would be cutting through primary forests, wetlands and areas inhabited by indigenous populations.

The following sections follow the guiding questions in the checklist as well as some additional considerations, to demonstrate how this project can address climate risks whilst ensuring environmental sustainability, minimizing unwanted consequences, as well as new or shifted vulnerabilities and other maladaptive outcomes.



(1) Ecosystems and ecosystem services

- **Adjust the route to ecosystems:** Analyze important ecosystems in the area where the train track shall be built. Try to circumnavigate them wherever possible; assess alternative routes for sections crossing primary forests or protected areas.
- **Consider ecosystem services:** Understand the railway's potential impact on surrounding ecosystems and their services (e.g. water regulation, carbon sequestration, biodiversity); ensure the project causes no or minimal disruptions in ecosystem functioning; incorporate ecosystem-based approaches into project design and planning.
- **Invest in conservation and restoration:** If natural ecosystems are converted into infrastructure for this project, invest in conservation and restoration of ecosystems in another area close by (offset). However, consider that the disruption or partition of an ecosystem can't be easily offset. For example, a railway cutting through a forest may provide new pathways for illegal logging, it may partition the habitat in two, and affect local species and ecosystem functioning.

(2) Climate systems

- **Calculate the carbon footprint of the project:** Estimate the construction-related emissions of the railway track, including the production and transportation of resources and inputs. Calculate the anticipated emissions during operation and maintenance of the train and look at the energy sources for these operations. Compare emissions to alternative modes of transportation to see whether the railway is likely to lead to fewer transport-related emissions in the mid to long term.
- **Look into co-benefits and conflicts with sustainable development targets:** Estimate in what ways the train can support or undermine sustainable development, for example looking at sustainable energy, accessibility, and green transport and mobility systems. Following the findings from section 1 (Ecosystems and ecosystem services), understand the effects for climate change that come from the train project.
- **Climate-resilient design:** Using climate risk projections, estimate which part of the railway might be exposed to climate hazards and ongoing climate impacts. Adjust the plans so that the railway can withstand for instance sea-level rise and storms, extreme heat, as well as landslides, and other climate-related risks. Take measures to make the tracks, trains, stations, and other elements resilient to the specific risks of the area and consider emergency response systems.
- **Integrate early warning systems:** Implement a robust monitoring and early warning system to track environmental and social indicators. This system will help identify potential maladaptive outcomes early on and trigger appropriate responses.

(3) Social system

- **Climate and vulnerability assessment:** Conduct a comprehensive climate and vulnerability assessment that identifies root causes of vulnerability. Integrate elements into the project that address those vulnerability drivers.
- **Analyze social dynamics and potential tipping points:** Investigate in what ways the project interacts or changes social dynamics, for example through changed mobility patterns, livelihood impacts or care work distribution. Together with affected populations, formulate ways to shape social changes in a positive and inclusive way.

(4) Equity-related outcomes on low-income populations, women and girls, and marginalized ethnic groups

- **Assess the diversity of the target group / project beneficiaries:** The project design and business plan can tell a lot about the target population it is made for. If the train is planned as high-end luxury train, or with no public services connecting the train station to surrounding urban and rural settlements, it might increase social inequalities because poor people are unable to afford, access and use the new transportation system. Therefore, ensure that the benefits of the project are distributed equitably. Include the needs and inputs of indigenous and marginalized populations into the project design. Plan the railway system in a way that it is safe, accessible and affordable for all to use, e.g. through progressive pricing or discounts for poor or disadvantaged people; accessible infrastructure for disabled users and elderly; and enough station and street lighting and safe connecting services for women traveling alone at night.

- *Social safeguards and inclusivity:* Put in place social safeguards to ensure that the railway project does not adversely impact vulnerable communities or lead to the displacement of people.
- *Capacity building:* Invest in capacity building for local communities to help them cope with and adapt to potential impacts resulting from the train project, e.g. maintenance, training on disaster preparedness, sustainable land use, or livelihood diversification.

(5) *Equitable and inclusive adaptation processes*

- *Participatory processes:* Engage local communities, women and girls, lower-income people and marginalized groups in the planning, design, and implementation of the railway. Make stakeholder consultation accessible, feasible, affordable, safe, and easy to reach for a diverse group of participants, including timing and location, compensation, language requirements and overcoming sociocultural barriers.
- *Transparent communication and adaptable design:* Transparently communicate about project decisions, planning and implementation to affected groups and diverse stakeholders; provide opportunities for people to voice concerns or improvement suggestions, and allocate time and resources to address issues raised throughout the project timeline.

(6) *Financial and operational feasibility and sustainability*

- *Defining and measuring project success:* Include sociocultural, economic, and environmental considerations when defining adaptation success.

- *Assuring required inputs:* Understand what resources, financing, knowledge, data, and human capacity is needed over the project timeline, identify potential bottlenecks and risks to a successful implementation, and propose alternative plans in order to mitigate potential delays or project failure.
- *Monitoring and adaptive management:* Continuously track project progress and allow for adjustments to the project as new information, better contextual understanding, stakeholder needs, or potential challenges become clearer. The plan should include trigger points for reassessment and potential changes in response to evolving conditions.

(7) *Avoiding long-term negative consequences of lock-ins and path dependency effects*

- *Long-term planning:* Ensure the project is designed with long-term sustainability in mind and assess the longevity and long-term costs as well as future consequences of the adaptation strategy, including primary, secondary, and tertiary impacts and negative externalities associated with the railway project on both humans and ecosystems. Avoid short-term fixes that may lead to maladaptive outcomes in the future.
- *Avoid lock-in:* Assess the risk of locking people into development pathways that can prevent future climate adaptation and/or erode sustainable development, for example if the new train track attracts more people to settle in a hazardous region.
- *Knowledge sharing and learning:* Encourage knowledge sharing among stakeholders, including the client, local communities, and project partners, so that best-practice approaches and lessons learned can be spread.

