Early VfM AdaptationToolkit:

Delivering Value-for-Money Adaptation with Iterative Frameworks & Low-Regret Options

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Introduction to VfM Information and the Toolkit

Background

As adaptation moves from theory to practice, there is a need to select, prioritise and implement adaptation interventions. At the same time, as DfID starts to finance large adaptation programmes, there is a need to ensure Value-for-Money (VfM). However, the identification and appraisal of options, and the identification of VfM adaptation, are challenging.

To provide support for these challenges, DFID has produced information notes on early adaptation and value for money, including:

- A Report on Early VfM Adaptation.
- An Early VfM Adaptation Toolkit.

Both the report and toolkit are built around the use of iterative climate risk management frameworks, as recommended in the recent IPCC 5th Assessment Report (IPCC, 2014).

These frameworks can help in sequencing adaptation activities over time and for identifying early actions that are likely to offer good returns on investment, i.e. that deliver VfM.

They include an early focus on low- and no-regret adaptation, priority areas for mainstreaming resilience and early actions that start preparing for long-term challenges.

The Report and the accompanying Toolkit will be useful for any programme that aims to build resilience, i.e. for (i) advisers designing projects as part of a portfolio e.g. in DFID country office (direct adaptation programmes or mainstreaming of adaptation into other non-climate country programmes or sector support) and (ii) for DFID support (finance, technical assistance) of country national/sector plans (e.g. National Adaptation Plans, sector adaptation plans or projects, Climate Funds) or local adaptation.

The early VFM Adaptation Report:

The aim of the Early VfM Adaptation Report is to set out the latest thinking on how to maximise value for money from adaptation programming.

The report:

- Sets out the latest thinking on iterative adaptation and how to use this to maximise value for money.
- Outlines how to use these iterative frameworks for the early identification and framing of adaptation.
- Provides examples of early adaptation interventions that are likely to be priorities.

The Early VfM Adaptation Toolkit:

The aim of the toolkit is to help DFID advisers to design adaptation projects or portfolios that maximise VFM.

The Toolkit is a word based document, structured around the six steps in the adaptation policy cycle. For each step it provides relevant context and support, potentially useful sources of information, case study application and examples. It therefore provides potentially useful information for concept notes and business cases.

Outline of the Toolkit

The Early VfM Adaptation Toolkit is structured as follows:

- Introduction and outline of the adaptation policy cycle. This provides the background and context for the Toolkit, including an outline of the iterative adaptation framework.
- **Step 1. Identify risk, vulnerability and impacts**. This provides a general introduction to the identification of risks, focusing on the information needs for using an iterative framework. It provides information sources and case study applications.
- **Step 2. The theory of change** (part, 1 without programme scenario). This step sets out the context around the theory of change for climate change adaptation and identifies the current problem that DFID is seeking to influence, highlighting the challenges around adaptation in the context of long-term and uncertain future benefits. It then outlines how an iterative framework and portfolios for adaptation can address these problems and help maximise value for money.
- **Step 3. Identify possible adaptation options and sequence these over time**. This section provides information to help identify and sequence early VfM adaptation. It outlines the types of interventions that can be included within an iterative framework and why each of these is likely to deliver value-for-money. It then provides a description of these interventions, and outlines their potential benefits, and when they are likely to deliver value for money adaptation.
- **Step 4. Early prioritisation of options**. This section provides information for short-listing (initial prioritisation) of promising VfM adaptation options. It provides results from a review which highlights low-regret options and provides case study examples.
- **Step 5. Theory of change part 2, with programme scenarios**. This step looks at how to develop a theory of change for the adaptation programme intervention, including how to develop the logical framework and design the monitoring and evaluation framework.
- **Step 6. Appraisal of adaptation options**. This section provides relevant information on the economic appraisal of adaptation options, including cost-benefit ratios and value for money analysis, for potential use in business cases, as well as worked examples and further information sources.

ADAPTATION CYCLE

Outline of the Adaptation Policy Cycle

Key Messages in this Section

- This section introduces the adaptation policy cycle - the basis for the toolkit.
- It presents a DFID-specific version, aligning to the business case process.
- It outlines how this cycle can be aligned to iterative adaptation frameworks.

The Adaptation Policy Cycle

Earlier studies of climate change focused on assessing vulnerability or future impacts, using vulnerability or impact assessment. In turn the results of these studies were used to identify broad lists of possible adaptation options.

In recent years, however, there has been a shift towards adaptation assessment. While these studies still use information from vulnerability or impact assessments, adaptation plays a much more central role in the objectives and analysis. Indeed, these studies are focused around the identification and implementation of real adaptation, within the context of policy and development, and have a short-term and immediate time focus.

A broad set of steps in undertaking an adaptation assessment have been identified, and are summarised in guidance from the PROVIA initiative (see box). These outline five types of broad steps.

i) Identifying vulnerability and impacts;

ii) Identifying adaptation measures;

iii) Appraising adaptation options;

iv) Planning and implementing adaptation; and

v) Monitoring and evaluation.

Box 1. Initiatives on Adaptation

Programme of Research on Climate Change Vulnerability, Impacts and Adaptation (PROVIA) is a global initiative which aims to provide direction and coherence at the international level for research on vulnerability, impacts and adaptation (VIA).

http://www.unep.org/provia/

Provia was supported by the Mediation Project (Methodology for Effective Decision-making on Impacts and AdaptaTION). This project provided scientific and technical information about climate change impacts, vulnerability and adaptation options, including the adaptation learning cycle, methods, decision support and information.

http://mediation-project.eu/

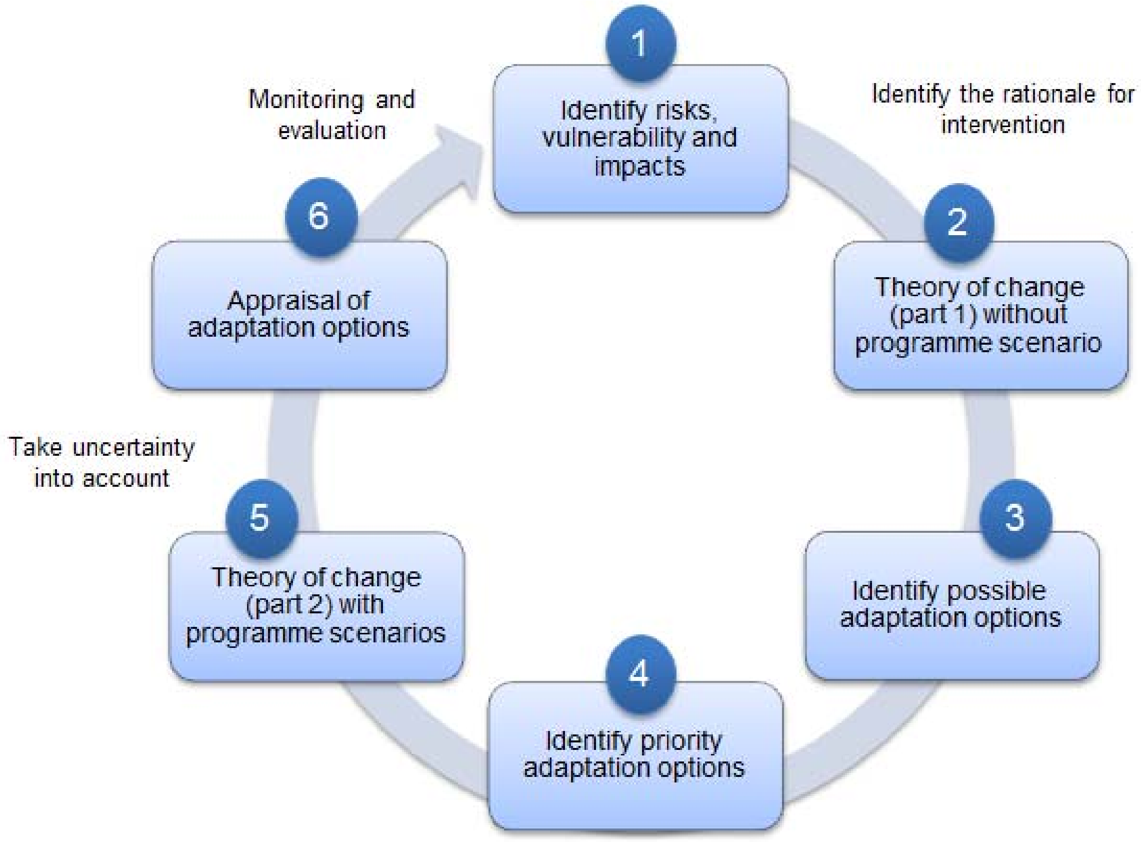
DFID Specific Context

The adaptation cycle above has been adapted to align to the DFID context. This has led to a cycle of six stages of Business Case Development, as set out in the diagram below, with an additional phase of monitoring and evaluation.

Steps 1 to 5 are aimed at advisers who are developing a Strategic Case.

Step 6 is aimed primarily at DFID economists for use during the economic appraisal of programme options.

Figure 1. DFID Cycle for designing programme options and carrying out options appraisal



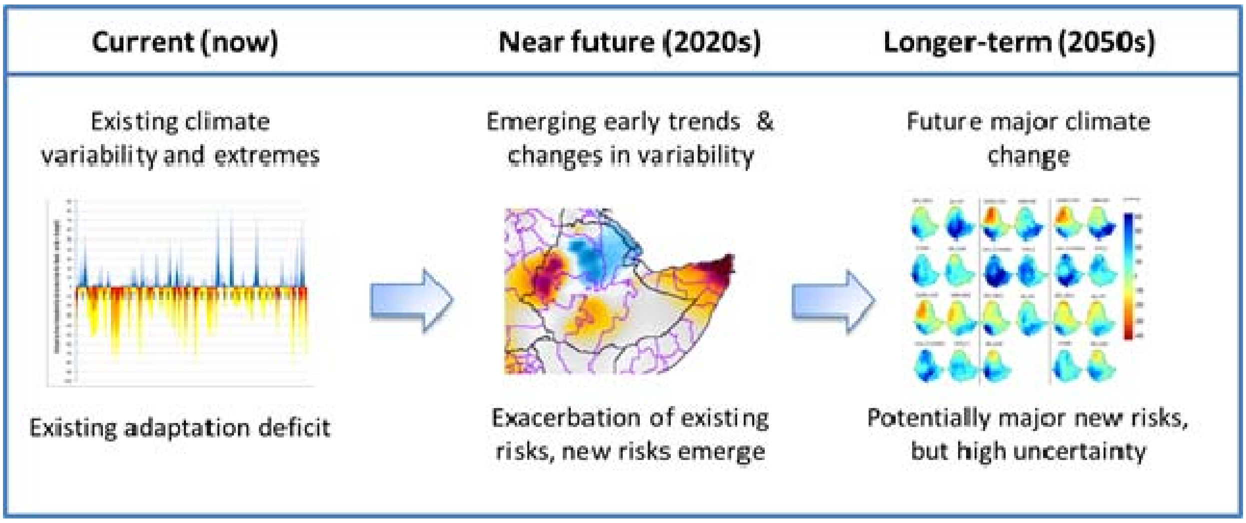
This toolkit provides useful information and support for these various steps.

The Move to Iterative Adaptation Frameworks

The focus of early adaptation has changed in recent years, away from a longer-term perspective around the future impacts of climate change, to the here and now, i.e. for implementing adaptation over the next few years.

As a result, climate change is now viewed in more dynamic terms, starting with the problem of current climate variability and extreme events (the adaptation deficit) as well as considering future climate change uncertainty.

Figure 2. Climate change – from current variability to future, uncertain change



There is now a greater recognition of the need to address **current climate variability and extreme events** (such as rainfall variability, droughts, floods and tropical storms). These impacts already cause large economic impacts in developing countries, as well as affecting millions of livelihoods. Examples are provided in the box below.

These impacts of current climate variability are often known as the '**adaptation deficit'**.

Addressing this current adaptation deficit provides immediate economic and livelihood benefits and also enhances resilience to future climate change.

At the same time, while the **future impacts of climate change** are potentially large, there is **high uncertainty** over the changes that will occur. Examples are also provided in the box.

In recognition of these challenges, a new framework for climate change adaptation is being recommended, for example, in the recent IPCC 5th Assessment Report, which is based around an **adaptive management framework**, also known as iterative climate risk management (IPCC, 2014).

This starts with the existing problem of current climate variability and extremes, i.e. the adaptation deficit, then considers future climate change impacts using a framework of decision making under uncertainty. More details are provided in the theory of change chapter (step 2) and the early identification of options (step 3).

The early Adaptation VfM toolkit uses this iterative approach, as this can help in sequencing adaptation activities over time and in identifying early actions that are likely to offer good returns on investment, i.e. that deliver VfM.

Box 2. The evidence base on current climate variability and future uncertainty

As part of the toolkit development, a series of case studies were undertaken to build the evidence base.

These case studies highlighted that the current costs of climate variability in developing countries are high. A synthesis of the findings is provided below.

Nepal. Nepalese agriculture is predominantly small-scale, and is heavily dependent on natural rainfall. As a result, climate variability has large impacts on crop yields, and there are large annual variations in production. The sector is also affected by climate extremes, notably floods associated with the monsoon, but also periodic droughts. Current rainfall variability and low season river flows also affect hydro-electricity plants, which dominate generation, and thus lead to rolling blackouts in many months of the year. These interruptions have a high economic impact, with the value of lost load equivalent to 0.3% of GDP in dry years. Water-induced disasters associated with the monsoon rains, notably floods, are frequent and lead to loss of life and major damages. The direct impacts of these events are large, estimated at an average economic cost equivalent to 1.5% of GDP/year. In exceptional years, the economic damages cane be much larger, equivalent to 5 % of GDP, and have wide ranging indirect and macro-economic costs. Source: MoSTE, 2014.

Kenya. Kenya is affected by periodic floods and droughts related to El-Niño Southern Oscillation (ENSO) events. The 1998-2000 drought was estimated to have economic costs of $2.8 billion from the loss of crops and livestock, forest fires, damage to fisheries, reduced hydro-power generation, reduced industrial production and reduced water supply. The 1997/98 floods affected almost 1 million people and were estimated to have total economic costs of $0.8 to $1.2 billion arising from damage to infrastructure, public health effects and loss of crops. The continued annual burden of these events leads to large economic costs (possibly as much as $0.5 billion per year, equivalent to around 2 % of GDP) and reduces long-term growth.
Source: RECC study (SEI, 2009)

Samao. Samoa is periodically affected by major cyclones, which lead to damage from high wind-speeds and storm surges. These lead to major damage and losses, with the largest loss events estimated at over 30% of GDP, associated with damage to buildings and infrastructure.
Source: World Bank EACC Samoa study (2010).

The case studies provide evidence that there are large economic costs from current climate variability and natural hazards in LDCs today, and thus there is a major adaptation deficit. These existing costs are a priority area for early adaptation, as tackling the deficit provides immediate economic benefits, as well as building resilience to future climate change.

Interestingly, the case studies above reveal much higher economic costs than the recent estimates in the IPCC SREX (2012), which reviewed losses from current natural disasters and reported a value of 0.3% of GDP (on average) for low-income countries.

The higher values found in the case studies may be affected by the countries chosen, but is also due to the wider coverage (climate variability as well as natural hazards). As a result, the evidence from the case studies strengthens the case for early low-regret adaptation to address the deficit as a priority area for delivering value for money adaptation.

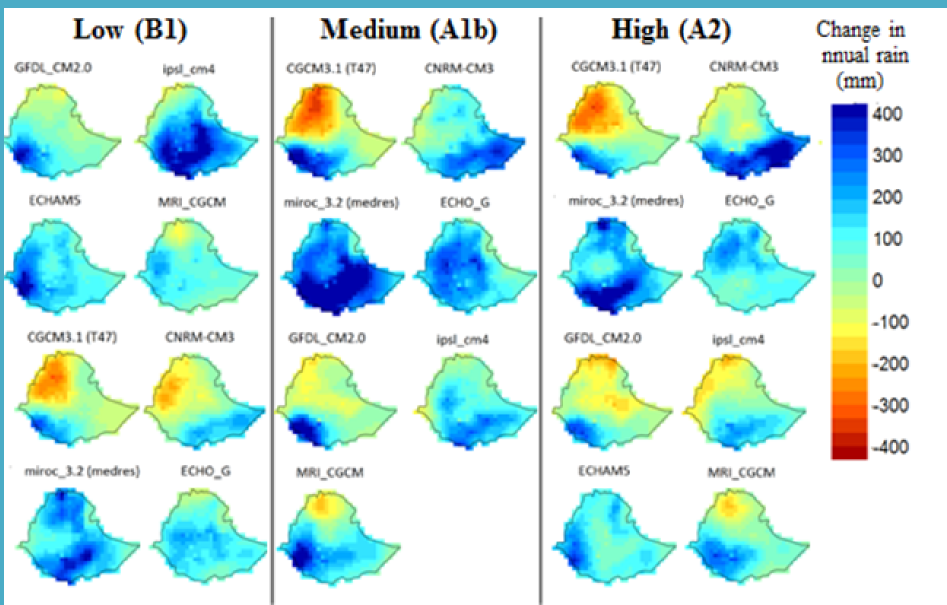
Box 3. Uncertainty

While adaptation involves several difficult aspects, the most challenging is uncertainty (UNFCCC, 2009: Hallegatte, 2009), particularly in relation to future projections of climate change. This arises for two reasons:

First, future greenhouse gas emissions – and thus the level of climate change that will occur over time - are uncertain. It is currently not clear whether the world will implement the emission reductions (mitigation) needed to limit global warming to 2 degrees relative to pre-industrial levels (the 2°C goal) and many commentators consider higher emission scenarios towards a 3 or 4°C warmer world are more likely. The future emission path makes a large difference to future warming and changes in other climate parameters, such as precipitation.

Second, even when a future emission scenario is defined, there are still large variations projected from different climate models. This arises because of structure and sensitivity of the models, the regional and seasonal changes associated with global temperature, and the difficulty in projecting complex effects such as rainfall. As a result, different climate models often give very different results even for the same scenario and same location.

This can lead to a very high range of uncertainty. An example is shown below for the change in annual rainfall with climate change in Ethiopia in the 2050s, comparing alternative climate models and scenarios.



Source Watkiss et al, 2013.

As the figure shows, there is even disagreement on the sign of the change, i.e. whether rainfall will increase in the North (blue) or decrease (orange). These uncertainties also exist for individual months of the year, and for other parameters such as extreme rainfall or drought periods. Even for more robust changes, such as average temperature increases, future differences are large. It is stressed that it is not possible to use probabilities to get around these problems, because of the uncertainty across both future scenarios and models. This uncertainty grows when different socio-economic scenarios (e.g. population projections) and alternative impact models are considered, which adds to the uncertainty above.

