Long-term Strategies in a Changing Climate

Published by:

giz Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH

On behalf of:

Federal Ministry for the Environment, Nature Conservation and Nuclear Safety

of the Federal Republic of Germany

Published by:
Deutsche Gesellschaft für
Internationale Zusammenarbeit (GIZ) GmbH

Registered offices
Bonn und Eschborn

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GIZ is responsible for the content of this publication.
Berlin, 2019

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SUMMARY

Introduction. The 2015 Paris Agreement agreed the goal of limiting temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit to 1.5°C'. In line with this goal, the Agreement also called on all Parties to 'formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS)'. These long-term strategies typically extend out to the year 2050. As of early 2019, eleven Parties had communicated their LT-LEDS to the UNFCCC. However, the Paris Agreement also agreed a global goal for adaptation and this raises the question of how to integrate adaptation goals into LT-LEDS, i.e. so that they are climate resilient. Alongside this, a recent UNFCCC paper on long-term adaptation planning has set out the role for national adaptation plans as the main vehicle for adaptation planning in the decades to come, while maintaining synergy with Paris goals. This raises a similar question, i.e. how to ensure that long-term adaptation plans align with emission reduction. Finally, as mitigation and adaptation are both moving to a long-term perspective, an emerging question is whether to move to combined, synergistic climate resilient and low carbon long-term strategies.

Against this background, the IKI Support Project for the Implementation of the Paris Agreement (SPA), funded by the German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU) and implemented by the Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, has commissioned this research review to investigate and stimulate discussion on the technical and political economy issues with long-term climate resilient and low emission development strategies. This research report summarizes the findings and sets out some initial recommendations and future priorities.

Mitigation and Adaptation. Both mitigation and adaptation reduce the risks of climate change. Mitigation lowers greenhouse gas (GHG) emissions (or captures carbon) to reduce change at the global scale, while adaptation includes a range of measures at different scales to react to or prepare for impacts. This means that in theory, there could be a global optimal mix of the two. This mix would depend on their relative costs and benefits, but also the level of residual damage (the costs after mitigation and/or adaptation). In practice, however, mitigation and adaptation are complements, not substitutes. This is because the benefits of mitigation mostly arise later in time (after 2050) - so only adaptation can reduce climate impacts in the next few decades. At the same time, climate change will lead to long-term major impacts, including the risks of catastrophic global discontinuities (tipping points) – and only mitigation can reduce these risks because they are beyond the limits of adaptation. There are also different imperatives for action by country grouping. The primary narrative for Least Developed Countries (LDCs) is likely to be integrating cost-effective mitigation in long-term adaptation plans, as these countries will experience the largest relative impacts of climate change before 2050. In contrast, developed countries must reduce emissions if the Paris goal is to be achieved, and these countries also have better capacity and finance to adapt. This suggests that the primary narrative for these countries will be to develop LT-LEDS and mainstream adaptation into these strategies to build climate resilience (i.e. to climate proof them).

Linking mitigation and adaptation. There is an existing literature that looks at the potential linkages between mitigation and adaptation in national and sector policy and planning. The IPCC 4th Assessment Report (2007) identified four linkages:

- Adaptation actions that have consequences for mitigation;

- Mitigation actions that have consequences for adaptation;
- Decisions that include trade-offs or synergies between adaptation and mitigation;
- Processes that have consequences for both adaptation and Mitigation.

In subsequent studies (e.g. OECD, 2017: IPCC, 2018), these are framed more simply around positive and negative linkages around options, e.g.:

- Mitigation strategies or options that are beneficial for adaptation or adaptation strategies or options that are beneficial for mitigation (win-win or synergistic);
- Mitigation strategies or options that make adaptation more difficult (trade-offs);
- Adaptation strategies or options that make mitigation more difficult (i.e. increase GHGs);

Evidence base for integration. The study has reviewed the links above, undertaking a review for each sector. This has identified a large number of potential linkages. However, a more detailed analysis reveals that most of these are quite minor: only a small number of linkages are important at the national level, i.e. that would have a material impact on national GHG emissions or nationally important climate risks (see matrix below). These are considered the priority areas for integration. The review has also found that policy publications have focused more on the win-win linkages, but this research study has identified that there are just as many linkages that are negative or involve trade-offs. While it does make sense to promote the positives, to encourage uptake, it is important that these trade-offs are not overlooked.

Win-win	**Adaptation that has consequences or trade-offs with mitigation**	**Mitigation that has consequences or trade-offs for adaptation**
• Climate smart agriculture. • Protection and rehabilitation of carbon sinks, including forestry. • Ecosystem based adaptation. • Climate 'proofing' mitigation infrastructure. • Passive ventilation for building energy use	• Increased air conditioning. • Increased pumped irrigation. • Increased fertiliser use. • Desalinisation. • Low density urban planning.	• Biofuels and bioenergy. • Energy efficiency for buildings. • High density urban planning. • Renewable-energy technologies that use water or affect water management.

Review of LT-LEDS and LT-CRS. The research has assessed whether integration opportunities are being taken up in long-term strategies, starting with the submitted LT-LEDS. A review of the eleven strategies that have been submitted to the UNFCCC[1] finds that LT-LEDS are almost exclusively focused on mitigation (though this is their primary objective). In general, there is little integration of adaptation and little analysis of how the changing climate could affect low emission plans over time. Where links are mentioned, it is mostly in the forestry and natural resource management sectors. Part of the reason for the low level of integration is because these countries have separate adaptation plans. The exception is Mexico, which has an integrated plan that captures more (but not all) linkages. The research has also reviewed national adaptation plans (NAPs). A review of the thirteen NAPs

[1] Benin, Canada, Czech Republic, Fiji, France, Germany, Mexico, Marshall Islands, Ukraine, United States, United Kingdom.

submitted to the UNFCCC[2] finds most of these are focused on the short-term (2025 or 2030). However, there are a number of other long-term climate resilient (adaptation) strategies, notably in Rwanda and Burkina Faso. These short and long-term plans are very focused on adaptation, though they some include low carbon development including synergistic plans in agriculture and forestry. The review concludes that the integration of climate change impacts and adaptation in LTL-EDS, and low carbon futures in long-term adaptation or climate resilient strategies (LT-CRS), are at an early stage. This leads to the question of why this is?

Political economy, entry points, barriers and solutions. As well as the analysis of mitigation and adaptation options, the review has considered the political economy of mitigation and adaptation, and how this affects potential integration. Following from above, while there are potential synergies between mitigation and adaptation, and high-level aspirations to deliver these, there is relatively little integration in practice. The reason for this is that there are important barriers to integration, which include policy, technical, market, financial and governance barriers that act to reduce the integration of mitigation and adaptation. The report has reviewed these issues as part of the political economy analysis, finding:

- Mitigation and adaptation involve different entry points and programming modalities. Mitigation is considered through stand-alone (long-term) plans, while adaptation is increasingly programmed by mainstreaming into existing policies and plans (short-term). These policy barriers currently act to make integration more challenging, but they can be overcome, noting this may involve a different approach for developed versus LDC countries, reflecting the modalities and entry points.
- Mitigation and adaptation are taken forward by different sectors: mitigation focuses on the major emitters, while adaptation focuses on the most climate sensitive. The development of long-term plans are usually undertaken by different teams, with different disciplinary expertise (i.e. different people develop mitigation versus adaptation plans). These organisational and institutional barriers can be overcome with a greater focus on inter-disciplinary strategy development and by ensuring greater equivalence of mitigation and adaptation in objectives and scenario development.
- There are often a number of market failures that act to prevent integration or synergies. There are policies that can help address these. For example, carbon prices would mean adaptation plans would prioritise lower emission options as standard, while increased information on the financial risks of climate change would create incentives to consider adaptation options more directly in low carbon planning. Positively, there are initiatives that are developing these.
- There are information and technical issues associated with integration. GHG emission sources are well known, and reductions can be targeted deterministically, prioritising and incentivising the most cost-effective measures. In contrast, planned, pro-active adaptation is time and pathway dependant, site and context specific, and involves high uncertainty and multiple criteria. Its appraisal requires extended cost-benefit analysis and decision making under uncertainty. There is a need to develop more integrated analysis frameworks and tools to help integrated analysis.
- Last, but not least, there are financial and economic barriers to integration. The benefits of synergistic policy and integration are often ancillary (co-benefits) or non-market in nature. As a result, integration may make sense from an economic perspective, but not from a financial one (for

[2] Brazil, Burkina Faso, Cameroon, Chile, Colombia, Ethiopia, Fiji, Kenya, Saint Lucia, Sri Lanka, State of Palestine, Sudan, Togo.

private investors). It is noted that there has been a major uplift in climate finance flows for mitigation, but to date, adaptation finance flows lag behind, and are primarily from the public sector. However, this is changing and recent announcements indicate much higher flows of finance for adaptation, which if combined with development assistance, could deliver at scale.

The research has mapped the individual barriers to each of the major opportunities for mitigation and adaptation integration (synergies and trade-offs), and also considered the potential solutions. This finds that they differ by sector/option. This means there is no single solution that will unlock integration or enhance synergistic win-win options, it will require a portfolio. More positively, the review finds there are solutions to all of the barriers and there are already positive examples where such change is happening. A priority is to learn what works and scale up. A key finding is that there is a key role for the public sector (including development cooperation partners) to create the enabling environment to address barriers and enhance long-term strategy integration.

Findings. The study has used the study findings to add three questions.

- ***What is the evidence base for integrated mitigation and adaptation planning in long-term strategies?*** The research finds that there are opportunities for synergistic (win-win) integrated mitigation and adaptation in long-term strategies, but there are also potential trade-offs. The research has reviewed the potential linkages by sector, finding a large number of these exist, however, a relatively small number of these are likely to be important and these maj are considered the priority areas for integration. The review of submitted LT-LEDS finds that highlight the potential role for adaptation co-benefits, but do not translate this through into integrated analysis and options, with the exception of the agriculture and land-use sectors. This implies that integrating climate resilience into LT-LEDS - and low carbon measures in adaptation long-term strategies – is challenging to deliver in practice. These challenges are caused by barriers that act to prevent or reduce synergistic or even integrated implementation. More positively, the review finds these barriers can be overcome, and identifies an important role here for this from development cooperation.
- ***What are the entry points for linking adaptation and mitigation in long-term strategies?*** The research has reviewed the political economy and entry points for mitigation and adaptation. This finds that mitigation and adaptation are currently implemented through different national planning processes. Mitigation has mostly been taken forward in stand-alone low carbon plans, both short and long-term (LT-LEDS). In contrast, adaptation is generally planned through a mainstreaming modality, which seeks to integrate into current policy and development, rather than implementing measures in stand-alone projects or programmes. There is therefore a need to consider how better to undertake joint (consideration) of mitigation and adaptation in LTS. However, this is likely to use different modalities and entry points by country grouping. The LDCs typically have long-term visions, but strategic planning is carried out through the medium-term lens, i.e. 5-year plans. A possible entry point is to use these core long-term visions and integrate mitigation and adaptation into these, rather than producing stand-alone plans. This could then cascade down into medium-term national and sector development plans using a mainstreaming approach. There are some countries where this has already occurred, though it does require a shift to economic, finance and planning ministries. For developed countries, the entry points and implementation pathways are likely to be different. For these countries, the focus is likely to be on enhancing the mainstreaming of adaptation in LT-LEDS. There might also be additional entry points in the development of sector LT-LEDS and integration into sector strategies and plans, to ensure sector specific barriers are targeted.

- ***How can climate resilient LT-LEDS and integrated LC-CR be realised and achieve transformation in the context of sustainable development?*** Recent climate reports have recommended a shift from current governance arrangements towards multi-level governance, collaborative multi-stakeholder partnerships, and more. This will be needed to deliver transformational change, but it involves major political change. At a more pragmatic level, there are some success factors that could enhance integration of adaptation and mitigation in LTS. These include the presence of a high-level champion, the involvement of strong Ministries, and the availability of climate finance, accompanied by technical assistance, information and capacity building support. These aspects can be advanced with development cooperation and there are already successful case studies that demonstrate this through capacity strengthening.

Finally, the study has identified a number of priorities for further investigation. The most important recommendation is to undertake a study to answer the question of how much might climate change influence an LT-LEDS, in quantitative terms, with an analysis of the changes in scenarios and emission (e.g. cooling demand), as well as an analysis of possible adaptation integration options. This should also identify the potential barriers to integration options and how these can be overcome. A similar analysis could be undertaken to examine mitigation co-benefits for long-term adaptation strategies. The results of these assessments will help to highlight the importance of these linkages, to identify priorities areas, and will provide valuable lessons for future tools and wider development cooperation support to enhance mitigation and adaptation integration. A further finding is that barriers are critical when implementing synergistic options and mitigation and adaptation integration. A further recommendation is therefore to undertake work to document the main barriers, and identify possible solutions to address these, drawing together good practice case studies to identify insights and learning. This would help to identify where to focus development cooperation support, so as to most effectively create the enabling environment for integrated long-term strategies.

1 INTRODUCTION

This study, on **Long-term strategies in a changing climate: Research study and recommendations** has been commissioned under the IKI "Support Project for the Implementation of the Paris Agreement (SPA)". The SPA is a project funded by German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (BMU), and is implemented by the Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH.

The research has been commissioned to investigate and stimulate discussion on the technical and political economy issues with long-term climate resilient and low emission development strategies, using a literature review and analysis of the findings. This report summarizes the findings of this research and sets out some initial recommendations and future priorities.

1.1 Rationale and Objectives

The term low emission development strategies (LEDS) was initially introduced by the UNFCCC in 2008. In 2015, the Paris Agreement[3] agreed the goal of 'holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C' [Article 2a]. In line with this goal, the Agreement also called on all Parties to 'formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS)', taking into account their common but differentiated responsibilities and respective capabilities [A4.19]. These long-term strategies typically extend out to the year 2050. As of early 2019, eleven Parties had communicated their long-term strategies to the UNFCCC.

The Paris Agreement also agreed a global goal for adaptation, 'enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring adequate adaptation response in the context of the aforementioned temperature goal' [Article 7.1]. Further, a recent UNFCCC technical paper on Long-term adaptation planning (AC/2018/12) has set out the role for national adaptation plans to 'serve as the main vehicles for national adaptation planning and implementation in the decades to come, while maintaining synergy [with]… the goal to limit the rise in global average temperature'.

This raises the question of how to integrate adaptation goals into LT-LEDS, i.e. so that they take account of the changing climate, i.e. for climate resilient long-term low emission development strategies. It also raises the question of how to ensure that long-term adaptation planning is consistent with low energy pathways. As there are initiatives to shift both mitigation and adaptation to a long-term planning perspective, a subsequent question is whether there is a need for better integration, i.e. towards combined, synergistic low carbon and climate resilient long-term development strategies.

