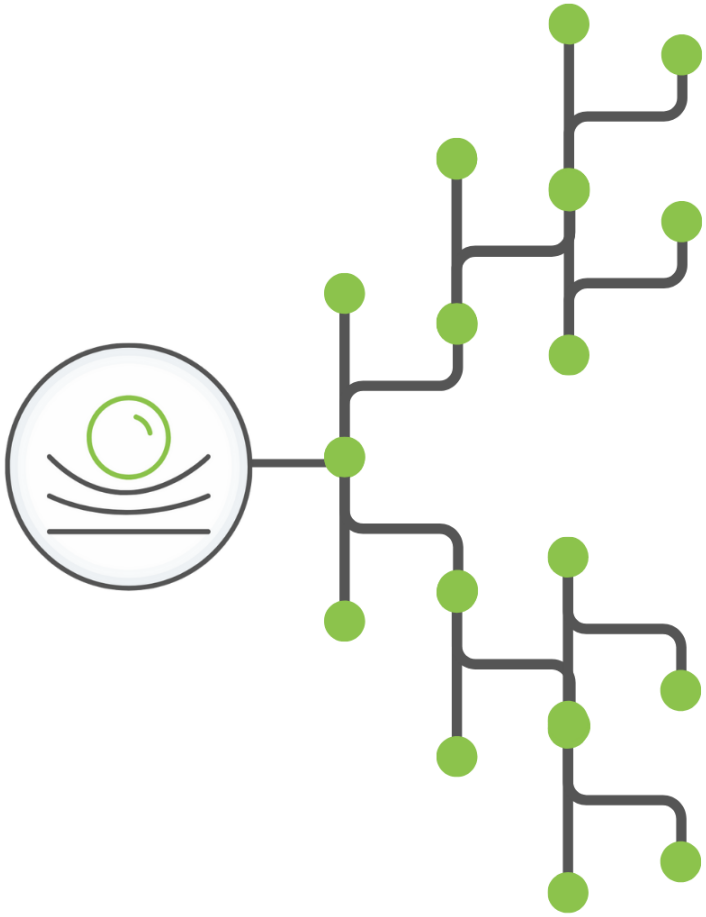
REGILIENCE

Regional Pathways to Climate Resilience



ADDRESSING MALADAPTATION - implications for decision-makers

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About

REGILIENCE aims to foster the adoption and wide dissemination of regional climate resilience pathways, following a demand-driven approach and bearing in mind the expertise and knowledge acquired, as well as the solutions available from Innovation Packages and other sources. The project aims to support the Green Deal targets and communication by implementing Innovation Packages that will address key community systems and comprises the adaptation solutions and pathways deemed essential for climate and social resilience in the specific regional contexts and the set timeline. The REGILIENCE project aims to facilitate the replication of Innovation Packages in 10 vulnerable and low-capacity regions, in additional to those targeted by the Innovation Package projects, after a selection process and the signature of a workplan agreement. This ambition is aligned with the Horizon Europe's proposed Mission "Prepare Europe for climate disruptions and accelerate the transformation to a climate-resilient and just Europe by 2030". It will implement the LC-GD-1-3-2020 RIA project results on the Innovation Packages. The project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036560.

In this subtask on maladaptation, we aim to support regional stakeholders and communities in identifying and avoiding maladaptation risks. This deliverable will contribute to our envisaged performance and impact targets outlined in the Grant Agreement, by translating our findings into capacity-building and training. Furthermore, we aim to advance the integration of maladaptation into existing tools that promote good practice in adaptation. This deliverable identifies the main roots and causes of maladaptation, presents case studies of maladaptation and introduces a self-assessment tool to identify and mitigate risks of maladaptation in the planning phase.

Related Key Performance Indicators:

- Indicator 1: 290 individual support activities have been provided to prioritised regions on climate resilience pathways, where the work on maladaptation contributes to broader support activities to increase awareness raising on the risk of maladaptation (through interviews). Furthermore, REGILIENCE will organize one workshop.
- Indicator 5: 5 relevant online platform knowledge access upgrades have been implemented. Interlinking the self-assessment tool for maladaptation with the adaptation support tool *Climate-ADAPT* (EEA) will be one way in which REGILIENCE upgrades a relevant online platform.
- Indicator 6: 30 sharing & learning activities on climate resilience pathways have been carried out.

Related Impact Targets:

- Impact target 1: 10 regions (or provinces, counties, or equivalent) co-design climate resilience pathways, supported by REGILIENCE in addition to the regions targeted by the Innovation Packages, as a previous step to sign a climate resilience contract. We are currently in the process to discuss if and how the self-assessment tool to identify risks of maladaptation will be tested in the Innovation Packages case studies of the projects ARSINOE, IMPETUS, and TransformAr. In addition, it will be used to support the regions and communities which will be further supported by REGILIENCE in 2023.
- Impact target 5: 20% increase in usage of knowledge platforms compared to the previous system. People already using platforms such as Climate-ADAPT can expand their evaluation of planned adaptation actions through the self-assessment tool to identify risks of maladaptation.

- Impact target 6: 600 citizens have improved their knowledge and capacities on climate resilience pathways. Through interviews with experts and non-experts and testing the self-assessment tool with the staff of regional administration and stakeholders, the maladaptation tasks of this project enhances the knowledge and capacities of citizens by accommodating more participation in adaptation planning.

Statement on mainstreaming gender

Moreover, we acknowledge the need to mainstream gender aspects as a transversal aspect in the project's activities. The need for gender mainstreaming arises from persistent inequalities in power distribution and access to services and opportunities between people of different sex and/or gender identities. As demonstrated by literature and advocated in the European and international arena, this influences the understanding and perception of climate change dynamics and effects. Women and men, but also people in the LGBTQI+ community, are differently affected by the accelerated change of climate. Only by taking into consideration their diverse visions can scientific research reach meaningful and universal conclusions that properly inform climate action.

For these reasons, the REGILIENCE consortium is committed to including gender and intersectionality as a transversal aspect in the project's activities. In line with EU guidelines and objectives, all partners – including the authors of this deliverable – recognise the importance of advancing gender analysis and sex-disaggregated data collection in the development of scientific research. Therefore, they commit to paying particular attention to including, monitoring and periodically evaluating the participation of different genders in all activities developed within the project, including workshops, webinars and events but also surveys, interviews and research, in general. While applying a non-binary approach to data collection and promoting the participation of all genders in the activities, the partners will periodically reflect and inform about the limitations of their approach. Through an iterative learning process, they commit to plan and implement strategies that maximise the inclusion of more and more intersectional perspectives in their activities.

This has practical implications for maladaptation, which can have gender-specific effects, which increase existing gender inequalities: such as sanitary structures being compromised more strongly for women, when the risk of flooding and actual flooding increases; or maladaptive actions decreasing marginal income of households, often enhancing pressure on women. Also, disenfranchisement and discrimination of the LGBTQ+ community is overproportional and with the effects of climate change and maladaptive effects that exacerbate climate change will add to the burden. Whenever different gender perspectives are not included or actively made part of adaptation decision-making processes, this increases the risk for maladaptation. Gender aspects were also considered in the process of developing a tool to avoid maladaptation, by ensuring a balanced distribution of interviewed experts. This will also be crucial when updating the self-assessment tool for maladaptation. Here, we consider the power of mainstreaming tools and guidelines towards being gender neutral.

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Abbreviations

AST	Adaptation Support Tool
CBA	Cost-Benefit Analysis
DAC	Development Assistance Committee (of the OECD)
EEA	European Environment Agency
EU	European Union
GHG	Greenhouse gases
IPCC	Intergovernmental Panel on Climate Change
OECD	Organisation for Economic Co-operation and Development
RCP	Representative Concentration Pathways

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Project partners

Executive Summary

Adaptation to current and future impacts of climate change is urgently needed, but should not be done unplanned or rushed, to avoid adaptation actions turning out to be maladaptive outcomes. Maladaptation can create irreversible damage and increase vulnerability: Maladaptation comes in different forms, such as lock-ins, or drawbacks for various groups in the short- or long-term, or by creating compromises in the same or a different sector than the actual adaptation action. It occurs, when climate change adaptation actions have negative side-effects or outcomes, directly or indirectly, at a later point in time or in other areas, sectors, or parts of society, usually unintended. Therefore, there is a need to guide and push for careful considerations in the planning phase of adaptation actions. The risk of such negative outcomes on potentially different groups and sectors at different points in time should be taken seriously, so as not to worsen the situation inadvertently.

This manual introduces a self-assessment checklist tool that helps anticipate and avoid maladaptation risks. The tool is designed to be used in the planning phase of adaptation actions.

To facilitate a better understanding of maladaptation and guide the reader through the conceptual basis of the tool, this manual also provides valuable insights on the conceptualization of maladaptation, its root causes, and different types, including real-world examples, sourced from existing literature as well as expert and practitioner interviews. The main roots and causes for maladaptation include: 1) Not dealing with future scenarios and uncertainties adequately; 2) Being stuck in siloed systems and lack of participation; 3) Unsustainable financial steering; 4) Prioritizing short-term, popular solutions; 5) Limited information and improper use of data; 6) Geographic or demographic reasons and 7) Implementation failure/ shortcomings.

The research and interviews, also yielded in a list of risk factors of maladaptation, that were the basis for developing the tool. The risk factors to maladaptation when planning adaptation actions are:

- Lack of effectiveness
- Insufficient knowledge and understanding
- Lack of coherence
- Lack of sustainability and path dependency
- Lack of relevance

Developed in the context of the EU-funded project REGILIENCE, the tool has been primarily designed for application in the context of planning regional adaptation, however, it is widely applicable/adaptable for uses within different scopes including national, local, and individual adaptation as well as in the private sector.

1 Introduction

The **impacts of climate change** are already felt globally, be it through an increase in climate-related extreme events such as droughts or a gradual change in environmental conditions. Despite global efforts to reduce emissions of greenhouse gases, climate change is the biggest threat to the future of people and nature. This is due to the inertia of the climate system and the longevity of some greenhouse gases. Besides a rapid and effective reduction of greenhouse gases, **urgent and immediate action** to address climate risks and adapt socio-ecological systems to present and future changes is needed. This requires the involvement of all societal actors from local to global levels (e.g. governments, households, private sector, NGOs) (IPCC, 2022b; Magnan, 2014).

Adapting to climate change is a complex and challenging task (Barnett & O'Neill, 2010). As more and more adaptation actions are planned and implemented, the risk of negative impacts emerging from adaptation actions increases. When adaptation actions fail to mitigate or reduce the vulnerability to climate change but instead worsen the situation, this is referred to as maladaptation. Maladaptive outcomes are usually unintended and can affect the same or a different sector in which the adaptation action was planned. It can negatively affect the group that was targeted by the action, or other social groups and impacts can become apparent now or in the future. In some cases, vulnerabilities are shifted spatially, e.g. to other countries, regions, or communities. Adaptation actions that contribute to the degradation of the environment or reinforce climate change are also associated with maladaptation. The root causes of maladaptation can mainly be traced back to insufficient planning and the lack of participation of relevant social groups.

As investments for adaptation are scaled up, it is important to ensure that adaptation actions succeed in decreasing vulnerability to climate change without causing any negative side effects. **Maladaptation can be avoided** through flexible, inclusive, cross-sectoral, and long-term planning and implementation of adaptation actions (IPCC, 2022a). The monitoring and evaluation of adaptation are crucial to ensure that adaptation efforts are successful in reducing or mitigating climate change-related risks without having any detrimental effects. Furthermore, successes and failures can inform adaptation actions in the future to ensure that potential negative impacts are avoided or minimized. To achieve this, it is important to spot and counteract these risks at an early stage in the project cycle.

Although maladaptation is an emerging concern within the adaptation discourse, the knowledge of **how to avoid negative impacts in practice is limited**. Practical guidance which breaks down scientific findings to the challenges of adaptation planning on the ground hardly exists. This manual, therefore, **presents a tool that helps planners and implementers of adaptation projects** to spot and mitigate potential maladaptation risks (primarily in a regional context, but applicable to different contexts, see chapter 4), also supporting stakeholders who engage in such processes. The tool builds on the current state of knowledge on maladaptation (chapter 2) derived from a literature review and interviews with (mal)adaptation experts. Furthermore, we address the lack of conceptual clarity by providing a comprehensive definition of maladaptation (chapter 4.1). Chapter 3.3 gives an outlook on different approaches to avoid maladaptation in the future. Background information on the tool and how it was developed can be found in Annex I. The need to consider maladaptation risks during the planning phase is the motivation for this work and we hope that the manual is a building block toward strong planning phases of adaptation actions in regions.

2 Maladaptation in theory

2.1 Review of existing maladaptation definitions

Currently, no comprehensive definition of maladaptation exists. The roots of the concept date back to the 1990s, and initial definitions mainly refer to the exacerbating of the negative effects of climate change or an increase in vulnerability through an adaptation action (Magnan, 2014). The term maladaptation is also commonly used in evolutionary biology to describe populations that are not well adapted to environmental conditions (Brady et al., 2019). Here, **we focus on maladaptation in the context of climate change**.