STEP 1

Identifying Risk, Vulnerability and Impacts

Key Messages in this Section

- This section outlines the steps in identifying relevant information on climate change risk, vulnerability and impacts for the adaptation cycle and iterative approach.
- It provides a simple decision tree and links to more detailed information.
- It provides sources on useful information and provides examples of country case study applications.

Introduction

The previous section provided the adaptation policy framework, and highlighted the use of iterative approaches to identify broad areas for early possible adaptation.

This chapter provides information on the first step in the cycle: the identification of risks, vulnerability and impacts. Importantly, it outlines the key information needed for using the iterative approach, noting this requires different information to normal climate change studies, and will require different evidence lines, taken from a variety of information and studies. In collating relevant information, it is highlighted that the definitions of risk, vulnerability and impacts vary, as outlined in the box below.

The Toolkit does not propose specific definitions, but highlights the need to consider information from a wide variety of studies, i.e. pooling information from existing vulnerability assessments, future impact studies, etc. An example is presented later in the chapter.

Box 4. Definitions of risk, vulnerability and impacts

One of the issues with climate change impact, vulnerability and adaptation studies is the definitions of key terms, particular risk and vulnerability. Differences in definitions have emerged, from different fields of research e.g. from the risk management, adaptation, resilience literature.

In the risk management field, there are well accepted definitions. Risk is generally measured as a combination of the probability (likelihood) of an event (a hazard) and its consequences (severity). In general, vulnerability is seen as a component of risk, as in Risk = f {Hazard, Exposure, Vulnerability} where hazard is the extent, severity and probability of a climate related hazard; exposure is the extent and value of elements that would be affected were the hazard to be realised; and vulnerability is the susceptibility of the elements to the hazard.

In the adaptation literature, a different definition of vulnerability has been used, which moves away from this technical definition, to consider the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity (IPCC, 2007).

Aiming to simplify this, the IPCC (e.g. in the 5th Assessment Report, 2014) provides an updated and broad ranging definition for vulnerability: as

the propensity or predisposition to be adversely affected.

Impacts are generally used to refer to effects (outcomes or consequences) on natural and human systems, i.e. on health, infrastructure. In the climate change impacts literature, they are associated with physical endpoints, e.g. numbers of deaths, change in agricultural productivity. In the past, they often differed from risk management studies by focusing on projected trends, rather than probabilistic events, though more recent impacts studies assess both trends and changes in extremes.

Information Needs and Applications

There is now a very large evidence base on climate change risks, vulnerability and impacts. An important first step in the toolkit is therefore pointing towards the most relevant information for the iterative framework.

In very simple terms, the use of an iterative framework requires a number of information inputs that are slightly different to most existing studies:

- First, information on current climate variability and extremes is needed, as this provides the analysis of the current adaptation deficit, i.e. the starting point for adaptation. While many LDC vulnerability studies have some relevant information for this step, there are other sources of data that are relevant.
- Second, there is a need to complement this information with a policy review. This provides the link to current and planned policy, and moves the focus towards mainstreaming.
- Finally, there is also a need to consider future climate information and possible impacts (risks). However, in contrast to many studies, a critical issue is to assess uncertainty. This can be assessed qualitatively with narratives, or quantitatively using analysis of climate model uncertainty.

In most countries, much of this information will be available, though there is a need to access different sources to compile it. To help with this, information sources are presented later in the chapter.

It is also highlighted that the balance of information will vary with application and context, i.e. whether this is:

(i) Advisers designing adaptation programmes or projects, e.g. DFID country office adaptation

(ii) Mainstreaming of adaptation into non-climate country programmes or sector support

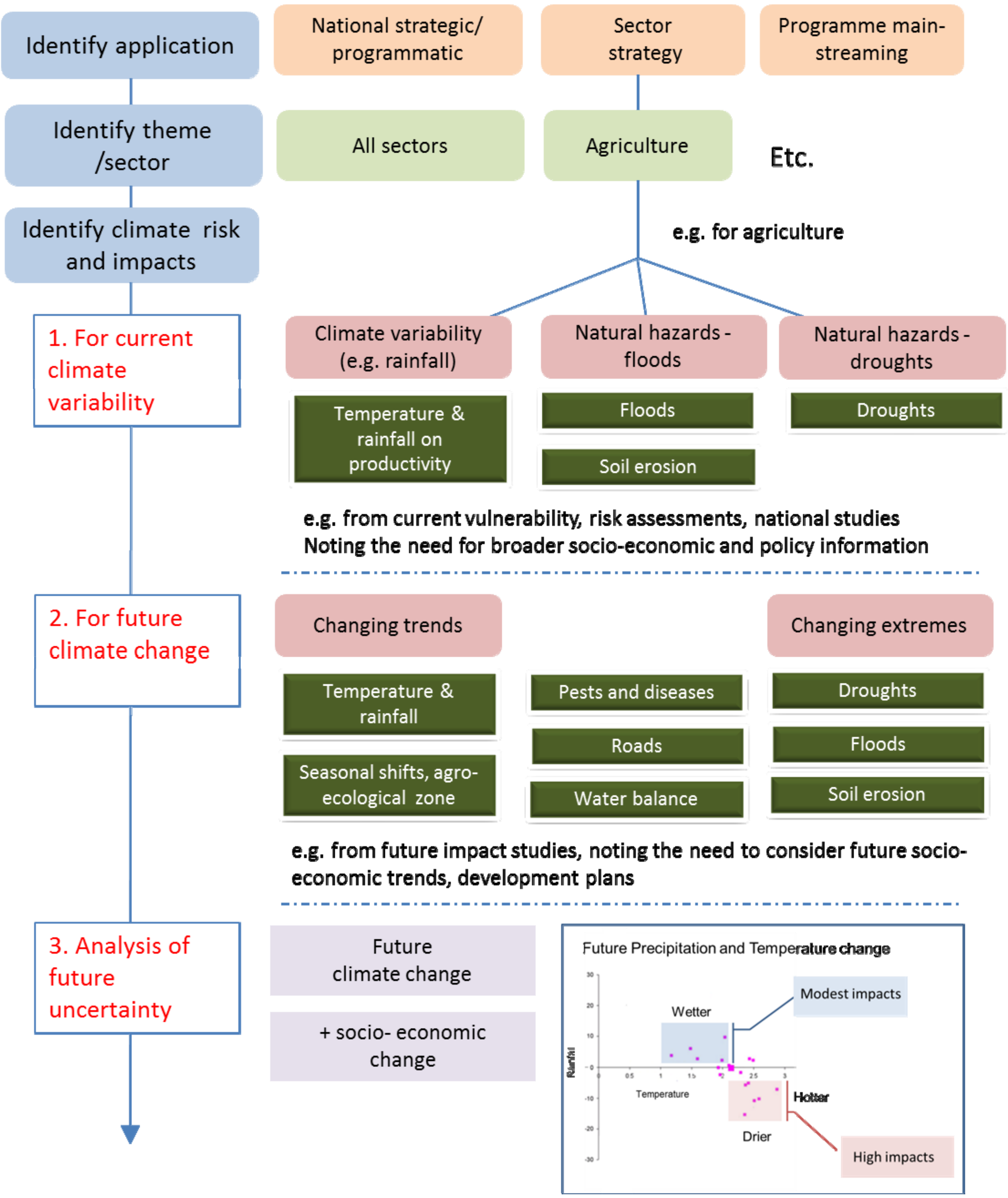
(iii) Assessing DFID support (finance, technical assistance) for country national/sector plans, such as for National Adaptation Plans, sector adaptation plans or projects, or local adaptation.

A simple set of issues to consider is presented below with decision trees, with a high level simple outline, and a link to more detailed process steps and guidance.

A Simplified Process Tree

In terms of the information needs, a simple decision tree is presented below, outlining the climate relevant information need for applying an iterative framework.

Figure 3. Identification of Risks and Priority Areas for Action, and Uncertainty



Information sources for these areas are outlined later.

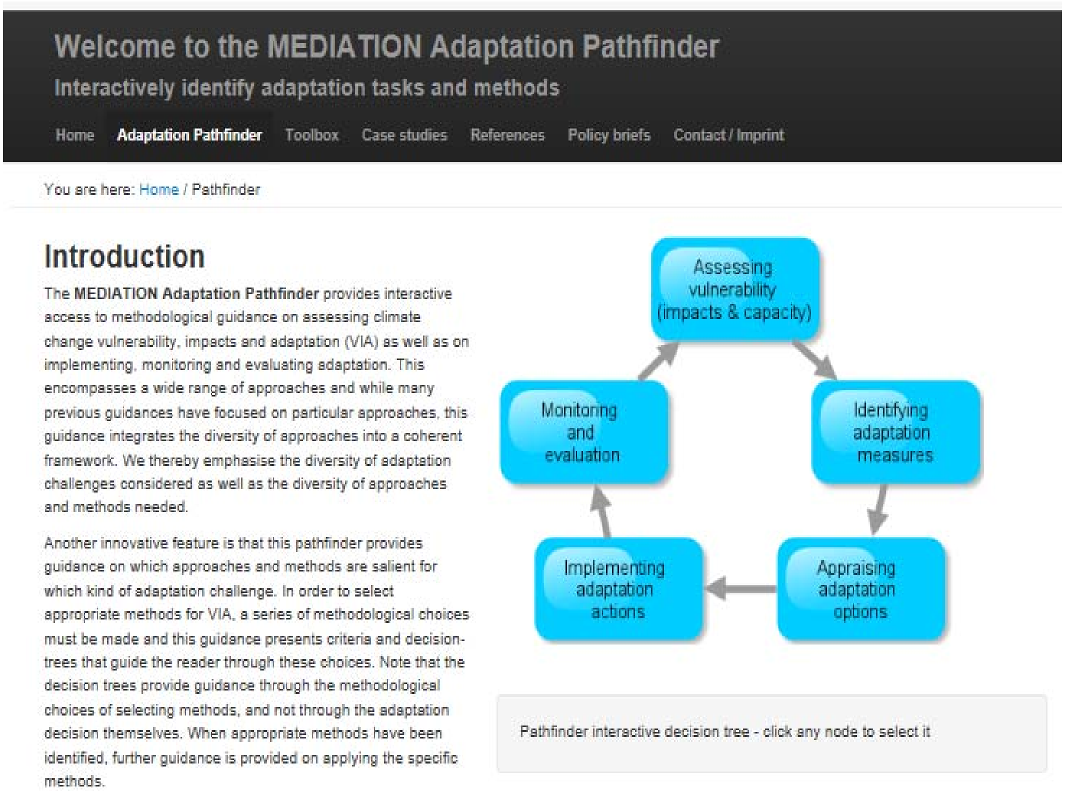
More Detailed Decision Trees

A more detailed set of decision trees have been produced as part of the PROVIA study and the Mediation project. These provide a diagnostic framework that supports selecting salient approaches and methods for a given adaptation challenge.

This includes the PROVIA Guidance on Assessing Vulnerability, Impacts and Adaptation to Climate Change, available at:
http://www.unep.org/provia/Portals/24128/PROVIA_guidance_report_low_resolution.pdf

It also includes the Mediation common platform and its adaptation pathfinder http://www.mediation-project.eu/platform/. The platform follows a very similar adaptation policy cycle as the toolkit, and can thus provide additional support for each of the stages for DFID advisors, and provides entry points for each step of the cycle.

Figure 4. Mediation Adaptation Pathfinder



Information Sources

A number of additional information sources are provided below, focusing on the additional information need for iterative frameworks.

Assessing current climate variability and extremes

A useful starting point for most countries is to look at the **National Adaptation Programmes of Action** and **National Communications**.

- Databases of all country NAPAs and NCs are available from the UNFCCC: Submitted national communications for all countries are downloadable from: https://unfccc.int/national_reports/annex_i_natcom/submitted_natcom/items/7742.php

- Submitted NAPAs for all countries are downloadable from: https://unfccc.int/adaptation/workstreams/national_adaptation_programmes_of_action/items/4585.php

Information on **extreme events** (**natural hazards)** (including droughts, floods, etc.) can be found in a number of databases, with country specific information, including impacts and losses.

- The CRED/OFDA International Disaster Database, EM-DAT (Emergency Events Database) (http://www.emdat.be/) contains worldwide data, by country, for natural disasters (floods, droughts, storms, mass movements, etc.) from 1900 to the present. This includes country-level disaster profiles. The database is free and allows users to download available data.

- The Dartmouth Flood Observatory provides a Global Active Archive of Large Flood Events. The database is free and allows users to download available data. with excel .xls files for all events, 1985-present (http://www.dartmouth.edu/~floods).

- There is also the NatCatSERVICE database from Munich Re www.munichre.com and the SIGMA database of SWISS RE covering natural and man-made disasters http://www.swissre.com/sigma.

- There is a country-by-country tool to assess disaster risk, developed by UNEP's Global Resource (http://www.nat-hazards-earth-syst-sci.net/9/1149/2009/nhess-9-1149-2009-supplement.pdf) and the Natural Disaster Hotspots: A Global Risk Analysis at Columbia University (http://www.ldeo.columbia.edu/chrr/research/hotspots/).

- There is also the UNEP PreView tool for visualising natural disaster data in more detail (http://www.grid.unep.ch/activities/earlywarning/preview).

- Reliefweb is a well-known country-by-country database of emergency appeals, maintained by UNOCHA (United Nations Office for the Coordination of Humanitarian Affairs) http://www.reliefweb.int. DesInventar (http://www.desinventar.org/) is a conceptual and methodological tool for the construction of databases of loss, damage, or effects caused by emergencies or disasters, and there are databases of disasters for a number of countries.

- The World Bank Climate Portal also provides current climate information for countries The Climate Change Knowledge Portal (CCKP) is a central hub of information, including information on baseline climate, natural hazards, impacts and vulnerabilities, with Climate Adaptation Country Profiles (http://sdwebx.worldbank.org/climateportal/index.cfm)

- Information on the broader impacts of climate variability are more fragmented. There are often studies on the impacts of climate variability on agriculture, which include economic studies (Ricardian studies). These use regression analysis to consider how factors, such as climate, soil, and household variables, are correlated to land value or farm net revenues. As an example, there is the Climate Change and Agriculture in Africa study (from the Centre for Environmental Economics and Policy in Africa) which includes studies in eleven separate countries (http://www.ceepa.co.za/Climate_Change/index.html). There are also frequently studies on major impacts of variability, e.g. low river flows on hydro-electricity, the impacts of heavy rainfall on soil erosion, etc.

Future climate projections and uncertainty

A number of additional information sources are also provided below for future climate change risks.

A key starting point and source of information is the DFID Evidence on Demand:

- **TOPIC GUIDE: Adaptation: Decision Making under Uncertainty**

This provides particularly relevant information on what we know about future climate change, and climate change uncertainty.

A number of additional sources are outlined below.

- There is frequently information on future climate change for a country. This may include a number of global climate model runs or analysis of many global climate models (an ensemble). An example can be found with the UNEP country profiles: http://www.geog.ox.ac.uk/research/climate/projects/undp-cp/

While these provide useful information, the resolution of these models is course, and for many countries, downscaled data is preferable. There are two main forms this may take.

- The first uses Regional Climate Models (RCM) which typically work at a grid level of between about 25 km and 50 km. The second uses empirical (statistical) downscaling to align global climate model information to local meteorological station data.

However, regional climate model runs are often only available for a limited number of scenarios and models. As an example, there may be a downscaled regional climate model run using the PRECIS model for the A1B scenario. However, the use of a small number of regional models does not capture climate model uncertainty, i.e. it is not a substitute for multi-model ensemble analysis. Indeed, it can even be counter-productive by giving implicit confidence without capturing the underlying model bias, e.g. whether the model is warmer, wetter, etc.

- An alternative is to use downscaled data sets. A number of data sets exist which provide downscaled global climate ensembles.

- The University of Cape Town Climate Information Portal has downscaled (statistical) data for all of Africa and Asia on a met station basis. It also has a linked portal on documentation that facilitates the best use of the climate data, interpretation and actions. http://cip.csag.uct.ac.za/webclient2/app/

- The World Bank Climate Portal also has information on current and future climate data for countries. The Climate Change Knowledge Portal (CCKP) Beta is a central hub of information, data and reports about climate change. It has information on baseline climate, future projections, natural hazards, impacts and vulnerabilities and adaptation. (http://sdwebx.worldbank.org/climateportal/index.cfm)

- There are also Climate Adaptation Country Profiles, which are operational tools for adaptation, disaster risk management, and development practitioners to access just-in-time reference information on adaptation to climate change. http://sdwebx.worldbank.org/climateportal/index.cfm

Country Case Study: Ethiopia CR Strategy

An example of the information sources and analysis for vulnerability, risks and impacts is presented below. This is compiled from the work undertaken as part of Ethiopia's Climate Resilient Green Economy (CRGE) initiative, and the analysis for developing the information for the Climate Resilience Agriculture strategy (Watkiss et al, 2013).

The Strategy used the iterative framework advanced in the Report and Toolkit. This started with the present adaptation deficit, considered the mainstreaming of climate in development (2015 – 2025), and started to prepare for (uncertain) long-term changes (through to 2050), linking these together to provide a climate resilience strategy.

Information on Current Climate Variability (the Adaptation Deficit)

To understand the current effects of climate variability and extreme events in Ethiopia, the study combined information from vulnerability, risk and impact studies.