In response to this question, GIZ have commissioned this research, to investigate these issues and provide initial recommendation on whether, why and how to link emission reduction and adaptation. This includes the technical aspects, i.e. the analysis of the roles of and interactions between adaptation and mitigation in a long-term development strategy, but also the political economy of integration,

[3] https://unfccc.int/sites/default/files/english_paris_agreement.pdf

including the entry points and potential barriers to the uptake of integrated climate resilient LT-LEDS.

The study objectives are framed towards answering the following guiding questions:

a. Is there a substantial basis in academic research (from various fields) to combine or link long-term strategies for adaptation and mitigation?
b. If so, what are concrete entry points for combining or linking adaptation and mitigation in long-term strategies, both in terms of technical rationale and political economy? If not, to develop rationale and narrative for development of separate long-term strategies or alternative planning processes.
c. How can a possible interfacing between mitigation and adaptation strategies be realized aiming at transformational change in the long term, in the context of sustainable development? What are practical avenues in terms of institutional setup and research support necessary to understand and consider linkages between adaptation and mitigation in long-term strategies?

This research report investigates these issues. It summarizes the analysis of the research and sets out some initial recommendations. It is primarily presented to stimulate discussion and inputs from other stakeholders. The research report is set out as follows:

The early sections provide the context for mitigation and adaptation. It reviews the potential synergies and trade-offs between mitigation and adaptation at the global, national and sector level. This addresses the first question above on the evidence base for linking mitigation and adaptation in long-term strategies.

The report then reviews existing long-term strategies to assess the degree of current integration, considering LT-LEDS and National Adaptation Plans that have been submitted to the UNFCCC.

The report then looks at the political economy of LT-LEDS and the entry points for combining mitigation and adaptation. This considers the potential barriers to integrated planning.

The final section brings together the study findings and recommendations, summarising the findings for in terms of the three questions above, and identifies further priorities for research and analysis.

2 POLICY BACKGROUND

The early focus on climate change policy at the international level (under the United Nations Framework Convention on Climate Change (UNFCCC)) focused on mitigation and on the Annex 1 countries. However, in more recent years, this has widened to all countries, and was initially advanced with the Nationally Appropriate Mitigation Action (NAMA) (policies and actions that countries pledged to undertake as part of a commitment to reduce greenhouse gas emissions). Most recently, it has been taken forward with the Nationally Determined Contributions (NDCs), established under the Paris Agreement, which set out national determined efforts by each country to reduce national emissions: these are normally framed as actions that will be undertaken in the period 2020-2030. The Paris Agreement also called on all Parties to 'formulate and communicate long-term low greenhouse gas emission development strategies (LT-LEDS)', taking into account their common but differentiated responsibilities and respective capabilities, which extends the time-frame (typically) out to the year 2050.

In the international context, the early focus on adaptation was different, with greater attention on developing countries and in particular the least developed countries. This was advanced initially through the National Adaptation Programmes of Action (NAPAs), which provided a process for Least Developed Countries (LDCs) to identify priority activities that respond to their immediate needs to adapt to climate change. This was followed up with the National Adaptation Plan (NAP) process that was established under the Cancun Adaptation Framework. Most recently, adaptation has been included under the NDCs. While the primary focus of the NDCs is on mitigation, submissions (especially from developing countries) also set out actions and financing needs for adaptation. However, there has been rather less international focus on long-term adaptation strategies, other than a suggestion that NAPs could act as a vehicle for longer-term (post 2030) planning.

At the international level, therefore, mitigation and adaptation have been considered rather separately, and there are no current incentives for integration in the long-term context. For example, the information on LT-LEDS in the Paris Agreement (Article 4) does not make any explicit reference to the need to also ensure climate resilience, although it does highlight for these to be mindful of Article 2. Similarly, the text on adaptation is quite broad when referring to linkages with mitigation. Article 2.1b does highlight the need for 'increasing the ability to adapt to the adverse impacts of climate change and foster climate resilience and low greenhouse gas emissions development, in a manner that does not threaten food production)', and Article 7.1 sets out that 'Parties hereby establish the global goal on adaptation of enhancing adaptive capacity, strengthening resilience and reducing vulnerability to climate change, with a view to contributing to sustainable development and ensuring an adequate adaptation response in the context of the temperature goal referred to in Article 2'. The main conclusion is that, to date, mitigation and adaptation have been taken forward as rather separate processes, rather than as an integrated issue.

However, the situation is changing. There is a renewed interest in climate change and the linkages between mitigation and adaptation, not least following the publication of the IPCC 1.5°C report (IPCC, 2018). There is also a greater recognition of the need to include climate change as part of development, as outlined in the sustainable development goals (SDGs): climate change action is one of the SDGs (13) and there is another goal to (7) to ensure access to affordable, reliable, sustainable and modern energy for all. Furthermore, there is also a growing awareness in the financial markets on the implications of climate change (UNEP, 2018). All of these are putting greater emphasis on the need for integrated long-term climate change planning, i.e. climate change is becoming the new normal. Against this background, this rapid review has investigated mitigation and adaptation integration in long-term strategies, looking at the current evidence, and identifying early insights and future priorities.

3 MITIGATION AND ADAPTATION AT THE GLOBAL SCALE

The starting point of the review was to look at the interlinkages between mitigation and adaptation at the global scale. This helps frame the long-term issues and it also identifies differences in country perspectives that are important for subsequent national level analysis.

Both mitigation and adaptation reduce the risks associated with climate change. Mitigation involves reducing greenhouse gas (GHG) emissions and/or capturing carbon – to prevent change at the global scale. Adaptation includes a wide range of measures – at different aggregation scales - to prepare for, or reduce the harm from, the impacts of climate change. As mitigation and adaptation both reduce climate impacts, it is possible to consider different levels of each at the global scale.

This has been investigated primarily in the economics literature. Using an economic framework, it is possible - at least in theory - to explore the complementarity or even the substitutability of mitigation and adaptation at the global level. A small but established economic literature of global economic integrated assessment models (IAMs) have assessed the economic costs of climate change (see reviews, e.g. Tol, 2018), as well as possible policy responses to reduce these impacts with mitigation or adaptation. Some of these models also allow indicative analysis of the optimal mix of global mitigation and adaptation. These use a general framework that applies at the global and national level. First, they assess the future impacts (and economic costs) of climate change. They then assess the benefits of either mitigation or adaptation in reducing these impacts. If the economic benefits of acting outweigh the costs, then there are net benefits and policy action is justified. The studies also look at varying levels of mitigation and levels of adaptation, to assess their relative effectiveness. There is, however, a further trade-off. Both mitigation and adaptation action reduce, but do not entirely remove, the impacts of climate change, thus, there is a level of residual damage. This means that the optimal (economic) policy needs to consider all elements – the economic costs of climate change, the costs and benefits of action (in reducing impacts, either from mitigation or adaptation, or a combination of the two), and the residual impacts after action.

Global modelling studies that undertake this type of analysis (see reviews by Agrwala et al., 2011: Watkiss et al., 2015) generally find that a mix of mitigation and adaptation is optimal, but they tend to have a greater focus on adaptation. These modelling studies do select some early mitigation, but they tend to favour adaptation over aggressive mitigation. They generally optimise to 2.5°C or more of warming (e.g. Nordhaus, 2016), which is higher than the Paris agreement, and reduce remaining impacts with adaptation or else bear the residual damage. It is noted that this is partly due to the lack of action to date[i]. The greater effectiveness of adaptation arises because the benefits of mitigation primarily emerge in the later part of this century, due to the inertia in the temperature response to GHG reductions. This means that mitigation benefits are low in present value terms when higher discount rates are used[ii]. However, even at low discount rates, adaptation is often found to be much more cost-effective than mitigation, because it targets specific risks, rather than general temperature reductions.

However, there are a number of reasons why these global 'experiments' do not tell the whole story. The first is the coverage of the models (Watkiss and Downing, 2008) and in particular, their ability to assess the risks of large-scale, non-linear global catastrophic events, often called tipping points (Lenton et al., 2008). These tipping points, such as the collapse of the West Antarctic Ice Sheet or runaway warming, are beyond the limits of adaptation and can only be avoided with mitigation. IAM modelling studies that include risk aversion to tipping points find that the optimal policy mix changes, with much greater and earlier mitigation action (e.g. Hof et al., 2014; Cai et al., 2015), although these still require high levels of adaptation. Indeed, the risk of potential outcomes involving non-marginal impacts actually leads to a breakdown of standard cost-benefit analysis. For these reasons, the implementation of aggressive early mitigation to reduce the probability of exceeding tipping point thresholds can be seen as a form of insurance policy. There is also other literature that highlights additional reasons to invest aggressively in mitigation earlier. This is because it requires long-term investments deployed on a large scale (due to slow capital turnover) (Bosello et al., 2013) and because a delay in mitigation reduces the percentage of impacts that can be avoided (Warren et al., 2013) or leads to irreversible impacts (see IPCC, 2018). However, while tipping points change the results of these modelling assessments, and the role of mitigation and adaptation policy, the key problem is that there is little robust evidence on the temperature levels that might trigger these tipping events (Kriegler et al., 2009; Levermann et al., 2012).

The second issue concerns the inertia and lags involved in the climate system. These means that even aggressive, early mitigation will not reduce economic impacts significantly in the next two to three decades, as temperature pathways only diverge significantly after 2040 (IPCC, 2013: Hof et al., 2014). This is one of the reasons why it is extremely difficult to limit warming to 1.5°C.

The third issue concerns international climate governance. There are important ethical assumptions involved in a global policy mix of mitigation and adaptation, as impacts are not evenly spread over space and time. As well as issues with discounting (and inter-generational weighting), a further issue relates to the geographical distribution of impacts, and whether to adjust welfare losses to take account of different incomes in different regions (equity weights), noting this affects the aggregate global economic costs significantly (Anthoff et al., 2012). The assumptions on discounting and distributional weights requires ethical positions, on which many people will disagree. This highlights that the challenges involved in setting international targets for the mix of mitigation and adaptation are extremely complicated.

Previous analysis has therefore concluded (Watkiss et al., 2015) that mitigation and adaptation are policy complements rather than substitutes, as <u>only adaptation can address near-term impacts</u> (to 2050) and <u>only mitigation can avoid long-term tipping points</u> as these are beyond the limits of adaptation. In theory there could be a space between these for policy substitution (between mitigation and adaptation), but it is impossible to know what this is, because of climate sensitivity and uncertainty: even if emission reductions do align towards a 2°C pathway, the high levels of uncertainty in the climate system mean that much higher levels of warming could still occur. If the temperature thresholds for major tipping points are low, e.g. around 2°C, then this policy space does not exist, because aggressive mitigation will be needed to avoid these catastrophic outcomes.

In the context of this review of long-term strategies at the national level, these global issues are important for the following reasons.

- First, the distribution of global climate change impacts will not occur evenly. There are much higher impacts in Sub Saharan Africa and South Asia, where relative economic damages (as a % of regional GDP) are projected to be double the global average (e.g. OECD, 2015). The Least Developed Countries (LDCs) are particularly affected in relative economic terms, because they have climate sensitive economies, are close to climate thresholds and have low adaptive capacity (To, 2018). They will bear the brunt of climate change in the next few decades and these impacts can only be reduced with adaptation. As a result, there will be high levels of early climate impacts that cannot be addressed with mitigation (up to 2040) and the largest need for adaptation will be in developing countries.

- Second, while mitigation and adaptation are often presented as being complements, in practice they involve different incentives, which affect the potential for integration. Mitigation is a public good and its benefits are generally experienced at the global level, primarily over long-time scales, while the costs are borne locally and in the shorter term. It requires international coordinated action to be effective. In contrast, adaptation is generally short to medium-term in nature. It involves a mix of local public goods provision but also other planned and private adaptation actions, involving many disparate actors, who may act either autonomously (and/or reactively) or through planned action (including pro-actively) to preserve the status quo or minimize losses. Adaptation benefits tend to be local, near-term and accrue to those that take the action, as do the costs (unless funded through international assistance).

4 MITIGATION AND ADAPTATION AT THE NATIONAL SCALE

In practical terms, mitigation policy is predominantly implemented from a national policy perspective, flowing from international negotiations and agreements, and cascading down to sectors. Similarly, while adaptation is often a response to a local impact, the overall policy framework for adaptation now flows mostly from the national level, consistent with the UNFCCC process and National Adaptation Plans (NAPs). The linkages between mitigation and adaptation at the national level is therefore critical, but to date, this has not translated through into an integrated policy framework, i.e. the two have been somewhat separated. This section assesses the potential integration and inter-linkages between adaptation and mitigation. It starts with the framing of these linkages, then goes on to investigate the potential synergies and trade-offs between mitigation and adaptation action at the sector level.

There is an existing literature that looks at the potential linkages between mitigation and adaptation in national and sector policy and planning. These often present these synergies and trade-offs using a matrix. The IPCC 4th Assessment Report (Klein et a., 2007) identified four linkages:

- Adaptation actions that have consequences for mitigation;
- Mitigation actions that have consequences for adaptation;
- Decisions that include trade-offs or synergies between adaptation and mitigation;
- Processes that have consequences for both adaptation and mitigation.

In subsequent studies (e.g. OECD, 2017), these are often framed more simply around options, e.g.:

- Mitigation strategies or options that are beneficial for adaptation (win-win or synergistic);
- Adaptation strategies or options that are beneficial for mitigation (win-win or synergistic);
- Mitigation strategies or options that make adaptation more difficult (trade-offs);
- Adaptation strategies or options that make mitigation more difficult (i.e. increase GHGs);

These are used to construct simple matrices of linkages (noting the first two can also be combined). For example, the OECD (2017) uses the following matrix:

	Positive for mitigation	**Potential trade-off with mitigation**
Positive for adaptation		
Potential trade-off with adaptation		N/A

And the annex to the IPCC 1.5°C Special Report (IPCC, 2018: Chapter 4 annexes, de Coninck et al., 2018) looked at the positive (synergies) and trade-offs (negatives) sequentially, as below:

Mitigation option	**Adaptation synergies**	**Adaptation Trade-offs**
Option mitigation 1		

Adaptation option	**Mitigation synergies**	**Mitigation Trade-offs**
Option adaptation 1		

It is highlighted that much of the literature has focused on promoting the positive synergies, i.e. win-win options of mitigation and adaptation. However, there are also linkages that are negative or involve trade-offs. It is important to consider both in analysing LTS, although this could translate into different levels of ambition. For example, for LT-LEDS, there is a difference in ambition between a strategy that actively seeks to *deliver* synergistic adaptation, from one that minimises climate risks to new low carbon infrastructure. Similarly, for a long-term adaptation strategy, it might be preferable to have synergistic win-win options that reduce GHG integrated, but it might be sufficient to avoid GHG increases.