The **concepts of maladaptation and adaptation** are closely intertwined, as maladaptation is a possible outcome of adaptation action. The IPCC defines adaptation as "the process of adjustment to actual or expected climate and its effects, to moderate harm or exploit beneficial opportunities" and distinguishes between adaptation in human and natural systems (IPCC, 2018). Chi et al. (2021, p. 13) refer to adaptation as a "vulnerability reduction process". The three key elements of vulnerability are exposure, sensitivity, and adaptive capacity (Chi et al., 2021).[1] Accordingly, adaptation actions can be categorized depending on which of the elements they address: 1) the reduction of **exposure** of a system, sector, or social group to climate change, 2) the reduction of **sensitivity,** and/or 3) the increase of **adaptive capacity** (Barnett & O'Neill, 2010; Magnan, 2014). The concept of adaptation is however not easy to delineate, as it covers adaptation goals, processes and outcomes, and different policies, plans, and practices similarly. In the absence of a clear definition of adaptation, it is even more challenging to define maladaptation (Glover & Granberg, 2021).

Attempts to frame and define maladaptation resulted in a **myriad of different definitions**. In a frequently cited work by Barnett & O´Neill (2010), maladaptation is described as an "action taken ostensibly to avoid or reduce vulnerability to climate change that impacts adversely on or increases the vulnerability of other systems, sectors or social groups" (Barnett & O'Neill, 2010). This definition is criticised for being incomplete, as it neglects that adaptation actions can also have adverse impacts on the system, sector, or social groups targeted by the adaptation action (Magnan et al., 2016). Furthermore, an adaptation resulting in an uneven distribution of costs and benefits among different social groups can also be classified as maladaptation (Jones et al., 2015).

The IPCC (2014) associates maladaptation with an **increased vulnerability to climate change** but adds an **increased risk of adverse climate-related outcomes** (e.g. through increased greenhouse gas emissions (IPCC, 2018) and diminished welfare to the definition. Jones et al. (2015) suggest moving beyond welfare and including aspects like psychological wellbeing, health, and cultural identity (Jones et al., 2015). Maladaptation also involves a **temporal dimension**, as some adaptation actions may only turn out as maladaptive in the future (IPCC, 2014; Jones et al., 2015). Jones et al. (2015) argue that maladaptation does not necessarily arise from adaptation actions only, as actions that do not consider climate change can also lead to maladaptation. Moreover, some definitions of maladaptation also include **inaction** (IPCC, 2014; Jones et al., 2015), which is justified by the fact that it can be a viable adaptation strategy not to act, which therefore can also result in maladaptation. However, the definition in the latest IPCC report refers to actions only

[1] However, vulnerability can be also conceptualized different. In the IPCC definition, vulnerability is a component of risk, consisting of susceptibility to harm and the capacity to cope and adapt (IPCC, 2018)

(IPCC, 2022b). In general, a literature review on maladaptation by Chi et al. (2021) concluded that most of the definitions involve an increase in vulnerability to climate change. However, adaptation does not only influence climate risks but also wider economic, social, cultural, and psychological factors (Jones et al., 2015).

According to Jones et al (2015), there are three possible outcomes of an adaptation process: **successful adaptation, failed adaptation, and maladaptation**. Failed adaptation neither has positive nor negative impacts. Only those adaptation processes, which have a significant negative impact on climate risk or wellbeing (including the distribution of climate risk and wellbeing) now or in the future are recognised as maladaptation. However, it can be challenging to decide whether impacts are significantly negative (Jones et al., 2015). Glover & Granberg (2021) point out that **maladaptation is not necessarily 'black and white', and there are different ways to frame it**. They propose to conceptualise adaptation outcomes as lying somewhere along a continuum from success to failure, while acknowledging that a specific adaptation process can be successful in some aspects but failed in others (Glover & Granberg, 2021). The endpoints of this continuum, i.e. maladaptation and successful adaptation are illustrated in Figure 1.

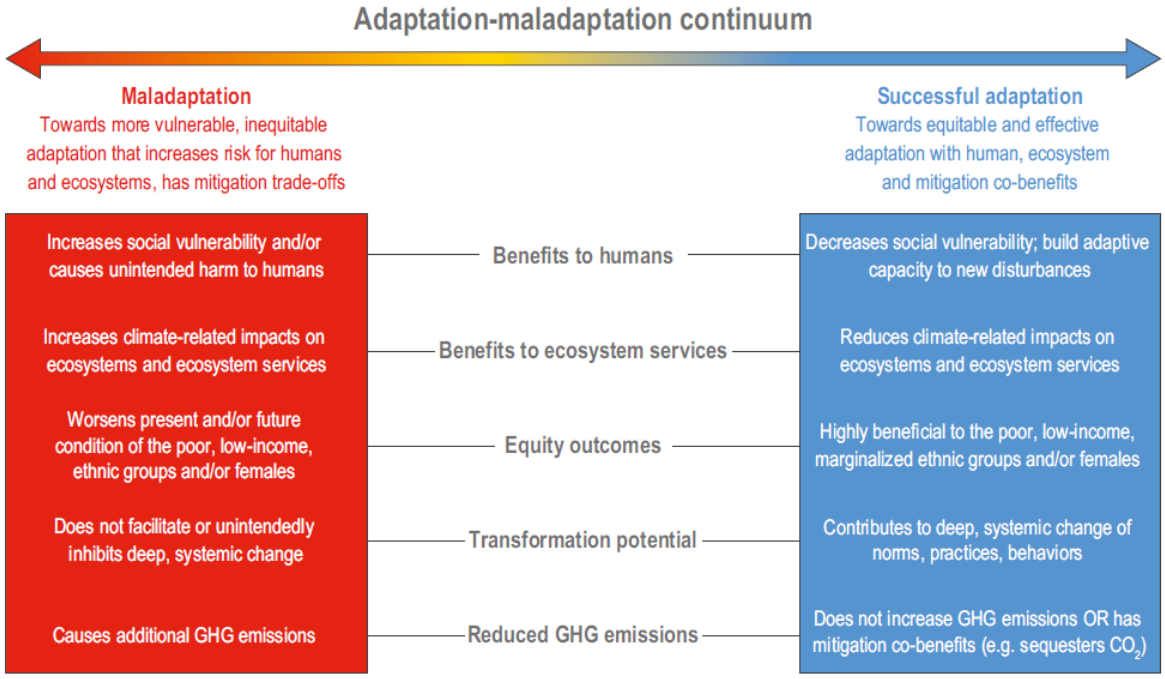

Figure 1: Continuum of adaptation outcomes from successful adaptation to maladaptation (IPCC, 2022a)

In general, this review of the literature has shown that there is a **wide array of different definitions**, ranging from more specific to more encompassing definitions, some highlighting processes, and others departing from the outcomes of an adaptation action. Despite the dissent on certain aspects (e.g. whether inaction can be considered maladaptation), at the core, all definitions agree that **maladaptation is undesirable and that efforts are needed to mitigate or avoid it**.

However, deriving a clear and comprehensive definition of maladaptation is crucial, as definitions lay the foundation for the development of frameworks and tools which help to assess maladaptive outcomes or identify and mitigate maladaptation risks. Therefore, we need a definition that is sufficiently specified but not too detailed. We aim to define maladaptation in a way that enables us to **translate maladaptation from a theoretical concept into a practical issue** (see chapter 4.1). The

following chapters deal with different dimensions of maladaptation, which helps us to approach the concept of maladaptation.

2.2 Types of maladaptation

The co**mplexity in defining maladaptation** implies that the processes potentially leading to maladaptation and the manifestations of maladaptation are highly diverse. Furthermore, the practical applicability of this abstract concept remains limited. Therefore, some authors proposed classifications of maladaptation outcomes or processes, often linked to examples of maladaptation.

From a review of a range of maladaptation case studies, Juhola et al (2016) identified three different types of maladaptive outcomes: **rebounding vulnerability** (increasing current or future vulnerability of the same group initially targeted by the adaptation action, which can happen in three different ways: increasing exposure, increasing sensitivity, or decreasing adaptive capacity), **shifting vulnerabilities** (increasing current or future vulnerability of other groups, often involving spatial spill-over effects) or **eroding sustainable development** (negative impacts that affect the society as a whole, e.g. increasing GHG emissions, negative impacts on environmental conditions or social and economic values) (Juhola et al., 2016). Chi et al. (2021) distinguish more broadly between two types: risk substitution (increased vulnerability to other risks) and risk transfer (relocation of vulnerability).

Other classifications focus on the processes that lead to maladaptation. Barnett & O'Neill (2010), for example, identify five pathways that could potentially lead to maladaptive outcomes (increasing emissions of greenhouse gases; disproportionately burdening the most vulnerable; high opportunity costs; reducing incentives to adapt; path dependency) (see also chapter 3.1).

Magnan (2014) distinguishes between **environmental, sociocultural, and economic maladaptation** and outlines factors that contribute to avoiding maladaptation. Adaptation actions that do not address these guidelines conversely also carry a higher risk for maladaptation. The framework by Jones et al. (2015) establishes two categories to assess outcomes of adaptation action, namely **impact on climate risk and wellbeing**. Furthermore, they consider distributional and temporal aspects. The symptoms of maladaptation can be traced on different levels: the environment for adaptation, political economy and institutions, and the planning and management of adaptation strategies. The IPCC report lists types of maladaptive actions, but without representing a formal categorization (IPCC, 2014). Schipper (2020) suggests a broader classification of infrastructural, institutional, and behavioural maladaptation.

In general, these classifications could be helpful to gain a better understanding of maladaptation. However, to date, there is **no commonly approved and all-encompassing list of types of maladaptation**. Some of the classifications mix causes and outcomes of maladaptation. Furthermore, the classification of types of maladaptation is artificially constructed (Magnan, 2014), and application in practice might be limited. As with the definition of maladaptation, specific classifications might be suited for different applications.

2.3 Roots and causes of maladaptation

To be able to avoid negative outcomes from adaptation actions, it is important to be aware of the main roots and causes of maladaptation. Adaptation involves many systems, fields, time frames, development processes, and actors. Neglecting feedback between sectors and groups and

focusing on short-term benefits can cause maladaptation (Climate-Eval Community of Practice, 2015). For instance, some adaptation actions designed for certain systems can induce **different vulnerabilities in other systems** because these actions do not consider interdependent systems (Chi et al., 2021). From the literature analysis and the expert interviews, the occurrence of maladaptation can be tied to the following 7 roots and causes, related to lack of planning and process-related or operational shortcomings: **1) Not dealing with future scenarios and uncertainties adequately, 2) Being stuck in siloed systems and lack of participation, 3) Unsustainable financial steering, 4) Prioritizing short-term, popular solutions, 5) Limited information and improper use of data, 6) Geographic or demographic reasons, 7) Implementation failure/ shortcomings:**

Not dealing with future scenarios and uncertainties adequately

The main challenge when adapting to climate change is to find an adaptation option which "systematically links present challenges with future threats" (Magnan, 2014, p. 3). The future, however, is inherently uncertain. This concerns for example the development of emission pathways, the manifestation of climate change impacts, and the characteristics of future societies (Magnan, 2014). In the context of adaptation, this causes a **'shifting baseline'** problem (Bours et al., 2014; Climate-Eval Community of Practice, 2015; Jones et al., 2015).

Not considering **future scenarios and associated uncertainties** in adaptation planning can lead to unintended negative effects. Waiting for more comprehensive scientific data is therefore tempting but not a viable option as uncertainties about the future will remain. Additionally, longer time periods are needed for adaptation actions to become effective and not acting in anticipation of future scenarios will inevitably cause natural and socio-ecological systems to be maladapted to climate change (Climate-Eval Community of Practice, 2015; Hallegatte, 2009; Magnan, 2014). Chi et al. (2021) consider uncertainties as one of the main reasons for maladaptation.

Being stuck in siloed systems and lack of participation

One more abstract but very relevant reason for maladaptation lies in the remit of decision-makers, which can lead to maladaptation, which is territorial (e.g. ministry remit to look at its borders), or when ministries dealing with international cooperation have a narrow view (e.g. development in a specific area). This leads to **silo remits** where only the narrow action is looked at, not considering other, wider strategies and lacks a systemic perspective (Interview with Markus Benzie; Interview with Paddy Pringle).

The **lack of participation** can be structural, where some groups are systematically disadvantaged, or occur due to power and resource asymmetry, with a combination of both being very common. The structural issues arise i.e. when not all stakeholders are part of the decision-making process (Interview with Ebun Akinsete). Such processes, that do not actively consider all stakeholders and manifest pre-existing structures lead to *procedural injustice* (Chi et al., 2021). **Resource constraints** of the already disadvantaged groups (i.e. less time to get involved, or lack of an organisational structure and therefore visibility in political processes (Albizua et al., 2019) hinder the groups, even more, to take part in the process. This can lead to only the most educated/ people with the most time to dedicate to take the decisions. When this is the case, adaptation strategies can act to unequally distribute wider social and economic costs and benefits among different social groups ((Jones et al., 2015).

Parallel, those groups with more power are overrepresented and have stronger negotiation skills, than the ones that are most vulnerable (Interview with Roger Street).

Unsustainable financial steering

Traditional ways of assessing risk and calculating costs can lead to maladaptation. Estimating costs is easier, than estimating benefits, which can lead to processes were all kinds of benefits are described that are not real, and the assumptions are not balanced. In turn, softer co-benefits can be the result, which may be desirable in the short-term, but shift away the focus from a systematic analysis. (Interview with Wouter Vanneuville). These types of practices of financial steering with maladaptive effects can be extended to operations run by the Green Climate Fund (GCF), where risk aversion classifications limit thorough climate adaptation. This happens, where e.g. social risk groups are considered too risky, so they don't get projects (Interview with Paddy Pringle).