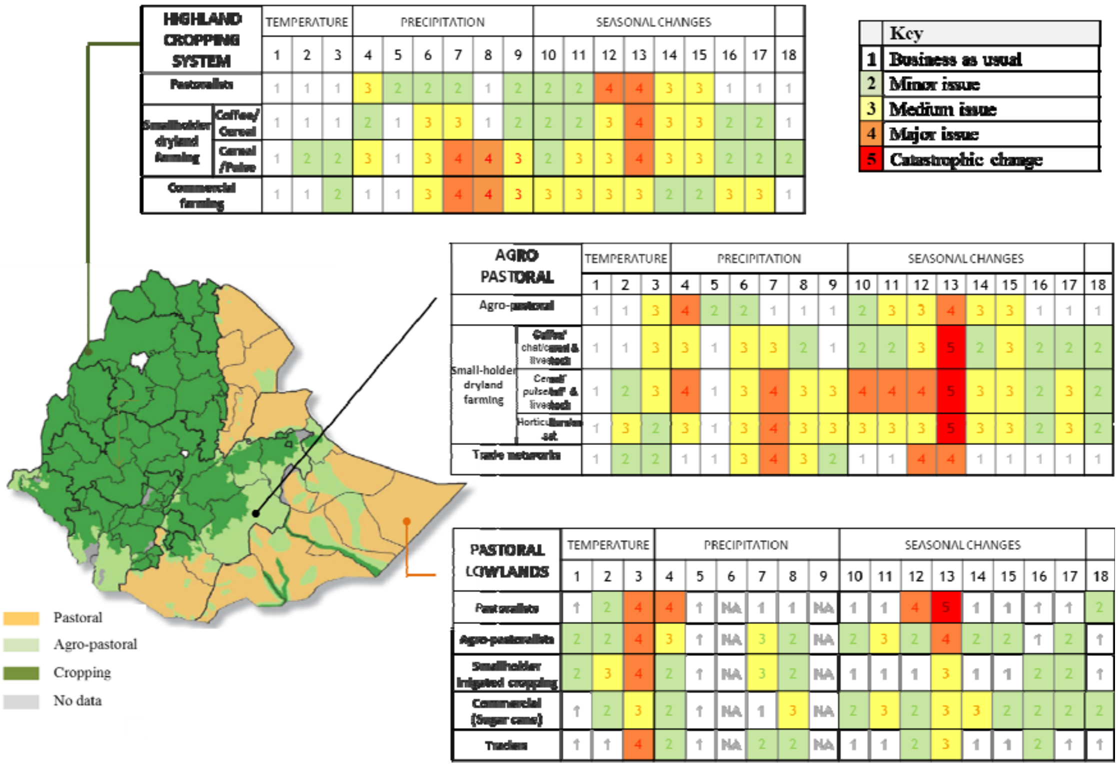
- It started with a review of livelihood based vulnerability assessments, which are the primary approach used in the Ethiopian NAPA and ongoing vulnerability mapping work (by Government and Development Partners), to look at existing climate risks (e.g. shown in the Figure below).

- It complemented this with a more detailed analysis of major hazards, using a risk based mapping analysis (consistent with disaster risk management approaches), assessing historic flood risks, soil erosion risk areas, etc. This step also drew on the international databases of natural hazards (e.g. EM-DAT), the Government disaster database, to look at historic impacts (damages, people affected, costs) and disaster/humanitarian reports.

- Finally, it assessed the baseline of impacts of current variability, using the results of impact assessments (e.g. studies of agricultural impacts, extreme events) including economic assessment. This drew on academic and grey literature on the impacts of climate on agriculture (e.g. Ricardian studies), information from relevant Ministries and studies by Development Partners.

When these evidence lines were combined, this built up a comprehensive picture of the current adaptation deficit, identifying key risks, by area, and providing indicative costs. The findings indicated that the impacts of current extremes and climate variability were equivalent to around $500 million a year, or 2.5% of GDP. Reducing these costs is a priority for early adaptation. It also identified key priority areas for early action, e.g. in relation to the effects of rainfall variability on (rain-fed) agricultural production, soil erosion risks, natural hazards, etc.

Figure 5. Example of a vulnerability matrix output



Information on Future Climate Change and Uncertainty

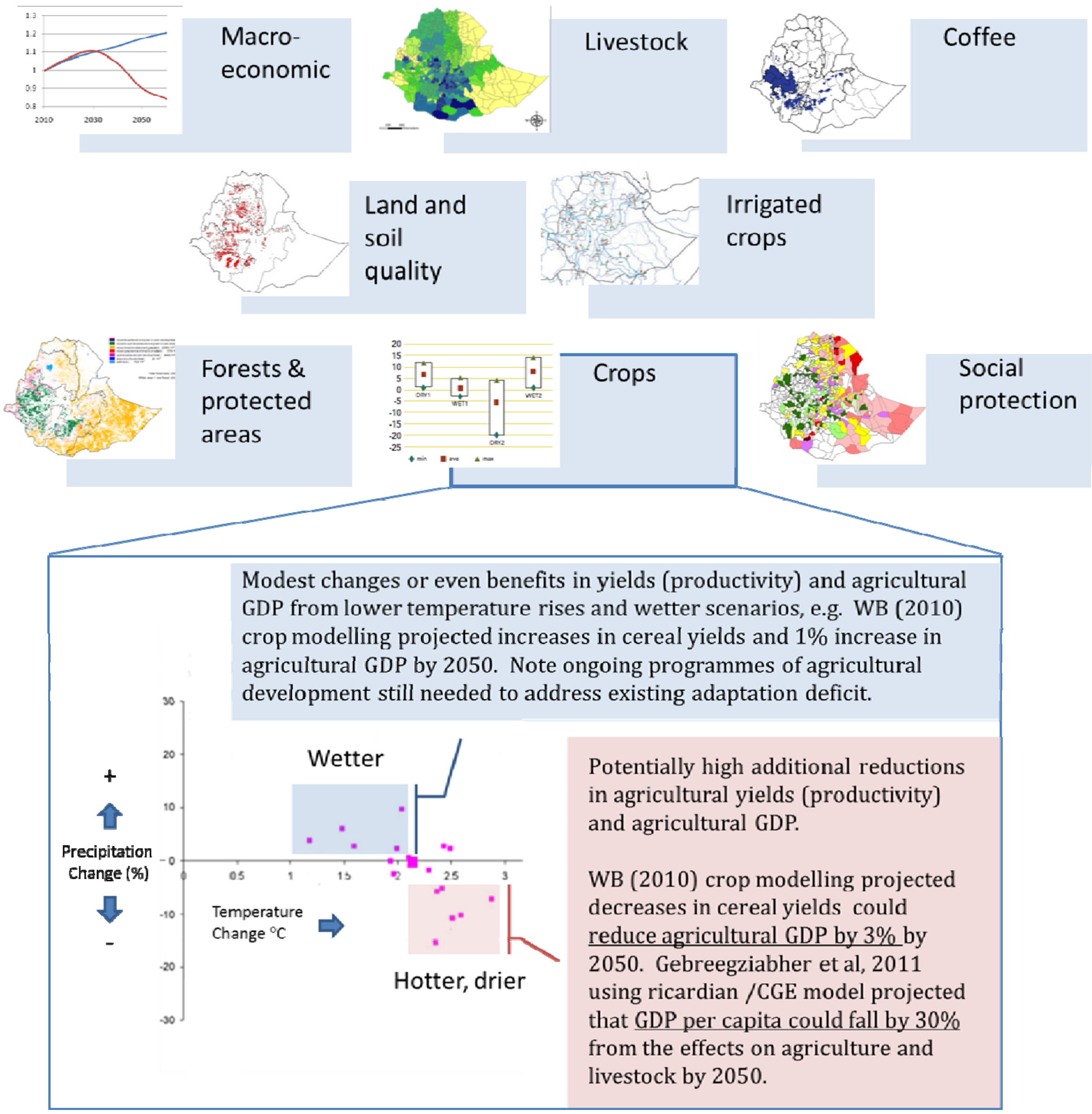
The analysis then looked at the potential risks from future climate change. This combined:

- A review of future climate projections and broad risks for Ethiopia based on information in previous national studies.
- A review of future impact assessments, such as the World Bank EACC study for Ethiopia, which ran crop and water models to look at future impacts.
- A review of future climate uncertainty, based on the downscaled information in the University of Cape Town Climate Information Portal and the World Bank Climate Portal.

This highlighted a number of potentially large risks, shown below. It also revealed that there was very high uncertainty. For example, the change in future rainfall projections reported a very wide range, of +/- 30% over the next 30 – 40 years.

The Strategy developed narratives of possible future risks and uncertainty for each of the major risks. This allowed the identification of major areas of focus for mainstreaming and for early iterative planning to address major future changes.

Figure 6. Major Future Risks and Narrative Example for Cereal Crops



STEP 2

Theory of Change (the Problem)

Key Messages in this Section

- This section discusses the context for the theory of change for climate change adaptation.
- It identifies the current problem that DFID is seeking to influence, highlighting the challenges of adaptation in the context of long-term and uncertain future benefits.
- It then outlines how an iterative framework for adaptation can address these challenges. This involves a set of complementary actions (a portfolio) whic:

  - Tackles the current adaptation deficit,

  - Mainstreams climate change into development, and

  - Starts preparing for future (and uncertain) long-term challenges.
- The rationale for this framework is explained, and how it helps maximise value-for-money for ‘early’ adaptation, i.e. over the next 5 – 10 years.
- Finally, the concepts of early no- and low-regret adaptation, and how these fit within the iterative framework are discussed.

Introduction

The potential for adaptation – and the identification of promising early options - has been known for many years. However, to date, there has been very little practical implementation (see Berrang Ford et al, 2011).

This is partly due to the lack of available finance, but it is also due to other issues, notably the nature of climate change – which takes place in the future – and with high levels of uncertainty, which tends to favour inaction.

This section discusses these challenges in the context of the theory of change, i.e. in relation to the problem that DFID is seeking to influence.

It then outlines how an iterative adaptation framework can address these challenges, and help in maximising value for money.

The Challenges with Early Adaptation

A number of challenges have emerged with the practical implementation of adaptation. These problems are compounded with the move towards real adaptation, i.e. to the ‘here and now’, because of the need to make decisions and investments over the next five to ten years (‘early’ adaptation).

The problem with future climate change

The climate is already changing (IPCC, 2013) and this is already leading to early impacts, particularly in developing countries (IPCC, 2014). However, the more significant impacts of climate change will happen in the future, as the rate of temperature change increases and major climate shifts emerge. Most climate change models and assessments have focused on these larger and longer-term issues (e.g. around the middle of the century (2050s) and beyond), because this is when a clear climate change 'signal' emerges, relative to the noise of underlying climate variability.

As these impacts arise in the future, e.g. towards the middle of the century, the benefits of adaptation also arise (predominantly) in this time period. This means that the costs of early adaptation action (today) are high when compared to the future discounted benefits of adaptation (tomorrow). Indeed, at the conventional discount rates, these discounted future benefits are extremely small and therefore rarely justify early action now. Furthermore, in this context, it is important to balance resource allocations and benefits from financing current development versus investing in adaptation to deliver future benefits.

The issue of uncertainty

The future effects of climate change – and thus the future benefits of adaptation - are uncertain – as highlighted in the previous chapter (box 3).

Earlier adaptation studies used a predict-then-optimise approach, where a climate model produced a defined future (usually around mid-century), which was then assessed to derive estimates of impacts.

In response, an optimised adaptation response was identified. These approaches assume perfect foresight and ignore uncertainty, and thus they provide little information of relevance for short-term decisions and long-term uncertainty. This is because they tend to assess adaptation responses for one defined future at a time, rather than for all the range of futures. This leads to recommend central solutions, which have the potential to waste resources by over-investing against risks that do not emerge, or implementing measures that are insufficient to cope with more extreme outcomes.

Of course, the consideration of uncertainty, where all possible futures are considered, makes decision making and real short-term investment much more challenging. This uncertainty acts as a barrier to adaptation, i.e. as a reason for inaction.

Where to focus?

Climate change has a large number of potential impacts, and this leads to a large number of potential areas to consider for adaptation. A critical question is therefore where to focus resources and how to select and prioritise early options?

While an initial focus on major risks is useful (e.g. in Step 1), this can still lead to a very large number of possible adaptation options being identified. As an example, most National Climate Change Strategies identify several hundred adaptation options and such a large number is unhelpful when available resources are considered. It is therefore important to identify and prioritise adaptation interventions, i.e. to direct available resources most effectively, efficiently and equitably, and thus to deliver Value for Money.

Using Iterative Adaptation Frameworks

In recognition of these challenges, the focus of adaptation has changed over recent years.

There is now a greater focus on starting with current climate variability and extreme events. These impacts of current climate variability are often known as the 'adaptation deficit'.

Addressing this current adaptation deficit provides immediate economic and livelihood benefits and also enhances resilience to future climate change. It is also recognised that adaptation (to future climate change) will be less effective if current adaptation deficits have not been addressed (Burton, 2004).

However, while reducing the deficit is generally beneficial, there is an economic component to consider. Some level of adaptation deficit exists in all countries, even in highly developed economies. This partly reflects the trade-off between the costs of reducing the deficit versus the costs of bearing 'residual risks'. This means it is optimal to reduce but not eliminate the deficit, i.e. only to reduce climate risks to the point where benefits are equal to costs.

At the same time, the future benefits and high uncertainty associated with future climate change are now recognised, and in response, the use of more flexible frameworks are being advanced, that allow learning and iteration.

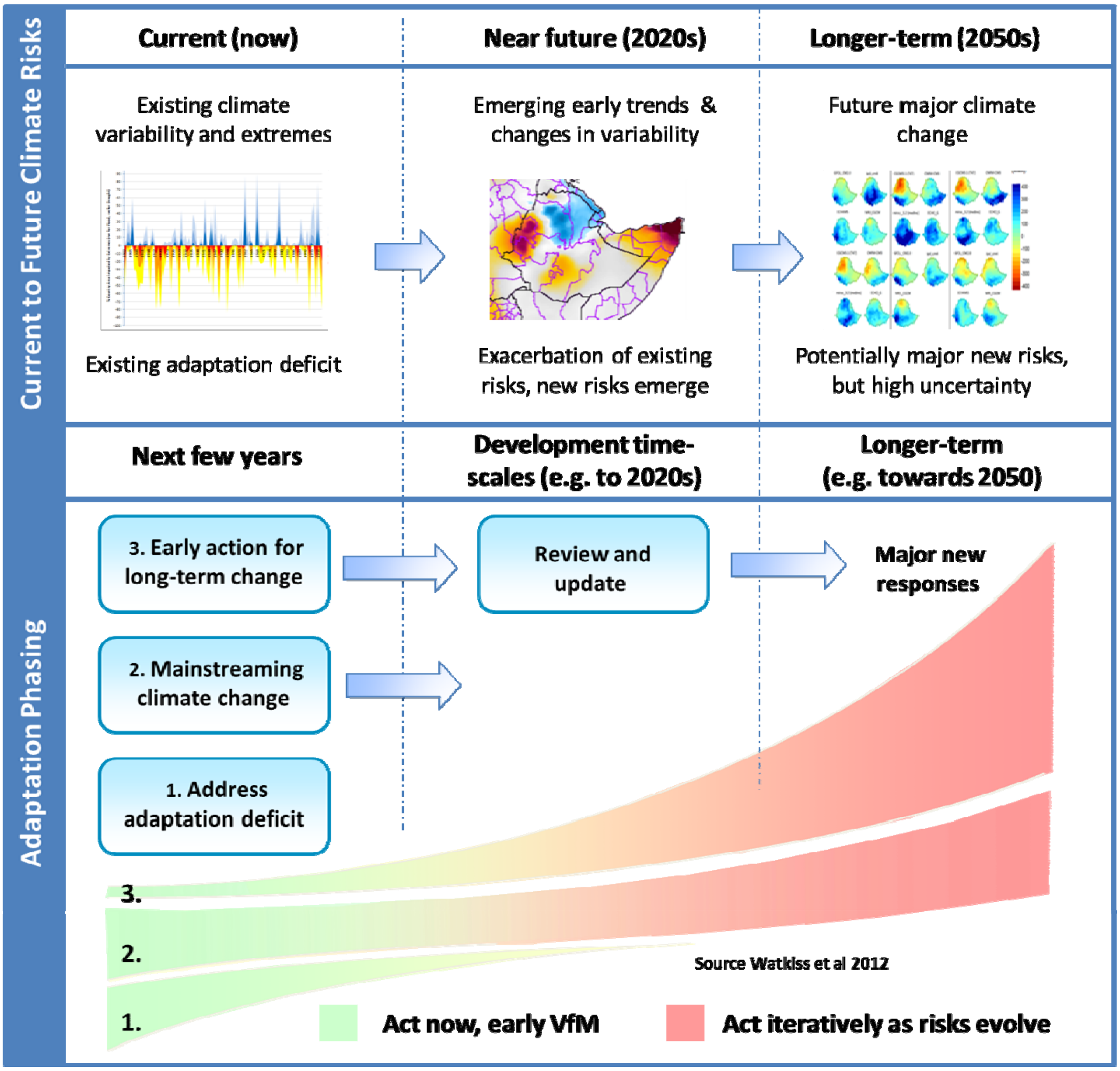
To address these two elements, a new framework for climate change adaptation has emerged, illustrated in the Figure below. The framework starts with climate change at the top, which is split into a number of linked risks, each related to different policy problems and time-scales, with increasing uncertainty.

In response, an adaptive management framework is recommended for adaptation (bottom), also known as iterative climate risk management (IPCC, 2014). This involves complementary responses that cover different challenges across the time-periods and climate challenges. Three broad sets of complementary adaptation activities are identified: 1) addressing current risks, 2) mainstreaming climate into development and infrastructure (e.g. to address future exposure) and 3) building iterative responses to address future long-term risks. These **iterative frameworks can help maximise value for money adaptation.**

The three interventions involve different activities.

1. The first area targets the current adaptation deficit, to reduce the impacts of climate variability, and also build resilience for the future. This often includes interventions termed no- or low-regret measures, which are good to do anyway (even without climate change).
2. The second area targets short-term decisions with long life-times, i.e. which will be exposed to climate change in the future (e.g. infrastructure, development planning decisions). This can be addressed using risk screening and mainstreaming, with early priorities around low-cost robustness and flexibility.
3. The final area addresses the long-term (and uncertain) risks of future climate change, building iterative response pathways using a framework of decision making under uncertainty and identifying early action to allow learning for future decisions. This allows responses to evolve over time (with a learning and review cycle) so that appropriate decisions can be taken at the right time, allowing for action to be brought forward or delayed as the evidence and observations (of climate change) emerge.

Figure 7. An Iterative Framework for Climate Change and Adaptation.



These frameworks have been recommended widely in the literature, including in the recent IPCC SREX report (2012) and more recently in IPCC 5th Assessment Report (2014).

Variations on these themes exist in the literature, e.g. there may be further sub-divisions, or alternative terms, but the key thing is around the timing of responses, with (1) immediate action to address the deficit, (2) short-term actions that will be exposed in the future, and (3) early action to address future risks, to keep options open and avoid the risks of lock-in. Each of these involves slightly different types of decisions – and information – and thus involves slightly different aspects.

The benefit of using these frameworks is that they provide a way to select the early priority areas for adaptation and to help deliver value-for-money.