5 EVIDENCE BASE ON SYNERGIES AND TRADE-OFFS BY SECTOR

The review has investigated each of the main sectors considered in LT-LEDS and LT-CRS, to investigate the specific synergies and trade-offs involved. This draws on recent reviews (OECD, 2017; de Coninck et al., 2018 for the recent IPCC Special Report on 1.5°C) as well as the wider literature. This provides the main evidence base to address the first question (see earlier section) on whether there is a basis in academic research to combine or link long-term strategies for adaptation and mitigation.

Energy and electricity supply and demand, including in buildings

The energy sector will see significant changes in the next decades due to a gradual decarbonisation of systems, and a progressive shift toward renewable technologies in most countries (mitigation). There are major synergies and trade-offs between mitigation and adaptation for energy demand and supply. There are also potential synergies between mitigation and adaptation, such as hybrid systems taking advantage of an array of sources and time of use strategies, which could increase system resilience.

On the demand side, many studies highlight that rising temperatures will increase energy demand for cooling in the built environment (e.g. De Cian and Sue-Wing 2017; Hasegawa et al., 2016; Labriet et al. (2015). These indicate large increases in cooling demand and air conditioning in warmer countries. This means that adaptation to warmer temperatures – to address discomfort and productivity losses/ occupational limits from overheating – will increase GHG emissions (a trade-off) unless electricity is decarbonised. However, there are alternative adaptation options which have lower emissions. These can include higher efficiency cooling systems, to replace fossil fuel generation (switching to renewables, on grid or locally), or through building design (passive ventilation, such as blinds/shutters, orientation, shade, etc), which could be included in the design of new houses (building codes).

For mitigation, there is a focus on reducing GHG emissions from energy use in buildings, noting that these can be associated with emissions from heating (in colder countries) or cooling (in warmer countries), or a mixture of the two. Note that while cooling is almost exclusively powered by electricity (and predominantly from AC), heating is delivered through many different energy fuels and systems, that often include fossil fuels. The reduction of building energy use for heating is therefore a key theme of most OECD LT-LEDS (see earlier), and has centred on energy efficiency (building insulation, improved boiler efficiency) and low carbon energy (changing to lower carbon fuel, renewables etc.). Many studies discuss potential synergies between reducing heating demand and reducing cooling demand, e.g. through design measures that reduce the energy use in houses (and zero emission houses) (Mima and Criqui, 2015). However, there is also the risk of trade-offs, as measures to reduce energy use for heating can lead to over-heating in warmer conditions (Kovats et al, 2016), i.e. there is a need for careful design to actually deliver synergies. There is also an issue with whether passive design is as effective in reducing thermal discomfort and heat related impacts (including mortality) from heat extremes: AC has been shown to be very effective in reducing these risks (Ostro et al., 2010) and the switch to passive systems may include residual risks. Furthermore, planned alternatives to AC involve barriers to implementation, due to higher up-front capital costs and institutional barriers: passive technologies need to be built at the design phase by one actor (the construction firm) to generate benefits for another (the household owner).

There are also potential risks to energy supply (especially electricity) from climate change (Van Vliet et al 2016: IISD, 2018). As mitigation involves a different generation mix, with a stronger share of renewables, there is a need consider the resilience of long-lived, climate sensitive infrastructure such as hydro-power, wind, and solar. There is also a need to ensure cross-sectoral linkages of competition for water. There are also linkages as climate change can have impacts on energy generation for fossil power, which increases GHG emissions from reduced generation or losses from damage. Most of the focus has been on the risks of climate change on hydropower (Turner et al., 2017) from changes in river flows, evaporation and safety. These impacts vary with location. In some regions there will be negative impacts but in others there could be positive impacts (e.g. from increasing water availability increasing total generation). The inclusion of climate risk screening for hydropower projects has therefore been advanced in new design (e.g. Bonzanigo et al., 2015). This is an area of potential synergy, though in practice, the implementation is sequential (i.e. hydropower is considered for reducing electricity emissions in the national mix, whereas it is at the detailed project design stage where adaptation is included). Climate change can also have potential impacts on wind power (from affecting wind regimes, the risk of major storm and potentially storm tracks, notably for cyclones and hurricanes) and on solar (photovoltaic system, cloud cover, temperature), but these impacts are likely to be modest relative to current risks (e.g. Tobin et al, 2014). For wind power generation, the average changes are likely to be small in energy generation capacity by mid-century and so do not justify a large up-front investment in 'climate proofing' wind turbines given their short technical lifetime (twenty years), though the potential change in risk of major storms is still an issue. There are also important linkages for water under climate change for concentrated solar power (CSP) (Wild et al., 2017). Higher temperatures may also reduce electricity production from thermal power plants (Mideksa & Kallbekken, 2010), and reducing the efficiency of transmission (also affected by changing patterns of extremes): these would mean higher emissions per unit of generation. Carbon capture and storage reduces plant efficiency and has considerable water energy demands.

The integration of climate risks into renewable energy development is one area where there has been a greater integration of practice, although this is not always reflected in LT-LEDS. This has been a focus of climate risk screening for major renewable energy investments, notably hydropower, among the Multi-Lateral Development Banks (see EBRD, 2015: World Bank, 2016) and there is even emerging guidance (e.g. World Bank, 201) on how to do this. Similarly, there have been initiatives for integrating adaptation in renewables at the country level, for example as part of the Strategic Mitigation, Adaptation and Resilience Tool (SMART) and Pacific 2050 Pathways Package (Climateworks, 2018a: 2018b).

It is currently unclear if disruptive energy systems e.g. involving different technologies, such as mini-grids, or different actors such as IT companies, will make it more or less easy to integrate adaptation. Much of the literature identifies these as opportunities for building resilience, or highlight that diffuse systems could provide greater resilience to climate shocks (IPCC, 2018). However, this is not necessarily true. As an illustration, smaller-scale grid systems are unlikely to have gone through the same level of due diligence and will have lower operating criteria thresholds, which means they maybe inherently more vulnerable. There is there is likely to be a lower level of investment in climate resilience measures at smaller sites, because asset values are lower. Capacity and preparedness are likely to be lower. Similarly, systems that involve greater use of IT run the risk of converging and cascading interactions (Dawson et al, 2016), e.g. from power disruption and through ICT links, due to interdependent linkages. Therefore, it is possible that disruptive energy systems are actually more vulnerable to smaller extreme weather events, and only offer more resilience in an extreme case where the main grid systems or stations fail. What is clear is that for both conventional and alternative energy systems, the increasing pattern of extreme weather events will mean climate resilience is a priority.

Agriculture

The agriculture sector is also a major source of potential synergies and conflicts. There is a large literature on the potential for synergistic agriculture through climate smart agriculture. These aim to deliver on triple outcomes: productivity increases (income growth), reduced greenhouse gas emissions (mitigation) and enhanced climate resilience (adaptation) (FAO, 2013: IFAD, 2016). This is particularly important in developing countries, as the agricultural sector is highly climate sensitive, but also that it is the main source of GHG emissions, though they have been recommended in developed countries (e.g. UBA, 2012: BC, 2013). Climate smart agriculture includes a number of sustainable agricultural land management (SALM) practices that are beneficial for mitigation and adaptation, including soil and water conservation, agroforestry, and improved pasture and grazing management. These reduce climate related risks from rainfall variability and soil erosion, increase soil organic matter and soil fertility increasing productivity, and reduce emissions by reducing soil emissions or preventing more emission-intensive activities. These contrast with more traditional measures to increase productivity, such as fertiliser use or increased irrigation, which increase GHG from fertiliser production and energy use in water abstraction and pumping (though they can reduce land-use emissions by increasing productivity, and reducing future land-use pressures). Recent work (GIZ, 2018) has identified the very large emissions from soils, and highlighted the role of sustainable land management (SLM), noting that increasing soil organic carbon (SOC) is key to the benefits of many SLM practices.

There are many existing initiatives on climate smart agriculture, particularly in developing countries. Most of the current NAPs have a strong focus on these approaches, and they are being mainstreamed into many national agricultural strategies (irrespective of long-term emission targets). There is also an uptake of these in many LT-LEDS (see later review). However, climate-smart options often involve opportunity or policy costs, higher risks, or may involve benefits that arise over longer time periods (McCarthy et al., 2011) and often involve institutional, financial and capacity barriers. This explains the relatively low uptake of their use to date. Furthermore, in practice they may involve a trade-off between productivity, mitigation reduction and resilience, i.e. it is not as easy as first appears to deliver triple wins – noting that if such gains were easy to achieve, there would already be widespread application of these approaches.

There can also trade-offs involved in the agriculture sector between mitigation and adaptation objectives. The most common adaptation measures identified in the literature to address falling productivity from climate change (Porter et al, 2014) are increased fertiliser use (embodied GHG emissions) and irrigation, which involves energy use for pumped irrigation and GHG emissions (when this is powered by diesel or grid electricity). It is possible to reduce the use of fertiliser, or improve irrigation technology (Ignaciuk and Mason-D'Croz, 2014) but these still involve some conflict with mitigation (hence the focus on CSA above, as well as other options such as more climate resilient varieties, enhanced weather and climate services, etc. see Quiroga et al., 2018).

There is also an issue of the linkages between mitigation and adaptation for biomass, bioenergy and biofuels including bio-energy with carbon capture and storage (BECCS). The linkages between mitigation and adaptation are complex, because of the interaction with land availability, land prices, agriculture (Obersteiner et al, 2010; Valin et al., 2015), as well as competition for water and effects on ecosystems. Previous studies have highlighted important conflicts between bio-energy at scale and agriculture, with possible food price shocks also highlighted (OECD, 2017), although there might also be potential synergies if climate smart agriculture is practiced.

In the livestock sector, some synergies between mitigation and adaptation exist, for example by breeding animals with lower emissions per unit of dry matter intake while reducing livestock diseases (through better health management practices), and improving grassland management (which can help increase carbon stocks). However, there are also potential and complex trade-offs: for example, novel technologies on animal breeding may cause consumers health concerns that need consideration.

It is also highlighted that while the academic literature talks about behavioural change around low carbon diets, this is not advanced in LT-LEDS, even though it could have important resilience benefits (from lower intensity of production).

Forestry and natural resources

Forest protection, restoration and afforestation are cited in many LT-LEDS and have an important role in sequestration. These investments are often cited as having adaptation benefits, i.e. they form synergistic policy, because of the role of forests in ecosystem services: forestry can deliver adaptation benefits through enhanced watershed management, soil erosion protection, etc. but also have large co-benefits from their role in livelihood and economic benefits (timber and non-timber products), as well as broader ecosystem service benefits (Angelsen et al. 2014). However, climate change will have potential impacts on forestry and can lead to impacts from shifting agro-climatic zones and extremes, changes in pest and disease, altered forest fire risks, etc. This therefore means that specific adaptation options for forestry may be needed, and these should also be integrated (synergistically) in forest mitigation projects (Ravindranath, 2007). These tend to centre on species choice (including more resilient varieties or species), improved and sustainable planting and management regimes, early warning monitoring and surveillance (pests, fire), buffer zones (Khabarov et al., 2016). It is also highlighted that failure to include these adaptation options in forest mitigation projects could affect the performance or even viability of these investments, which are important given the long life-times of forestry projects (and thus risk to future climate change).

The restoration and conservation of other carbon sink ecosystems, such as wetlands (terrestrial) and blue carbon (mangroves and coastal wetlands), not only increase the resilience of the natural environment, but also contribute to preserving both the mitigation and adaptation services provided by such ecosystems. For example, wetland protection or restoration can reduce flood risk, while also storing carbon and supporting biodiversity and coastal ecosystems have important adaptation benefits through their resilience function in reducing sea level rise and storm surge (Holly et al., 2012). Joint mitigation and adaptation activities therefore include the reinforcement or enhancement/expansion of existing measures to conserve biodiversity (and ecosystem services).

However, there is a need to consider the impacts of climate change on these systems, with additional measure e.g. protected areas, buffer zones, ecological corridors, reducing habitat fragmentation, and enhanced information and monitoring. While many LT-LEDS cite the potential for natural systems, they do not necessarily include these additional adaptation options. Furthermore, there is often little consideration of barriers and governance. These systems often have high opportunity or transaction costs, and planning for multiple objectives (e.g. biodiversity protection and carbon sequestration) increases the complexity of planning processes and data needs.

It is noted that as well as protecting and enhancing sinks, there is also more interest in investing in ecosystem-based adaptation (EBA), as an alternative to engineered protection (i.e. such as flood protection barriers or dikes). This includes mangroves and wetlands (storm surge), room-for-river through to small scale (sustainable urban drainage), and these have (some) mitigation co-benefits. Such initiatives are being advanced by many organisations, including GIZ[4]. These EBA options tend to focus on the primary goal of adaptation, while identifying mitigation as a co-benefit.

Water supply and demand

There are mitigation-adaptation linkages emerging for the water sector. Water demand in hotter climates is likely to increase with rising temperatures, due to increasing evapotranspiration and losses, as well as higher per capita consumption (though this is conditional on water pricing policy, supply availability, etc.). This may increase energy use associated with water systems (e.g. groundwater pumping, transfers or desalinisation) (Mima et al., 2011) and these effects may be exacerbated by climate change reducing precipitation in some countries (IPCC 2013). While there is a growing focus on adaptation planning in the water sector and emerging examples (e.g. Lempert et al, 2010; UNESCO, 2018), there has been less attention to date on the energy linkages, especially in relation to long-term mitigation objectives. The main focus has been on cooling water abstraction for power stations (from systems), where changes in water availability, or water temperatures, can act to limit abstraction: this has been a problem in the past (such as in Europe, EEA, 2008). There has been les consideration of the impact of rising water demand from climate change increasing energy demand.

Transport

Transport is another key sector for long-term emission reduction strategies. The main focus is on decarbonisation (electric vehicles and alternative fuels), efficiency and public transport. On the climate change side, most of the concerns are around risks of extreme events: flooding, heat waves, droughts and storms, i.e. where climate change affects transport infrastructure design criteria, and operation (Przyluski et al., 2011). There has been some discussion that public transport enhances resilience, by providing alternative transport options during shocks (IPCC, 2018), but this argument falls down unless these systems have integrated adaptation (and also carries a risk of system shocks). It is also highlighted that there are large co-benefits from mitigation policy in the transport sector (air quality, health, congestion) but these co-benefits are not climate change related (at least not primarily).