Additionally, the way projects and their success are currently assessed does not serve sustainable project outcomes. Traditional project analysis, such as Cost-Benefit Analysis, etc. favours financing unsustainable solutions. The traditional profitability assessment of project practices such as focusing on discount rates drives choices towards the cheapest options rather than the more resilient and sounder ones (Interview with Paddy Pringle).

Prioritizing short-term, popular solutions

A focus on solutions with **benefits in the short term** is often driven by politics and their limited legislation periods and a lack of awareness of the (upcoming) climate risks amongst the population. This may lead to addressing flood risks by structural protection measures (e.g. dams, embankments) instead of implementing prevention measures such as water retention in the landscape or improved urban and territorial planning (Interviews with Jaroslav Mysiak, Chrysi Laspidou, and Annemargreet van der Leuuw). Focusing on the short-term can lead to lock-in, limiting any adjustments that may be necessary, as well as other options for adaptation. The root of this can lie in a lack of critical analysis of the options and/ or due to insufficient projections (Eriksen et al., 2021), and can have a high cost both financially, as well as socially, and environmentally. If the analysis of long-term, as well as negative and positive spill-over effects, are insufficient, adaptation capacities and resilience in the long term may be compromised (Eriksen et al., 2021).

Apart from the more visible outcomes in the short term, the **prioritisation of other, competing goals** can also out beat thorough adaptation actions. For instance, a city council can create more value in urban, than in rural areas: therefore, the incentive to build in urban areas, also close to the coast is very high, enabling the council to build even more when the value of the area rises and it gains popularity (Interview with Annemargreet van der Leuuw).

Limited information and improper use of data

Maladaptation can also be caused by **lack of data** (i.e. pour data on system dynamics around the problem, low and coarse scales), **limited usage of data** (i.e. is not adapted to local and regional context, cherry-picking data, or only using one's own data and focusing on certain (RCP) scenarios, can lead to missing out on the full picture,) or **limited access to data**, (data only includes downscaled info; missing relevant info. Therefore, incomplete data and the way data is treated can contribute to forming narrow boundaries when thinking about adaptation actions (Interview with Markus Benzie and Jaroslav Mysiak).

Geographic or demographic reasons

Maladaptation can also occur because **demographic or geographic events** were not factored in or anticipated: i.e. geographic reasons (for instance where rivers were reallocated artificially because of the growth of the city; when it rains, the river goes back to the natural path causing overflow and flooding, or population growth (leading to the reallocation of the river). These changes can also be tied to a lock-in effect when the adaptation actions cannot be modified when the event occurs and are therefore not flexible enough (Interview with Aitor Corchero).

Implementation failure/ shortcomings

Even if an adaptation option is well planned and takes various risks and aspects into consideration beforehand, there is a risk of maladaptation when it comes to the **implementation of an action**. According to Adger et al. (2009), the risks of implementation failure can occur under the following circumstances:

- **Physical** – either in terms of infrastructure or natural conditions: constrains the performance of the adaptation option.
- **Financial** – cost and funding: refers not only to the absolute cost of the option but also to the ability of the implementing organisation to fund the option.
- **Social** – Includes community attitudes, landholder personality, and the landholder's economic circumstances that may prevent them from adopting the options: reactions and attitudes of stakeholders, affected parties, and pressure groups to each adaptation option.
- **Institutional** – refers to complexity (number of different entities involved and how they interact) and responsibility (accountability for outcomes): institutional factors within the implementing organisation, regulatory or market constraints for the option (Lukasiewicz et al., 2014).

Additionally, it is important to acknowledge, that negative impacts from **maladaptation harm society as a whole but the relative harm to some groups are often stronger**, i.e. such as ethnic minorities and low-income households (Interview with Chrysi Laspidou; IPCC, 2022c)), resulting in different effects of adaptation actions for different people. For instance, women and elderly people are usually over proportionally feeling the negative effects of maladaptation. In action, this means, that different experiences of risk of men and women are omitted in the planning process, which may lead to (further) inequities between groups (Eriksen et al., 2021). If project designers omit this reality in their planning process, an adaptation outcome will likely have adverse effects on some parts of society. This may cause (further) inequities between groups and can be limited if there is a lot of work as a group put into what adaptation success means (Eriksen et al., 2021).

Overall, there are different levels and effects of the roots and causes of maladaptation. Where **some causes may be systematic, others trigger an adaptation action to become less flexible, and others exacerbate existing issues**. In our work, we built on the roots and causes from different layers to better understand the risks of maladaptation, which can be used as warning posts for potential maladaptation.

2.4 The complexity of maladaptation

The previous sections have shown that maladaptation is a **complex and multifaceted** phenomenon. **Maladaptation can refer to a process, a state, or an outcome** (Juhola et al., 2016), and the different types of maladaptation (chapter 2.2) show that it is very distinct what maladaptation can look like in practice. This is also reflected in the many different definitions of maladaptation (chapter 2.1), as it is **hard to capture all aspects which can constitute**

maladaptation in one definition. Most of the definitions evolve around an **increase in vulnerability** (Chi et al., 2021), but there is a lack of consensus on what exactly constitutes maladaptation. This concerns for example the question of whether inaction and autonomous adaptation (in contrast to planned adaptation) should be included in the definition of maladaptation. Jones et al (2015) argue that deliberate inaction (i.e. choosing business as usual) can constitute a viable adaptation strategy and therefore should be considered in the definition of maladaptation. In contrast, Juhola et al. (2016) warn that the addition of autonomous adaptation and inaction makes it impossible to set any clear system boundaries, which hinders any empirical applications of the concept. Accordingly, they suggest that maladaptation should be limited to deliberate decisions to adapt (Juhola et al., 2016). Indisputable, however, is the fact that both inaction and planned and autonomous adaptation can lead to maladaptive outcomes.

The literature on maladaptation, at the time of writing, is mostly restricted to theoretical deliberations and only a few concrete cases have been studied so far. Therefore, little is known about the practical implications of maladaptation and how to avoid it. In this regard, the **monitoring and evaluation** (M&E) of the impacts of an adaptation action is essential to be able to identify maladaptation as such in the first place and to advance our knowledge of maladaptation in general. However, M&E of adaptation is a challenging task. Due to the long timeframes of adaptation actions, the differences in local circumstances, and difficulties to measure 'avoided impacts', no universal set of indicators exists to measure adaptation successes and failures (Bours et al., 2014). In total, Bours et al. (2014) identified twelve practical challenges which are inherent to adaptation M&E, each accompanied by possible mitigation strategies.

As maladaptation is in most cases an unintended side effect of adaptation (IPCC, 2018), it is even more difficult to grasp. Maladaptive effects are **not restricted** to the same sector(s) or social group(s) initially targeted by the adaptation action, thereby an increase in vulnerability can also occur on other spatial scales. Furthermore, some adaptation actions may only turn into maladaptation in the long term. This makes it **extremely challenging to compile a consistent set of assessment criteria for maladaptation** that can be applied to a wide range of different adaptation actions at any point of the project cycle. Moreover, due to the qualitative nature of maladaptation indicators, it is difficult to determine a way to measure them (Chi et al., 2021). Even with some criteria existing for assessing maladaptation, their application remains subjective (Magnan et al., 2016) and there are no useful suggestions for thresholds at which negative impacts can be considered maladaptation (Juhola et al., 2016). Jones et al (2015) point out that an adaptation action has to be assessed in the context of all alternative strategies. Accordingly, the least-worst option in a range of possible strategies should not be considered maladaptive, but partially successful even if it results in a slight increase in risk (Jones et al., 2015).

Moreover, prevailing **framings tend to consider adaptation actions as either adaptation or maladaptation but neglect the vast space between them** (Tubi & Williams, 2021). Tubi & Williams (2021) reflect a handful of the complexities illustrated through a desalination case, where they find: "(1) tradeoffs between adaptive and maladaptive effects are inevitable; (2) that such effects are highly variable across space and time; (3) are powerful determinants of future risks and adaptive capacities; and (4) reflect (and potentially reinforce) social power relations.'' (Tubi & Williams, 2021). Also, it can be **difficult to assess and consider other options for adaptation once the main narrative (i.e. "large-scale engineering options are needed") is set**. This has been an issue in evaluating and re-evaluating different options for water supply in South- Africa, Spain, and France, according to Boutroue et al. (2021). They argue that rather than evaluating the adaptive potential of a single project, the actors assess it "relatively to a range of perceived options".

Overall, from the literature review, it remains diffuse what maladaptation is exactly. The different manifestations of maladaptation across space and time, amongst others, make maladaptation a complex phenomenon. However, more and more practical frameworks and tools evolve that address the risk of maladaptation (see next chapter).

3 Maladaptation in practice

3.1 Examples of maladaptation

Maladaptation is not a theoretical problem, but there is increasing evidence that it is **already happening in many sectors and regions**. Maladaptation has been studied in the agricultural sector (including forestry) over proportionally, as well as in relation to large infrastructure projects (IPCC, 2022a). However, the concepts of successful adaptation and maladaptation are overall still not receiving sufficient attention from researchers and policy makers (Tubi & Williams, 2021), which obscures the actual extent of maladaptive outcomes and hinders the process of learning from past mistakes (Magnan, 2014).

A literature review of maladaptation case studies revealed that some cases are unanimously considered maladaptation, while others are discussed more controversially. This reflects the complex nature of maladaptation, which is only rarely 'black and white'. There is a continuum between success and failure, and it is important to consider that an adaptation action can be considered successful or maladaptive in different aspects (Glover & Granberg, 2021). Moreover, there is **no single standardised assessment framework to analyse adaptation processes and outcomes** (Bours et al., 2014). This inconsistency makes it challenging to compare the analyses of different adaptation actions. In addition, assessments of maladaptation are inherently subjective. Therefore, depending on how short- and long-term costs and gains are weighted, the assessment of an adaptation action may come to different results (Jones et al., 2015). Apart from this, even the same adaptation option can involve different degrees of maladaptive potential, as adaptation is context-specific, and outcomes are influenced by the ways adaptation is planned and implemented (IPCC, 2022a). The following examples of maladaptation aim to illustrate this.

A commonly described example of simply shifting negative effects to other sectors is the **installation of air conditioners** in response to heat waves, especially in an urban context. The high energy demand impacts adversely on emission reduction targets and rising energy prices disproportionally affect low-income households (Chi et al., 2021). Other examples deal with the **spatial shift of vulnerabilities**, which can also entail spill-over effects in other areas. For example, the construction of coastal infrastructures can lead to increased erosion elsewhere (Juhola et al., 2016). Moreover, Magnan. et al. (2016) warn that this may encourage a process of migration to areas which remain hazardous in the light of future climate change.

In the context of maladaptation, **desalination** is studied as a strategy to enhance freshwater supply in the face of changing climatic conditions. In Melbourne, for example, a desalination plant was built in combination with a pipeline to meet the freshwater demand under decreasing rainfall. Barnett & O'Neill (2010) present a set of five criteria to assess the maladaptive potential of an adaptation action, which is still seminal today (Tubi & Williams, 2021). They find that the desalination plant and the pipeline are energy-intensive and therefore associated with high **greenhouse gas emissions**. Moreover, higher water costs will especially **burden vulnerable groups**, like low-income households. Compared to other adaptation options, the economic, social, and environmental costs are high. This is referred to as '**high opportunity costs**'. Furthermore, the seemingly unlimited availability of water (Tubi & Williams, 2021) and the shift of responsibility away from the end-user undermines incentives for responsible water use. As with most infrastructural projects, the desalination plant and the pipeline are associated with limited flexibility to adapt in the future, as the capital and institutions committed to the infrastructure represent a high sunk

cost. This phenomenon is referred to as path dependency (Barnett & O'Neill, 2010). Therefore, according to Barnett & O'Neill (2010), all five criteria for maladaptation apply to the case of desalination in Melbourne. For another desalination plant in California, however, Juhola et al. (2016) did find no evidence for reduced incentives to limit the water consumption of private households. A more nuanced approach is offered by Tubi & Williams (2021) who find that desalination is both associated with adaptive and maladaptive effects, whose relative importance varies depending on the local (socio-political) context. Moreover, they point out the potential spatial and temporal dimension of effects and the influence of desalination on future adaptive capacity and vulnerability. For example, costs and benefits of desalination may be unequally distributed and the risk of maladaptive impacts may change with future sea level rise (Tubi & Williams, 2021). The question whether supply-increasing water policies are intrinsically maladaptive is discussed in further detail in Boutroue et al. (2021).

Intensification of agriculture is a widely adopted strategy to cope with the impacts of climate change. In Spain, the government promoted the construction of dams and channels which replaced traditional irrigation methods in some regions. In combination with heavy machinery and the use of pesticides, this led to an increase in average yields. However, a closer look reveals that not all farmers have benefited equally. Beneficiaries of the irrigation project were mostly large-scale intensive farmers. On the contrary, the vulnerability of small-scale farmers not only about climate change increased. The promotion of large-scale irrigation resulted in a displacement of traditional farmers and a concentration of land in fewer hands, therefore entrenching existing power structures. This is reflected in a lack of political organisation of small-scale farmers, which limits their ability to influence decision-making processes in their favour. However, large-scale intensive farmers are also at risk of increased exposure to present and future changes due to higher water consumption and financial constraints. This adaptation action can therefore be classified as maladaptation, especially because it increases existing inequalities in the agricultural sector (Albizua et al., 2019).