Using Iterative Frameworks to Select Early VfM Adaptation

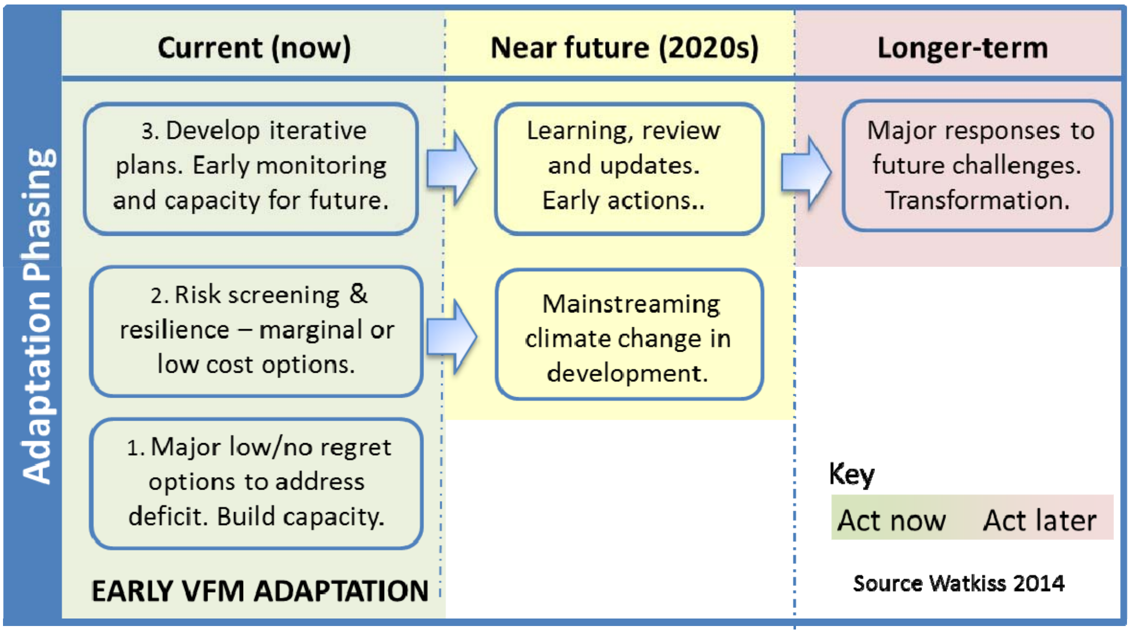
The framework presented above allows the identification of adaptation interventions that start with the current adaption deficit and build resilience for the future, taking account of uncertainty. These frameworks can be used to identify priority areas for early adaptation.

It is stressed that while much of the VFM focus will be on addressing the current adaptation deficit, focusing on this area alone (at the expense of longer-term changes) will lead to mal-adaptation. For example, failure to account for long-term risks when designing short-term responses could increase future impacts by increasing future exposure. Furthermore, the historic climate is not a good predictor of the future (with climate change), and thus optimising responses against historic experience is unlikely to be sufficient.

All of the three response areas are therefore an essential part of early adaptation, i.e. for decision and investments over the next 5 – 10 years. Indeed, a good adaptation programme will comprise of a portfolio of interventions that cover all of these different aspects, as together, these provide the key focus for delivering value for money adaptation.

The priority areas for early VFM adaptation are shown in the Figure below, and highlighted on the left hand side (in green).

Figure 8. Priority Areas for Early VfM Adaptation.



It is also stressed that the <u>nature of interventions</u> will vary for each of the three early VFM areas in the figure above. Early interventions to tackle the adaptation deficit will focus on concrete action (implementation), while early actions for the medium and longer-term (2 and 3) will involve marginal aspects, early planning, or information and evidence gathering, rather than large-scale action or major investment.

These early VFM options are often called '**<u>no-regret</u>**' or '**<u>low-regret</u>**' options.

They are now seen as an early priority for adaptation finance, for example, the IPCC SREX report (2012) highlights that *low-regret; actions are a starting point for adaptation, as they have the potential to offer benefits now and lay the foundation for addressing projected* *changes*. However, there are differences in the literature on exactly what constitutes no – and low-regret adaptation, as outlined in the box below. There is no agreed definition (at least of low-regret options), especially around the type of options and their timing.

To help address this, the toolkit provides a way of identifying types of low-regret actions, aligned to the iterative framework, to help deliver early value-for-money adaptation.

Box 5. What are No- and Low-regret Options?

What are no-regret options?

The concept of no-regret options has been advanced for mitigation, where it relates to measures which can reduce GHG emissions and save costs (i.e. that generate a positive net present value) such as energy efficiency. A similar concept has emerged for adaptation. In this case, **no-regret adaptation** is defined (by the IPCC) as adaptation policies, plans or options that*:*

'generate net social and/or economic benefits irrespective of whether or not anthropogenic climate change occurs'.

This often focuses on options that address the current adaptation deficit (e.g. disaster risk management), efficient options that are similar to the mitigation domain (e.g. improving irrigation efficiency) or options that address existing problems (e.g. reducing post-harvest losses), though many of these are actually development options. These no regret options provide immediate economic benefits, and they are therefore an obvious area of early Value for Money adaptation. They also have the potential to build the foundation for adaptation to future climate change, i.e. building resilience. A variation of no-regret options are **win-win** options. While there is no formal definition, these are options with wider social, environmental or ancillary benefits, and thus benefits may involve non-market values, GHG mitigation cross-sectoral synergies, etc. that are difficult to include in a standard project appraisal.

What are low-regret options?

There is no agreed definition of low-regret options. A number of definitions have been proposed:

- Options or interventions that are no-regret in nature, but have opportunity, policy or transaction costs. As an example, some climate smart options for agriculture are no-regret in theory, but involve opportunity costs, meaning in practice they are low-regret.
- Options that are probably worth doing in the current climate, and also have benefits in addressing climate change in the future. This often includes low cost options that have benefits that are difficult to monetise (e.g. capacity building, better climate information, etc.). It can also include options that are low cost and provide future information to enable better decisions in the future, or the opportunity for learning.
- Options or interventions where the costs are low and the future benefits are high, i.e. low cost measures that can provide high benefits if future climate change emerges (noting the benefits are in the future, rather than immediate). This can also include interventions that perform well over most, but not all, possible future climate change scenarios.
- Options that are robust or flexible, and thus address uncertainty. This can include options that are robust, i.e. that perform well across many different climate futures (addressing uncertainty), rather than a measure that performs optimally to one defined central future (and poorly to others). It also includes options that are flexible, i.e. that allow changes in plans or project design over time, to take account of new knowledge.

A number of additional points are also highlighted.

- A number of options that are considered low-regret in some studies are considered high-regret in others. This often applies to technical/structural (hard) options. This difference can be explained by the different framing of studies, i.e. whether the potential impacts of future climate change and uncertainty are considered or not.
- Many no- and low-regret options are non-technical (soft) in nature. This can make their appraisal more challenging. It is also noted that these soft measures may not always be a substitute for hard adaptation.
- A number of studies highlight the potential for community-based adaptation as a no-regret option, as practical adaptation at the community level seeks win-win outcomes – that benefit both local communities and the ecosystems on which they depend. This involves a different orientation to a standard technical based and national perspective.

Why aren't these options already implemented?

A final question is given the nature of these options, especially no-regret options, why haven't these been already implemented. Several studies have investigated this question and these identify a number of issues:

- Sometimes the no- or low-regret characteristics of these options are associated with non-market sectors or ancillary benefits, thus while they have a positive social present value, they provide lower returns than other options.
- In many cases, there are high opportunity costs. For example, climate-smart agriculture often involves some loss of land, or up-front labour costs.
- There can be underlying barriers, e.g. access to finance, lack of information and awareness, risk aversion to new techniques.
- There are often transaction costs, as well as institutional/socio-institutional barriers to overcome. This may therefore require some planned interventions or support, and a focus on capacity building and awareness-raising.

These barriers are extremely important. The successful analysis of early low-regret adaptation will need to consider these, otherwise the uptake/implementation of promising options will be low. This necessitates a focus on these issues, alongside technical or economic appraisal.

Sources: Watkiss et al, 2013; IPCC AR4, 2007; IPCC SREX, 2012; UKCIP, 2006; UKCIP, 2008; HMT, 2009; Wilby and Dessai, 2010; Conway and Schipper, 2011; Ranger and Garbett-Shiels, 2012
.

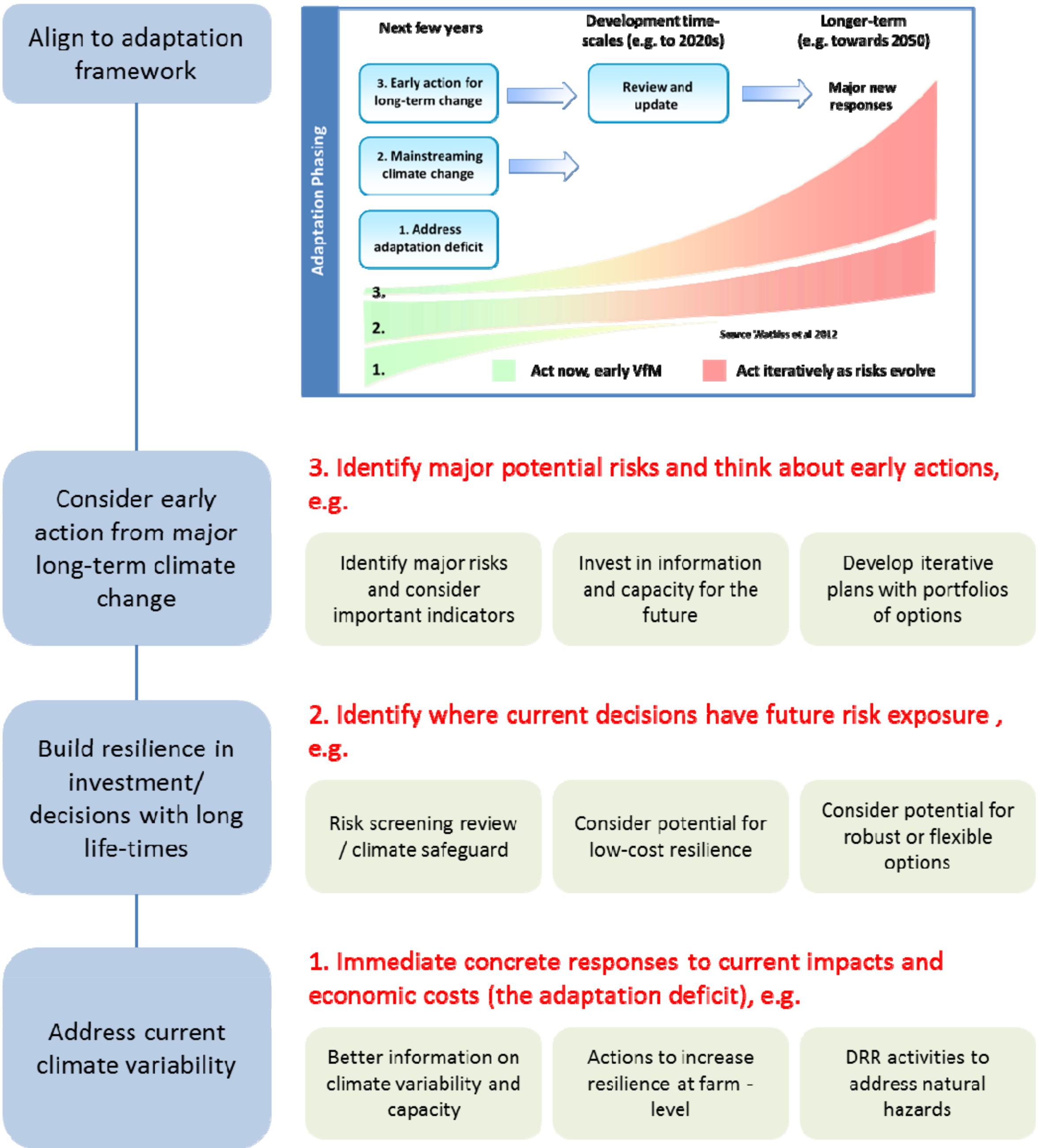
Outline Process Trees

The section above highlights a number of important conclusions:

- Adaptation is unlikely to involve an individual intervention. It is likely to require a response that recognises evolving risks, which are likely to change over time, and involves a set of response to different types of problems and context.
- While the immediate focus may be on addressing current climate variability, it is important to have a balanced adaptation portfolio, recognising the need to start preparing for future challenges as well as addressing problems of today.
- Early value for money adaptation will include a mix of interventions, which includes some direct no-regret activities, but also low-regret options tackling short and medium-term issues, and some early planning for long-term challenges. Importantly these different activities are complementary and are linked.

A process step and decision tree for these steps is outlined below. This involves the identification of relevant risks, for both current climate variability, and future climate change including uncertainty.

Figure 9. Identification of Early Priority Areas for Adaptation.



As with the earlier steps, more detailed information and decision trees are available in the PROVIA guidance and Mediation adaptation pathfinder.

STEP 3

Identify and Sequence Adaptation Options

Key Messages in this Section

- This section provides information to help identify and sequence early VfM adaptation.
- It outlines the types of interventions that can be included within an iterative framework and why each of these is likely to deliver value-for-money.
- It provides a description of each of these option types, and outlines their potential benefits, their justification, and the cases when they are likely to deliver VFM.

Introduction

The previous section provided a general framework to identify broad areas for early possible adaptation with the use of an iterative framework. This chapter focuses down on the identification (selection) of possible early VfM adaptation using this framework.

- It provides a typology of early VfM actions that fit within an iterative climate risk management framework, i.e. a classification of types of early VfM adaptation.
- It describes some of the key aspects of each option, outlining the benefits, transferability, etc.
- It outlines which contexts and applications are likely to deliver value for money (as well as those which may not).

Issues with Identifying Early (VfM) Adaptation

In looking at the early identification and prioritisation of adaptation, it is useful to compare the similar early steps for mitigation, to highlight key differences.

There are widely accepted methods for identifying and prioritising promising options for reducing greenhouse gas (GHG). As mitigation is concerned with reducing a global burden, it is possible to compare options directly across and between sectors using cost-effectiveness analysis and the metric £/tCO_2. This provides a simple and efficient way to prioritise options and to assess potential benefits/outputs. However, it is much more challenging to identify and prioritise early adaptation for a number of reasons:

- There are no simple common metrics to compare and prioritise adaptation interventions. While mitigation targets a common burden of GHG, which can be measured in terms of £/tCO_2 abated, adaptation targets a large number of sector-specific impacts. The analysis of impacts and subsequent adaptation benefits therefore involves additional steps (e.g. who is exposed? how are they affected by climate? and what impacts arise as a result?)

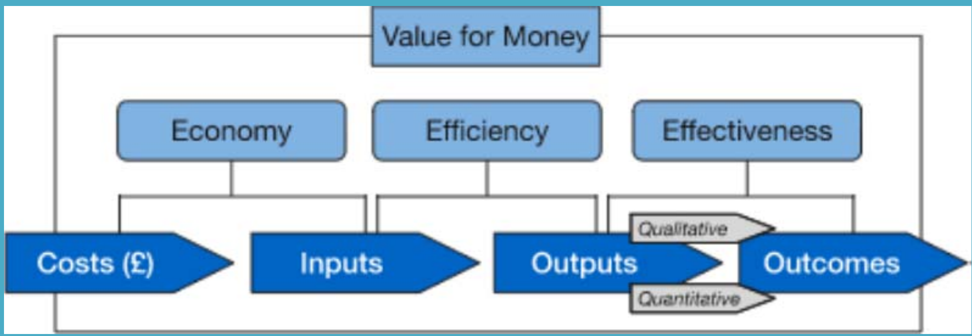
- Following from this, baseline risks, and potential adaptation benefits, are site and context specific, i.e. they vary. There are much greater issue of transferability involved in adaptation (what worked well elsewhere, may not work well locally).
- Adaptation has to account for the dynamic and changing nature of climate change over time, i.e. the baseline impacts and the levels of adaptation benefits vary. This requires an additional time element as well as the consideration of inter-dependencies.
- There are a set of different challenges (or problems) for adaptation to address, related to current climate variability, near-term mainstreaming, and future climate change. This requires portfolios of options, rather than a single, linear optimised solution (as with mitigation).
- There is high uncertainty associated with future climate change, impacts and thus with future adaptation benefits. This uncertainty cannot be ignored with the use of central projections and estimates (as with mitigation). Uncertainty needs to be included in the selection of adaptation options and the decision framework for prioritisation.
- Many promising early adaptation options are non-technical in nature, or involve qualitative, ancillary or non-market sector benefits (unlike the technical, quantitative focus of mitigation options). This makes the analysis of outcomes and benefits, and subsequent economic appraisal, much more challenging.
- There is usually high variability in the baseline, for example with annual rainfall variability or probabilistic extreme events (e.g. floods and droughts). This makes it difficult to monitor and evaluate short-term adaptation outcomes, because it is difficult to attribute adaptation outcomes against this underlying variability. Furthermore, many of the early adaptation steps to address longer-term climate change which extend beyond normal project monitoring cycles. While process based indicators can be used to address this problem, these are less tangible than outcome based indicators.
- There is a strong overlap between many adaptation activities and existing development. Indeed, adaptation cannot be considered as a stand-alone activity and it needs to be integrated (mainstreamed) with underlying sectoral or development priorities and activities.

While this list of challenges may seem daunting, the iterative framework – and the use of low- and no-regret options - can help in identifying early promising areas for adaptation, i.e. to help select Value for Money. This is already recognised in the ICF thinking on VfM (see box).

However, it is necessary to move beyond this general framework towards a more specific and practical basis, i.e. to allow the selection of early VfM adaptation. This is the focus of this section.

Box 6. Adaptation Value for Money and the ICF

VFM in DFID is about maximising the impact of each pound spent. This is analysed through the lens of the 'three E's': economy (buying inputs of the appropriate quality at the right price); efficiency (how well we convert inputs into outputs) and effectiveness (how well the outputs from an intervention achieve the desired outcome on poverty reduction).



At a project level, DFID guidance supports VFM analysis at three levels:

- *Economy (spending less):* This refers to ensuring lowest cost procurement of goods and services within project design, and focuses on making sure that the unit costs are benchmarked against market norms. For example, from an adaptation perspective, this might involve ensuring that the costs of a water saving technology purchased were in line with international market expectations.
- *Efficiency (spending well):* This refers to ensuring that the choice of goods and services to be procured ensures that the procurement of goods and services results in the envisaged outputs. The input to output ratios are the key consideration. From an adaptation perspective, this might involve ensuring that the technology selected would deliver the desired reduction in volumes used for irrigation compared to similar alternative technologies.
- *Effectiveness (spending wisely):* This refers to the selection of those outputs most likely to result in the desired outcomes (and impacts). From an adaptation perspective, this could be ensuring that the water saving technology selected was the most (cost) effective way of making an agricultural community more resilient. Alternatives to be considered might include, adopting more drought resistant crops, investing in water capture and storage capacity, or diversifying livelihoods away from agriculture.