Infrastructure

There is a focus on enhancing the resilience of infrastructure and investing in low carbon infrastructure (MDBs, 2017), noting this includes many of the sectors above. OECD (2017) reports that less than half the G20 have integrated both mitigation and adaptation into infrastructure planning, and highlights there is scope to enhance climate adaptation and mitigation goals in infrastructure plans. What is clear is that the global demand for new infrastructure will be very large over future years, with estimates of $57 trillion (Global Commission on The Economy and Climate) to $95 trillion (OECD, 2017) by 2030, the latter equivalent to $6.3 trillion/year over the next decade, thus the integration of adaptation and mitigation within this will be key to global and national targets. There have also been some studies that have highlighted there could be increased GHG from adaptation

[4] https://www.giz.de/en/worldwide/37322.html

infrastructure (from the embodied emissions in material), such as coastal dikes (OECD, 2017) but these emissions are considered to be low.

Cities

While it is covered in many areas above, there is a particularly focus on mitigation and adaptation linkages in cities: cities are a primary source of global GHG, and they also vulnerable to future climate change, which is important given the high population density and assets (Hunt et al., 2011). They also often involve separate governance structures, that mean opportunities for integrating mitigation and adaptation exist beyond the national and sector level.

There are potential synergies around many measures, associated with design and construction that can be implemented by cities (IFC, 2016). These cover energy use, water use, water management, disaster risk management, waste management and others. They also include cross-cutting capacity and regulations (e.g. standards, planning controls). Rosenweitz et al. (2015) identifies efficiency (buildings, transportation, and industry), modifying layout of buildings and districts, the choice of construction materials and reflective coatings and increasing the vegetative cover and highlights that mitigation strategies that yield concurrent adaptive benefits should be prioritized - though this may be more difficult in practice. This is borne out by the level of uptake of integrated measures, suggesting important barriers (governance, regulatory, behavioural and financial barriers). As an example, Lehman et al. (2015) explored the barriers and opportunities for adaptation planning in cities, finding action depends on three main variables: information, resources, and incentives. They also confirm the importance of the institutional context, including barriers and opportunities associated with mainstreaming adaptation, multi-level governance and participation: these barriers were specific for local or urban adaptation action, due to dependency on the national regulatory framework. However, there is one key trade-off that is identified. Spatial planning policies that aim to reduce urban emissions by designing less carbon intensive cities often recommend high density, mixed used, development to reduce energy and transport demand (see LT-LEDS). However, higher building density increases the urban heat island effect and thus can lead to building overheating, increasing the use of energy in building cooling (McEvoy et al., 2006: de Coninck et al., 2018). This issue is highlighted as one of the key trade-offs for integrated mitigation and adaptation planning, i.e. where maximising for one (e.g. high density for low carbon cities) is detrimental for the other (increased urban heating and higher cooling demand for energy) and vice versa.

Aside from long-term strategies, there are many initiatives in this area. There has been a focus on low carbon and climate resilient cities, funded by organisations such as GIZ[5], as well as global initiative among cities themselves (e.g. the C40 initiative[6]) although often in these cases, mitigation and adaptation are being advanced as slightly separate goals.

Cross-sectoral

There has been the development of some guidance and tools to help assess linkages between mitigation and adaptation, which are often cross-sectoral in nature. There has been a major focus in the MDBs for climate risk screening processes for new investments, which include mitigation infrastructure (MDBs, 2017). There are also specific tools that seek to look at linkages, such as the scoping tool

[5] https://www.giz.de/en/worldwide/43392.html
[6] https://www.c40.org/

produced as part of the SMART initiative in the Pacific (Climateworks, 2018a; 2018b), which is also accompanied by a downloadable xls tool and is focused on 2050 pathways. This tool aims to support Pacific Island leaders in their long-term mitigation planning, by helping to identify the interlinkages between mitigation approaches and adaptation or resilience outcomes; where there are co-benefits to be realised and trade-offs that need to be considered or minimised in planning. It provides a high-level overview of the interactions of each mitigation action against each adaptation and resilience indicator, and also a summary of some types of implementation barriers for each.

5.1 Discussion

The review above identifies a large number of potential synergies and trade-offs across all sectors. This highlights that for detailed planning, there are a large number of possible linkages to consider. However, many of these are rather minor and context specific. The review has therefore considered which of the potential linkages are likely to be most important. This considers two issues. First, by identifying the most climate sensitive low emission technologies, i.e. where future climate risks could be very important to the capital investment and operation. This draws on the climate risk literature and existing climate resilient programming at the country levels and from international finance institutions (e.g. OECD, 2017; IPCC, 2018; World Bank, 2015b). Second, by identifying which adaptation options have the largest potential influence on greenhouse gas emissions (positively or negatively) by looking at emissions pathways (such as considered in the LT-LEDS below). This identifies that the most important linkages are likely to be around:

- The integration of adaptation (climate resilience) in renewable energy (mitigation) – this can involve a mix of positive linkages but also potential trade-offs, depending on the renewable source and location/context;
- Higher average and peak temperatures altering future energy demand (reducing cold-related heating, increasing heat related cooling), and the linkages for adaptation options for building cooling, which can involve trade-offs (mechanical cooling from air conditioning which increase energy use, enhanced building energy efficiency to reduce cold heating demand leading to over-heating) or synergies (passive cooling from enhanced building design);
- The impact of bioenergy and biofuels (including carbon capture) on agriculture, affecting land-use and prices (likely to be negative) and the linkages or trade-off for adaptation objectives including cross sectoral issues (e.g. water availability, agricultural production under climate change);
- The potential for mitigation and adaptation synergies from climate smart agriculture;
- The impact of agricultural adaptation (increased irrigation, fertiliser) on energy demand affecting mitigation objectives negatively;
- The impacts on energy demand from adaptation to address increased water demand or produce new sources of water demand (notably desalinisation);
- The synergies between reduced deforestation or afforestation and enhancement of other natural sinks (e.g. wetlands) and the positive effects on adaptation (from ecosystem-based adaptation), while noting the need to ensure these mitigation-based initiatives need to ensure species/design are climate smart;
- The trade-off between urban planning and density – whether to select high density (to reduce GHG emissions) or select low density (to reduce urban heat island effects).

These are summarised in the table below.

Table 1 Important synergies and conflicts between mitigation and adaptation.

Win-win	Adaptation that has consequences or trade-offs with mitigation	Mitigation that has consequences or trade-offs for adaptation
• Climate smart agriculture (low carbon and resilience) • Protection and rehabilitation of carbon sinks, including forestry (as long as future climate is included in species choice and design) • Ecosystem based adaptation (e.g. wetlands, mangroves) • Climate 'proofing' mitigation infrastructure (notably hydropower). • Passive ventilation for building energy use (for cooling).	• Increased air conditioning (increasing electricity demand). • Increased pumped irrigation (increased energy demand). • Increased fertiliser use to increase agricultural production. • Desalinisation (increased energy demand). • Low density urban planning.	• Biofuels and bioenergy -land availability and prices, impacts on food production and water-use, • Energy efficiency for buildings – potential increasing overheating risk. • High density urban planning – reducing emissions but increasing urban heat island and cooling demand. • Renewable-energy technologies that use water or affect water management, e.g. hydropower and concentrating solar power.

The recent IPCC 1.5°C report (IPCC, 2018) was relatively optimistic that a mix of mitigation and adaptation options implemented in a participatory and integrated manner can enable rapid, systemic transitions. However, the review about highlights that there are linkages that are negative or involve trade-offs. While it does make sense to promote the positives, to encourage uptake, it is important that these trade-offs are not overlooked.

6 REVIEW OF INTEGRATION IN LONG-TERM STRATEGIES

The next part of the study has been to review the current national Long-Term Low Emission Development Strategies (LT-LEDS), to assess current practice on integrating climate risks. The review has also considered the level of mitigation integration in national adaptation plans and longer-term climate resilient strategies

6.1 Review of Long-Term Low Emission Development Strategies

The review has assessed whether synergistic mitigation and adaptation options are being developed in long-term low greenhouse gas emission strategies, starting with the submitted LT-LEDS. At the current time (early 2019), there are eleven countries listed as having submitted LT-LEDS to the UNFCCC[7]. These are:

- Canada's Mid-Century Long-Term Strategy;
- Czech Republic: Climate Protection Policy Summary;
- Fiji's Low Emission Development Strategy 2018-2050;
- France: Strategie nationale bas-carbone;
- Germany: Climate Action Plan 2050;
- Mexico's Climate Change Mid-Term Strategy;
- Republic of the Marshall Islands: Tile Til Eo - 2050 Climate Strategy "Lighting the way";
- Ukraine 2050 - Low Emission Development Strategy;
- United States: Mid-Century Strategy for Deep Decarbonization;
- United Kingdom: The Clean Growth Strategy.
- There is also a Benin Strategy (Benin: Strategie de developement a faible intensit de carbone et silient aux changements climatiques 2016-2025) but as this is a short-term strategy it has not been reviewed here.

Further, while it is not submitted, there has also been a further LT-LEDS which has been included in this review:

- European Commission: Long-Term Strategy (EC, 2018): Clean Planet for All: A European strategic long-term vision for a prosperous, modern, competitive and climate neutral economy.

These are summarised in the table below. In analysing these strategies, we consider three evaluation criteria:

- Do the strategies consider climate change in future socio-economic and mitigation scenarios? i.e. does the analysis take account of changes involved in delivering LT-LEDS in a warmer world, noting it is almost certain that the world will have warmed by 1.5 to 2°C by 2050, relative to pre-industrial levels;
- Do the strategies set out an overarching narrative on the benefits of integration mitigation and adaptation in LT-LEDS?
- Do the strategies identify synergistic options for mitigation and adaptation or identify any potential trade-offs?

[7] https://unfccc.int/process/the-paris-agreement/long-term-strategies

Table 2 Analysis of adaptation Linkages in LT-LEDS

LT-LEDS	Adaptation Linkages
Canada's Mid-Century Long-Term Strategy	The LTS is focussed on mitigation, and examines an emissions abatement pathway consistent with net emissions falling by 80% in 2050 from 2005 levels. The Strategy identifies key objectives and building blocks that could underlie Canada's transition to a low-GHG economy. There is some mention of adaptation or (climate) resilience[iii], notably in sustainable forest management to tackle the twin challenges of mitigation and adaptation. However, there is a strong reference to the Pan-Canadian Framework on Clean Growth and Climate Change. Canada's Plan to Address Climate Change and Grow the Economy (2016). This has a more explicit focus to help Canadians manage the effects of climate change, by building capacity for adaptation and strengthening resilience, with commitments to develop and implement strong, complementary adaptation policies and action on climate resilience.
Czech Republic: Climate Protection Policy Summary	This sets out long-term indicative emission reduction targets: to pursue the indicative level of 70 Mt CO2-eq of emissions in 2040 and 39 Mt CO2-eq of emissions in 2050. This focuses on the energy sector, final energy consumption, transport, agriculture and forestry, and waste. There is little mention of adaptation or (climate) resilience[iv]. However, the documents sets out that the Czech Republic's approach to climate change can be divided into a policy aimed at reducing emissions of greenhouse gases and into a policy of adaptation and strengthening resilience to the adverse impacts of climate change, and it identifies that the Climate Protection Policy is complementary to the approved Strategy on Adaptation to Climate Change in Czech Republic (2015).
France: Strategie nationale bas-carbone	The Strategie Nationale Bas-Carbone (National Low Carbon Strategy) sets out ambitious emissions reduction targets by sector (transport, building sector, industry, energy, waste, agriculture and forestry) to cut greenhouse gas emissions by 75% by 2050 ("factor 4" reduction from 1990). There is little mention of adaptation or (climate) resilience[v], though there is a reference to ensure agriculture measures take account of the challenge of climate change, and for forestry species to be better adapted. However, there is a separate French National Strategy for Adaptation to Climate. The Strategy does set out that coordination between these the Low carbon and Adaptation policies will focus on seizing opportunities for synergy and resolving any conflicts between the measures put in place. Close cooperation will be particularly important in sectors which are heavily dependent on natural resources, i.e. agriculture and forestry. However, it is not prescriptive on what these are[vi].
Fiji's Low Emission Development Strategy 2018-2050	Fuji's LEDS (MoE, 2018) has a central goal to reach net zero carbon emissions by 2050 across all sectors of its economy (focusing on electricity, energy, transport, waste, reduced deforestation). Net negative emissions are projected through extensive afforestation measures, reduced deforestation, and increased use of sustainable forest plantations in the AFOLU sector, as well as blue carbon (protect and restore coastal wetlands). The LEDS is underpinned by similar visions contained in national development frameworks, including "a better Fiji for all," which guides A Green Growth Framework for Fiji (2014). The LEDS focuses on mitigation, i.e. on emissions and mitigation options. There is a separate chapter on climate change adaptation and resilience, which refers to the National Adaptation Plan Framework (2017) and adopted National Adaptation Plan (NAP) (2018). The document states the long-term mitigation actions envisioned in the LEDS are intended to align directly with, and complement, the adaptation actions prioritised in the NAP, and there is discussion of how measures in the LEDS align with the NAP, with analysis for all sectors (not just land-use and forestry). However, climate change is not factored into demand forecasts (e.g. the impact of warmer temperatures on electricity demand).
Germany: Climate Action Plan 2050	The Climate Action Plan 2050 addresses the areas of action energy, buildings, transport, industry, agriculture, land use and forestry. It also sets out overarching targets and measures. The guiding principle presents a 2050 vision for each area of action, while milestones and measures focus on 2030. There is low mention of adaptation or (climate) resilience[vii], other than in international development, in agriculture (on the general need for adaptation) and forestry (climate resilient varieties and measures to safeguard contribution to mitigation). However, there is a separate "German Strategy for Adaptation to Climate Change" (DAS) that was published December 2008. The Strategy comments on observed and expected climate change.