In general, infrastructural projects are often characterised through inertia and irreversibility, and therefore have a high risk for maladaptation. Hallegatte (2009) suggests that soft adaptation options are less likely to result in maladaptive outcomes, as they can be easily adjusted, and the risk of sunk costs is lower compared to hard options. An example for such a soft adaptation option would be climate insurances in agriculture. A study on the broader social and ecological consequences, however, revealed that insurances may lead to alterations in land-use strategies and the involvement in social networks, undermining the farmers ability to mitigate climate risks (Müller et al., 2017). Changing crop choices towards drought-tolerant crops may also result in higher vulnerability if market volatility and future trends are not considered in the decision (Schipper, 2020).

With the outline of some examples above, we hope to make the phenomenon of maladaptation more tangible. However, this section also highlights once again the complex nature of maladaptation: Not all maladaptation cases seem to be maladaptation at first sight, some only turn into maladaptation when considering long-term or side effects. Furthermore, the chosen adaptation option also needs to be considered in the context of alternative adaptation options (including the option of 'doing nothing'). In the end, it is not important to merely decide whether a case study qualifies as maladaptation or not but to use the findings from case studies to advance our understanding of maladaptation and to learn how to minimize risks of maladaptation in the future. Avoiding all potential negative effects of an adaptation action may in most cases not be possible, therefore considerations are needed on how to offset them.

3.2 Conceptual frameworks for maladaptation evaluation

Despite a lack of clarity on the concept of maladaptation, some frameworks exist that attempt to support decision-makers in assessing potential maladaptation risks and mitigating these risks in the planning phase of an adaptation action.

Jones et al (2015) developed a framework that involves the main constituents of maladaptation. The two main elements are **climate risk** and **wellbeing,** which change over **time.** Furthermore, the framework integrates the **distribution** of impacts (collective climate risk & distribution of climate risk, collective wellbeing & distribution of wellbeing). However, this framework is mostly meant to improve the understanding of maladaptation and does not provide precise indicators for assessing adaptation actions (Jones et al., 2015). From a practical perspective, it is of higher relevance to identify factors or processes that likely lead to maladaptation than to assess maladaptation as an end-state, therefore Jones et al (2015) compile a list of potential maladaptive symptoms.

The **Pathways Framework** by Barnett & O'Neill (2010) distinguishes five criteria for identifying maladaptation risks and applies these criteria to the case study of water management in Melbourne. They find that the desalination plant and the pipeline which were built in response to water stress meet all five criteria and could therefore be classified as maladaptation (Barnett & O'Neill, 2010). Chi et al. (2021) propose to combine this framework with spatiotemporal modeling to be able to assess, compare and select an adaptation project based on the simulation of alternative future scenarios.

Table 1: Criteria for assessing risks of maladaptation according to Barnett & O'Neill (2010)

Criteria for assessing risks of maladaptation
Increasing emissions of greenhouse gases (positive feedback mechanism leading to further adaptation needs)
Disproportionately burdening the most vulnerable
High opportunity costs
Reducing incentives to adapt
Setting paths that limit the choices available in the future (decreased flexibility and path dependency)

The **Precautionary Framework** highlights the importance of developing adaptation strategies that take uncertainties and potential negative impacts of an adaptation strategy into account (Hallegatte, 2009). Hallegatte (2009) proposes six principles that aim to enhance the robustness of a decision under high levels of uncertainty: 1) no-regret strategies (benefits even in the absence of climate change); 2) reversible and flexible options; 3) safety margin strategies; 4) soft adaptation strategies 5) strategies that reduce decision-making time horizons; 6) taking into account conflicts and synergies between strategies. This framework focuses on infrastructure and engineering adaptation options but could, however, be applied to a wide range of other adaptation actions (Magnan, 2014).

Magnan (2014) developed the **Assessment Framework**, which is an advancement of the Pathways Framework and the Precautionary Framework. Same as the Precautionary Framework, it is designed for an ex-ante assessment, i.e. to prevent maladaptation before the implementation of adaptation policies, plans, or projects. The framework consists of eleven guidelines that address environmental, sociocultural, and economic maladaptation (Table 2). This framework is

specifically designed for application in coastal areas. The authors argue that adaptation initiatives have a lower risk of maladaptation the more guidelines they consider.

Table 2: eleven guidelines for avoiding maladaptation

Avoiding environmental maladaptation
1. Avoid degradation that causes negative effects in situ
2. Avoid displacing pressures onto other environments
3. Support the protective role of ecosystems against current and future climate-related hazards
4. Integrate uncertainties concerning climate change impacts and the reaction of ecosystems
5. Set the primary purpose as being to promote adaptation to climate-related changes rather than reduce greenhouse gas emissions
Avoiding sociocultural maladaptation
6. Integrate local social characteristics and cultural values about risk and the environmental dynamics
7. Integrate and develop local skills and knowledge related to climate-related hazards and the environment
8. Call on new skills that the community is capable of acquiring
Avoiding economic maladaptation
9. Promote the reduction of socio-economic inequalities
10. Support the relative diversification of economic and/or subsistence activities
11. Integrate any potential changes in economic and subsistence activities resulting from climate change

The **Feedback Framework** proposes a **typology of maladaptive outcomes**, which derive from a refined definition of maladaptation. It can be used to assess the actual or potential negative outcomes of specific adaptation policies or projects (Juhola et al., 2016). The types of maladaptation are linked to different affected entities: the targeted group (rebounding vulnerability), other groups (shifting vulnerability), or society as a whole (eroding sustainable development). Juhola et al. (2016) furthermore highlight the need to set clear system boundaries (including the geographical and temporal scale), define thresholds of when negative outcomes are to be considered as maladaptation and distinguish between maladaptation as an outcome or process.

The newest IPCC report conceptualises successful adaptation and maladaptation as endpoints of a continuum and suggests five criteria to identify the maladaptive potential of adaptation options, namely benefits to humans, benefits to ecosystems, equity outcomes, transformational potential, synergies and trade-offs with climate mitigation (IPCC, 2022a).

In general, these frameworks help to conceptualise the risk of maladaptation and make the processes associated with maladaptation more tangible. They advance from the difficulties in defining adaptation, which provides a useful step to improve the practical relevance of maladaptation. However, the mere **ability of frameworks to reduce maladaptation on the ground is limited**. Therefore, developing tailor-made decision-support tools for adaptation practitioners is a crucial step in moving from theoretical deliberations to practical applications of the maladaptation concept. Thereby, the different conceptualizations shape the operationalization of maladaptation. The following chapter provides an overview on different tools existing in the climate change adaptation context and outlines how to develop good decision-support tools.

3.3 Decision support tools

All the challenges associated with adaptation highlight the need for providing practical support and guidance for decision-makers. Decision support tools are methods and other knowledge resources that are designed to "facilitate decision-making for adaptation to climate change" (Palutikof et al., 2019, p. 644). Palutikof et al. (2019) discuss ten guidelines for the **development of decision-support tools**, thereby following the life cycle of a decision-support tool. The guidelines address the questions of how to involve practitioners, how to design and construct the tool and how to ensure long-term relevance. Applying these guidelines enhances the effectiveness, relevance, usability, and legitimacy of the decision-support tool. For example, the authors propose to closely engage the potential user in the development of decision support tools in a process of co-development or co-production rather than the usual consultation process. **Decision-support tools should be tailored to the needs of adaptation practitioners**. Moreover, it is important to use language, datasets, and concepts that are familiar to the target group of the tool. The circumstances within which adaptation takes place are subject to permanent changes and tools need to provide the flexibility to update time-sensitive information and incorporate new insights or recent examples. Further recommendations include the need to be aware of potential barriers to the take-up of the tool, the building of more context-specific and targeted tools (instead of more general resources), which can also be achieved through the translation of existing tools to different sectors or areas (thereby making use of the credibility and experience embodied in the original tool) and the continued improvement of the tool based on comprehensive impact evaluations. Lastly, sharing evaluation results supports a process of learning and capacity building and is important to ensure that decision-support tools are steadily improved (Palutikof et al., 2019).

Several **tools help to adapt to climate change**, for example, the Adaptation Support Tool (https://climate-adapt.eea.europa.eu/knowledge/tools/adaptation-support-tool) which aims to assist policy makers to develop, implement, monitor, and evaluate adaptation strategies and the Urban Adaptation Support Tool (https://climate-adapt.eea.europa.eu/knowledge/tools/urban-ast/step-0-0) which focuses more specifically on urban areas. Both platforms can be linked with the European Union Covenant of Mayor's scoreboard, which also offers guidance on what direct and systematic aspects should be considered when planning adaptation measures, with a focus on assessment. The UKCIP Adaptation Wizard (http://www.ukcip.org.uk/wizard/) for adaptation in organisations and the US Climate Resilience Toolkit (https://toolkit.climate.gov/) addresses communities. Some tools have a specific regional focus, for example on coastal regions (e.g. CoastAdapt - https://coastadapt.com.au/). Furthermore, some EU member states have adopted tools with a national or regional focus (e.g. the Klimalotse in Germany).

In general, these tools are designed to enable good adaptation. Some of them also include aspects of maladaptation, but so far, no tool addresses maladaptation specifically.

3.4 Avoiding maladaptation

In the previous chapters, we have outlined how adaptation can lead to maladaptation and we have identified the main roots and causes of maladaptation. This chapter is devoted to recommendations on how to avoid maladaptation in practice, and future research needs are outlined. This builds on the recognition that avoiding maladaptation before the implementation of an adaptation action is possible through addressing potential risk factors.

Better anticipating future development

The temporal dimension of adaptation makes it challenging to anticipate future outcomes, as the future is inherently uncertain. Not considering this in adaptation planning can lead to

maladaptation. Waiting for the uncertainties to diminish is also not a viable option as it is likely that uncertainties will remain Magnan, 2014). Instead, Hallegatte (2009) suggests using scenario analysis and choosing the most robust option instead of the best option for a certain future climate. This is also associated with low regret strategies, i.e. strategies that are beneficial even without climate change (Hallegatte, 2009). Magnan. et al. (2016) highlight the importance of maintaining flexibility in face of current and future climate-related changes or new scientific knowledge. Moreover, to reduce uncertainties it is crucial to use all existing information (Hallegatte, 2009).

Dealing with maladaptation complexity

The evaluation of adaptation processes and impacts is fundamental to be able to identify maladaptation and expand our knowledge of maladaptation. Jones et al. (2015) argue that the evaluation of maladaptation can never be truly objective, as there are no fixed boundaries that determine successful adaptation, failed adaptation, or maladaptation. Therefore, Magnan (2014) points to the need to enhance objectivity and refers to the lack of quantitative and objective indicators.

It is important to **understand adaptation and maladaptation** jointly: while there are reasons to focus work on maladaptation, maladaptation should not be considered in isolation. According to Tubi & Williams (2021, p.5) "successful adaptation and maladaptation are not complete opposites", as there are not always equivalent indicators for maladaptation/adaptation, for instance, emissions of greenhouse gases. Put differently: There may not be an optimal adaptation. The authors argue that due to uncertainties trade-offs will be inevitable and should therefore be studied along with the adaptation options to decrease any negative impact. The risk of maladaptation should not keep stakeholders from focusing their efforts on adaptation.

Having all stakeholders and people impacted participate

People who might be affected by an adaptation action should be made part of its planning process. **An informed decision- making process should be facilitated especially for marginalized groups who are likely to suffer the strongest in case of maladaptation should be made available and accessible.** This is important to represent the diversity within communities and not have the decisions lie with those that have the most power and time to take a decision (Eriksen et al., 2021). Additional to all people guiding the way to prioritize adaptation actions, they should also be based on a thorough assessment of environmental risk as a starting point: rather than retrofitting adaptation project goals and rebranding existing development projects into adaptation projects, assessing climate and environmental risks should be the starting point for planning adaptation measures. If the development agenda is used, the blurring can have unintended consequences, both for the adaptation action and societal development (Eriksen et al., 2021).

Enabling more integration by aligning strategies and working across sectors

One solution to overcome silo- thinking that limits maladaptation could be to use, other 'doors'. International law already has a **do-no-harm approach** to policies of countries (i.e. transboundary harm), which could be a principle to explore also for adaptation planning. Similarly, the Paris agreement has the goal of adaptation and all signatories accept that risks and adaptation do not stop at the border. Here the objective could be building adaptive capacity and resilience (and reducing vulnerability) on the local, regional and national level, but aligned with the global goals that serve also transboundary cooperation. In practice, the countries can highlight what they are doing and how it promotes global goals (i.e. agriculture being more resilient in one place can help supply chains elsewhere). Starting the conversation and articulating goals for adaptation as a global goal would automatically boost the conversation on maladaptation because the effects of

interdependence have to be addressed even more trans-nationally (Interview with Markus Benzie).

Allocating funding to the right adaptation actions

With the continuation of traditional project assessment and awarding schemes, as well as a current trend towards financialization (of utilities), there is a **need to limit the risk of maladaptation that is caused by finance incentives.** Rethinking the systems of awarding future grants for adaptation projects should currently be trying different techniques to see what works better than the current schemes that fail (Interview with Paddy Pringle), especially **considering the need for flexibility**: changes in implementation should be welcomed and possible, where they are necessary for better adaptation, meaning that the project finance plan must allow for flexibility for this. Additionally, from the assessment side of how one judge's projects need to change, with questions that steer planners away from only their silo (Interview with Paddy Pringle).