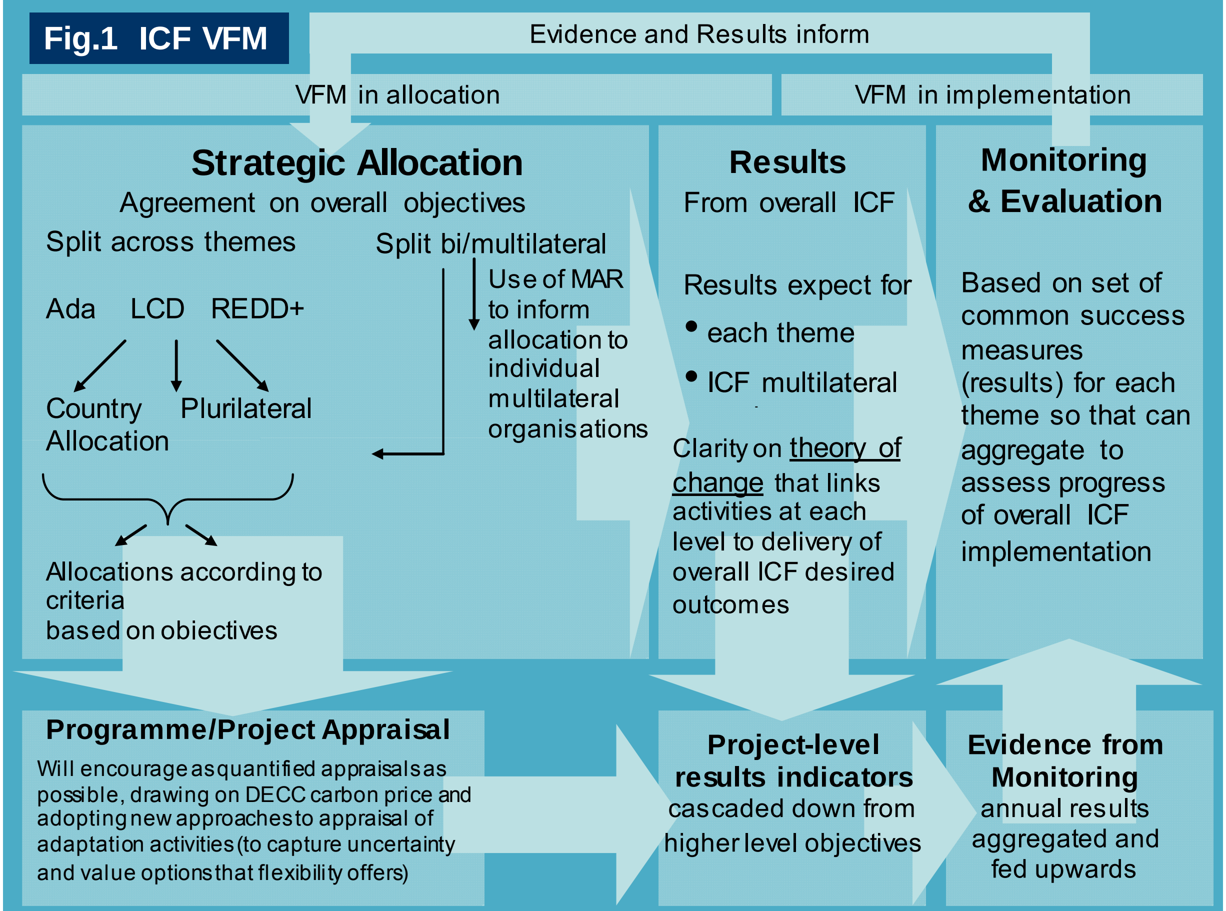
The International Climate Fund (ICF) uses VFM considerations at a strategic level in relation to the allocation of resources and at a project level to improve design and maximise outcomes. This is set out below.

- At a *strategic* level, VFM may be used to support allocation approaches. For example, VFM may inform the balance between capacity building and project investment, or the allocation of resources between countries or sectors on the basis of vulnerability. VFM may be viewed from an operational angle, such as the potential speed of disbursement, absorption capacity of different beneficiaries and delivery channels, and scaling up/leverage potential;

- At an *implementation* level, VFM can drive effective project design through the promotion of **low- and no-regret measures**, the identification of co-benefits (mitigation or poverty reduction), and innovation potential. Results frameworks are used to provide a common set of indicators that can be aggregated.

The promotion of no- and low-regret measures can be considered a supporting factor to ensure effectiveness both at the project and ICF level.

ICF VFM



No- and low-regrets approaches are promoted in ICF guidance as a way of ensuring a fair balance between across competing development priorities. Several no-regret options are identified in the ICF Implementation Plan[1].

- Continued investment in knowledge and climate data – both globally and at country level;
- Integrating adaptation into national plans and budgets to strengthen climate monitoring;
- Strengthening global, regional and national disaster risk reduction strategies';
- Improved watershed management;
- Supporting sustainable agriculture approaches and improved pasture management.

[1] International Climate Fund (ICF) Implementation Plan 2011/12 – 2014/15 Technical Paper

No/Low Regret Options and Early VfM Adaptation

The application of low- and no-regret options within the iterative framework (as set out in the previous step) provides a general framework for identifying early adaptation. This was shown in Figure 3 – with the areas shaded in green early priorities. These included:

1. Low and no-regret options (including capacity building) which address the existing adaptation deficit;
2. Low-regret options which build early resilience at low cost, or enhance resilience/flexibility, within near-term policy/infrastructure with a long life-time (as this will be exposed to climate change in the future);
3. Low-regret options that start to prepare for long-term future change today, e.g. as part of iterative plans.

This set of early adaptation options is therefore likely to deliver value-for-money.

In identifying these early priorities, there are a number of important considerations.

- The three types of early interventions (above) are very different in nature. They will involve different types of options (technical versus non-technical) which lead to different types of benefits. These differences need to be considered in their appraisal.
- There are issues over the transferability of options, i.e. some 'low-regret' options are highly beneficial in one context, but may not be in another, i.e. it depends.
- There are important linkages over time, i.e. to ensure short-term options (1) do not increase vulnerability in the long-term.
- There are often barriers to the implementation of promising options – indeed this is why they have not been implemented already - and these need to be overcome to ensure successful implementation: this often requires complementary action, e.g. technical options and institutional strengthening.

To help address these aspects, this step advances a typology for early VfM adaptation.

A Typology for Iterative Management and Early VfM Adaptation

To implement the iterative framework/low-regret adaptation concept, it is useful to have a more systematic approach for categorising early VfM adaptation.

To do this, the study has built an extended typology (a **classification of types of early VfM adaptation**). This is shown in the Figure below. This provides a way to structure the identification of promising options, in line with the iterative framework and to identify interventions likely to deliver good value-for-money.

The typology identifies a set of no and low-regret options (early VfM options) across the three areas of the iterative framework. These are presented in the figure. It is stressed that these activities are complementary and not a linear sequence, though there is a general time dimension from top to bottom.

Note that each of these interventions addresses different elements (applicability) and has different characteristics, also shown in the figure[2]. They also have different information needs, e.g. those towards the top will require information on current variability while those towards the bottom information on uncertainty.

Figure 10. Types of Promising Early VfM Adaptation

EARLY VFM ADAPTATION	Type of early adaptation	Description	Information needs	Examples
1. Low/no regret options to address deficit	a) Good development	Options that are beneficial to do now. Often no-regret, but really just core development.	Baseline development status	Rural roads. Pest management. Access to finance.
	b) Addressing current climate vulnerability	Options that reduce current climate risks, and build resilience (climate relevant development).	Current vulnerability & hazard data	Soil and water conservation. Disaster risk reduction.
	c) Capacity Building	Supporting actions to deliver enabling environment for adaptation.	Baseline and institutional information	Improved climate services (forecasts) Awareness raising. Institutional strengthening.
2. Risk screening, resilience & mainstreaming	a) Low cost, robust and flexible options	Risk screening and mainstreaming climate into plans or investment for future resilience	Future climate risks and uncertainty	Low-cost over-design Upgradeable infrastructure Flexible design
	b) Capacity and information	Information to reduce risks. Capacity building and research to build information and evidence	Baseline information and uncertainty	Risk mapping Siting/land-use plans to avoid future risks. Research and pilots
3. Addressing future climate challenges	a) Iterative adaptation pathways	New interventions for new challenges – information and early action for future decisions	Future climate Thresholds and uncertainty	Iterative plans, with research and monitoring programmes
	b) Trans-formative change	Structural, systemic or societal change recognising limits of adaptation	Societal futures, thresholds, uncertainty	Structural economic change. Population relocation.

[2] This set of options are similar to the prioritises for investment in adaptation set out in the DFID topic guide on uncertainty, but with greater differentiation.

The types of interventions also vary in nature with the type of action.

For those options that address the current adaptation deficit (1), a differentiation is made between options that have a strong overlap with current development (*good development*), which may be more appropriate for implementation through existing country programmes, and options that directly address climate variability (*addressing climate variability*). Both these will be associated with concrete actions (e.g. technical implementation, major investment, scale-up and roll out of promising options, etc.).

Alongside this, there is also a separate category of *capacity building*, reflecting the need for non-technical options to help deliver adaptation. Importantly many of these are qualitative in nature, and have different characteristics to more outcome based options. However, they provide the enabling environment to deliver other options and are thus critical for implementation success.

For those options that focus on mainstreaming and resilience (2), a differentiation is made between resilience building (building resilience into infrastructure or development) using *low-cost options, robustness and flexibility* versus using *information and capacity*. The former is primarily associated with looking to make current investments more resilient, while also noting the trade-off between early action (and costs) and longer-term benefits (hence not all early resilience offers value-for-money). The latter is focused around building and using information to reduce future exposure or impacts, e.g. with risk mapping and screening.

Finally, for those options that address the future climate challenges (3), a differentiation is made between the *iterative adaptation pathways*, which build adaptation responses with learning, and *transformative adaptation*, which involves major structural or societal changes.

It is stressed that while 'good development' options (at the top) are not really adaptation, they are included as these are often listed in National Adaptation Plans.

Similarly, while transformative adaptation (at the bottom) is not really associated with early low-regret actions, there are some linkages between early action and long-term challenges which may require early consideration in the broader context of VfM.

The Benefits of Different Interventions

Following from the different characteristics and applications, the different types of early VfM options involve different types of benefits. These are mapped out in the figure below.

The second column (the type of benefits) highlights the nature of the benefits of each options. This provides the **justification for its inclusion as an early VfM intervention**.

Those at the top tend to have more outcome-based outputs, which are more quantitative in nature. These can deliver immediate economic benefits (today) as well as building resilience for the future. In contrast, capacity building and information provide non-technical benefits, which are often qualitative in nature, and are thus more process based. However, these still deliver benefits (in economic terms) through the value of information.

The final column highlights that the timing of the benefits also varies. Those at the top lead to more immediate benefits and outcomes. Those at the bottom are more focused on the future, necessitating consideration of discounted benefits and uncertainty.

These differences are important when considering how to assess the options in subsequent appraisal, e.g. in the expected results and for subsequent monitoring and evaluation frameworks. The final column provides a summary of how benefits can be assessed and the potential tools involved. As an example, those options addressing existing climate variability will focus more on the current vulnerability and risk assessment. In contrast, the development of longer-term responses will consider future climate change and uncertainty, and aspects such as robustness or flexibility which requires additional attributes to a conventional CBA.

Figure 11. Benefits of promising early (VfM) Adaptation

EARLY VFM ADAPTATION	Type of early adaptation	Type of Benefits	Timing of benefits	Analysis of benefits
1. Low/no regret options to address deficit	a) Good development	Productivity Efficiency Outcome-based	Now	Classic benefit to cost ratio
	b) Addressing current climate vulnerability	Reducing current climate impacts of variability	Now + potential for future resilience to CC	Benefit to cost ratio but requires climate information
	c) Capacity Building	Value of information Enabling environment Process-based	Some benefits now + better adaptation in future	Less outcome based often qualitative Value of information
2. Risk screening, resilience & mainstreaming	a) Low cost, robust and flexible options	Protect investment Reduced risk Robustness/flexibility	Some now, but mostly future Resilience	Requires future climate information (envelope/range)
	b) Capacity and information	Value of information Enabling environment Process-based	Some now, but mostly future Resilience	Less outcome based often qualitative Value of information
3. Addressing future climate challenges	a) Iterative adaptation pathways	Learning, value of information, option value, avoided lock-in	Future. Action to improve future decisions	Qualitative narratives or more complex iterative appraisal
	b) Trans-formative change	Avoiding major irreversibility, major lock-in, option values	Future. Action now to avoid/adjust to major changes	Futures analysis

Overview of Option Types

A brief description of the options is outlined below. For each of these the text includes a description of the option and characteristics, with some examples, and why the option represents value for money.

1) Addressing current climate variability and building resilience

1a) Good development

The first area is primarily focused around no-regret options that can be considered 'good development'. These are options that have positive social net present values, i.e. they are good to do anyway. However, these options may not have been implemented already due to various barriers (e.g. access to finance, awareness) or the fact they have non-market benefits, etc.

These options do not have an explicit climate focus, but provide general resilience by improving baseline efficiency or productivity: the logic being that if efficiency levels are higher, then the farmer/community/system will be more resilient to current variability and shocks, as well as future climate change.

As an example, building rural roads will have major benefits to rural communities, which will include greater resilience against current climate variability and extremes (e.g. by providing access to markets, enabling access in the event of disasters, etc.). However, these are not specific interventions that target climate variability or future climate change, and thus there are important issues of whether they are adaptation (i.e. additionality). As a consequence, many commentators do not consider they should be labelled as adaptation, i.e. they are development options, and should really be funded under ODA, rather than adaptation budgets. However, most LDC national climate change strategies include some of these types of interventions, so they are included here for completeness.

This category is extremely broad in nature. Typical examples that are frequently cited in the context of adaptation are:

- Farm-level management, e.g. enhanced management, inputs, technology, access to finance, etc.
- Rural roads (noting that this relates to building new roads: making rural roads more resilient to climate extremes, now and in the future, would fall under in the categories below).

These options are generally focused on concrete actions, e.g. major programme and project implementation. Benefits are associated with current activities and arise immediately.

In many cases, the analysis of options can be undertaken using existing methods (e.g. cost-benefit ratios), noting that in cases where this involves non-market sectors or elements, this is more challenging. However, some studies (e.g. Cartwright et al, 2013) highlight that in the context of adaptation, traditional cost-benefit analysis does not capture inequality and the most vulnerable, as it focuses on more valuable assets and groups. Furthermore, conventional CBA focuses on projects for which costs and benefits are more easily defined, such as infrastructure projects, location-specific actions and the introduction of technologies, rather than the social, ecological and institutional interventions. Berger and Chambwera (2010) also highlight that discounting often works against longer-term more sustainable options.

A key issue is that due to the overlap with current development, in many cases these options will already be in government or development partner support programmes, and thus there are important issues of assessing baseline levels before considering additional adaptation.

Justification for early adaptation (value for money)

Clearly there is an area that delivers value for money through economic efficiency (effectiveness and efficiency), as options that enhance productivity or improve efficiency tend to have high benefit to cost ratios. Furthermore, these benefits are associated with current activities and arise immediately, thus they score well in terms of discounted present values. In many cases these options are already within DFID development portfolios, and BC ratios for these interventions have been previously assessed and compiled, e.g. through the bi-lateral aid review.

1b) Directly Addressing Current Climate Variability (Climate Resilient Good Development)

The next category is the primary area of focus for early no- and low-regrets adaptation action. It is focused on addressing the impacts and economic costs of current climate variability and extreme events, i.e. on reducing the current adaptation deficit. This also involves many existing development options, but the key difference (to 1a above) is that these interventions are explicitly targeted at climate related vulnerability. They can therefore be considered as *climate-resilient good development*.

Targeting these existing climate related impacts provides economic benefits today, and also builds resilience to future climate change. As above, this tends to focus on options that have positive social net present values, i.e. which are good to do anyway, but which for various reasons, are not already in place. Typical examples include:

- Sustainable agricultural management (soil and water conservation). In recent years this has been re-labelled as climate smart agriculture, but includes options that have been advanced for many years, such as soil management (e.g. erosion control), conservation agriculture, agroforestry, rain-water harvesting, etc. These options help address climate variability risks to rain-fed agriculture, e.g. by reducing the effects of soil erosion, or increasing moisture content and thus increasing productivity. These options also have environmental benefits, including reduced greenhouse gas emissions.

- Disaster risk reduction/disaster risk management. There is an obvious overlap between DRM and adaptation, and thus an early focus is preventative action to reduce the impacts of climate-related hazards, i.e. floods, droughts, wind-storms, storm-surge, etc. This includes a focus on DRM options such as early warning systems. However, some of the options that typically fall within DRM may actually be high-regret (e.g. certain types of infrastructure) in the context of a changing climate.

A key difference to the good development options (above) is that options that target climate variability and extreme events are very site and context specific, i.e. they vary with the baseline risks in a country and even local conditions such as local river catchments, highland versus lowland rain-fed agriculture, etc.

As a result, these adaptation options are risk specific, and thus require analysis of baseline risks, and consideration of the transferability of options. Importantly, what might be appropriate (low-regret) in one country or region will not necessarily be appropriate for another.

This links to the information needed to appraise these options, both in relation to current risks and the potential effects of climate change in the future, which can be challenging (see box below). However, there is already existing DFID guidance in many areas, for example the DFID Economists' Guide Chapter on Disaster Risk Reduction or Guidance on Climate Smart Agriculture which provides information on such issues.

Box 7. Issues in assessing climate variability and extremes

For current climate variability, the key issues driving risks include the level of inter-annual variations in rainfall level, the timing of the onset of rains, rainfall during key periods (e.g. crop maturation), the frequency and intensity of heavy precipitation events or dry spell duration, etc. These are typically more difficult to assess, even for current climate variability. They are also much more challenging for future climate change, and it is often difficult to get information on these risks from climate models, and any results that are provided have high uncertainty.

For the analysis of extreme events, e.g. droughts and floods, there are similar challenges. Most current risk assessments build up historic information on extreme events, looking at the probability of events, and building probability loss-damage curves. This requires considerable resources and expertise. In many cases data are not available, thus simplified approaches are needed.

Finally, many of these natural hazards, e.g. major floods or droughts have indirect consequences, and they are thus cross-cutting in nature. This makes the full analysis of risks involved, and for some risks (e.g. droughts), impacts are dependent on complex causal chains that are dictated by meteorology, hydrology, local vulnerability, socio-economic conditions and multiple factors.

In the context of future climate change, it is highlighted that historic climate data (e.g. the historical probability of extreme events) is not a good predictor for the future, because of the influence of climate change on the frequency and intensity of events. This means that the implementation of technical options (e.g. defence infrastructure) using conventional approaches may sometimes lead to mal-adaptation (high cost or capital intensive projects that are targeting existing risks may not be low regret due to future climate change and uncertainty, or at least may be high-regret in some cases).