Mexico: Mexico's Climate Change Mid-Term Strategy	Mexico's mid-century strategy (MCS) provides the vision, principles, goals, and key actions to build a climate resilient society and to achieve low emissions development. The MCS includes two separate sections, one on mitigation and one on adaptation. The need for mitigation action is identified in five areas: (1) the clean energy transition; (2) energy efficiency and sustainable consumption; (3) sustainable cities; (4) reduction of short-lived climate pollutants; and (5) sustainable agriculture and protection of natural carbon sinks. On adaptation, priority actions are: the protection of the population from adverse impacts of climate change, such as extreme hydrometeorological events; as well as to increase the resilience of strategic infrastructure, and to conserve / protect / manage natural resources and ecosystems. The strategy also has a third set of cross-cutting policies. These include a mix of policies, market instruments, capacity building, awareness raising, and monitoring and evaluation.
Republic of the Marshall Islands	The 2050 Climate Strategy – which is RMI's long-term low greenhouse gas emission climate-resilient development strategy under the Paris Agreement – is to outline a long-term pathway for RMI to achieve its objectives for net zero emissions and 100% renewable energy, as well as to facilitate adaptation and climate resilience in a way that ensures the future protection and prosperity of the country and its women, men and youth. This builds on the NDC commitments out to 2030 but also analyses more ambitious scenarios, that then progress to zero emissions by 2050. The focus is on traditional emitting sectors and it is does not consider sinks or adaptation linkages. However, the Strategy has a separate section on adaptation. It commits to producing a National Adaptation Plan by the end of 2019 that sets out short, medium and long-term milestones to adapt to the impacts of climate change and transition to climate resilience, incorporating milestones to be achieved, for example by 2020, 2025, 2030 and 2050 – as well as suggested measures to achieve them.
The White House United States Mid-Century Strategy for Deep Decarbonization	This strategy, produced under President Obama, is clearly no longer White House policy, but it does provide a useful analysis of potential US LTS. The document sets out the critical technologies and strategies required for achieving at least 80 percent reductions by 2050, based around transitioning to a low-carbon energy system, sequestering carbon through forests, soils, and CO_2 removal technologies, including bioenergy with carbon capture and storage (BECCS) and reducing non-CO_2 emissions. There is a reference on the need to balance land sector climate mitigation and adaptation, which highlights the need to consider species, pests, water, etc. and raises the opportunities for mitigation and adaptation with wetlands and agricultural opportunities such as agroforestry. However, there is low consideration of other mitigation and adaptation linkages[viii].
Ukraine 2050 - Low Emission Development Strategy	This Low emission development strategy focuses on energy efficiency, renewable energy, modernization and innovation and transformation of market and institutions, as well as reducing other GHG and the absorption of carbon and reduction in GHG emissions in the land use. It does mention the consequences of climate change, but adaptation is primarily only mentioned[ix] briefly as part of the raising awareness programme, and in broad terms with respect to farming and forestry. However, the LTS recognises the need to prioritise adaptation as much as mitigation in the future.
United Kingdom: The Clean Growth Strategy	The UK Clean Growth Strategy (CGS) primarily focuses on the low carbon path to 2032, though it also reports on the broader development towards UK's target is to reduce its greenhouse gas emissions by at least 80 per cent by the year 2050, relative to 1990 levels and 2050 pathways. There is little explicit mention of adaptation or (climate) resilience. There are some brief references to some linkages, but these are not translated into policy[x]. However, climate risks and adaptation are considered through a different process, with the UK Climate Change Risk Assessment (which looks at risks out to 2100) and a National Adaptation Programme, which identifies urgent adaptation priorities, both of which are mandated under law, and are published every five years.
European Commission: Long-Term Strategy	The LTS sets out a vision that can lead to achieving net-zero greenhouse gas emissions by 2050. It sets out alternative future pathways for emissions reductions, and seven building blocks (energy efficiency in building, renewables, clean mobility, circular economy, smart networks, bio-economy and carbon sinks, and carbon capture and sequestration).

	There is little explicit mention of adaptation or (climate) resilience, and most references are broad[xi]. The strategy does sets out that delivering the vision will reduce the impacts of climate change and therefore reduce European adaptation costs. Nevertheless, three of the key priorities in the strategy do highlight linkages, notably the need for agriculture and forestry (bio-economy) for adapting to climate change, to strengthen infrastructure and make it climate proof, and providing support to third countries in defining low-carbon resilient development. Furthermore, there is a separate EU adaptation strategy and many short-term policies and strategies have more explicit linkages, including (e.g. forthcoming National Energy and Climate Plans (NECPs) under the Regulation on the Governance of the Energy Union) which will reflect the need to climate-proof sectors that are crucial to emission reduction (e.g. land use, agriculture, energy or transport).

Do the strategies build climate change into future scenario?

The first question considers whether LT-LEDS have undertaken an integrated scenario modelling exercise, to take account of climate change projections as well energy and emissions projections. For example, this considers whether energy demand projections and scenario modelling take account of future warming and the increase in cooling demand (for hot countries), or whether water supply or agriculture production has taken account of climate change and the increased water demand, etc.

A key finding is that, at least as reported in the main documents, the analysis of future mitigation plans (e.g. future energy demand) has not factored in climate change in any of the LT-LEDS, i.e. energy demand is still based on the historic climate, not with 1°C of warming and thus the change in heating and cooling demand. This is reflected in other sectors as well, i.e. future projections of agricultural emissions do not take account of productivity changes or irrigation demand under climate change, the effects of climate change on carbon sinks and their mitigation potential are not assessed, etc.

While it is possible that climate change is included in underlying scenario analysis that underpins some LT-LEDS, this is not reported, and none of the studies consider alternative scenarios of climate change by 2050. While these studies might assume that low carbon pathways are delivered globally, even in this case, 2°C of warming (relative to pre-industrial) would make a major difference to energy demand, e.g. for cooling (in hot countries) and reductions in heating energy demand (in cold countries).

This omission is important for two reasons. First, it means that the LT-LEDS are inaccurate. To put this in context, the projected change in global mean surface air temperature for the mid- 21st century (2045-2065) relative to the reference period of 1986–2005 are a mean estimate of 1°C (RCP2.6) to 2°C (RCP8.5) (IPCC, 2013). Even these levels will change global energy consumption, with estimates of an increase of 7–17% by 2050 due to warming (De Cian and Sue Wing, 2017). This is driven by much higher increases in tropical countries, and identifies a key linkage between high temperatures, cooling demand and electricity use for air conditioning, which in the absence of decarbonisation will make LT-LEDS more difficult to achieve. However, for colder countries (e.g. in Europe) it also means that reductions in energy consumption, driven by reductions in cold related heating, are not factored in the emission targets or costs of the analysis. The second consequence of this omission (that of missing climate projections) is that the high-level narrative for mitigation and adaptation linkages is not prioritised.

Is there a strong narrative on the need to integrate adaptation and mitigation in LT-LEDS?

Most of the LT-LEDS highlight the objectives of The Paris Agreement including adaptation, as well as mitigation (and thus low carbon and climate resilient development). They also highlight the general role of mitigation in reducing impacts domestically and thus reducing domestic impacts from climate change, and thus adaptation needs (and costs). Some (e.g. the EU LTS) infer that a failure to adapt is likely to lead to higher economic costs, which will reduce resources available for other areas, including mitigation.

However, while there is some high-level narrative, most LT-LEDS do not translate this through into a high-level integrated analysis. Indeed, with the exception of the Mexico and RMI strategies, adaptation is generally not included, and many strategies (e.g. Germany, UK, Canada, Czech Republic), stress that adaptation is instead considered in complementary adaptation strategies, i.e. there is a policy or strategy on long-term mitigation and a separate policy or strategy on adaptation. Even in the strategies that do consider mitigation and adaptation (e.g. Mexico), the two are presented in two separate chapters.

The one exception is the most recently submitted LT-LEDS, from Fuji, which has developed a LT-LEDS and a NAP at the same time, and includes a discussion that highlights that these have been aligned. It also sets out a framework for future analysis for considering climate resilience in mitigation measures.

Do strategies identify synergistic options and trade-offs for mitigation and adaptation?

Finally, dropping down to the sector and option level, there is little specific discussion of the mitigation and adaptation synergies and trade-offs involved in any of the LT-LEDS strategies. There is some discussion of synergies and some trade-offs in the Mexico Strategy, but beyond this most LT-LEDS only include discussion on the potential synergies in the land-use and natural resource sector, primarily on forestry, and to a lesser extent on agriculture. However, even here, the discussion is often generic, and there are rarely concrete options, and certainly not policies to incentivise low carbon and climate resilient uptake.

There is even less discussion of the mitigation and adaptation trade-offs, which are generally omitted in LT-LEDS, and certainly not included in any detail. As an example, where building energy use is mentioned, there is sometimes a discussion of possible opportunities to reduce emissions and build climate resilience, but rarely any discussion of trade-offs (higher insulation to reduce heat loss can sometimes increase over-heating potentially). Finally, there is little discussion of the necessary governance and policy arrangements that would be needed to address mitigation and adaptation together i.e. most discussion is around policy incentives for mitigation. Where there is discussion of options that could be win-win (e.g. agroforestry, climate resilient forestry), studies do not set out how to actually deliver synergistic policy, and are not transparent about the potential trade-offs, or opportunity or transaction costs, that might exist in practice.

The overall conclusion is therefore that LT-LEDS are focused primarily on mitigation (although of course, this is their primary objective) and they have not integrated adaptation. In most cases, adaptation is signposted as a separate process, advanced in separate policy or strategy documents.

However, this finding is not new. Previous studies have investigated mitigation and adaptation strategies and their linkages. For example, Neufeldt et al. (2010) investigated this with a case study in Europe. They found a strong sectoral separation: sectors that were major emitters, such as energy, focused on mitigation, while those with significant adaptation needs, such as water, focused on adaptation. Using a time series analysis, they found that adaptation policy and actions also lagged behind mitigation, and the difference in timing also contributed to the separation of the two domains. These findings also apply to the review of LT-LEDS here. There is little integration, and for long-term strategies, adaptation still lags behind mitigation.

6.2 Review of Long-term climate resilient strategies (adaptation plans)

A further review has been undertaken on long-term national adaptation plans. As highlighted above, the current adaptation focus is on the short-term with the NAPs and the NDCS (2030). At the current time (early 2019), there are thirteen NAPs submitted to the UNFCCC (Brazil, Burkina Faso, Cameroon, Chile, Colombia, Ethiopia, Fiji, Kenya, Saint Lucia, Sri Lanka, State of Palestine, Sudan and Togo[8]. In addition, the analysis has considered a medium-term integrated low-carbon, climate resilience plans from Rwanda. We assess these against the same criteria as above, i.e. do adaptation strategies include the impact of mitigation on socio-economic development, is there a broad integrated narrative, and what are the synergies and trade-offs involved.

[8] https://www4.unfccc.int/sites/NAPC/News/Pages/national_adaptation_plans.aspx

Table 3 Analysis of Mitigation Linkages in NAPs and longer-term climate resilience strategies

Document	Mitigation Linkages
Kenya National Adaptation Plan 2015-2030	The Kenya NAP has the objective of enhanced climate resilience towards the attainment of Vision 2030 and beyond, and thus seeks to integrate adaptation in the countries long-term development vision. The NAP proposes macro-level adaptation actions and sub-actions in 20 planning sectors, categorising them into short-, medium- and long-term time frames. It does include an objective to also enhance synergies between adaptation and mitigation actions in order to attain a low carbon climate resilient economy, however, there is a few specific examples of this, other than an identified gap risk and vulnerability assessments of energy infrastructure, and generic long-term initiatives to promote climate smart agriculture.
Brazil NAP to Climate Change	The Brazil National Adaptation Plan to Climate Change (BMOE, 2016) set outs the adaptation priorities for Brazil, and includes a vision that for the next four-year horizon, all (vulnerable) government-policy sectors must have climate-risk management strategies in place. The plan includes a principle to Implement adaptation and mitigation measures from the standpoint of co-benefits. There are linkages to low carbon plans in the sector specific strategies, notably for agriculture, as well as the identification of climate risk for renewables. However, there are not strong linkages (to mitigation) for cities) and in general linkages are generic, rather than specific to Brazil's longer-term mitigation plans.
Fiji National Adaptation Plan framework	The Fiji's National Adaptation Plan Framework (MoE, 2017) identifies the need to align to the climate change landscape, including mitigation. The focus of the NAP is climate adaptation planning, and while it does not directly address mitigation actions, it does consider mitigation co-benefits by prioritising low-regret options, identifying mitigation co-benefits.
Burkina Faso National Adaptation Plan	The NAP sets out the goal for Burkina Faso to 'manage its economic and social development more efficiently by implementing planning mechanisms and measures taking account of resilience and adaptation to climate change between now and 2050'. It includes a set of long-term adaptation objectives, and an analysis by sector and a global adaptation plan for the country. The actions in the energy sector do include some mitigation related actions (ensure a sustainable supply of energy for cooking; reduce electricity consumption, energy-saving technologies in industry and construction). There are also actions for forestry and agro-forestry which would have strong mitigation benefits, as well as climate smart agriculture actions. Under the medium- and long-term adaptation action plan for the environment and natural resources sector, there is also a specific objective to reduce GHG.
Ethiopia Climate Resilience Green Economy (CRGE) and National Adaptation Plan	The Ethiopian CRGE vision and strategy (FRDE, 2011) set out a vision to become a middle-income status by 2025 in a climate-resilient green economy, though the initial strategy focused on mitigation activities in four areas: improving crop and livestock production practices, protecting and re-establishing forests for their economic and ecosystem services (including as carbon stocks), expanding electricity generation from renewable sources of energy, and leapfrogging to modern and energy-efficient technologies in transport, industrial sectors, and buildings. Six priority sectors were identified: agriculture, livestock, urban, transport, industry and energy, and work is underway to produce detailed climate resilient (CR) sector strategies for all CRGE sectors, with CR strategies already in place for: i) Agriculture and forestry; ii) Water and Energy; and iii) Transport. These sector strategies do provide more consideration of inter-linkages, notably with the consideration in agriculture and forestry. The National Adaptation Plan (FRDE, 2019) focuses on vulnerable sectors: agriculture, forestry, health, transport, power, industry, water and urban, and identifies 18 adaptation options – these include enhancing alternative and renewable power generation and management, and soil and water conservation (climate smart agriculture). There is a general objective to ensure the NAP aligns to the CRGE strategy (emissions reductions) as well as the GTPII (national growth and development strategy).
Rwanda National Strategy for Climate Change and Low Carbon Develop-ment	The Rwanda Green Growth and Climate Resilience Strategy (RoR, 2011) set out a long-term vision for Rwanda to be a developed climate-resilient, low-carbon economy by 2050. It set out a series of objectives to deliver this, with energy security, low carbon energy supply, sustainable land and water management, development and preservation of ecosystem services and to reduce vulnerability to climate change. The strategy set out fourteen Programmes of Action (PoA), across a range of sectors, complemented with a set of enabling actions, big wins and quick wins. The strategy does include some explicit synergistic options, primarily in the PoA for sustainable intensification of (small-scale) agriculture, and a further PA on sustainable forestry, agroforestry and biomass. There was also an integrated PoA for efficient and resilient transport systems, and for Low Carbon Urban Systems, with the design of buildings to reduce the demand for energy and water and address climate risks such as flooding. There are also some potential linkages in relation to sustainable land use management, climate compatible mining, green industry and private sector development, and ecotourism, conservation and PES. The vision has been advanced more recently in national and sectoral development strategies, including the new long-term development vision to 2050.

Do strategies build mitigation trajectories and technical change into future scenario?