Maladaptation is very difficult to eliminate because many different risks and aspects can change over time. By analyzing previous cases of maladaptation and building on different research steps, this manual features the **self-assessment tool**, presented in the next chapter, that aligns with the most important needs in the form of a self-assessment checklist. Overall, it is important to be aware and make more people aware of the different risks of maladaptation (more in chapter 4.2). While this means that planning may take a bit longer, with the use of the concise questions of the tool, it will be rather quick to spot the different risks and take the first step to avoid maladaptation.

4 Developing a self-assessment tool for maladaptation

The review of existing decision support tools (chapter 3.3) revealed that rarely any tools are designed specifically to avoid adaptation actions leading to negative impacts. Because of the urgent need to scale up our efforts to adapt to climate change, adaptation actions must succeed in decreasing vulnerability to climate change without causing any negative side effects. We argue that it is important to consider the risk of maladaptation early in the process of adaptation action and propose a self-assessment checklist that addresses this gap. While *ex-post* evaluations assess the effectiveness of an implemented action which helps to advance our knowledge of maladaptation and support a process of learning from mistakes, the ***ex-ante* analysis** is useful to mitigate the maladaptation risk of a specific adaptation action before the implementation (Magnan, 2014). We acknowledge that both approaches are equally important but focus here on the development of an *ex-ante* tool that is designed to identify processes that could lead to maladaptation in the future, rather than assessing maladaptive outcomes. This way, we aim to avoid maladaptation before it occurs. In the following, we first provide a practical and comprehensive definition of maladaptation and identify risk factors of maladaptation, which builds the basis for the development of a maladaptation self-assessment tool.

4.1 A practical definition of maladaptation

To develop an *ex-ante* tool for identifying processes that could lead to maladaptation, we need to be able to delineate what maladaptation is exactly. The literature review has shown that until now, no definition is commonly accepted. This was also reflected in interviews we carried out with experts on (mal)adaptation, each highlighting different aspects which were associated with

maladaptation. Therefore, we propose a clear and comprehensive definition of maladaptation that can be used to guide practitioners and planners to mitigate maladaptation risks on the regional level. Focusing on this practical application, and based on the different conceptualisations analysed in chapters 2.1 and 2.2, we define maladaptation as follows:

Maladaptation refers to a process of planning and implementing an intentional adaptation action that may in the short- or long-term lead to increased vulnerability (to climatic or non-climatic risks) or diminished wellbeing (of the same or other systems, sectors, or social groups targeted by the adaptation action). Furthermore, maladaptation can also be associated with negative impacts that undermine sustainable development for the society as a whole. Adaptation actions that likely reduce the flexibility to adapt in the future or ignore local contexts are associated with a high risk of maladaptation.

This definition builds on existing definitions and provides clarity on some contested aspects (e.g. whether to include inaction and initiatives not labelled as adaptation (IPCC, 2014; Jones et al., 2015; Juhola et al., 2016a) or on how to frame maladaptation (Jones et al., 2015; Juhola et al., 2016a; Magnan et al., 2016)). The definition includes a classification of maladaptive outcomes but also accounts for processes that are associated with maladaptation. (For a detailed outline of the key features of the definition and the considerations behind it, see Annex V.)

However, this definition should not be considered as the endpoint of theoretical deliberations on maladaptation. It is tailored to the aim to develop an *ex-ante* self-assessment tool. There might be other applications, which call for different definitions.

4.2 Risk factors of maladaptation

The processes leading to maladaptation and potential maladaptive outcomes are diverse. Therefore, a comprehensive list of specific risk factors of maladaptation was developed by combining and refining existing frameworks and classifications. Table 3 presents the 5 categories of risk: 1. Lack of effectiveness, 2. insufficient knowledge and understanding, 3. lack of coherence, 4. lack of sustainability and path dependency, and 5. Lack of relevance, as well as corresponding risk factors that were identified:

Table 3: Risks of Maladaptation[2]

Category of risk	Risk Factors that could lead to maladaptation
1 LACK OF EFFECTIVENESS (OECD DAC, 2022) (= the intervention is not achieving (or is unlikely to achieve) its objectives)	Inefficient conversion of inputs (funds, expertise, natural resources, time, etc.) into outputs, outcomes, and impacts; is important because resources are limited (OECD DAC, 2022)
	Poor quality of implementation (lack of controls, cut-off budget, lack of ongoing monitoring, revision and maintenance, involvement of affected social groups) (POOR GOVERNANCE) (IPCC, 2022, Ch. 17, P. 23, Jones et al., 2015)

[2] The full table, including all references can be found in Annex IV

	Focusing on narrow one-off projects without targeting the region's key climatic risk Inadequately/insufficiently addressing upcoming/future climate hazards (World Bank, 2010)
2 INSUFFICIENT KNOWLEDGE and UNDERSTANDING (= the information of the adaptation action (outcomes) was not or could not be considered thoroughly)	Ignoring local knowledge, perceptions, and expectations of communities regarding risk reduction and vulnerability (IPCC, 2014; Interview Ebun Akinsete) Lack of consideration of regional values, assumptions, and norms
	Failing to understand risks and system dynamics (Jones et al., 2015)
	Not dealing with knowledge gaps/uncertainties appropriately (IPCC, 2014)
	Lack of Awareness about maladaptation
3 LACK OF COHERENCE (OECD DAC, 2022) (= the intervention is not compatible with other interventions in a country, region, sector or institution, or internationally)	Adaptation is localised and fragmented, with no or limited coordination or mainstreaming across sectors, jurisdictions, or levels of governance (SCOPE) (IPCC, 2022,16-32)
	Not building regional/social capacity and social/institutional engagement to deal with climate change, e.g. by fostering dependency and passivity and penalising adaptation pioneers (Barnett & O'Neill, 2010)
4 LACK OF SUSTAINABILITY over time (OECD DAC, 2022) and PATH DEPENDENCY (IPCC, 2022) (=the intervention's benefits will not last financially, economically, socially, and environmentally; sustainability in the sense of the continuation of results; not environmental sustainability)	Lack of (ongoing) monitoring and evaluation, lack of ongoing learning and adaptive management
	Reducing flexibility (Barnett & O'Neill, 2010) and future adaptive capacity by locking the region into inflexible solutions and path dependence (e.g., because of high sunk costs (Jones et al., 2015), making path correction in line with developing knowledge/evidence difficult and precluding alternative adaptation options (IPCC, 2014)
	Predominantly focusing on short-term benefits and economic growth, thereby forgoing long-term benefits (IPCC, 2014)
	Disproportionately high opportunity costs (Barnett & O'Neill, 2010, Findlater et al., 2022)
5 Lack of RELEVANCE (OECD DAC, 2022) (= not doing the right things)	Doing significant harm (EU Taxonomy, 2022) to the environment and/or depleting natural (non-renewable) resources at the expense of future generations (including regional, national, EU, and global objectives (e.g. climate change mitigation (Barnett & O'Neill, 2010; Jones et al., 2015), sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention, and control, protection and restoration of biodiversity and ecosystems))

	Decreasing the overall well-being of individuals, households, and communities, including impacts on a,) livelihoods, b) social equality and cohesion (IPCC, 2022), and c) physical and mental health (IMPACT) Unjustly distributing costs and benefits and increasing social inequalities (Jones et al., 2015) (at the expense of other individuals (IPCC, 2022c), (vulnerable) social groups or economic sectors (within the region or in other regions, Magnan & Mainguy, 2014)
	Not responding to the needs of targeted social groups (Barnett & O'Neill, 2010)
	No defined objective(s), or unrealistic/ unrealisable objectives (OECD DAC, 2022)
	Lack of considering non-climatic factors/developments (AST climate-ADAPT, 2022; Jones et al., 2015)
	Inadequate depth of the adaptation action (adaptation mainly to maintain existing practices through incremental change with minimal change in underlying values, assumptions, or norms instead of fostering transformational change) (IPCC, 2022; (Jones et al., 2015)
	Inappropriate timing of the action: too late/too early, too slow (SPEED) (IPCC, 2014; IPCC, 2022; (Jones et al., 2015)

For each of the categories and factors of risk suitable questions were developed, and later refined, for the self-assessment tool of maladaptation. The questions were then re-categorized to fit the steps of the Climate-ADAPT AST Tool, this is why they are in a different order and different categories in the self-assessment tool for maladaptation.

4.3 The self-check tool for maladaptation

The objective of the self-assessment tool for maladaptation is to pre-check (ex-ante) adaptation actions for potential maladaptation risks. The target groups of this tool are primarily adaptation planners and practitioners on a regional level, but it can also be applied in a wide range of contexts. Most adaptation actions are fostered by the public sector, but the importance of the private sector and community organisations in adaptation is growing (IPCC, 2022a), and we, therefore, encourage decision-makers on all levels to use the tool to spot potential maladaptation risks.

When going through the checklist, planners are advised to check one adaptation action at a time. The questions on the checklist are designed to screen if the project is properly planned to avoid maladaptation. The possible answers are:

> *Yes – properly planned,* means there is a low or no maladaptation risk for this aspect/question) 😊
> *No – gaps in the planning,* means there is a risk of maladaptation ☹

The maladaptation tool was subject to a review by adaptation planners in a regional context. When sending out the self-assessment tool for maladaptation, an easily understandable introduction with what, why, who, when, and how was added to give a quick overview of what the document is about. Additionally, guidance was given, in the form of definitions and aspects the reviewers

should pay attention to during the review. Below, the version of the self-assessment tool from August '22 can be seen (for more details and the full version (including description) that was sent out for review, see Annex I & Annex II):

Identifying potential risks of maladaptation

Adaptation action for analysis:

Risks and Vulnerabilities	YES	NO
1. Are the climatic risk(s) of the region… a) …known? b) …taken into account in the adaptation action? *Regional climatic risks, such as floods, heatwaves, droughts, and sea-level rise are caused by climatic conditions and can be exacerbated by climate change. A region can face one or several different climatic risks, which can affect livelihoods, ecosystems, and the economy. Therefore, the adaptation action shall address these risks.*	☐ ☐	☐ ☐
2. Is the climatic risk analysis fit for the future? *Climate risks can change or intensify in the future, and they can interact with others, such as health or economic risks, or with neighbouring areas (creating complex/compound risks)*	☐	☐
Identifying Adaptation Options		
3. Is the adaptation action weighted against the (financial and non-financial) costs and benefits of other adaptation options? *Adaptation shall prioritize the most effective and efficient actions providing the most benefits, especially given resource constraints.*	☐	☐
4. Is the adaptation action timely? *An action, which is too early, too late, or too slow can generate false expectations and cause maladaptation.*	☐	☐
5. Does the adaptation action secure long-term benefits (not only short-term benefits)? *This can happen when local adaptation actions address short-term risk management over long-term transformative strategic planning to reduce long-term risk.*	☐	☐
6. Is the available information sufficient to plan and implement the adaptation action? *Planning based on assumptions might not address properly the region's climatic risks and fail to solve adaptation needs. The remaining uncertainty shall be properly addressed by tools like scenario planning, adaptive management, or robust/resilient pathways/strategies.*	☐	☐
7. Does the adaptation action contribute to relevant international, national, local, or sectoral (climate adaptation) objectives?	☐	☐
8. Is the adaptation action unlikely to have negative social effects?	☐	☐

Actions may e.g. decrease the well-being of (vulnerable) social groups, increase social inequality, and decrease social cohesion and gender equality. The (most vulnerable) groups that will be affected by the adaptation action shall be identified, their needs shall be known, and it shall be revised if the adaptation action is aligned with these needs.		
9. Is the adaptation action unlikely to have negative effects on the following: d) e) a) …climate change mitigation (not adding significant amounts of GHG emissions?	☐	☐
b)…the sustainable use and protection of water and marine resources? *The action shall not be expected to be detrimental to the good status or the good ecological potential of bodies of water, including surface water and groundwater; or to the good environmental status of marine waters.*	☐	☐
c)…the transition to a circular economy? *The action shall not be expected to: (i) lead to a significant increase in the generation, incineration, or disposal of waste, except for the incineration of non-recyclable hazardous waste; or (ii) lead to significant inefficiencies in the direct or indirect use of any natural resource at any stage of its life cycle which are not minimised by adequate measures; or (iii) cause significant and long-term harm to the environment in respect to the circular economy.*	☐	☐
…pollution prevention and control? *The action shall not be expected to lead to a significant increase in the emissions of pollutants into the air, water, or land.*	☐	☐
…the protection and restoration of biodiversity and ecosystems? *The action shall not be expected to be: (i) significantly detrimental to the good condition and resilience of ecosystems; or (ii) detrimental to the conservation status of habitats and species.*	☐	☐
10. Does the adaptation action (if necessary) establish a long-term resilient system by overcoming existing practices (so-called transformational adaptation)? *Transformational adaptation implies profound changes (of underlying values, assumptions, and norms) in the system(s) that go beyond short-term measures and foster long-term resilience. It is different from incremental adaptation, which promotes minor adaptation actions without questioning the existing practices.*	☐	☐
Implementing Adaptation		
11. Are the risks (of maladaptation) of the adaptation action being discussed with all stakeholders? *Stakeholders shall be aware of uncertainties, assumptions, risks, and their possible consequences when engaging in or supporting an adaptation action.*	☐	☐
12. Have the expectations and best interests of the stakeholders been considered? *This means that all interested stakeholders are allowed to voice their views, and it was made transparent how the views, especially conflicting ones) are taken into account (e.g. regarding drinking water supply during drought, housing in flood areas)*	☐	☐
13. Are mechanisms in place for coordinating the adaptation action across sectors?	☐	☐

Two or more sectors (e.g. water, agriculture, health) shall coordinate data, strategies, investments, etc. for coherence between actions.		
14. Are mechanisms in place for coordinating the adaptation action across governance levels (e.g. municipal, regional, national)?	☐	☐
15. Are the resources available for the adaptation activity used in the most effective and efficient way? *Resources like funds, expertise, and natural ones are limited and often can only be employed once; they shall be dedicated to the most promising/beneficial actions. Investment, operational, and maintenance costs shall at least be considered.*	☐	☐
16. Is there a procedure in place for the review and if necessary, re-design of the adaptation action? *This might be necessary in case of a rise in energy prices, changes in demographics, etc., which can negatively impact the outcomes of the adaptation action. The procedure shall define timing and decision-making.*	☐	☐
Monitoring and Evaluating Adaptation		
17. Are monitoring and evaluation procedures in place to assess the effects of the adaptation action? *Procedures such as reporting, feedback, and learning shall be based on action-specific, measurable, achievable, relevant, and time-bound (SMART) objectives so that they can contribute to establishing a catalogue of successful adaptation actions.*	☐	☐

The self-assessment tool for maladaptation helps with making decisions that decrease the risk of maladaptation by identifying the risk during the planning phase. This tool was developed to have a specific tool focusing on maladaptation. Many other tools touch upon maladaptation indirectly. In preparation, maladaptation has been studied through literature research and interviews with experts and researchers over the past 6 months.