While the benefits of these options are associated with current activities and arise immediately, many early options will also provide enhanced benefits in the future, under conditions of a changing climate. As highlighted previously, the analysis of these future benefits is more complex, due to uncertainty, and there is a need to make sure that current actions do not increase vulnerability or risk in the future.

Because of this uncertainty, the most promising low-regret options in this category are often focused on non-technical, ecosystem-based, or community-based activities. This uncertainty also means that structural or engineered adaptation, e.g. major flood protection or water storage projects are <u>not</u> considered low-regret, at least in all contexts. For these options, which involve longer time-frames, there is a need consider the effects of future climate change, to consider potential changes and avoid mal-adaptation.

In some cases, it is possible to assess some options using conventional appraisal methods, e.g. cost-benefit analysis. However, in many cases these options involve non-market benefits, e.g. the health benefits of DRM, the ancillary environmental benefits of sustainable agriculture. They may therefore require other techniques, e.g. cost-effectiveness analysis or multi-criteria analysis.

While, this category of options is considered to be one of the main areas of focus for early adaptation, there is often an overlap with current development programmes, e.g. agricultural development or DRR activities. Indeed, in many cases, these options will already be in government or development partner support programmes. An example is highlighted from a recent case study in Ethiopia in the Box.

Box 8. Are promising options already in the baseline?

The Ethiopian Climate Resilient Strategy for Agriculture (see earlier case study) identified the current risks of climate variability and future possible impacts from climate change.
On the basis of this analysis, it short-listed 41 promising adaptation options, through a process of analysis, multi-attribute assessment, expert elicitation and stakeholder consultation.

The study also undertook a policy review, coupled with an investment and financial flow analysis, mapping existing programmatic activities and budgets in the Ministry of Agriculture.
The analysis revealed there was a substantial overlap between activities currently financed under the Federal MoA budget and the 41 promising resilience (adaptation) options identified.

The analysis indicated that over the period 2007-2013, approximately 63% of the MoA budget was planned for resilience-oriented activities, and around 38 of the 41 priority options identified were already included in various plans or programmes (though some gaps were also noted).

This highlights an extremely important point: an adaptation programme that focuses on the existing adaptation deficit needs to undertake detailed baseline analysis, to assess what options are already included, and where additional options or scale-up of existing options is needed.

Justification for early adaptation (value for money)

Again this is an area that delivers value for money through economic efficiency (effectiveness and efficiency), as these options reduce the current impacts and economic costs of climate variability.

As these benefits are associated with current activities and arise immediately, they score well in terms of discounted present values. As an example, a recent review (Mechler 2012) reports that the benefits of investing in DRM outweigh the costs of doing so --- on average, by about four times the cost in terms of avoided and reduced losses (with BCs of 5:1 for floods, 4:1 for windstorms). Similar most reviews of climate smart agriculture report high BCrs. However, in many cases these benefits are dependent on the valuation of health or environmental benefits (non-market sectors), and there can sometimes be important opportunity or transaction costs that need to be factored into the analysis.

1c) Building Capacity

One type of option that is commonly reported as being low-regret and highlighted in nearly all adaptation plans is capacity building.

Capacity building is a broad term (UKCIP, 2008) that involves: gathering and sharing information, i.e. undertaking research, collecting and monitoring data, and raising awareness through education and training initiatives; creating a supportive institutional framework that might involve changing standards, legislation, and best practice guidance, and developing appropriate policies, plans and strategies; and creating supportive social structures, such as changing internal organisational systems, developing personnel, providing the resources to deliver the adaptation actions, and working in partnership. Typical examples include:

- Strengthening of meteorological and climate forecasting/projections.
- Enhanced monitoring (e.g. physical measurements such as hydrological flows, human disease burden, agricultural pests and disease, etc.).
- Vulnerability or risk analysis and mapping.
- Climate information, knowledge and dissemination (including portals) and services.
- Climate research programmes.
- Training.
- Awareness raising programmes (on risks or adaptation options).
- New (climate) institutional arrangements or institutional strengthening, etc.

Capacity building is an important precursor or complement to successful adaptation, providing the necessary architecture to enable current and future decision making, providing the necessary baseline information to assess current and future benefits, providing critical early actions to allow later options, etc. It is therefore highly relevant as part of a portfolio of measures, providing enhanced information for current (or future) decisions, providing information to raise awareness, strengthening relevant institutions involved in climate change, etc. It therefore has strong overlaps with other areas, either as part of complementary responses (i.e. investing in seasonal forecasting capability to improve early warning systems) or as part of the evidence base for addressing future climate change (see later).

Following from this, the literature reports that interventions to address the adaptation deficit (1a and 1b above) are more effective when implemented in combination with capacity building. As an example, a portfolio of improved seeds, soil and water conservation, better extension services and improved climate information, was found to be most effective in enhancing agricultural production in climate vulnerable areas of Ethiopia (Di Falco and Veronesi 2012). This highlights that successful adaptation will involve a combination of outcome and process based adaptation (technical and socio-institutional interventions).

Justification for early adaptation (value for money)

These capacity building options are generally low cost to implement, although there are sometimes capital costs associated with equipment (e.g. monitoring stations).

They provide high benefits, which can arise immediately, though these are less direct that the categories above. These benefits arise from <u>providing the information base and enabling environment</u> to improve the effectiveness and efficiency (VfM) of adaptation options (as in 1a and 1b). However, these benefits are often qualitative or non-technical in nature, which makes their analysis more challenging, especially for outcome-based indictors (hence the frequent use of process-based indicators).

Nonetheless, it is possible to assess the benefits of these options, and to demonstrate the justification for them, through the <u>value of information</u> that they provide. This is explained in the box below. When these benefits are included, it is clear that capacity building leads to high benefit:cost ratios: as an example, a review of the cost-benefit studies of enhanced climate services (e.g. seasonal forecasts, information for early warning) have been reviewed and found to produce B:C ratios of at least 4:1 (Watkiss and Hunt, 2014) in terms of current benefits.

Box 9. The Value of Information

In economic terms, investment in capacity building can be justified through the value of information, or through the concept of quasi-option value.

Information has a value, as it leads to different actions with learning, and allows higher benefits or lower costs as a result. It is possible to place an economic value on information. To do this, the analysis calculates the value or cost without information, and then compares this to value or cost if learning from this information takes place and action is taken. The difference between these is the economic value of information (VOI) (Teisberg, 2002).

This can be used for assessing the benefits of enhanced information or capacity for decisions or actions today, but it can also be used to improve the decisions for future decisions as well. Indeed, this future concept of VOI has been used in the analysis of alternative climate change mitigation paths, with analysis of the global economic gains from eliminating uncertainty around climate change earlier. In the context of climate change adaptation, better information about future climate change risks is likely to prove beneficial in making decisions on resource allocation for adaptation options. For example, information on changes in temperature and sea-level, or the severity of future droughts, are likely to be important in leveraging resources to manage infrastructure such as sea walls, reservoirs, etc. (Neumann and Price, 2009). This allows more formal economic analysis, as in real options analysis (see later).

While the capacity building benefits in this category are associated with current activities and arise immediately, e.g. from investing in information or capacity today to reduce the adaptation deficit, they also provide benefits for improved future decision on future climate change (see later categories, especially 2b and 3a).

2) Building Resilience to the Future

This set of options seeks to build resilience to future climate change. This set of options relates to activities that enhance resilience in current (or near-term) decision that will be exposed to climate change in the future. This differentiates them from actions focused on the current climate (in 1 above) and for future decisions and future climate (in 3 below). In terms of early value-for-money, this leads to certain types of interventions, rather than resilience building per se. Two particular areas are highlighted.

2a) Low cost options, robustness and flexibility

A common option recommended for early adaptation option is building climate resilience, particularly for near-term decisions that have long life-times, i.e. major development policies, land-use change, infrastructure, urban planning, etc. This is sometimes referred to as 'climate proofing', though this term is not recommended, as it is mis-leading and is unlikely to represent Value for Money (see box).

Box 10. Climate Proofing versus Building/Enhanced Resilience

The term climate-proofing implies actions to protect against all future climate risks, irrespective of costs. This is problematic for two reasons. First, in many cases it is not possible to do this, i.e. to completely climate-proof and there will always be some residual risks. Second, the over-design of infrastructure and programmes to withstand all future risks is an extremely inefficient use of resources, i.e. it will lead to many cases where benefits exceed costs, and climate proofing is not good value for money (i.e. it is more economically efficient to have some level of residual risks). While it is somewhat more complex, the term building resilience is therefore preferable.

The focus is on building resilience against future climate change. While this may sound sensible, the additional marginal costs of building resilience need to be considered against the benefits, especially because.

- The economic lifetime of an investment or policy may be relatively short, at least with respect to the major changes from climate change. A major road resurfacing project may only have a 15 year lifetime, which makes it unnecessary to design it for the climate of 2050.
- Even if a major project or investment is exposed to future climate change, these risks (and thus the benefits of resilience) will occur in the future, and need to be discounted when comparing to the additional costs of investment today. In many cases, even if there are benefits in the future, it may not make economic sense to increase up-front capital investment.
- Due to the uncertainty with future climate change, the benefits of enhanced resilience may only arise under some rather than all futures.

For these reasons, <u>some early resilience building options will represent value-for-money, but many will not</u>.

One potential set of low-regret/value-for-money options are in cases where it is possible to introduce *low cost resilience*, e.g.:

- Introducing higher safety margins in long-lived infrastructure at the design stage or during replacement cycles, in cases where these have zero or low marginal costs, i.e. low-cost overdesign. This might include, for example, designing storm water drainage capacity to cope with higher future water flows than might arise from future climate change.

In general it is more costly to introduce such measures when retrofitting, thus the focus is on new projects or planned replacement cycles, although there can be some exceptions (such as when retrofitting increases efficiency).

This has a strong overlap with the concepts of risk screening and enhanced resilience, i.e. in looking to build resilience in general offices programmes and policies (mainstreaming), as well as in the design of specific adaptation options to address future climate change. It also links closely with the information and capacity (2b) outlined below and the use of risk information, e.g. in siting of infrastructure to reduce risks.

There are also a number of other potentially low-regret/value-for-money options which seek to introduce alternative concepts to *address future climate uncertainty*. A number of options are highlighted:

- One option is to introduce <u>flexibility</u> into the design of infrastructure or policies. As an example, this might involve the use of sea defences that can easily be upgraded in the future with rising sea level (e.g. using soft, ecosystem based options, rather than engineered responses). It can also include flexibility for the future at the design stage, allowing measures or policies to be adjusted later to cope with future climate conditions (e.g. building extra headroom in new developments to allow for further modifications in the future).
- Another set of options is to introduce policies/designs that are more reversible, or to reduce life-times (e.g. of infrastructure) so that future replacement cycles can more easily take account of climate change.

- Finally, an alternative approach is to design development strategies or options to perform well (though not necessarily optimally) over a wide range of future climate conditions, often termed robustness.

However, there are usually additional costs in building in flexibility or robustness, and the benefits therefore need to be traded off against the benefits these deliver. For these reasons, these types of low-regret/value-for-money areas of focus will be on:

- Critical infrastructure (e.g. hospitals, water and sanitation plants) or critical nodes (e.g. bridges in the road network), as the loss of these has high direct and indirect costs, and/or involve high costs to replace/repair.
- Long-lived infrastructure that will be expensive to retrofit later. This will potentially include major projects/capital investments such as water storage projects, port facilities, hydro-electric plants, etc. where future climate change may affect not just the assets but future operational performance.
- Irreversible decisions (e.g. land-use change, urban plans).

rather than as a general approach for use in all policies, programmes and plans.

Additional information on the concepts of decision making under uncertainty are provided in the DFID Topic Guide on Uncertainty. Some relevant information on robustness and flexibility, and the Topic Guide, is included in the box.

Box 11. Robustness, Flexibility and Adaptation Decision Making under Uncertainty

Robustness. Robust options (in the climate change literature) are those which perform well over a wide range of future climate scenarios, rather than performing optimally for one single or central future[3]. While some robust options will meet the definition of low-regrets, not all robust options are no- or low-regret options, and their main advantage is that they provide a better hedge to take account of future uncertainty.

There are new decision support tools which can help to identify robust options, notably robust decision making, a decision support tool that aims to help take robust or resilient decisions today, despite imperfect and uncertain information about the future. This approach is premised on robustness rather than economic optimality, and in that case a robust option may offer better value-for-money than one that is not.

Flexibility. Flexible options are those that allow more effective responses in the future through their flexible design[4]. These allow options to be amended, upgraded or altered through learning. An example would be for upgradeable dykes or barriers that allow increases in future heights (for example, with the use of sand dunes and natural vegetation) rather than a one-off irreversible engineered response.

Associated with this are the concepts of learning, the value of information (see earlier) and option values. It is possible to assess flexibility, learning and future option value in economic terms through the use of real options analysis. ROA is an economic decision support tool that quantifies the investment risk associated with uncertain future outcomes. The approach can be

[3] Note that this notion of climate robustness differs slightly from that used in statistical analysis, where robust statistics are statistics that perform well for data drawn from a wide range of probability distributions. Perhaps the best-known example of this concept is that of the median which is a robust measure of the central tendency, (average), given alternative distributions. This contrasts with the mean that is a poor measure of central tendency, given its susceptibility to influence from e.g. outliers in a distribution.

[4] The definition of flexibility used in the climate literature differs to its usual use in economics where the flexibility of markets – and specifically the ability for prices and quantities to adjust between equilibria – is important.

used to consider the value of flexibility, e.g. over the timing of a capital investment, or to adjust the investment as it progresses over time with new information (learning). ROA has been cited as a possible decision tool for adaptation, including in UK's HMT supplementary guidance on adaptation, but in practice it is technically complex and resource intensive to apply.

Topic Guide: Adaptation Decision Making under Uncertainty

The purpose of the Topic Guide: Adaptation Decision Making under Uncertainty is to stimulate thinking about how climate change may alter the long-term outcomes of development interventions today and how they can be better designed from the outset to have outcomes that enhance climate resilience and are themselves robust and adaptable to long-term stresses, like climate change.

The topic guide offers an overview of the latest thinking on how to manage the changing and uncertain climate in development decisions today. The key premise is that climate change will affect the long-term outcomes of many development interventions. Indeed, interventions that are beneficial today may prove to be damaging in the long-term if they do not take account of climate change. This gives a strong rationale for ensuring that programmes and projects are robust and adaptable to climate change. Importantly, climate change and its uncertainties should not be an after-thought in development interventions – they must be addressed from the outset of the process and throughout the project cycle.

The specific challenge addressed in this topic guide is that the future climate is deeply uncertain. This is not just a scientific issue – it has real implications for DFID. If uncertainty is not tackled properly from the outset today, there is a significant risk of taking not enough, too much or the wrong types of interventions. This could mean a lower value for money of investments, or in extreme cases, wasted investments or adverse outcomes.

The central message from this topic guide is that accounting for the changing and uncertain climate need not be complicated and should not paralyse action. This topic guide introduces a range of concepts and tools for dealing with the changing and uncertain climate in designing and implementing development interventions – many are suitable for all development professionals, but in the final Chapter, we also include a set of more involved methods for those interested in quantitative options appraisal.

The topic guide begins with a brief introduction to the main issues concerning climate change adaptation and climate-resilient development from a DFID perspective. Section II then introduces climate uncertainty and explains where this is important in development interventions, giving a number of case study examples. Sections III and IV then consider what practical steps development professionals can take to address the changing and uncertain nature of climate in their work. The first part discusses the design and implementation of policies and programmes that are robust to uncertainty. The second part focuses on more technical issues for quantitative options appraisal.

Justification for early adaptation (value for money)

The justification for early adaptation – and value for money – is more complex in relation to future resilience, and involves real trade-offs between the level of action and the benefits that are realised.

Enhanced resilience offers potential benefits through the protection of assets or policies to future change - either in terms of the protection of asset/investment in itself to future damage from climate change - or the performance of the policy or asset over its intended lifetime (and thus the delivery of the stream of anticipated benefits). However, as highlighted in the text above, these future (discounted) benefits need to be considered against the additional costs today. For this reason, the focus of early value-for-money is likely to be in the cases where low-cost over design is possible, or when investing in critical infrastructure or irreversible decisions.

In the context of flexibility, the primary benefits are linked to the value of information (from learning) and the ability to better resolve future uncertainty. In value-for-money terms, the primary focus is likely to be on large, irreversible up-front capital investments, where there is an opportunity cost of waiting (e.g. where there is a large existing adaptation deficit or a loss of revenue from delaying a project or policy).

Finally, for robustness, the primary benefits are through enhanced performance (and the delivery of more certain benefits) in the context of future climate change uncertainty, i.e. the potential to deliver higher present values across a range of futures, rather than an optimal response to one central future. Again, this will have highest application – in VfM terms – for major or irreversible decisions with long-life times.

2b) Information and capacity

A closely related option, though separated because of the nature of the benefits, is around *information and capacity* to build resilience or reduce future risks.

This particularly relates to adaptation options that build information that can be used in near-term decisions to take account of future climate change. Examples include:

- Risk/hazard mapping and the use of this information in siting infrastructure or land-use planning to reduce exposure to the future risks of climate change. This might use information (risk maps) to inform set-back zones in low lying coastal areas at risk of future sea-level rise (climate risk screening).

- It might also include the use of similar information to raise awareness for individuals to change decisions, or to change regulations or standards to reflect future impacts.

Note that this also needs to include the investment in capacity and communication/ dissemination of this information, to ensure it reaches those end-users who can derive benefits from it.

Justification for early adaptation (value for money)

The main benefits of investing in information and capacity to improve near-term decisions to address future climate change are through the value of information (see earlier). As an example, risk mapping has the potential to provide information to reduce future property damage (e.g. from flooding associated with climate change). It also helps people to make decisions on where to live and what prevention measures to take (World Bank, 2011).

Investing in information and supporting capacity has potentially high benefit:cost ratios, and as it generally involves low costs, it is a low-regret option.

However, while the generation of information (e.g. risk maps) are low cost, the implementation of these in decisions such as land-use policy has a more complex balance of costs and benefits.

For example, the use of this information in land-use planning produces benefits of considerable value, but the cost of producing these benefits is high also. As an example, set-back zones or land-use constraints are likely to lead to high opportunity costs, e.g. from the foregone opportunity of the use of the land. This may be a particular issue if large areas are included or high protection levels are put in place (against risks that may or may not occur). Similarly, options that seek to increase standards (e.g. building codes) will involve increase costs (generally speaking) and there is therefore the issue of discounted and uncertain future benefits, and the level of protection (or over-protection) included. For this reason, while producing this information is a value-for-money option, the subsequent use of it will require a much more considered analysis.