Most of the NAPs are short-term (2025 or 2030), and therefore have a different time period to the LT-LEDS. The strategies sometimes consider mitigation trajectories with respect to energy use (and renewables), but don't consider the implications of other mitigation scenarios (i.e. in buildings, transport, etc) and how this will change climate risks. As an example, while greater use of renewables may be anticipated, the risks to these energy systems (e.g. from increasing temperatures, more frequent floods, droughts, etc.) are not given high prioritisation. It is also highlighted that these studies do not have the same level of detailed modelling on population, socio-economic trajectories, and technical analysis as the LT-LEDS strategies, i.e. they tend to be less scenario focused. They are also not explicit in identifying different future mitigation scenarios and assessing what this might mean for adaptation challenges, i.e. the differences in risks for a business as usual as compared to a low emission pathway. Overall, the main focus is on looking at mitigation co-benefits, rather than integrated analysis.

Is there a strong narrative on the need to integrate adaptation and mitigation in LT-LEDS? Do strategies identify synergistic options and trade-offs for mitigation and adaptation?

Most of the short-term NAPS focus on mitigation co-benefits, rather than integrated planning. There is generally a positive storyline – especially in the integrated strategies – on the need and the benefits of delivering low carbon and climate resilience together, though in practice, these are predominantly promoted separately (with the exception of agriculture and forestry). There is also relatively little detail on the options and the policies needed to deliver integrated mitigation and adaptation and most of the focus is on climate smart agriculture, agroforestry, and forestry. As with LT-LEDS, the discussion is primarily about the positive benefits of integration, with very little or no discussion of potential trade-offs.

While there is a general narrative of the benefits of integrated analysis, the analysis of current plans shows this has not translated across into practice. LT-LEDS are not integrating adaptation, and adaptation plans are not integrating the shifts from low carbon pathways. Most of the studies reviewed identify the potential for mitigation and adaptation co-benefits, rather than being an integrated analysis. Further, most of the studies only identify generic or theoretical linkages, but do not set out concrete options or actions to achieve integration (or deliver co-benefits) and they rarely mention the very real trade-offs involved, or the barriers to uptake. Some of this is perhaps due to silo thinking, i.e. the teams developing LT-LEDS are clearly very different from the teams developing NAPs and long-term resilience plans.

Alongside these national studies, there also are a number of general initiatives which are promoting more environmentally friendly development, often termed green growth (World Bank, 2012: NCE, 2014). These point to the positive win-win outcomes for cleaner development pathways, i.e. which do have the objective of more integrated mitigation and adaptation. These green growth pathways tend to focus more on mitigation, although there are some adaptation examples. While there are undoubtedly some positive examples, these green growth opportunities may be lower in practice than anticipated (Tol, 2012). Furthermore, while green growth and mitigation may have some benefits for developing countries, some caution is needed. There is some academic literature that identifies that reducing poverty – in its own right - is an effective way to reduce vulnerability to climate change (Anthoff et al, 2012). This means there could be a potential trade-off between mitigation and poverty reduction goals: introducing ambitious mitigation in developing countries could increase energy costs and this might be detrimental for the poorest, by reducing poverty reduction and increasing their climate vulnerability.

Finally, it is highlighted that the IPCC 1.5C report (IPCC, 2018) promotes climate-resilient development pathways (CRDPs), defined as trajectories that strengthen sustainable development at multiple scales and efforts to eradicate poverty through equitable societal and systems transitions and transformations while reducing the threat of climate change through ambitious mitigation, adaptation and climate resilience. The review of LT-LEDS and NAPs/LT-CRS finds that these concepts have not yet translated into practice.

7 THE POLITICAL ECONOMY, ENTRY POINTS AND BARRIERS FOR INTEGRATION IN LT-LEDS

The analysis in the previous chapter identified the low uptake of integrated long-term strategy, and the challenges involved in synergistic policies. This chapter looks in more detail at the political economy in involved in long-term strategies and integration and the potential barriers to mitigation and adaptation in LT-LEDS and LT-CRS, and considers potential ways to overcome these. This address the earlier question of what are the entry points for linking adaptation and mitigation in long-term strategies?

7.1 Political economy and entry points

As well as the analysis of mitigation and adaptation options, the review has considered the political economy of mitigation and adaptation, and how this affects potential integration. It is noted that the sections above find that while there are potentially positive synergies between mitigation and adaptation, and high-level aspirations to deliver these, there is relatively little integration in practice. This evidenced by the review of the LT-LEDS and NAPS/LT-CRS. The reason for this is that there are important barriers to integration, which include policy, technical, market, financial and governance barriers that act to reduce the integration of mitigation and adaptation (Cimato and Mullan, 2010: Cimato et al., 2017; Watkiss et al. 2017). The report has therefore reviewed these barriers alongside the political economy analysis.

Modality, entry points and policy barriers

In the climate policy context, the UNFCCC has set out separate processes for mitigation (e.g. with NAMAs and LT-LEDS) and adaptation (NAPAs and NAPS). While there have been some moves to more integrated reporting, notably with the NDCs, mitigation and adaptation are still reported separately in these submissions. The lack of more direct integrated reporting requirement therefore acts against integrated analysis, even though UNFCCC guidance highlights the need to consider mitigation and adaptation linkages.

There are also major differences that emerge when these UNFCCC initiatives are translated through into national activities. The key differences are over the modality used and the associated entry points.

Mitigation has mostly been taken forward in stand-alone low carbon plans, both short (NAMAs) and long-term (LT-LEDS). These have been developed using sector specific emission trajectories and low carbon analysis methods. The nature of low carbon planning also generally has a long planning period, with trajectories out to 2050 (in line with LT-LEDS and long-term emission reduction goals).

In contrast, adaptation is a cross-cutting issue, and it is generally planned and implemented through a mainstreaming modality (OECD, 2015b). Mainstreaming is the integration of climate change adaptation into current policy and development, rather than implementing measures in stand-alone projects or programmes. There is a strong logic for this alternative modality: adaptation requires a broader analysis of policy objectives and wider costs and benefits, not just climate change, and mainstreaming has important advantages as it can leverage from underlying activities and development budgets. However, this means that adaptation focuses on different entry points to mitigation, i.e. the opportunity for integration, and adaptation generally seeks entry points associated with the medium term national and sector development planning process and associated plans. This involves a shorter planning horizon, typically focused on the next five years.

As mitigation and adaptation use different approaches and entry points, this acts against integrated analysis. It also makes it harder to assess co-benefits, because there are different analytical methods and time periods involved.

It is also highlighted that mitigation and adaptation often work through a different policy lens and incentives. Mitigation addresses the cause of climate change, using carbon prices, policy or other measures to incentivise the reduction or replacement of fossil fuels in existing goods and services (i.e. substitution) or to enhance energy efficiency. In contrast, adaptation is an anticipated or reactive response to the impacts of climate change. It involves additional or alternative activities to preserve the status quo or minimize losses, and it usually requires additional costs.

There are therefore important policy barriers to integration. Some of these can be overcome, but it does mean additional aspects, e.g. to extend adaptation planning out over longer time-horizons, and to develop joint scenarios.

It is noted that the need for more integrated planning is being recognised, and leading to a greater focus on integrating both mitigation and adaptation into national development planning. For the developing countries, this can also be seen as part of a wider set of development objectives associated with the sustainable development goals (SDGs). Climate change action is one of the SDGs (13) and there is another goal to (7) to ensure access to affordable, reliable, sustainable and modern energy for all. There are separate initiatives connecting climate action to the Sustainable Development Goals, such as NDC-SDG Connections that has tools[9] to analyse and compare how climate actions formulated in Nationally Determined Contributions (NDCs) corresponds to each of the 17 Sustainable Development Goals (SDGs).

For LDCs, it is identified that many countries have long-term visions, e.g. aspirational long-term economic development plans that may extend to 2050. However, strategic planning is carried out through the medium-term lens, i.e. in 5-year plans. Nonetheless, in the context of long-term strategies, one entry point is to use these core long-term economic visions and integrate mitigation and adaptation into these, rather than producing stand-alone plans. This could then cascade down into medium-term national and sector development plans using a mainstreaming approach. This would align to the IPCC focus on climate-resilient development pathways. There are some examples where this has already occurred (e.g. in Rwanda – see table 2). However, this integration is not easy for a number of reasons. These long-term visions are led by the economic, finance and planning ministries, while climate change is usually led by environmental ministries: integration into national visions is therefore difficult. For LDCs, an alternative would be to develop long-term adaptation plans, and integrate low carbon perspectives within these, but the use of stand-alone plans would be likely to create a parallel process and thus be counterproductive. It is noted that in the longer-term, there will

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[9] https://klimalog.die-gdi.de/ndc-sdg/

be more focus for LDCs to consider future energy costs and the risks of carbon intensive lock-in (as LDCs move to middle and high-income status).

Governance and organisational issues and barriers

There are also important governance and organisational issues involved in integration that can also act as barriers. Mitigation and adaptation are generally taken forward by different sectors: mitigation focuses on the major emitters (energy, transport, industry, and sometimes forestry and agriculture), while adaptation focuses on the most climate sensitive (agriculture, water, health).

They also involve different organisations and actors, with mitigation delivery primarily through the private sector (energy markets), but adaptation primarily through the public sector (health, natural resource management) or in sectors with a strong public involvement (e.g. water). These sectors and organisations have different objectives.

Mitigation and adaptation work with different numbers of actors with varying levels of capacity. Adaptation typically requires multiple actors and institutions with different objectives, jurisdictional authority and levels of power and resources. It can also involve large numbers of individual actors (e.g. a climate smart agriculture programme has to work with many thousands of individual subsistence farmers). A key finding from the literature is that adaptation is a process (Moser and Ekstrom, 2010) and there is a recognition that implementing adaptation is challenging for organisations. There is an emerging literature on science-practice orientated research for supporting adaptation decisions (Hegger et al, 2012, Beier et al, 2016), which highlights success factors for programming. A key finding is that there is a need for high organisational capacity to do proactive adaptation (Ballard et al, 2013). This organisational capacity is a particular challenge for LDCs.

Importantly, there are often different teams undertaking mitigation and adaptation planning, notably between LT-LEDS and NAPS, with different disciplinary expertise among the people who develop these respective plans. For example, energy modellers, who develop demand projections and assess technological change, often have less expertise in climate change impacts. Conversely, adaptation planners have specific expertise that aligns to different perspectives, e.g. designing actions that focus on the most vulnerable.

Market failures

There are a number of market failures that act to prevent integration or synergies (Cimato and Mullan, 2010). Market failures are imperfections in market mechanisms that prevent the achievement of economic efficiency. These can arise for a number of reasons, such as a lack of information, the presence of externalities (when a particular activity leads to impacts that are not directly priced into the costs of goods or services), the characteristics of public goods, a difference in access to information among different actors, and misaligned incentives (HMG, 2013). These failures prevent the market (businesses or individuals) from taking efficient action, and also prevent efficient market solutions. As a consequence, the value of mitigation or adaptation is not reflected in market prices, or in the returns an individual or firm receives, and the level of action will be lower than the socially optimal or socially efficient level (i.e. the level which is ideal for society as a whole).

There are already carbon markets, and carbon trading and some carbon taxes in place, though these do not yet provide the necessary incentives for ambitious mitigation. This can be addressed by using shadow prices in appraisal, but application is patchy. If carbon prices reflected the external costs of GHG emissions (for example, as estimated by the Social Cost of Carbon, the marginal cost of a tonne of additional carbon emitted, Arent et al., 2014), and were fully internalised, adaptation plans would already be prioritising lower emission options, i.e. integrating of GHG reduction adaptation plans would already be incentivised. As it stands, some short-term adaptation plans do seek to include mitigation aspects, but they usually do this as part of a multi-attribute or multi-criteria analysis.

Market failures are likely to mean insufficient investment in adaptation is likely, relative to the risks (Cimato et al., 2017). This is partly because adaptation is needed in sectors where no markets exist, such as for ecosystems, or where markets are not functioning effectively (informal agriculture), but also due to the greater role for public goods.

There is also a further set of challenges when trying to address market failures for both mitigation and adaptation at the same time in the same policy environment: this means that while it is often possible to incentivise one or the other, doing both is more challenging because it requires integrated incentives and policies.

Information and technical issues

There are also information and technical barriers to integration. GHG emission sources are well known, and reductions can be targeted deterministically, prioritising and incentivising the most cost-effective measures (IPCC, 2014). Mitigation benefits are measured using a common burden (tonnes of GHG reduced), irrespective of location and sector, and many previous studies have prioritised using a cost-effectiveness analysis ($/t$CO_2$), which provides direct comparability across interventions. There is good existing information on options and on the costs of options, including databases and unit costs.

In contrast, adaptation benefits require quantification of reductions in impacts (not burdens), which are sector-, location- and context- specific. Furthermore, adaptation seeks to reduce climate impacts on existing activities and so it must take into account multiple objectives and criteria (from these existing activities and their policy objectives) at the same time. As a result, adaptation is more challenging and cannot easily be assessed with cost-effectiveness (which prioritises to one criteria). Moreover, planned, pro-active adaptation (the focus for LTS) is time and pathway dependant, involves complex and dynamic temporal dimensions with changing risks over time, it is site and context specific, and involves high uncertainty. The latter is a particular challenge (Wilby and Dessai, 2010). It involves scenario uncertainty (i.e. are we on a 2 or 4°C path?) and climate model uncertainty. This means that cost-benefit analysis is difficult to apply for adaptation, because of the complexity of analysis, as well as valuation challenges (non-market sectors and ideally there is a need for an extended multi-metric appraisal, that includes risk and uncertainty): its appraisal requires extended cost-benefit analysis (Chambwera et al., 2014) and a focus on decision making under uncertainty (Watkiss et al, 2014). The latter provide decision support to help identify options that are justified in economic terms, using principles such as robustness, diversity, flexibility, learning, and choice editing: but they are time and resource intensive to apply. The evidence base on options, costs and benefits for adaptation is therefore lower than for mitigation. A recent global review (ECONADAPT, 2017) found only 700 studies in total (academic and grey literature) on the costs and benefits of adaptation.

This makes integration of mitigation and adaptation difficult: for example, iterative adaptation does not fit to a LT-LEDS marginal abatement cost analysis. Synergistic options are often more complicated to design. For example, it is relatively easy to design a building to reduce energy use for heating (cold), but more difficult to extend design to reduce over-heating, factoring changing levels of each over a building's lifetime.

Finance and economics

Last, but not least, there are financial and economic barriers. The benefits of synergistic policy and integration are commonly ancillary (co-benefits) or non-market in nature. They also involve opportunity and transaction costs that make implementation costs higher. This means that integration may make sense from an economic perspective (in societal terms), but not from a financial one (for private investors) (UNEP, 2016). This limits their uptake by the private sector. This is compounded by the economics of long-term adaptation. The present value of future adaptation benefits is low due to discounting, which makes it more difficult to justify short-term integration investment. Importantly, integrated options (i.e. mitigation options that also have adaptation benefits) often have lower cost-effectiveness (compared to options that prioritise mitigation alone), as recognised in the IPCC 1.5°C report (2018). This is a particular issue for their private sector uptake. As a result, such options will require policy and governance policy support, and also potentially some level of financial support, to incentivise uptake (UNEP, 2018).