This tool brings added value to avoiding maladaptation because it offers a practical check for planners for revising their adaptation action in the planning phase. If used properly, it can help both with the decision-making when selecting from a range of adaptation options (identifying adaptation actions) and the careful implementation of the selected adaptation action (implementing adaptation).

5 Conclusions

The window of opportunity to foster a climate-resilient development is rapidly narrowing. Efforts towards climate resilience need to be upscaled now. In that context, also the risk of maladaptation needs to be addressed, otherwise risking ecosystem degradation, inequity, injustice, high levels of global warming, and vulnerability (IPCC, 2022a).

Maladaptation can occur for many different reasons, from insufficient planning to unexpected events that change the circumstances in the far future. The concept of maladaptation is being discussed more widely and with more people. It is also acknowledged more, that an adaptation action usually has winners and losers, and that some compromises and trade-offs may be inevitable.

Various challenges make it difficult to avoid maladaptation completely: still the lack of a widely accepted definition, the lack of data for precise future projections, or the serious consideration of such projections where they exist. But to converge and minimize the risks of maladaptation is possible and becomes more tangible if it is done in application to adaptation action.

This is our motivation to create the self-assessment tool to identify the risks of maladaptation. We hope that by better understanding the risks, the planning phases will be done more carefully, minimizing the risk of maladaptation by carefully considering which sectors, processes, and people could be affected. As the issue of adaptation and maladaptation is transboundary in nature in regions, it will often require efforts and coordination across borders to carefully weigh different adaptation options.

The work does not stop there but can go much further by going back to other adaptation options to check if there may be other, completely different options that are more suitable. It is essential to involve practitioners in any exercise around building, testing, and revising a decision support tool, which will be continued in the next months. In this manual, we do not argue against adaptation to climate change or aim to slow down adaptation action but to make it more effective by watching out for risks of maladaptation. Moreover, we need to consider that even with effective adaptation, not all losses and damages can be avoided. Therefore, the need to drastically reduce the emissions of GHG remains important and becomes more urgent.

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Annexes

Annex I: Methodology

The centrepiece of this manual is the self-assessment tool for identifying risks of maladaptation. The current version of the tool was prepared over 6 months and will be continued to be developed, tested, and used in the future. The current version is called Version 1 in this manual and was shaped in various steps, which are explained in this chapter. In a thorough literature review information on maladaptation and the risk factors of maladaptation were gathered, followed by expert interviews and various rounds of revising the set of questions for the checklist of the tool. Throughout the work, the focus lay on regions: while developing the self-assessment tool we closely considered planning aspects for regions and also formulated the checklist questions in a manner that they are easily understandable and relevant for people in regions.

Literature review

The literature was reviewed using the snowball principle by using the search terms *maladaptation*, *maladaptive outcomes*, *risk of maladaptation*, *maladaptation case study*, *adaptation trade-off(s)*, and *adaptation consequence*. The literature review was conducted from February to May 2022. Except for two articles (Spanish), all articles were in English. If additional articles were published or shared with the researchers, later on, these articles were also considered and taken up for analysis. The researchers collected from each article: the definition of maladaptation, types of maladaptation, roots, and causes of each maladaptation, existing frameworks for analyzing maladaptation, and ways on minimizing maladaptation. The finding was first collected in a table and then synthesized to a) prepare version 1 of the self-assessment tool and b) prepare the interviews with experts.

Interviews to refine information on maladaptation

20 expert interviews were scheduled with the aim to collect maladaptation case studies, as well as identifying the roots and causes of maladaptation.

The goal of the interview was to:

- better understand the roots and causes of maladaptation to better prepare the checklist questions and frame the self-assessment tool for maladaptation and
- gather concrete examples of maladaptation from the interviews. In a second step the case studies were assigned to categories as to which sector(s) and types of maladaptation category they would fall into.

All case studies and the categories can be found in a separate excel sheet. Initially, 5-10 maladaptation case studies were supposed to be selected to be analysed in depth, including 5 interviews per case study. For now, the list of case studies was compiled, but no deeper analysis of a few cases took place, to be able to first properly develop the self-assessment tool for maladaptation.

Most of the interviewees were researchers and experts who work in the field of climate adaptation. At the beginning of the interview, they explained they shared their job position and explained how this might influence their perspective on (mal)adaptation.

Deriving types of maladaptation

To prepare for the interviews and build a better understanding of maladaptation, the different types were also identified by studying the literature. To better understand the case and what type of maladaptation it is, we thought about:

What is the main outcome of the adaptation process? Is the desired outcome achieved?
At the stage when the decision was taken, was it clear that it could lead to maladaptation, or were certain assessments (climate risk, impact) ignored?
Does the adaptation option have negative effects on…
…the exposure to climate hazards?

…the environment in general, including mitigation?

…the distribution of positive and negative impacts: Does it cause or enhance existing inequalities/inequities? (different social group/present and future generations; geographical?)?

…the vulnerability to climate change (Sensitivity, adaptive capacity)

…the overall well-being of people (in terms of health, economic stability, nutrition stability?)

Are the main causes of maladaptation (for each type of maladaptation) identified?
Are the potential symptoms of maladaptation identified? à translate into warning flags for the decision support tool
Depending on the answers to these questions they were matched with the maladaptation types from section 2.1.

Categorizing risks

Different categories of risk for maladaptation were identified based on literature research (mainly Jones et al., 2015, IPCC report 2014, and IPCC Report 2022, and the input from the interview partners of the 1st round of interviews. Afterward, all aspects were checked against the OECD DAC criteria to ensure they are appropriate and compared with the EU taxonomy to ensure that this framework is in line with the broader ambitions of European sustainability policies. Finally, 5 different categories (A-E) were determined for assessing the risk of maladaptation, see Table 3.

Developing the tool

The tool was built based on the risks of maladaptation that were analysed beforehand, by combining the insights from the types of maladaptation, the literature review, and the input from the interviews (see section 4.3.). The self-assessment tool was created as a checklist in question format because this way the users can see clearly in which aspects there is a risk of maladaptation. the decision to create a self-assessment tool is based on the realization that only the people who are planning an adaptation action, have the information to judge the adaptation action options and their outcomes. Self-assessment tools have been proven to be useful in creating ownership, enabling decision-making, and yielding better outcomes because it makes planners pay attention to details in a guided manner.

Based on the findings from the interviews, we identified risk factor categories (Table 3) that can lead to maladaptation. The initial list was then checked against the IPCC risk factors of maladaptation and the OECD DAC criteria for evaluation, as well as broadly linked to the

categories of the climate-ADAPT Adaptation Support Tool to make the checklist coherent with existing efforts for a good adaptation. Overall, the questions that are now in the self-assessment tool Version 1 were tweaked, both content and language- wise to create a list that Is complete, yet not too long, and therefore useful in practice.

The first version of the tool was circulated amongst three experts in June 2022. In this review the 3 experts answered the following questions:

- Are all relevant risks factors for maladaptation reflected in the questions?
- For the purpose of being a warning flag for maladaptation risks: Are the questions appropriate to be answered in the planning phase of a specific adaptation action?
- Are the questions understandable and concise?
- Are there any other issues you find relevant?

The comments of the experts were revised and additional changes were made (see next section). Then, in August 2022 Version 1 was finalized and sent out for review to the interview partners and colleagues from the innovation actions. They were asked:

- Is the tool useful?
- Is anything missing?
- Do you agree with the wording?
- Are the questions understandable?

The goal of this second review is to fine-tune the questions before they are used by planners. The comments will be collected from August- October 2022.

Comparing the self-assessment tool for maladaptation with the Climate-ADAPT Adaptation Support Tool

After compiling this list, the checklist questions were loosely matched with the steps (1-6) of the climate-ADAPT tool, revealing some gaps of the climate adapt tool by complementing it with the question set on maladaptation. Then, the final checklist is matched with the categories of the climate-ADAPT tool to show where each question would be added to the climate-ADAPT platform. This approach aimed to ensure a) that we are not missing any important evaluation aspects and b) that the resulting set of questions is streamlined with other evaluation tools.

To better understand what aspects of maladaptation could already be covered by the Climate-ADAPT tool, in a table, we marked those cells, where there was no similar aspect in the AST tool to be able to check a potential integration of both tools in September 2022. These marked cells are visible in the table in Annex IV.

Annex II: The self-assessment tool version sent out for review

The REGILIENCE self-assessment tool for maladaptation

What? A self-assessment checklist that allows pre-check (ex-ante) adaptation actions, and spots those specific areas where further action to avoid maladaptation is recommended

Why? Avoid a well-minded adaptation action causes an increased vulnerability or harms livelihoods, ecosystems, and the economy

Who? Regional adaptation planners are likely the main users of this tool, but it can also be used by urban or sector planners

When? In the planning phase of a climate adaptation action

How? By responding 'yes' or 'no' to each of the 17 questions, you will identify the areas of risk, where further action is recommended. Such further action can build on the Climate-ADAPT Adaptation Support Tool

How much? The time you will require to fill in the self-assessment tool will depend upon the complexity of the planned adaptation action. A simple and well-known planned action can be assessed within less than one hour.

This is a self-assessment tool that allows pre-check (ex-ante) adaptation actions for potential maladaptation risks while projects are being planned. It is primarily targeted at regional adaptation planners, and it can also be used for urban or sector planning. Perhaps you know already the Climate-ADAPT Adaptation Support Tool or other tools that help with planning adaptation actions. This tool is similar, but its focus is on identifying the risk of maladaptation. So, when you are planning adaptation actions it will be useful to you to spot risks of how the action can lead to maladaptive outcomes, which limit the effect of the action or harm another region, sector, or group.

What is maladaptation?
Maladaptation describes actions that may lead to an increased risk of adverse climate-related outcomes, including increased greenhouse gas (GHG) emissions, increased vulnerability to climate change, or diminished welfare, now or in the future. Maladaptation is usually an unintended consequence. (IPCC, 2021)

What is an adaptation action?
An adaptation action is a specific action or measure that is taken to adapt to climate change. There can be different adaptation actions to choose from, which can be referred to as adaptation options.

The questions on the checklist are designed to screen if the project is properly planned to avoid maladaptation. The possible answers are:

- ***Yes*** *– properly planned,* means there is a low or no maladaptation risk for this aspect/question) 😊
- ***No*** *– gaps in the planning,* means there is a potential for maladaptation ☹

For instance, you will be asked if the climatic risks of the region are known. Then you select either 'yes' or 'no'. Some of the questions you will be able to answer immediately, whereas others you might wish to reflect on, consult with colleagues, or review documents. Once you completed all questions, you shall check questions marked with 'no' (because this means there is a risk of maladaptation) and reflect if further action is needed to minimize the risk. For this, it is useful to consult the Climate-ADAPT Adaptation Support Tool to check the steps of adaptation planning specifically linked to the aspects that you want to revisit.