3) Early Action for Addressing Future Challenges

This final category of adaptation sits within the final part of the iterative framework, in relation to the long-term risks of climate change. These have to address the high uncertainty involved.

3a) Iterative Adaptation Pathways

This category of action focuses on longer-term challenges, i.e. on future decisions to address future climate change. While these major events happen in the future, postponing adaptation may not be sensible if future impacts are potentially large or even catastrophic, irreversible, or if adaptation responses have a long lead-time.

The value-for-money focus is not on identifying large-scale interventions today, but instead on early low-regret / value-for-money options that are a priority for early adaptation, i.e. to start preparing for these future challenges. These involve iterative plans to take account of uncertainty, with early monitoring and pilots, to ensure future options are kept open and lock-in is avoided.

These approaches are often known as adaptive management**,** though the term adaptation pathways is also becoming widely used (Downing, 2012). The approach was recently recommended in the IPCC Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) (IPCC, 2012) and the IPCC 5th Assessment Report, which used the term iterative climate risk management.

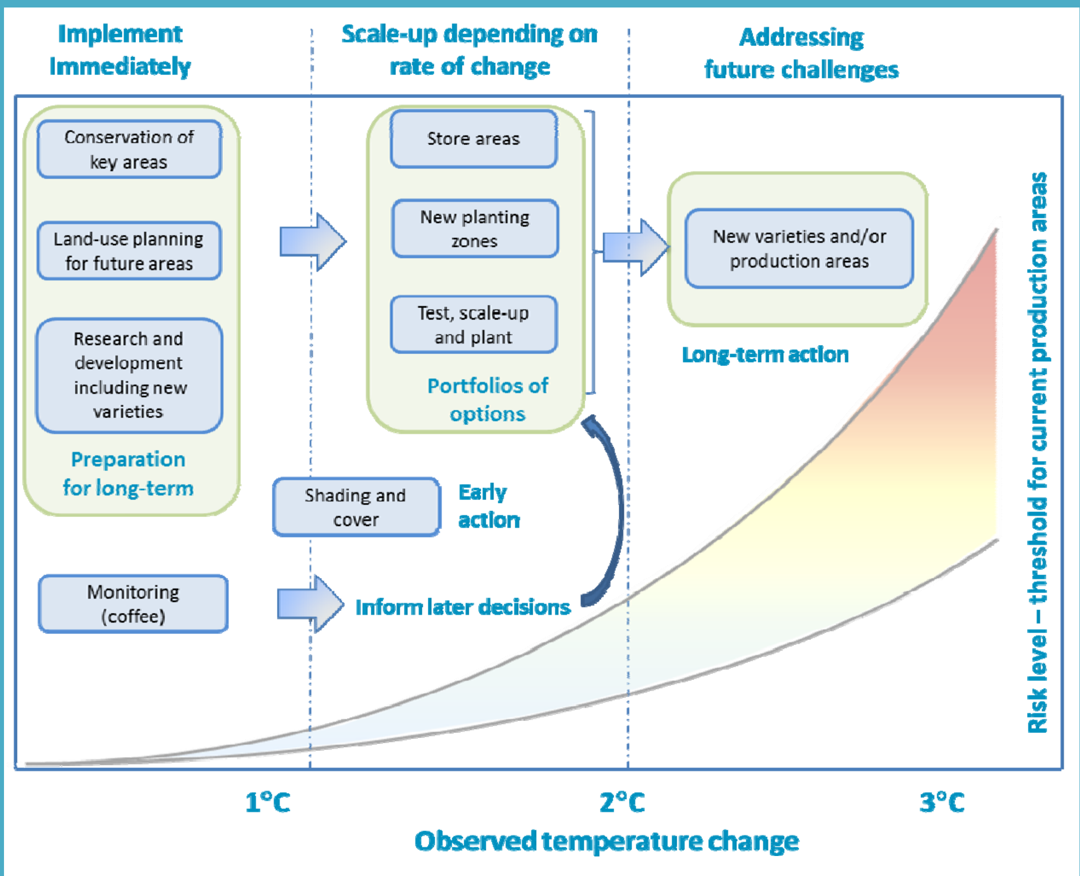
Adaptive management is an established approach that uses a monitoring, research, evaluation and learning process to improve future (management) strategies. In the adaptation context, the approach identifies possible future risk or impact thresholds associated with major future climate change. It then assesses options (or portfolios of options) that can respond. This may start with early measures (e.g. to address current climate variability) and then progress to more major (and expensive) interventions. Importantly indicators are identified to allow the monitoring of risks over time, and provide the cycle of evaluation and learning to update plans in the future. The focus is on the management of uncertainty over time, allowing adaptation to develop within a process of learning and iteration. The results of these iterative assessments are often presented as pathways or route maps. While most applications have been at the project level, notably for sea level rise (e.g. Thames Estuary 2100 project, EA, 2009), there are now examples emerging of more strategic or even national level plans (see the box below for an example from Ethiopia).

The advantage of this approach is that rather than taking an irreversible decision now about the 'best' adaptation option – and investing in an option which may or may not be needed depending on the level of climate change that arises - it encourages decision makers to adjust plans over time as the evidence emerges (Reeder and Ranger, 2011), such that that options can be brought forward– or delayed to a later time period – depending on how climate change actually evolves.

Box 12. An iterative example: Future Climate Risks to Ethiopian Coffee Production

An example is taken from the Ethiopia Climate Resilience Strategy, with an work-stream on coffee. Coffee dominates Ethiopian exports and future sector development is a major part of the country growth plans. However, research shows the current variety of export coffee (Arabica) could be affected if temperatures increase significantly from today, shifting many current coffee production areas out of their optimal range, and reducing quality and yield, potentially dramatically. The problem is that it is not clear if or when this might happen, and major impacts could start to in the next few decades or in the longer-term i.e. after 2060, according to whether temperature increases are at the higher or lower range of the model projections.

The iterative approach recognizes this could be a major challenge, but also that there is high uncertainty. In response, it planned a number of short- and long-term responses, which are inter-linked. There is an immediate need to develop a monitoring, awareness and capacity building programme, which is currently missing, and will provide the evidence and early signs of changes in yield and quality. A second set of early responses is to investigate and promote early adaptation options, which can help current plantations, such as the use of shade trees. Finally, a third set of actions is needed to start planning for major future temperature rises, which includes a number of options, (i) to develop an R&D program to develop or adopt new strains of Arabica that are resilient to the potential increase in temperatures – noting this would take up to 25 years (i.e. there is not time to wait for climate change to occur before starting this strategy) (ii) to identify potential new areas for production under future climate envelopes, and investigate the potential for production shifts. These options can be rolled out more quickly if temperature increases are rapid, or yield quality starts to fall, but if the rise is slower, then lower cost options should be sufficient.



As these iterative adaptation pathways tend to be aligned to specific sectors or risks, there is a large variation in the possible options. However, typical examples of low-regret/early value for money action in these pathways include:

- The development of the iterative risk plans, to identify major risks and develop response plans and early actions.

- Enhanced monitoring, climate information and early research. These are linked to the iterative plans, and are designed to provide information or to pilot early promising options. For example, they might be associated with tide gauge or sea surface temperature monitoring, to start tracking coastal changes, or they might be focused on pest and disease surveillance or forest health to look at early signs of a changing climate.

Justification for early adaptation (value for money)

It is highlighted that the early actions in this category are unlikely to be large-scale investment (though these may come later) and low-regret options will be focused on information and some early actions to target the current adaptation deficit. They are therefore low cost.

The benefits of these plans are mostly focused on the future, and they do not generally generate immediate outcome-based benefits. Their main benefit is the value of information produced (see earlier box), noting there are formal economic techniques that can help identify and value this information. These early steps can also be seen from a risk or insurance based perspective.

3b) Transformation

The final category is transformation or transformative adaptation. This term is not well defined in practical terms[5], but relates to long-term major, irreversible or systemic risks (structural/societal/economic), which are beyond the limits of conventional adaptation. These may require major long-term economic or societal transformation (e.g. major population shifts, major livelihood shifts).

Justification for early adaptation (value for money)

It is stressed that transformative adaptation is not an early value-for-money or low-regret priority today. However, there may be an early low-regret option to start developing the transformative vision - and identifying potential incremental steps towards this - when there are possible limits to adaptation in the long-term.

To illustrate, short-term adaptation may sustain current livelihoods or patterns of development in locations that will be unsustainable in the long-term e.g. due to the exceedance of major bio-physical, societal or economic thresholds. In such a case, the early value-for-money option will be to identify these risks, along with a long-term vision of what transformational change might look like. It will also identify any short-term actions that prevent future lock-in, and identify the intermediate (incremental) steps towards the long-term vision, taking account of uncertainty.

[5] The IPCC AR5 defines transformation as *a change in the fundamental attributes of natural and human systems. Transformation could reflect strengthened, altered, or aligned paradigms, goals, or values towards promoting adaptation for sustainable development, including poverty reduction.*

STEP 4

Initial Prioritisation of Early Adaptation Options

Key Messages in this Section

- This section provides information to help in the initial prioritisation (short-listing) of early VfM adaptation portfolios, i.e. for national or sector strategy.
- It outlines specific early interventions which are likely to deliver value-for-money, against key climate risks.
- It provides case study examples of how this approach can be used for prioritisation of adaptation national and sectoral planning.

Introduction

The previous section provided a typology and examples of early VfM options, aligned to the iterative framework. This chapter focuses down on the selection and initial prioritisation (short-listing) of early VfM adaptation, focusing on more practical elements. It presents the findings from detailed review of adaptation options, which identifies promising adaptation options which are likely to deliver VfM. Finally, it provides case study examples of the application of this approach in strategic (national and sector) adaptation planning.

Risk-based Prioritisation

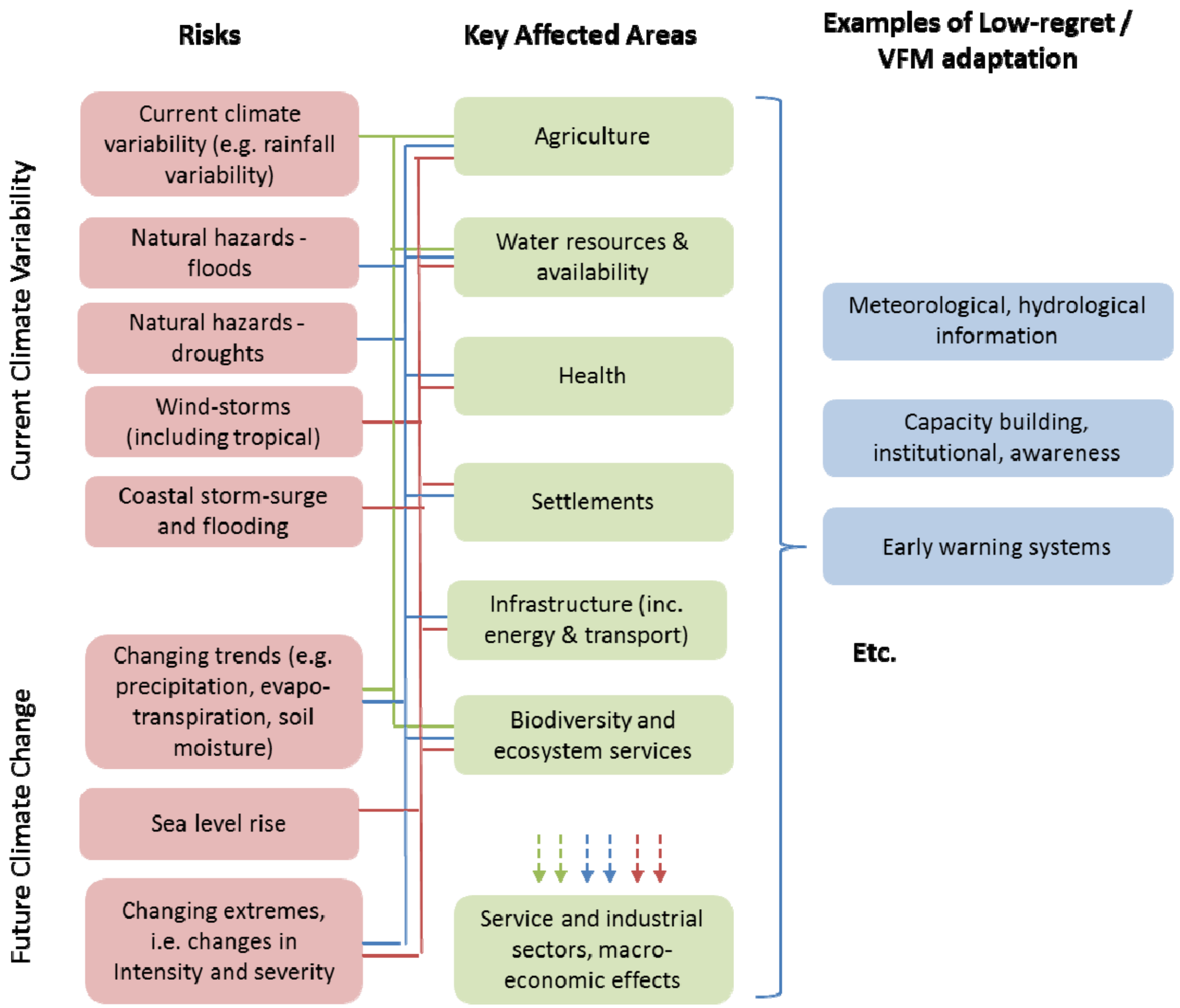
Step 1 of this toolkit outlined the identification of relevant information on climate change risk, vulnerability and impacts, focusing on an iterative approach. This was based around the potential risks of current climate variability (today) and the future potential impacts of climate change, noting uncertainty.

In turn, these changes will lead through to a number of potential risks to sectors/activities, noting climate risks often affect multiple sectors, as shown in the Figure below. This means there is the potential to frame adaptation from a cross-sectoral risk perspective, as well as at the sector level.

This step of the toolkit provides some initial information for early prioritisation and short-listing of adaptation options, drawing on a review which has identified promising early low regret options which are likely to deliver value for money. It focuses on the initial short-listing of options, which might be taken as part of a national or sectoral strategy, i.e. to start to prioritise out promising areas of adaptation, for subsequent detailed appraisal.

To do this, it focuses on a number of key cross-cutting risks, coving variability and trends, extreme events, and the coastal areas and sea-level rise, noting that there are strong linkages between these. It then reports on the findings of a review of promising options, highlighting the list of options that are likely to be early priorities. This focuses on portfolios of options that align with the iterative framework.

Figure 12. Illustration of Prioritisation Framework



While the information presented is general, it should help in the early selection of priority areas. The information is split into three main areas, addressing climate variability, extreme events, and coastal/sea-level rise.

Strategic Priority VfM Adaptation for Current Variability and Changing Trends

As highlighted in Step 1, current climate variability is already a major impact, affecting agriculture (especially rain-fed) and other water-related sectors. This is mainly due to rainfall variability and extreme events. Future climate change will affect average rainfall trends and patterns of variability, and these will combine with other changes (e.g. temperature, evapo-transpiration) to affect agriculture and other sectors.

In terms of the agriculture, there are a large number of current and future climate risks, acting on a broad range of activities and system boundaries, from farm-production through to overall value chains, and including cereal, cash crops and livestock.

Current impacts include climate variability (temperature and rainfall trends and variability), extremes (droughts, floods, storms), soil erosion (from heavy precipitation), the incidence and prevalence of temperature pests and diseases, etc. Many of these impacts are highly complex, involve multiple factors, and vulnerability is likely to be dominated by socio-economic factors and underlying issues (i.e. climate is only one element of risk).

Similarly, a very large number of different risks have been identified in relation to future climate change, as highlighted in the table below.

Table 1. Potential impacts of climate change on agriculture

Sector	Potential Impacts
Agriculture including cereals, cash crops, etc.	• Productivity changes: potentially positive as well as negative, from CO_2 fertilization, higher temperatures, changes in rainfall and rainfall variability, evapo-transpiration, changes in frequency and intensity of extremes including heavy precipitation and drought, involving many climate variables and impacting on many aspects of crop production, e.g. growth rates, development and flowering, maturity periods, etc. • Changes in length or timing of seasons. • Direct and indirect losses from extremes, e.g. direct loss of crops, damage and disruption to infrastructure. • Changes in pests and diseases (range of species and prevalence/incidence). • Changes in soil erosion (from changes in climate parameters, i.e. wind and water notably heavy precipitation) • Changes in soil conditions, hydrology, fertility and soil and land degradation (including desertification) • Changes across the value chain, effects on farm incomes, commodities, growth etc. and to livelihoods (e.g. health). • Changes in water availability (irrigation, supply and demand balance, etc.)
Livestock including poultry	• Productivity changes from climate variables (temperature, humidity, etc.) affecting animal health, growth, quality, reproduction, value, etc. • Increases in animal mortality, injury, reduced health or increased stress from extreme events (heat, drought, floods) including risks to housed animals (poultry). • Change in water availability. • Change in livestock feed availability / forage crops and feed quality. • Changes in disease and pests (range of species and prevalence/incidence). • Changes across the value chain, effects on farm incomes, commodities, growth etc. and to livelihoods (e.g. health)
Socially contingent	• Changes in suitability and sustainability of current agro-ecological zones, and livelihood zones / livelihoods, such as pastoralists. • Changes to food security, likelihood of famine. • Changes in livelihoods, society, increasing pressure, potential conflict, etc.

Source: Easterling et al, 2007; Strzepek and McCluskey, 2006; Reason et al., 2005; Agoumi, 2003; Dinar et al., 2009 Fischer et al., 2005; Kurukulasuriya and Mendelsohn, 2006; Thornton et al., 2006; Seo and Mendelsohn, 2006; Dinar et al., 2009).

In practice, there are an extremely large number of risks, acting in combination, at multiple levels, from farm level (yields) through to overall value-chains. This can make even the initial prioritisation of adaptation options quite daunting. However, as previous steps outline, it is possible to focus on major risks (which have high social or economic consequences, now or in the future), and to use the iterative framework to break up the problem into manageable pieces, by identifying strategic areas of early VfM adaptation.

As well as effects on agriculture (above), a major impact of current climate variability is on the use of water for other sectors or end-users (public water supply, hydro-electricity generation, manufacturing and industrial consumption and water for ecosystems and the services that they provide), noting this may relate to daily, seasonal annual variability.

These aspects are often framed around the issue of water security[6] and also the water-food-energy nexus.

Future climate change has the potential to impact on all of these, either through changes in trends (e.g. average precipitation trends, with increasing or decreasing trends) or by affecting rainfall variability. This may include daily - seasonal changes in flows or timing of rainfall, changes in evapo-transpiration and other factors affecting run-off, effects of temperature on glacial melt-water flows, as well as changes in extreme events (heavy precipitation, meteorological droughts). Again, as with agriculture, many of the impacts of these changes will be highly complex, involving multiple factors, socio-economic factors, and highly site specific (e.g. basin specific), but there are still early strategic priorities which can be the focus of early adaptation plans.