These differences are seen in recent climate finance flows. There has been a major uplift in climate finance flows for mitigation in recent years. Data from the Climate Policy Initiative (CPI, 2017) suggests that in 2017, global mitigation finance flows amounted to $400 billion/year, with most of this from the private sector. This is good news for LT-LEDS development.

In contrast, global adaptation finance flows were tracked at $25 billion/year, all from the public sector (although data on private adaptation finance flows is poor): this lower level of finance will act as a barrier to adaptation integration in LT-LEDS, as well as long-term adaptation planning in LDCS more generally. The one positive is that adaptation is usually financed and undertaken by different organisations and different budget lines than mitigation (i.e. in practice, this is not a zero-sum game, with the possible exception of countries that rely heavily on international development climate finance for mitigation and adaptation). The two will rarely compete for resources with each other, and there is more chance that adaptation competes against other public policies (education, health). The awareness of the need for adaptation finance may also increase, as the Task Force on Climate-related

Financial Disclosure (TCFD), established by the G20's Financial Stability Board, is increasing the understanding that climate risks are financial risks. It is also clear that adaptation finance flows will increase. For example, the World Bank and Asian Development Bank have made very large climate finance commitments. The World Bank Group has launched an action plan on climate change adaptation and resilience, under which it will increase direct adaptation climate finance to USD 50 billion over 2021-2025. The Asian Development Bank, as part of its new 'Strategy 2030', has pledged to provide $80 billion (cumulatively) in climate mitigation and adaptation financing by 2030. Such initiatives may change the awareness of these issues, and help to drive forward integration activities.

7.2 Mapping barriers and possible solutions

The research review has mapped the individual barriers to each of the major opportunities for mitigation and adaptation integration. Importantly, this finds that they differ. For some linkages, integration is made harder by policy and governance barriers. In others, it is due to information challenges, or a combination, etc. This has one key implication: it means there is no single solution that will unlock integration or enhance the uptake of synergistic win-win options, it will require a portfolio.

Table 4 Examples of Barriers to Mitigation and Adaptation

LT-LEDS option	Adaptation Linkage (synergy / trade-offs)	Barriers to Synergies	Possible Solutions
Hydro-power	Impacts of climate change on generation and safety Synergy or trade-off with water management, cross-sectoral demand (e.g. demand for water from agriculture sector)	Information, policy and regulatory barriers Misaligned incentives (constructors vs operators)	Climate risk screening, safeguards, design standards Coherence between energy, agriculture and water policies
Other renewables (e.g. solar, wind)	Impacts of climate change on operations (damage and disruption) Possibly trade-off with impact on energy prices (LDC)	Information, policy and regulatory barriers	Climate risk screening, safeguards, design standards Distributional issues considered in energy policy
Decentralised grids, energy storage	Possible synergy: Increased security of supply – but only if considered in design and siting (risks of weather-related disruption)	Information and regulatory barrier	Climate risk screening and integration of climate considerations into design and siting decisions
Buildings - insulation to reduce energy demand for heating / non-mechanical cooling	Possible synergies or trade-off: some cases reduce energy and heat, other cases can increase summer heat, unless designed to address risks	Information and regulatory barriers Financial barriers (construction cost versus owner)	Information Climate-smart design Building standards / codes Incentives for developers (market or other)
Urban density	Trade-off: low carbon through densification versus heat island Trade-off: Reduce potential for the promotion of urban densification	Information, regulatory barriers Financial - high opportunity costs of land	Analysis of benefits of urban green spaces Urban regulations and planning Options analysis to inform economic and financial analysis
Climate smart agriculture, e.g. example of agroforestry	Synergy of mitigation (carbon sequestration) and adaptation (soil stability, flood risk protection) Note some possible trade-off in dry environments (competition)	Information Transaction and opportunity costs Access to finance /up front finance)	Awareness raising and information Financial incentives to lower transaction costs, patient capital

Irrigation / Efficient irrigation systems and water conservation	Trade-off: increased irrigation to overcome changes in rainfall patterns (adaptation) increasing emissions. Also competition with other water users (e.g. hydropower) Synergy: more efficient irrigation solution, decarbonised or climate-smart water management	Information and inertia (farmers) Financial barriers	Awareness raising Market signals (water use) Coherence between energy, agriculture and water policies
Forest protection, rehabilitation and afforestation Similar issues for other carbon sinks	Synergies from ecosystem services (general enhanced resilience) but possible trade-off if afforestation/reforestation goals do not take account of climate change. Also possible trade-off from land-use (agriculture).	Policy and governance barriers (protection) Financial barriers and market failures (low financial return, non-market benefits, public good benefits)	Regulation (conservation) Payment for ecosystem (PES) schemes Coherence between agriculture, energy, and biodiversity policies
Ecosystem based adaptation	Synergies: alternatives to hard options for resilience, (e.g. coastal protection with mangroves), that act as carbon sinks. Potential trade-offs between resilience function and carbon sequestration potential.	Information barrier Policy barrier Market failure (non-market benefits, public good benefits) Opportunity cost of land	Payment for ecosystem (PES) schemes Coherence between agriculture and biodiversity policies Analysis of co-benefits in economic and policy appraisal / incentives
Bioenergy, biofuels.	Synergies if well managed; but potential trade-offs with land availability, agriculture, food security, as well as water availability (potentially affecting resilience).	Information barrier Policy barriers Financial barriers	Analysis (of consequences) including distributional effects Coherence between energy and land-use and agricultural policies
Bioenergy combined with carbon capture, utilization and storage (BECCS)	Potential synergy if combining with soil carbon management, agroforestry and afforestation; but potential conflict with respect to impacts on water, food and biodiversity	Information barrier Policy barriers	R&D Coherence between energy and land-use and agricultural policies

In summary, the barriers, and the potential solutions to address them are:

- Mitigation and adaptation involve different entry points and programming modalities. Mitigation is considered through stand-alone (long-term) plans, while adaptation is increasingly programmed by mainstreaming into existing policies and plans (short-term). These policy barriers currently act to make integration more challenging, but they can be overcome, noting this may involve different approach for developed versus LDC countries, reflecting the most promising modalities and entry points.
- Mitigation and adaptation are taken forward by different sectors: mitigation focuses on the major emitters, while adaptation focuses on the most climate sensitive. They also involve different actors, with mitigation delivery often through the private sector, but adaptation through the public. The development of long-term plans are usually undertaken by different teams, with different disciplinary expertise (i.e. different people develop mitigation versus adaptation plans). These organisational and institutional barriers can be overcome with a greater focus on inter-disciplinary strategy development and by ensuring greater equivalence of mitigation and adaptation in objectives, and in scenario development.
- There are often a number of market failures that act to prevent integration or synergies. There are policies that can help address these. For example, carbon prices would mean adaptation plans

would prioritise lower emission options as standard, while increased information on the financial risks of climate change would create incentives to consider adaptation options more directly in low carbon planning. Positively, there are initiatives that are developing these.

- There are information and technical issues associated with integration. GHG emission sources are well known, and reductions can be targeted deterministically, prioritising and incentivising the most cost-effective measures. In contrast, planned, pro-active adaptation is time and pathway dependant, site and context specific, and involves high uncertainty and multiple criteria. Its appraisal requires extended cost-benefit analysis and decision making under uncertainty. There is a need to develop more integrated analysis frameworks and tools to help integrated analysis.
- Last, but not least, there are financial and economic barriers to integration. The benefits of synergistic policy and integration are often ancillary (co-benefits) or non-market in nature. As a result, integration may make sense from an economic perspective (in societal terms), but not from a financial one (for private investors). It is noted that there has been a major uplift in climate finance flows for mitigation, but to date, adaptation finance flows lag behind, and are primarily from the public sector. However, this is changing and recent announcements indicate much higher flows of finance for adaptation, which if combined with development assistance, could deliver at scale.

Positively, many of these barriers are already starting to be addressed. For example, a common theme is the need to consider climate risk screening in the design of mitigation infrastructure. This is something that is already being advanced by the Multi-lateral development Banks (MDBs) (MDB, 2017), who are undertaking climate risk assessments and financing additional resilience (adaptation) for their routine investments, including their mitigation projects, thereby addressing information and financial barriers (e.g. ADB, 2014: 2015). There has also been some work enhancing awareness and highlighting the importance of integrating weather and climate-related risk into the planning stages of energy infrastructure development, as part of NDC development (IISD, 2018).

Similarly, new initiatives such as the Task Force on Climate-related Financial Disclosures are raising awareness of climate risks within the financial markets. As highlighted earlier, the levels of climate finance from the MDBs is increasing significantly, helping to address some of the financial and economic barriers, and many of the aspects in table above are areas that development cooperation is starting to consider.

A positive finding is that there are solutions to all of the barriers. The review identifies that there is a key role for the public sector to create the enabling environment to address these barriers and enhance integration. This includes a major role for international development cooperation to support these solutions, and help in best practice and dissemination.

8 DISCUSSION AND FUTURE PRIORITIES

8.1 Study Findings

The research undertaken in this report has reviewed the evidence on linking climate resilience into long-term low emission development strategies (LT-LEDS). It has shown that the current implementation evidence base is low. The study attributes this to a number of barriers, but also highlights how these can be overcome. This final section summarises the review findings by addressing three key questions and identifies future priorities.

What is the evidence base for integrated mitigation and adaptation planning in long-term strategies?

The research finds that there are opportunities for synergistic (win-win) integrated mitigation and adaptation in long-term strategies, but there are also potential trade-offs. The latter involve mitigation options making adaptation more challenging, and vice versa. The research has reviewed the potential linkages by sector, finding a large number of linkages. However, a relatively small number of these are likely to be important, in terms of national low carbon pathways / national climate resilience, and these major areas are considered the priority areas for integration.

While there is a general narrative of the benefits of integrated analysis, the analysis of current plans including submitted LT-LED shows this has not translated across into practice. LT-LEDS are not integrating adaptation, and adaptation plans are not integrating the shifts associated with low carbon pathways. Most of the strategies reviewed identify the potential for mitigation and adaptation co-benefits, rather than undertaking an integrated analysis. Further, most of the studies identify generic or theoretical linkages, but do not set out concrete options or actions to achieve integration (or deliver co-benefits) and they rarely mention the trade-offs involved. There is also little discussion of the barriers to uptake.

This implies that integrating climate resilience into LT-LEDS - and low carbon measures in adaptation long-term strategies – is challenging to deliver in practice. These challenges are caused by a number of barriers, that act to prevent or reduce synergistic or even integrated implementation, such as information, technical, governance, policy and financial barriers. Enhancing the integration of adaptation in LT-LEDS, and low carbon integration in LT-CRS, will therefore require a measures and actions to address these barriers, but the evidence shows this will require a portfolio of responses, addressing the individual barriers in each particular sector and area. There means there is an important role for development cooperation in identifying and helping to overcome these barriers.

What are the entry points for combining or linking adaptation and mitigation in long-term strategies?

The research has reviewed the political economy and entry points for mitigation and adaptation. This finds that mitigation and adaptation are currently implemented through different national planning processes. Mitigation has mostly been taken forward in stand-alone low carbon plans, both short and long-term (LT-LEDS). These have been developed using sector specific emission trajectories and low carbon analysis methods. In contrast, adaptation is generally planned through a mainstreaming modality, which seeks to integrate into current policy and development, rather than implementing measures in stand-alone projects or programmes. This also leads to a shorter-term focus on medium term development planning (the next five years). There is therefore a need to consider how better to undertake joint (consideration) of mitigation and adaptation in LTS.

The analysis also finds that long-terms strategies involve different incentives and issues by country grouping. The largest impacts of climate change before 2040 – in relative terms – will occur in the least developed countries (LDCs). These impacts can only be avoided by adaptation. However, economic development (and poverty reduction) can also reduce climate vulnerability in these countries, thus there are potential synergies between economic growth and adaptation). This indicates that the primary narrative for LDCs is likely to be towards integrating cost-effective mitigation and climate resilience in long-term development plans. In contrast, developed countries (including middle income countries) must reduce emissions if the Paris goal is to be achieved, and these countries also have better capacity and finance to adapt. This suggests that the primary narrative for these countries will be to develop separate LT-LEDS and mainstream adaptation to build climate resilience. This therefore leads to different entry points. These likely differences are reflected in the text of the Paris Agreement, which sets out the goal to communicate LT-LEDS taking into account common but differentiated responsibilities and respective capabilities.

For LDCs, it is identified that many countries have long-term visions, e.g. aspirational long-term economic development plans that may extend to 2050. However, strategic planning is carried out through the medium-term lens, i.e. in 5-year plans. A possible entry point is to use these core long-term visions and integrate mitigation and adaptation into these, rather than producing stand-alone plans. This could then cascade down into medium-term national and sector development plans using a mainstreaming approach. This would align to the IPCC focus on climate-resilient development pathways, and sustainable development. There are some examples where this has already occurred (e.g. in Rwanda). However, this can be challenging as long-term visions are led by the economic, finance and planning ministries, while climate change is usually led by environmental ministries. For LDCs, an alternative would be to develop long-term adaptation plans, and integrate low carbon perspectives within these, but the use of stand-alone plans would be likely to create a parallel process and thus be counterproductive.

For developed countries, the entry points and implementation pathways are likely to be different. For these countries, there is a need to enhance the mainstreaming of adaptation in LT-LEDS, i.e. the key entry point is likely to be through LT-LEDS themselves. However, this will require a change in current governance arrangements, as nearly all countries currently develop adaptation policy through separate strategies. There might also be additional entry points in the development of sector LT-LEDS and integration into sector strategies and plans, to ensure sector specific barriers are targeted.

How can climate resilient LT-LEDS and integrated LC-CR be realised and achieve transformation in the context of sustainable development?

Recent climate reports, such as the IPCC 1.5°C report (2018) have recommended a shift from current governance arrangements towards multi-level governance, collaborative multi-stakeholder partnerships, coordinated sectoral and cross-sectoral policy, strengthened global-to-local financial architecture and more. This will be needed to deliver transformational change, but it is highly aspirational, and it would involve a major paradigm shift from the current status quo. There are major barriers to such a change at the current time due to political dynamics, scepticism on climate change and the lowering of international co-operation.