Identifying potential risks of maladaptation

Adaptation action for analysis:

Risks and Vulnerabilities	YES	NO
1. Are the climatic risk(s) of the region… a. …known? b. …taken into account in the adaptation action? *Regional climatic risks, such as floods, heatwaves, droughts, and sea-level rise are caused by climatic conditions and can be exacerbated by climate change. A region can face one or several different climatic risks, which can affect livelihoods, ecosystems, and the economy. Therefore, the adaptation action shall address these risks.*	☐ ☐	☐ ☐
2. Is the climatic risk analysis fit for the future? *Climate risks can change or intensify in the future, and they can interact with others, such as health or economic risks, or with neighbouring areas (creating complex/compound risks)*	☐	☐
Identifying Adaptation Options		
3. Is the adaptation action weighted against the (financial and non-financial) costs and benefits of other adaptation options? *Adaptation shall prioritize the most effective and efficient actions, especially given resource constraints.*	☐	☐
4. Is the adaptation action timely? *An action, which is too early, too late, or too slow can generate false expectations and cause maladaptation.*	☐	☐
5. Does the adaptation action secure long-term benefits (not only short-term benefits)? *This can happen when local adaptation actions address short-term risk management over long-term transformative strategic planning to reduce long-term risk.*	☐	☐
6. Is the available information sufficient to plan and implement the adaptation action? *Planning based on assumptions might not address properly the region's climatic risks and fail to solve adaptation needs. The remaining uncertainty shall be properly addressed by tools like scenario planning, adaptive management, or robust/resilient pathways/strategies.*	☐	☐
7. Does the adaptation action contribute to relevant international, national, local, or sectoral (climate adaptation) objectives?	☐	☐
8. Is the adaptation action unlikely to have negative social effects? *Actions may e.g. decrease the well-being of (vulnerable) social groups, increase social inequality, and decrease social cohesion and gender equality. The (most vulnerable) groups that will be affected by the adaptation action shall be identified, their needs shall be known, and it shall be revised if the adaptation action is aligned with these needs.*	☐	☐
9. Is the adaptation action unlikely to have negative effects on the following: a. …climate change mitigation, Is the measure expected to lead to significant GHG emissions?	☐	☐

b. …the sustainable use and protection of water and marine resources? *The action shall not be expected to be detrimental to the good status or the good ecological potential of bodies of water, including surface water and groundwater; or to the good environmental status of marine waters.*	☐	☐
c. …the transition to a circular economy? *The action shall not be expected to: (i) lead to a significant increase in the generation, incineration, or disposal of waste, except for the incineration of non-recyclable hazardous waste; or (ii) lead to significant inefficiencies in the direct or indirect use of any natural resource at any stage of its life cycle which are not minimised by adequate measures; or (iii) cause significant and long-term harm to the environment in respect to the circular economy.*	☐	☐
d. …pollution prevention and control: *The action shall not be expected to lead to a significant increase in the emissions of pollutants into the air, water, or land.*	☐	☐
e. the protection and restoration of biodiversity and ecosystems? *The action shall not be expected to be: (i) significantly detrimental to the good condition and resilience of ecosystems; or (ii) detrimental to the conservation status of habitats and species.*	☐	☐
10. Does the adaptation action (if necessary) establish a long-term resilient system by overcoming existing practices (so-called transformational adaptation)? *Transformational adaptation implies profound changes (of underlying values, assumptions, and norms) in the system(s) that go beyond short-term measures and foster long-term resilience. It is different from incremental adaptation, which promotes minor adaptation actions without questioning the existing practices.*	☐	☐
Implementing Adaptation		
11. Is the risks (of maladaptation) of the adaptation action being discussed with all stakeholders? *Stakeholders shall be aware of uncertainties, assumptions, risks, and their possible consequences when engaging in or supporting an adaptation action.*	☐	☐
12. Have the expectations of the stakeholders been considered? *This means that all interested stakeholders are allowed to voice their views, and it was made transparent how the views, especially conflicting ones) are taken into account (e.g. regarding drinking water supply during drought, housing in flood areas)*	☐	☐
13. Are mechanisms in place for coordinating the adaptation action across sectors? *Two or more sectors (e.g. water, agriculture, health) shall coordinate data, strategies, investments, etc. for coherence between actions.*	☐	☐
14. Are mechanisms in place for coordinating the adaptation action across governance levels (e.g. municipal, regional, national)?	☐	☐
15. Are the resources available for the adaptation activity used in the most effective and efficient way? *Resources like funds, expertise, and natural ones are limited and often can only be employed once; they shall be dedicated to the most promising/beneficial actions. Investment, operational, and maintenance costs shall at least be considered.*	☐	☐
16. Is there a procedure in place for the review and if necessary, re-design of the adaptation action? *This might be necessary in case of a rise in energy prices, changes in demographics, etc., which can negatively impact the outcomes of the adaptation action. The procedure shall define timing and decision-making.*	☐	☐
Monitoring and Evaluating Adaptation		
17. Are monitoring and evaluation procedures in place to assess the effects of the adaptation action? *Procedures such as reporting, feedback, and learning shall be based on action-specific, measurable, achievable, relevant, and time-bound (SMART) objectives so that they can contribute to establishing a catalogue of successful adaptation actions.*	☐	☐

This checklist (Version 1, August 2022) has been developed in the framework of the REGILIENCE Project. It is still under improvement, and we aim for a better connection with other adaptation tools and insert case studies to illustrate challenges and solutions. If you use it, we would be grateful for your feedback, especially on the following questions:

- Is the tool useful?
- Is anything missing?
- Do you agree with the wording?
- Are the questions understandable?

For any questions, collaboration interests, or feedback please contact: Teresa Geidel (Fresh Thoughts Consulting GmbH), contact: teresa.geidel@fresh-thoughts.eu

What is the REGILIENCE project all about?

REGILIENCE, a project funded by the EU Horizon 2020 programme, will support communities, cities, and regions in their efforts toward building climate-resilient pathways. It will facilitate the identification and upscaling of the most promising resilience solutions: supporting their replication in 10 vulnerable and low-capacity regions in Europe; communicating them through various channels and actions; and inspiring policymakers, organisations, and individuals to become part of the change.

 This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 101036560.

Annex III: Interview guide for Expert Interviews

T3-3 Interview Round 1 Data Table

REGILIENCE T3.3: Draft Interview Guide Round 1: Learning lessons from adaptation

1. Objectives

- To identify potential examples for round 2
- To gather information about maladaptation
- To establish contact with experts for further work on (mal)adaptation

Interview partners: from env. or climate agencies, commission affiliates, research, and experts (as per the list in another file)

2. Introduction

We would like to invite you to take part in an activity being carried out by REGILIENCE, a 4-year project funded by the European Union within the framework of the H2020 Research and Innovation programme.
Currently, we are in the phase of preparing the cases we will investigate closely and are collecting information on different types of maladaptation (occurring at different stages) and from different sectors and regions. We are collecting lessons learned and insights from people who work on adaptation.
Name of the interviewee:
Institution and special interests or expertise:
Date:
Duration:

3. Questions

(If applicable make a reference to the introduction), considering the examples you gave and your work:

1. Are you familiar with the term “maladaptation”? How would you define maladaptation?

Our working definition (if needed): Maladaptation:

- Refers to actions that seek to reduce vulnerability to climate change but end up doing significant harm (Barnett and O'Neill 2010)
- (Adaptation) actions that fail to reduce climate risk but increase it instead and/or contribute negatively to the wellbeing of social groups (now/in the future) and/or lead to an inequitable distribution of costs/benefits among social groups (now/in the future) (inspired by Jones et al., 2015)
- Bear in mind: IPCC def. on exacerbating of carbon emissions
- Effects of one action worsening another sector/ area
- IPCC: 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. Maladaptation is usually an unintended consequence.

2. Which cases of maladaptation have you come across in your work?

Supporting questions (to guide the interview):

- Why do you consider this example a case of maladaptation?
- What was the original aim of the policy/project/intervention?
- What were/are the (expected) impacts or consequences of the policy/project/intervention?
- Why did it turn out to be a case of maladaptation?

Complementary question:

- Could you provide us with the names and contacts of researchers or other stakeholders or promoters involved in this example? Is there any written document/report available?

3. Do you know other examples related to [here to incorporate the sectors, where we have gaps in our mapping exercise]?

4. What are the causes / reasons for maladaptation? When or why does it take place?

5. Would you like to be informed and engaged in our next steps?

6. Do you have any recommendations to us for scientific papers or documents we should read or colleagues we should interview? Are you aware of any projects we should look into or articles we should read? Could you send them to us?

7. Are you also aware of any particularly successful cases of climate change adaptation and/or resilience projects, measures and activities? Can you share any relevant information (links or contacts) either now or via e-mail?

8. Is there anything you would like to mention that we haven't asked or addressed?

Finalisation
Thank you very much for sharing your knowledge and experiences with us! This helps us to better understand adaptation processes and avoid maladaptive outcomes in the future.

Annex IV: Full assessment tool to prepare interview guide

The interviews, as well as the self-assessment tool for maladaptation, are based on the table that was developed to better understand what relevant aspects shall be included in the self-assessment tool. This Annex shows the table (work in progress) which was used to fix categories of risk, as well as develop the questions.

Screening adaptation actions for maladaptation risks

This step aims to develop a self-assessment tool that allows pre-check (ex-ante) adaptation actions for potential maladaptation risks. In preparation, maladaptation has been studied through literature research and interviews with experts and researchers in T3-3. The process can be summarized in 4 steps:

1) Obtain a comprehensive list of risk factors that could lead to maladaptation (with input drawn from the IPCC report, studies on maladaptation, interviews on maladaptation, OECD DAC criteria, and the EU Taxonomy) (left column)
2) Matching Adaptation Support Tool actions (by EEA Climate-ADAPT) to the risk factors (right column)
3) Formulate checklist questions (middle column); the questions are designed to detect potential maladaptation risks (, No': reflecting a potential maladaptation risk, Yes': no maladaptation risk for this aspect/question)
4) Checking whether there are gaps between the checklist questions and the Adaptation Support Tool actions and add questions to the middle column if needed

This approach aimed to ensure a) that we are not missing any important evaluation aspects and b) that the resulting set of questions is streamlined with other evaluation tools. In blue are those concepts marked which shall be supported with a brief explanation/glossary for the final checklist.

1 LACK OF EFFECTIVENESS (OECD DAC, 2022) = the intervention is not achieving (or is unlikely to achieve) its objectives		
Factors that could lead to maladaptation	**Maladaptation risk screening questions**	**Climate-ADAPT Adaptation Tool developments (AST climate-ADAPT 2022) actions**
Inefficient conversion of inputs (funds, expertise, natural resources, time, etc.) into outputs, outcomes, and impacts; is important because resources are limited (OECD DAC, 2022)	Are the available resources planned and used most effectively? - the funds' - expertise and time - natural resources, time, etc.) used in the most effective way possible?	
	Have any barriers that have hindered an adequate	Gaps and barriers that hindered an adequate response in the past are

	adaptation response in the past been identified and mitigated? (if applicable) (S1)	identified and understood (S3)
		Stakeholder approval and support for the chosen set of priority options is ensured (S4)
Poor quality of implementation (lack of controls, cut-off budget, lack of ongoing monitoring, revision and maintenance, involvement of affected social groups) (POOR GOVERNANCE) (IPCC, 2022, Ch. 17, P. 23(Jones et al., 2015))	Are all prerequisites for good quality implementation in place? Such as political support secured, clear responsibilities assigned, sufficient human and financial resources ensured, feedback and learning processes established, relevant actors involved, and transformational change of values, assumptions, and norms addressed (if needed)) (S1)	A core team on adaptation is in place (S1)
		The adaptation action plan is developed, the roles and responsibilities of affected stakeholders are agreed upon, and the policy document is politically approved (S5)
		Steps for implementation are set (S5)
		Mechanisms for multilevel coordination are established, and a supportive governance framework is in place (S5)
		Human and financial resources are secured for the long term (S1)
Focusing on narrow one-off projects without targeting the region's key climatic risk Inadequately/insufficiently addressing upcoming/future climate hazards (World Bank, 2010)	Is the adaptation action addressing the key climatic risk(s) of the region? (S4)	A first overview of climate-related impacts and risks is gained (S1)
2 Insufficient KNOWLEDGE and UNDERSTANDING		
Factors that could lead to maladaptation	**Maladaptation risk screening questions**	**EEA Adaptation Tool** (AST climate-ADAPT 2022) **actions**
Ignoring local knowledge, perceptions, and expectations of communities regarding risk reduction and vulnerability (IPCC,	Are the knowledge, values, and expectations of stakeholders adequately considered in the decision-making process for the adaptation action? (e.g. all stakeholders are allowed	Steps for implementation are set (S5)
		Mechanisms for multilevel coordination are established, and a

2014); Interview Ebun Akinsete) Lack of consideration of regional values, assumptions, and norms	to voice their views, it is made transparent how the views, especially conflicting ones are taken into account, etc.) (S5)	supportive governance framework is in place (S5)
Failing to understand risks and system dynamics (Jones et al., 2015)	Are future changes in risk considered? (S2) Are the interactions between different drivers of risk and the impact they have on the risks considered? (S2)	Human and financial resources are secured for the long term (S1)
Not dealing with knowledge gaps/uncertainties appropriately (IPCC, 2014)	Are uncertainties identified and adequately dealt with in the design of the action? (e.g. scenario planning, adaptive management, robust/resilient pathways/strategies) (EEA Uncertainty guidance tool, 2022) (S5) Are knowledge gaps addressed in the process of the action? (S5)	Knowledge gaps and uncertainties in climate change are summarized and made explicit (S2)
Lack of Awareness about maladaptation	Are all stakeholders aware of the risk of maladaptation and its different implications? (S5)	A common understanding of climate change adaptation is developed among key stakeholders (S1)
		Target group-specific formats for awareness raising is carried out (S1)
3 LACK OF COHERENCE **(OECD DAC, 2022)** = the intervention is not compatible with other interventions in a country, region, sector or institution, or internationally		
Factors that could lead to maladaptation	**Maladaptation risk screening questions**	**EEA Adaptation Tool** (AST climate-ADAPT 2022) **actions**