At a more pragmatic level, however, there are success factors that could enhance integration of adaptation and mitigation in long-term strategies (OECD, 2015; Watkiss and Cimato, 2017). These include the presence of a high-level champion, the involvement of strong Ministries, and the availability of climate finance, accompanied by technical assistance, information and capacity building support. Other studies (WRI, 2018) identify success factors around policy frameworks (and commitments) that help push forward the process of mainstreaming, the presence of co-ordination mechanisms across government that support mainstreaming goals, and information and tools (WRI, 2018). These will need to be complemented with more targeted barrier analysis for each integration opportunity. These aspects can be advanced with development cooperation and there are already successful case studies that demonstrate this through capacity strengthening. The priority is to learn what works and scale up. A key finding is there is an important role for the public sector (including development cooperation partners) to create the enabling environment for this integration. Most of the barriers to integration can be overcome, and there are already positive examples where such change is happening.

8.2 Research and Policy Priorities

Finally, the study has identified a number of priorities for further investigation.

A key finding of the review is that most LT-LEDS do not consider the impacts of climate change – and the need for adaptation integration – in their scenario development and projections, e.g. how higher temperatures will alter energy demand, or productivity changes in agriculture. Similar issues arise for long-term adaptation plans, which omit the influence of low carbon transition on climate risks i.e. adaptation plans consider future climate risks to the current structure of the economy and society, not a low carbon future. Building in this type of analysis is complex and involves uncertainty – but it does signpost the need for integration.

Therefore, the most important recommendation is to undertake a study to answer the question of how much might climate change influence an LT-LEDS, in quantitative terms, with an analysis of the changes in scenarios and emission (e.g. cooling demand), as well as an analysis of possible adaptation integration options. This should also identify the potential barriers to integration options and how these can be overcome. This would be very valuable if undertaken in different countries (i.e. LDC vs MIC and in different regions with different climate risks). A similar analysis could be undertaken to examine mitigation co-benefits for long-term adaptation strategies (and answer the question of how important are mitigation linkages for adaptation strategies). The results of these assessments will help to highlight the importance of these synergies (and whether integrated mitigation and adaptation long-term strategies would be beneficial), to identify priorities areas, and will provide valuable lessons for the developing tools and wider development cooperation support to enhance mitigation and adaptation integration.

A further finding from the research is that barriers are critical when implementing synergistic options and general mitigation and adaptation integration. A further recommendation is therefore to advance further work to document the main barriers, and to identify possible solutions to address these. A useful starting point would be to expand the mapping of barriers for key LT-LEDS and LT-CRS options, and look for good practice case studies to identify insights and learning on how barriers can be overcome. It would also be useful to take this analysis forward with more specific case studies, with country analysis and studies to demonstrate these. This would help to identify where to focus development cooperation support, so as to most effectively create the enabling environment for integrated long-term strategies.

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ENDNOTES

[i] It is stressed that the exact economic costs, and the modelled level of mitigation and adaptation, is affected by the assumed discount rate and equity weights (applied at the global level). Note that a recent sub set of econometric studies project much higher economic costs from climate change, partly because they conclude that climate change will reduce growth rates (rather than just output) (Burke et al., 2015: Burke et al. 2018). The larger economic costs from climate change would have important implications for the level of mitigation and adaptation needed., i.e. they would justify more policy action.

[ii] It is highlighted that the use of discount rates in climate change economics has been highly contentious. This has centered on discussion on whether it is appropriate to apply typical social discount rates for climate change, because of inter-generational welfare This argument dates back to the use of lower discount rates in the Stern review (2006) (noting the Stern review used a lower value for the pure rate of time preference but it still discounted for growth) and remains a source of contention.

[iii] A search of the document identifies the following:
- Energy efficiency in the buildings sector has numerous co-benefits such as infrastructure resilience and lower operating and maintenance costs, as well as positive effects on national income and employment.
- In addition to their substantial long-term mitigation potential, changes in forest management practices could create co-benefits, including increased employment in the forest sector, reductions in black carbon emissions (where there is a reduction in slash burning), and increased adaptation efforts to improve the resilience of forests.
- To engage the interest of a sufficient number of landowners, as well as concerns about the resilience of some tree species to changes in climate and natural disturbances.
- Investing in public transit, green infrastructure, social infrastructure, Canada's trade and transportation corridors, as well as rural and northern communities, will provide a strong foundation for more inclusive and sustainable cities, and can also help to both address greenhouse gas emissions and enhance resilience to the impacts of climate change.
- Investments in green infrastructure and other streams, such as social and transportation, will reduce GHG emissions and support the resilience of infrastructure assets.
- Investments in sustainable infrastructure will enable greater climate change adaptation and resilience
Advancing cross-cultural learning on climate change mitigation and adaptation is one step in the journey towards reconciliation in Canada.
- Sustainable forest management already balances multiple objectives but now must also increasingly tackle the twin challenges of mitigation and adaptation.
- Significant investments, most notably in adaptation measures, need to be made in order to deal with the costs of climate change, some of which may materialise over a long-term horizon.

[iv] A search of the document found the following:
The Czech Republic's approach to climate change can be divided into a policy aimed at reducing emissions of greenhouse gases and into a policy of adaptation and strengthening resilience to the adverse impacts of climate change. This area is addressed in the following strategic documents: Strategy on Adaptation to Climate Change in the Czech Republic, the National Action Plan for Adaptation to Climate Change and the Drought Protection Concept.

[v] A search of the document finds the following:
- For agriculture, it highlights 'techniques for adapting to climate change, which enable production systems to be maintained or improved.
- This transition must also take into account the crucial challenge of adapting to climate change (crop varieties, water management, environmental risks etc.).
- Agro-ecological systems offer various shared benefits: protecting water quality, preserving biodiversity, improving soil quality etc. These factors help to increase the resilience of agricultural systems to climate change, which is another important factor in protecting farms, employment and output.
- As well as:
adapting existing (energy) networks to new operating conditions (adapting to climate change) a
urban densification is not desirable in all areas, nor in the same manner (references heat pockets)
close synergy between adaptation and mitigation, particularly for our forests
improving forestry quality and promoting timber-quality wood, introducing more productive
forestry species and/or species better adapted to climate change and the local conditions.

[vi] There is a cross reference. National Climate Change Adaptation Plan (PNACC): although focused on adaptation, this plan includes measures with direct consequences for climate change mitigation, including measures in line with Action 3: "Promoting the adaptive capacities of forestry resources and preparing the wood industry for climate change" (measures 3.1, 3.2 & 3.3).

[vii] A search of the document identifies the following:
- Even a full and ambitious implementation of the Paris Agreement will not prevent the level of climate change which is already inevitable. It is therefore essential to make use of synergies with the existing German Strategy for Adaptation to Climate Change wherever possible. That also applies to other areas of action of a transformative environmental policy such as conservation of natural resources and increased replacement of fossil resources with sustainably produced biogenic ones.
- Businesses' investment cycles should in future take the medium and long-term climate targets into account in order to avoid stranded investments or high adaptation costs.
- Immense investments in energy, transport and housing infrastructure; education and health; and urban development and public services in rural areas are needed to help advance the economy and society. It is important to keep the UN Sustainable Development Goal of building resilient infrastructure, promoting inclusive and sustainable industrialisation and fostering innovation (SDG 9) in mind in that regard.

- Specific opportunities to participate with low barriers to entry will be key for making the public more aware of their own responsibility for climate action and increasing their resilience to negative changes.
- The primary task of agriculture is to produce food on a sustainable basis. In addition to adapting agriculture to climate change, it is also the goal of the German government to take full advantage of its potential to contribute to climate change mitigation.
- The government funds research and development projects that will tap further potential for adapting to climate change and reducing greenhouse gas emissions in agriculture.
- Improvement of Agricultural Structures and Coastal Protection are intended to support farmers in implementing their adaptation strategies.
- The guiding principle for 2050 is closely aligned with the findings of the Intergovernmental Panel on Climate Change (IPCC), according to which forest conservation and sustainable forest management are an appropriate and cost-effective way to reduce greenhouse gas emissions. This simultaneously has positive ancillary effects on adaptation to climate change and sustainable development. At the same time, climate action measures must take into account the importance of forests as habitats for flora and fauna, places for water storage, economic factors, suppliers of raw materials and spaces where people can engage in recreational activities or simply enjoy the peace and quiet they offer.
- Adapting forests to climate change is particularly important for safeguarding and expanding the contribution of forestry to climate change mitigation. Sustainably managed, productive forests that are appropriate for their location, vital, near-natural and adapted to climate change – and primarily made up of native tree species, a target specified in the Forestry Strategy 2020 – will be able to safeguard all functions of forests, including climate change mitigation.
- The measures are aimed at forest adaptation based on growing a climate-tolerant and climate adapted mix of tree species.
- The German government's Forest Climate Fund is funding measures to maintain and expand the potential of forests and wood to reduce CO2 and to help German forests adapt to climate change.

[viii] A search of the document identifies the following:
- Without investments in resilience, costs will increase as climate change increasingly impacts the power sector. Higher temperatures can reduce the efficiency of thermal electricity production, reduce transmission capacity, and increase demand for electricity to cool buildings (DOE 2013, DOE 2016d, EPA 2015).
- Renewed investment in ambitious food crop yield improvement programs within the federal government, universities, and the private sector, particularly in order to increase the climate resiliency of key commodity crops;
- Deep decarbonization strategies in the land sector must be adaptive to future climate impacts. While increasing temperatures and CO2 levels might expand the growing season and increase plant productivity, changes in precipitation, extreme events, plant pests and diseases, and sea level rise could severely impact U.S. landscapes (Gill et al. 2013, EPA 2016a). When undertaking land sector mitigation efforts, stakeholders must consider the range of climate risks that could arise in the coming decades and plan accordingly.
Priorities include developing resilient crop breeds, wisely choosing tree species for forest expansion efforts, and promoting genetic diversity in forests and other landscapes that allow plants to adapt to changing environments. Water in particular could become a growing challenge, especially in drier areas of the western United States.
- Land carbon mitigation can also help to increase resiliency in the face of increasing climate impacts. Maintaining larger, more contiguous natural areas can support genetic resilience in the face of climate change while also preserving high carbon landscapes (Gill et al. 2013). Urban forests can help to reduce flooding by increasing uptake of water into soil and preventing runoff (Oberndorfer et al. 2007). Farmers and ranchers taking up agroforestry or perennial crops to increase carbon storage can also increase water retention in drought prone areas (FAO 2013). Taking advantage of mitigation opportunities that boost climate resilience will be key to delivering robust carbon sequestration in 2050 and beyond.
- Agroforestry also has benefits for climate change adaptation. The co-benefits of incorporating trees in agricultural systems—namely, increased water infiltration and water and nutrient retention—include greater resilience to droughts or floods. Trees also create microclimates that can keep soils cooler and create more favorable conditions for crops and livestock (Schoeneberger et al. 2012).
- To meet MCS goals, we will need to address these budget challenges to ensure federal agencies have the resources to fight wildfires and other natural disturbances as well as to implement restoration work that will increase forest resilience and carbon sequestration capacity.
- Programs should look to maximize natural ecosystem resilience to climate change, implement strong adaptation measures allowing for wetland restoration and migration, and limit future development in areas at risk, currently or in the future from coastal flooding.
Future federal research should focus on (1) providing regional- and local-scale GHG emissions estimates for coastal wetlands to help coastal managers better manage the carbon stocks, and (2) innovative, low-cost approaches to measuring and modeling GHG fluxes for linking climate mitigation and adaptation through wetland conservation and restoration. Better quantification of U.S. seagrass beds is another research priority, as these habitats are thought to provide substantial carbon sequestration benefits (Fourqurean et al. 2012).

[ix] A search of the document identifies:
- Promotion of replacement of energy intense products made of metal, concrete, plastic etc. with products made of wood grown under sustainable forestry', there are synergies between mitigation and adaptation.
- Implement and support best practices of farming and forest management, which take due
account of climate change and aim to prevent carbon take out from soils in agrocoenosis, increase the level of forest productivity and resilience, to preserve and accumulate carbon in forest phytomass and soil.
- Due account of regional (local) specific features of forests in the process of climate prevention measures implementation and adaptation thereto.
- Synergy in climate change prevention and adaptation thereto.
- Extension of awareness raising program on climate change outcomes, climate change prevention and adaptation thereto. To carry out awareness raising campaign to promote broad understanding by Ukrainian citizens of climate change problem, climate change prevention actions and adaptation thereto (including such co benefits as clean air and citizens health).
- In the long-term perspective, adaptation to climate change in Ukraine shall be treated with the same degree of priority as climate change prevention, and will include such aspects of policy planning and improvement as expansion of knowledge base, scientifically justified identification of needs and expenses, implementation of innovation approaches and establishment of conditions favourable for attraction of external investments.

[x] A search of the document finds the following:
- The Government will introduce a new agri-environment system to support the future of farming and the countryside, with a strong focus on delivering better environmental outcomes, including mitigation of and adaptation to climate change.

- Increasing resilience to rising temperatures is also a potentially significant climate change challenge and we are undertaking research into whether further measures on overheating are necessary for new homes.
- We will need new skills in forest design, a reliable supply of resilient planting stock, new opportunities for domestic timber, and a new generation of skilled people helping to enhance our towns, cities and countryside.
- We will explore the mitigation potential of new breeding technologies and any barriers to their deployment to improve agricultural and forestry productivity and resilience.

[xi] A search of the document finds the following:
- Better farming systems including agroforestry techniques that efficiently use nutrient resources exist, enhancing not only soil carbon but also biodiversity and improving resilience of farming to climate change itself.
- Carbon sinks are as important as reducing emissions. Maintaining and further increasing the natural sink of forests, soils, and agricultural lands and coastal wetlands is crucial for the success of the Strategy, as it allows the offsetting of residual emissions from sectors where decarbonisation is the most challenging, including agriculture itself. In this context nature based solutions and ecosystem-based approaches often provide multiple benefits regarding water management, biodiversity and enhanced climate resilience.
- There is also a note (in the city context) that planning and building public infrastructure to withstand more extreme weather events will be an imperative no regret option.
- The key strategies that mention adaptation or resilience are:
Promote a sustainable bio-economy, diversify agriculture, animal farming, aquaculture and forestry production, further increasing productivity while also adapting to climate change itself, preserve and restore ecosystems, and ensure sustainable use and management of natural land and aquatic and marine resources; Strengthen infrastructure and make it climate proof. Adapt through smart digital and cyber-secure solutions to the future needs of electricity, gas, heating and other grids allowing for sectoral integration starting at local level and with the main industrial/energy clusters. Continue the EU's international efforts to bring all other major and emerging economies on board and continue creating a positive momentum to enhance global climate ambition; share knowledge and experience in developing long-term strategies and implementing efficient policies so that collectively the objectives of the Paris Agreement are accomplished. Anticipate and prepare for geopolitical shifts, including migratory pressure, and strengthen bilateral and multilateral partnerships, for instance by providing support to third countries in defining low-carbon resilient development through climate mainstreaming and investments.