Adaptation is localised and fragmented, with no or limited coordination or mainstreaming across sectors, jurisdictions, or levels of governance (SCOPE) (IPCC, 2022,16-32)	Is the choice of adaptation actions done in alignment with relevant international, national, local, and sectoral actions to achieve mutual synergies? (S5)	High-level political support for adaptation is secured (S1)
	Are horizontal (i.e. across sectors) coordination mechanisms in place? (S5) Are vertical (i.e. across governance levels) coordination mechanisms in place? (S5)	A governance framework for implementation across levels and sectors is in place (S5) Institutional cooperation is set up (S1)
		Adaptation strategy is developed and politically adopted (S4)
		Governance effectiveness: Key instruments for integrating adaptation are identified and modified accordingly (S5)
		Mechanisms for horizontal coordination and cooperation are established (S5)
Not building regional/social capacity and social/institutional engagement to deal with climate change, e.g. by fostering dependency and passivity and penalising adaptation pioneers (Barnett & O'Neill, 2010)	Are mechanisms in place that avoid that an adaptation action becomes passive, cannot be changed, or is dependent on many other factors?	Key instruments for integrating adaptation are identified and modified accordingly (S5)
4 Lack of SUSTAINABILITY over time and PATH DEPENDENCY **(OECD DAC, 2022) and PATH DEPENDENCY (IPCC, 2022)** (=the intervention's benefits will not last financially, economically,		

socially, and environmentally; sustainability in the sense of the continuation of results; not environmental sustainability)		
Factors that could lead to maladaptation	**Maladaptation risk screening questions**	**EEA Adaptation Tool** (AST climate-ADAPT 2022) **actions**
Lack of (ongoing) monitoring and evaluation, lack of ongoing learning and adaptive management	Are monitoring and evaluation procedures (including reporting, feedback, and learning processes) planned to track the implementation process and (intended and unintended) impacts, and are mechanisms planned that allow for adjustments (if necessary)? (S6)	• The factors driving Monitoring, Reporting, and Evaluation (MRE) activities are well understood and the purposes of MRE are clearly defined and communicated (S6) • MRE system is tailored to specific conditions and priorities with specific purposes and objectives (S6) • Roles and responsibilities for MRE are clear and mechanisms for engaging relevant stakeholders are in place(S6) • MRE indicators and methods combine quantitative indicators with qualitative methods to capture perspectives from a range of relevant stakeholders, allowing for more effective triangulation of information and ensuring that the overall narrative of adaptation progress is robust, consistent, and contextualized (S6)

		• Results are synthesized and communicated in ways that are relevant to key audiences (especially policy-makers and decision-makers) (S6)
Reducing flexibility(Barnett & O'Neill, 2010) and future adaptive capacity by locking the region into inflexible solutions and path dependence (e.g., because of high sunk costs(Jones et al., 2015)), making path correction in line with developing knowledge/evidence difficult and precluding alternative adaptation options (IPCC, 2014)	Is there a pathway foreseen for re-planning, and re-assigning resources to an alternative/altered solution, if required? (S5)	MRE informs adaptation policymaking along the adaptation policy cycle, informs policy revision, and supports learning over time (S6)
Predominantly focusing on short-term benefits and economic growth, thereby forgoing long-term benefits (IPCC, 2014)	Does the adaptation action secure long-term benefits (not only short-term benefits)? S5	
Disproportionately high opportunity costs(Barnett & O'Neill, 2010, Findlater et al., 2022)		
5 Lack of relevance (OECD DAC, 2022) **(= not doing the right things)**		
Factors that could lead to maladaptation	**Maladaptation risk screening questions**	**EEA Adaptation Tool** (AST climate-ADAPT 2022) **actions**
Doing significant harm (EU Taxonomy, 2022) to the environment and/or depleting natural (non-renewable) resources at	Does the adaptation action comply with the 'do no significant harm' objective (that is, does not create unintended [significant?]	

the expense of future generations (including regional, national, EU, and global objectives (e.g. climate change mitigation(Barnett & O'Neill, 2010; Jones et al., 2015), sustainable use and protection of water and marine resources, transition to a circular economy, pollution prevention, and control, protection and restoration of biodiversity and ecosystems))	adverse impacts on the environment, including interregional and trans-borders)? (S5)	
Decreasing the overall well-being of individuals, households, and communities, including impacts on a,) livelihoods, b) social equality and cohesion (IPCC, 2022), and c) physical and mental health (IMPACT) Unjustly distributing costs and benefits and increasing social inequalities(Jones et al., 2015) (at the expense of other individuals (IPCC, 2022c), (vulnerable) social groups or economic sectors (within the region or in other regions)(A. Magnan & Mainguy, 2014) Unjustly distributing costs and benefits and increasing **social inequalities** (Jones et al., 2015) (at the expense of other individuals, (vulnerable) social groups (Barnett& O'Neill, 2010)., or economic sectors	Is the adaptation action safeguarding against negative social effects and distributive injustice (e.g. decreasing the well-being of (vulnerable) social groups, increasing social inequality, decreasing social cohesion, gender equality…) (including interregional and trans-borders)? (S2)	

(Magnan, 2014) (within the region or in other regions)		
		Transboundary issues are taken into account (S2)
Not responding to the needs of targeted social groups(Barnett & O'Neill, 2010)	Are the needs of targeted social groups (esp. the most vulnerable) identified and is the adaptation action aligned with these needs? (S4)	Main concerns that require an adaptation response are identified (S2)
		All affected stakeholders are involved (S1)
		An assessment and prioritisation system of adaptation options is developed in cooperation with stakeholders (S4)
No defined objective(s), or unrealistic/unrealisable objectives (OECD DAC, 2022)	f) Are the objectives of the adaptation action-specific, measurable, achievable, relevant, and time-bound (SMART criteria)? (S6)	The NAS, NAP, and/or SAP have clear measurable targets and objectives (S6)
Lack of considering non-climatic factors/developments (AST climate-ADAPT, 2022; Jones et al., 2015)	Are non-climatic stress factors (root causes, pressures, and conditions) that influence the adaptation outcome (such as economic and social development) considered? (S2)	Non-climatic stress factors identified and considered (S2)
	Are the adaptation actions weighed against the costs and benefits (financial and non-financial) of other adaptation options? (S5)	A full catalog of adaptation options for consideration is compiled (S3) Suitable adaptation options are described in detail (S3) Cost-benefits of adaptation options are assessed (S4)

		Preferred adaptation options are selected for implementation(S4) All necessary information on adaptation options is gathered to enable assessment (S4)
Inadequate depth of the adaptation action (adaptation mainly to maintain existing practices through incremental change with minimal change in underlying values, assumptions, or norms instead of fostering transformational change) (IPCC, 2022; (Jones et al., 2015)	Are transformational adaptation actions considered and assessed and planned where appropriate? (S5)	
Inappropriate timing of the action: too late/too early, too slow (SPEED) (IPCC, 2014; IPCC, 2022; (Jones et al., 2015)	Does the timeframe of the adaptation action consider both lead, implementation, and consequence timings and can inform the policy cycle over longer time scales? (S6)	

Annex V: definition of maladaptation

Maladaptation refers to a **process**[1] of planning and implementing an **intentional**[2] **adaptation action**[3] that may **in the short- or long-term**[4] **lead**[5] to **increased vulnerability** (to climatic or non-climatic risks)[6] or diminished wellbeing[7] (of **the same or other systems, sectors, or social groups** targeted by the adaptation action[8]). Furthermore, maladaptation can also be associated with negative impacts that **undermine sustainable development for the society as a whole**[9]. Adaptation actions that likely **reduce the flexibility to adapt in the future**[10] or **ignore local contexts**[11] are associated with a **high risk of maladaptation**.[12]

Background information on key features of the definition (bold terms) are provided below:

[1] By referring to a **process** instead of an outcome we stress the temporal dimension of the concept. Maladaptation is not an end state, but maladaptive outcomes can evolve over time (Jones et al., 2015; Juhola et al., 2016; Magnan et al., 2016).

[2] We understand **intentional adaptation** as a deliberate decision to adapt, in contrast to autonomous adaptation (adapting without consciously focusing on climate change). Furthermore, this notion doesn´t include inaction. From our literature review, we found that there are different perspectives on whether inaction and actions which are not labelled as 'adaptation' could be associated with maladaptation. Despite the exceptional need to address negative impacts deriving from inaction and actions other than climate change adaptation, we decided to limit the scope to specific actions designed to reduce the present or future vulnerability to climate change. This makes it possible to develop a practical tool that points to maladaptation risks of specific adaptation actions. To tackle maladaptive outcomes from inaction and other initiatives, tools with a different focus are needed. These could aim to remove barriers to adaptation or promote the mainstreaming of climate change in decision-making processes, for example (IPCC, 2014; Jones et al., 2015; Juhola et al., 2016).

[3] **Adaptation actions** include a broad range of different adaptation implementation forms, e.g. policies, plans, and projects. In the literature, they are also referred to as adaptation initiatives (A. Magnan, 2014).

[4] Temporal dynamics (not only about climate change) shape the outcomes of an adaptation action over time (Magnan et al., 2016). An adaptation action can be considered maladaptation when the **short-term** benefits are outweighed by the **long-term** costs (or vice versa). However, the temporal dimension makes it challenging to determine the 'final' outcomes of an adaptation action (Jones et al., 2015).

[5] An adaptation action **can lead to different outcomes.** Jones et al (2015), for example, categorize them as successful adaptation, failed adaptation, and maladaptation. Others argue that rather than these three distinct categories, there is a continuum from success to failure (Glover & Granberg, 2021).

[6] As it is the primary aim of an adaptation action to reduce the vulnerability to climate change, the aspect of achieving the opposite is included in most definitions. However, only limiting maladaptation to **increasing vulnerability** to climate change, as is the case in some early definitions, is not sufficient (e.g. IPCC (2001): "an adaptation that does not succeed in reducing vulnerability but increases it instead."). Adaptation actions do not only influence climate risks but also wider economic, social, cultural, and psychological factors (Jones et al., 2015). Chi et al. (2021) describe the process of increasing the vulnerability to other risks as 'risk substitution'.

[7] Here, we refer to **wellbeing** to encompass the potential adverse impacts of an adaptation strategy on wider, social, cultural, and psychological factors (Jones et al., 2015). This goes beyond the term 'welfare' used in the definition of maladaptation by the IPCC (IPCC, 2014, 2022a).

[8] While some initial definitions imply that maladaptation only affects '**other systems, sectors or social groups'** (Barnett & O'Neill, 2010), we point out that there can also be adverse impacts on **the same system, sector, or social group** targeted by the adaptation action. Following the categorization of maladaptive outcomes by Juhola et al. (2016), the latter can be described as 'rebounding vulnerability', while affecting other systems, sectors, or social groups is referred to as 'shifting vulnerability' (even though here we do not limit the scope to vulnerability concerning climate change but also include wellbeing). This highlights the spatial dimension of maladaptation, i.e. maladaptive outcomes can be displaced to neighbouring or connected areas (Magnan et al., 2016).

[9] Drawing from the types of maladaptation by Juhola et al. (2016) we acknowledge that maladaptation can affect entities on different spatial scales. Therefore, outcomes of an adaptation action may also **undermine sustainable development for society as a whole**. While reinforcing climate change through increased greenhouse gas emissions is occasionally mentioned in this context (IPCC, 2022a), maladaptation can also be associated with the degradation of environmental, social, or economic conditions (Juhola et al., 2016).

[10] In the face of climatic and non-climatic changes and associated uncertainties, **flexibility** is key to avoiding lock-ins into maladaptive pathways (Magnan et al., 2016). Accordingly, irreversible and inflexible options carry a high risk for maladaptation and require precaution mechanisms to prevent maladaptive outcomes in the future (Hallegatte, 2009). This is for example the case for large capital-intensive infrastructure projects, as they commit capital to paths that are difficult to change. Such inflexible adaptation options are often associated with high opportunity costs and represent a sunk cost (Barnett & O'Neill, 2010).

[11] Adaptation is mostly a local process, and local circumstances vary considerably (Bours et al., 2014). Adaptation actions should be consistent with the prevailing environmental, social, and economic factors and account for the internal mechanisms of a social-economic system (IPCC, 2014; A. Magnan, 2014). **Ignoring these local contexts can lead to maladaptive outcomes**, which often disproportionately burden the most vulnerable (e.g. ethnic minorities and low-income households) (IPCC, 2022a). Therefore, it is important to consider the preferences and needs of targeted groups (Jones et al., 2015; A. Magnan, 2014), whereby focusing on marginalized and vulnerable groups which often lack visibility in political processes (Albizua et al., 2019). These efforts are needed to avoid the inequitable and uneven distribution of maladaptive risks (Jones et al., 2015).

[12] Some definitions indicate that maladaptation is an 'unintended' consequence (IPCC, 2022a) or happens 'inadvertently' (IPCC, 2001). However, we intend to stress that there are reasons why an adaptation action turns into maladaptation. **Processes likely leading to maladaptation** can be identified before the implementation of an action, and it is possible to mitigate these risks (Magnan, 2014).