This section focuses on the low-regret options for addressing climate variability (now and for future climate change). The following section discuss the options for addressing extreme events.

Literature Review on Promising Low-Regret/VfM Adaptation

Agricultural adaptation is one of the more comprehensively assessed areas, and there are estimates of the benefits of adaptation (Agrawala et al, 2011). Most of the available studies have focused on a classical impact-assessment, focusing on irrigation and fertiliser use as a response to future climate change. However, there are a number of studies that consider a broader set of options including the consideration of non-technical and green options.

From a review of the existing literature for this study, a number of types of interventions have been highlighted which tend to be low-regret in nature, and therefore have the potential to deliver value for money in the agricultural sector to address variability and trends. These include

- Enhanced meteorological and hydrological data, information and monitoring;
- Capacity building including institutional strengthening and awareness raising;
- Farm level good development and climate resilience;
- Climate smart agriculture (e.g. conservation agriculture, soil and water conservation, agroforestry);
- Early warning systems (discussed in extreme section later);
- Climate risk screening and mainstreaming climate change into agricultural development and water management plans.
- Risk transfer including insurance;
- Iterative adaptive management.

There are also a number of options where the literature disagrees, i.e. on whether such options represent early value for money or are low regret. These include:

- Farm-level fertiliser use;
- Irrigation;

[6] Water security is defined by UN Water (2013) as: the capacity of a population to safeguard sustainable access to adequate quantities of acceptable quality water for sustaining lively-hoods, human well-being and socio-economic development, for ensuring protection against water borne pollution and water-related disasters, and for preserving eco-systems in a climate of peace and political stability.

Similarly, there are number of low-regret options that are identified for other water related sectors and more general water management in relation to variability. These include many of the options above (e.g. meteorological and hydrological data, institutional strengthening and governance, early warning systems, soil and water conservation, etc.) and also some additional options, which include both structural and non-structural interventions (UNECE, 2009; Wilby and Dessai 2010):

- Water efficiency use and leakage control:
- Integrated water resource management:
- Ecosystem based adaptation for watershed management:
- Enhanced conservation, restoration and protection of ecosystems
- Improved water and sanitation (water quality and health);

While there will be a large number of sector specific options, e.g. in relation to hydro-electricity generation, manufacturing water use, the listing above provides an early focus for strategic low-regret options.

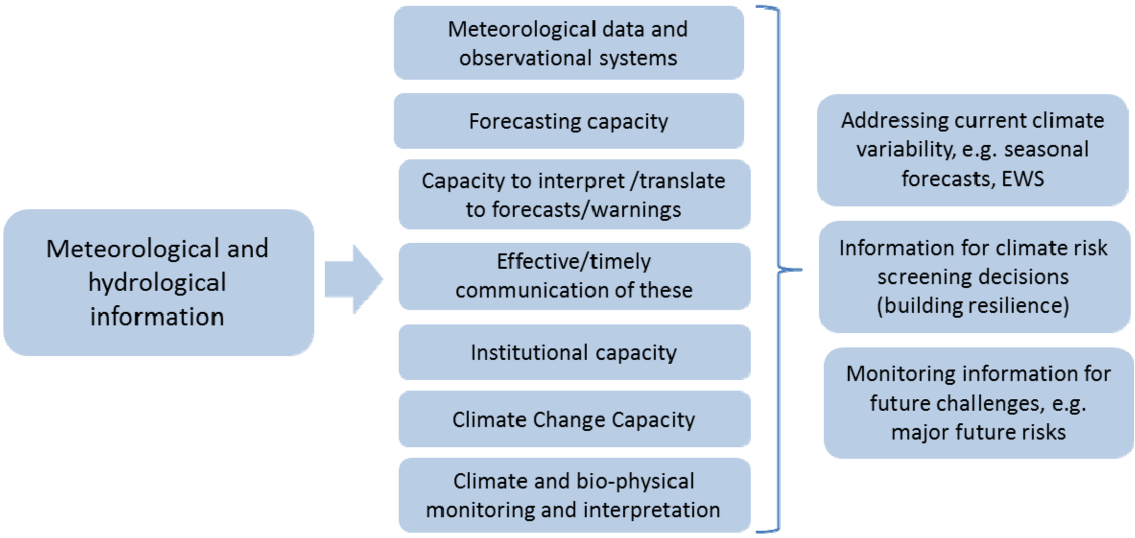
Discussion of Low-Regret Options

A discussion of some of the promising low-regret options is summarised below. More details of individual options are presented in the Appendix.

Meteorological and Hydrological Information and Services

There is a broad set of early low-regret options that are associated with meteorological and hydrological information and services. This includes (see figure) physical monitoring networks (data), but also the use of this information for forecasting (now and with future climate change), the effective communication of this information to end-users, and the institutional capacity to co-ordinate information and responses. In turn, this information and services supports many of the low-regret options in later sections

Figure 13. Meteorological and Hydrological Information/Services



These meteorological and hydrological services (MHS) provide:

- Information (inputs) for other low-regret options, for example, in the form of seasonal forecasts or early warning systems. Improving data availability and subsequent services are low-regret, as they are low cost and help address current climate variability.
- Information and services to help build resilience to current climate variability and future climate change, e.g. in decisions about infrastructure.
- Information for iterative adaptive management frameworks (addressing future climate challenges), which requires enhanced monitoring or climate information in new areas.

In many developing countries, existing meteorological, hydrological or oceanographic data sources and services are inadequate. This can be due to the coverage of quality controlled meteorological or hydrological stations, i.e. the quantity and quality of data, the ability to interpret this information into useful forecast or prediction services (e.g. to generate seasonal forecasts), and the ability to disseminate this information effectively to end-users (i.e. to communicate timely early warnings to the right end-users). It also arises because of the effectiveness of institutional arrangements and the management of information, as well as the communication between organisations (cross-governmental), e.g. from meteorological services to agriculture or disaster risk response).

Improving the quality and access of reliable meteorological and climate data and forecasting – and the dissemination and communication of this to end-users - is therefore key to addressing the existing adaptation deficit, and is a priority for early adaption for future climate change.

Assessing the benefits of these options is more challenging, as they are often qualitative and relate to the value of information generated. However, the review has identified high benefit:cost ratios (ranging from 2 to 40:1).

For agriculture, the main focus is around meteorological and agro-metrological data, the communication of information / seasonal forecasts through to farmers and communities, and the related user orientated extension and communication outreach programmes. There are also linkages to extreme hazards (e.g. floods and droughts) discussed in a later section.

For water users more generally, low regret options include enhanced meteorological and hydrological (including groundwater) data collection, quality control, and dissemination, with better baseline monitoring, and the use of this information in (integrated) water resource management and policy. There are also strong linkages for information for extremes (e.g. flood and drought forecasting) – discussed in a later section.

Capacity building including institutional strengthening and awareness raising

An early low-regret priority is for capacity building. This is a broad term, and includes information gathering and sharing (as above) as well as research, raising awareness and education, training. It also includes institutional strengthening and governance, which includes improvements to research and institutions, building new institutions, and establishing knowledge management, networks, and governance and policy frameworks, as well as the establishment of a supportive institutional framework for adaptation.

Importantly, these capacity building actions often provide the enabling environment, and enhance successful dissemination and uptake of other technical adaptation options. This is particularly important in the agricultural sector, given the large number of small actors, and enhanced human capital is needed for new techniques and technologies. The highly fragmented nature of the agricultural sector - with many poor smallholders - means that information barriers are large (such as on what crops might be good to specialise in, what early adaptation options might work); and there are economies of scale and scope from coordination, with enhanced extension services, farmer to farmer schemes, training, etc. As a result, expanding the mandate of existing institutional structures to include building adaptive capacity may be an effective means of reducing exposure to climate change, as in the case of agricultural extension services (Di Falco et al, 2011). There are also some broader governance issues, such as tenure and secure access to land. While some studies suggest land security makes farmers more likely to take action for adaptation, e.g. Bryan et al, 2009, these issues are very challenging and fall within broader development activities, i.e. climate change adaptation is not the primary driver.

Note that integrated water resource management and risk mapping/integrated land-use management also fall under this category of capacity building, but are discussed separately below.

Farm level climate related good development

Many studies report a large number of potential adaptation options that fall into the general category of good development, i.e. improved farm level management, practice and support. These generally focus on activities that improve productivity or address losses. They include a large number of options that address the problems of small scale subsistence farmers in LDCs, i.e. low levels of technology, limited farm inputs, low access to finance/credit services, lack of income diversification, limited extension services, inadequate transport networks and high transport costs, low market information, lack of information (or access to information), low level of education, and low coping capacity in relation to non-agriculture-related activities. Many of these are not specific to climate change and thus fall generally within agricultural development, rather than climate change, though many of them appear in national climate change strategies. The non-climate related options are not considered here. However, unless these underlying issues are addressed, adaptation will not be as effective, and the potential returns (benefit:cost ratios) for these basic interventions may often be higher than many specific climate related adaptation interventions.

There are, however, some options which have a climate dimension that are more directly relevant. These include (Ranger and Garbett-Shiels 2012: Watkiss et al, 2014):

- Crop switching/planting (agronomic management);
- Livestock resilience;
- Pest and disease management, including post-harvest losses.
- Sustainable agriculture land management and soil and water conservation (see separate section).

An obvious response to current climate variability (as well as future changes) is to introduce different varieties (crop switching) or to change planting dates and systems. This can include the use of different varieties (e.g. less temperature sensitive maize, drought resilient varieties, etc.), different crop mixes (e.g. a switch to cassava which has good resilience against variability) or shifting to short season crops to avoid extremes. However, there is often a general need for better yielding and more disease resistant varieties to increase productivity more generally, and thus there is the potential for no-regret options that enhance yield and improve resilience. As an example, Di Falco et al. (2012) undertook primary survey data on 1000 farms producing cereal crops in the Nile Basin, Ethiopia and found that changing crops increased crop productivity by 13 per cent. Furthermore, new cultivars are generally more responsive to higher input use (such as water and fertilizer) enabling greater increases in production when combined strategies are implemented (though this is not always a given, i.e. some resilient varieties may actually have a yield penalty). This option also links to R&D and crop selection development programmes, as well as protecting indigenous genetic resources.

There are also strong linkages to other options, i.e. portfolios, and these options are often most successful when combined with other measures, notably tree planting and soil conservation. As an example, soil conservation, water harvesting technology and crop switching work best when implemented together (Di Falco et al, 2011). This is critical because improved crop species and varieties cannot deliver their full benefits unless issues of water stress, low soil fertility, pests and diseases, etc. are also addressed.

However, there are important reasons why farmers aren't already adopting these improved varieties/practices: including the lack of information, money, labour, or land. Furthermore, in many cases, improved varieties can be exploited only when integrated in combination with improved agronomic management practices. Therefore the consideration of technical options alone is not sufficient – there is a need to address barriers to enhance the uptake of such options, and increase communication and awareness (linked to capacity building).

For livestock, there are again many underlying issues facing the current sector, which can be extremely complex, particularly for pastoralists. These again range from farm-level actions through to value chains. In terms of the more climate related options, low regret adaptation may include herd diversification (more resilient breeds or combinations of animals) and breeding programmes where these target yield/value improvement and disease resistance, as well as climate resilience. However, the challenges involved in such programmes should not be underestimated, i.e. many breeding selection programs and import of new animals/breeds have failed, due to a combination of practical and socio-institutional issues. Several studies also options to improve fodder and feed, including the enhanced resilience of these inputs as a key element for livestock resilience. There are also a number of studies that highlight rangeland rehabilitation and management as a low regret option.

There are high existing losses from pests and disease in many LDCs – both to crops and to livestock - and addressing these offers the potential to improve current productivity as well as reducing the potential impacts from increased or new risks from climate change, i.e. from changes in the spread, prevalence and incidence of climate sensitive pests/disease. This leads to a set of options around pest and disease management monitoring, surveillance and responses to the spread and development of plant and animal disease, as well as more resilient varieties of crops and livestock (to address current risks). For cereals, a related aspect is the high level of post-harvest losses where actions to reduce current losses increase general resilience and management activities or improved storage facilities are early no-regret options. For livestock, there are strong linkages with disease management more generally, i.e. improved veterinary services, disease prevention and control, policies and capacity building and extension services.

Note that a number of adaptation options that frequently are cited as early priorities, notably fertiliser use and irrigation, are not necessarily low-regret and these are discussed in a separate later section.

Sustainable agricultural land management / Climate smart agriculture

One of the most commonly cited low-regret adaptation options is climate-smart agriculture. Many of these are forms of sustainable agricultural land management (SALM) practices (or just sustainable agriculture) and have been around for many years. These include for example, techniques to improve soil water infiltration and holding capacity, as well as nutrient supply and soil biodiversity. These therefore improve underlying productivity, and in particularly help with climate related risks in the form of rainfall variability and soil erosion from rainfall. Many of these options also address underlying problems of the loss of soil fertility, which leads to decline in soil organic matter content resulting in limited water holding capacity, poor water infiltration rate, limited availability of water and nutrients less resource use efficiency to crop plants.

SALM includes options such as agroforestry, soil and water conservation, reduced or zero tillage, and use of cover crops (McCarthy et al., 2011). These options have the potential for increased productivity and food security, enhanced resilience, reduced carbon emissions. There are many different types of SALM. For the discussion here, we have identified a number of broad categories, each of which has subsequent sub-options.

- Conservation agriculture includes a broad range of options, which minimize soil disturbance. It includes reducing or eliminating tillage using crop rotation (low or no/zero tillage or strip/zonal or ridge tillage), cover crops and using crop residues for mulching and soil cover, which reduces wind and soil erosion, increases water retention, and improves soil structure, thus increasing production, especially against a background of high climate variability. It also reduces GHG emissions and sequesters carbon (e.g. through residues).

- Soil and water conservation (SWC) measures reduce soil erosion and retains moisture (controlling runoff), thus is beneficial for current climate variability and a largely no regret option for future climate change. These include a number of sub-categories:

    - Soil conservation structures, which include bunds (soil and stone), trees, grass strips, contour levelling, and terraces (stone, bench, contour, extreme), shade trees and waterways. These are particularly relevant in upland or highlands, where soil erosion is an issue. These options also enhance soil carbon and are thus a climate smart option.

    - Soil and water farm management, including agronomy and options such as cover crops (planted post-harvest or intercropped), intercrops, improved fallows (legumes) and alley crops, which can improve soil and water conservation characteristics by keeping cropland covered during the entire year (reducing erosion and enhancing moisture), and for some options (legumes) increasing soil fertility. It also includes integrated nutrient and soil management, e.g. with residue and manure crop fertilisation (organic). These soil management options increase soil carbon, and are thus a climate smart option.

    - Water conservation measures, which include tied ridges (in situ water harvesting), rain-water harvesting, small-scale water-harvesting structures such as dams and ponds.

- Agroforestry has the potential to increase organic matter, soil fertility, soil water holding capacity, improve the resilience of the soil and reduce soil erosion. This can include crops or tree-land or trees on crop-land. It also reduces GHG emissions and can provide additional income. It provides many benefits in addressing current climate variability and future climate change.

As well as addressing existing issues of current climate variability, and leading to productivity improvements, these options also build resilience against future climate change. They therefore have an extremely good fit as a potential low-regret option. However, many of these benefits are realised through long-term productivity gains through improved soil structure and the reduction in soil erosion, or wider benefits (e.g. GHG reductions, environmental benefits). They therefore do not tend to perform as well under CBA as some conventional measures, unless these issues are factored in. Two additional issues are important in their consideration.

First, the geographical applicability of SALM options varies, because of different climate risks, thus transferability is important. There are large differences in the most applicable measure for different countries and sites. As an example, Kato et al (2009) found difference in the effectiveness of options between high-rainfall areas and drylands, and even within regions with these areas. Soil management and conservation is important in all areas, but for different risk factors: the risks of water erosion in the highlands, and the wind-blown loss of soil in the drylands. There is also a wide range of costs per hectare between sites, reflecting these differences among regions, agro-ecological conditions, pre-project land uses, and the differences in cost structure of the various types of activities considered (McCarthy et al., 2011).

Second, many of these options have opportunity or policy/transaction costs (McCarthy et al., 2011), e.g. opportunity costs of labour and land, up-front cash outlays. It is important to consider these as in the short run they are an important barrier to adoption, particularly in subsistence economies (who generally have the highest opportunity costs).

Early warning systems

These are discussed in the next section, under extremes.

Water efficiency

An obvious no-regret option to address climate variability is for water efficiency, notably loss reduction. For example, controlling leakages in water pipes is almost always considered a very good investment from a cost–benefit analysis point-of-view, even in absence of climate change (Hallegatte, 2009). Similarly, there are potential low-regret options in the form of water re-use, as well as in relation to demand efficiency and management (e.g. including correct pricing – though this is a much broader issue than adaptation).

Integrated Water Resources Management

Integrated Water Resources Management (IWRM) is a broad term, but has been defined (GWP, 2010) as a process which promotes the coordinated development and management of water, land and related resources, in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems.

It adopts a cross-sectoral policy approach, designed to replace the traditional, fragmented sectoral approach to water resources and management, which can result in unsustainable water resource use. Importantly it looks to ensure a strategic analysis of water resources, including the balance of demand and supply, taking account of the role of ecosystems and ecosystem services (their role in water management, but also their water resource needs such as maintaining environmental flows for rivers), as well as pollution.

IWRM involves a number of components which include enhanced meteorological, hydrological (surface and groundwater) monitoring, institutional and capacity building, information dissemination and awareness raising, strategy and planning (IWRM plans), monitoring and enforcement, which in turn will lead to the enabling environment and implementation for specific options (e.g. water-efficiency improvements). Many of these issues are discussed above, though the key element here is to combine these within an integrated framework. It has also important links to extremes (see next section. Finally, there are close links with water allocation, financing and water pricing.

While IWRM will start at a national (or trans-boundary) level, IWRM plans are usually undertaken at the basin or water catchment level (i.e. with plans for specific river basins), though with consideration of lakes and aquifers. It thus involves a cascade from macro to micro level, from national (or international) aspects down to river basin and even down to local (water management) level.

IWRM is broadly recommended as an early low-regret option, which addresses problems of current climate variability and water management more broadly. By improving water management, and looking towards the supply and demand balance, it also provides greater resilience for future climate change, especially where this includes potential changes in rainfall (decreasing trends or higher variability) and water availability.

It involves many process based activities, with qualitative benefits, as well as providing the enabling environment for better decisions (value of information) and an enforcement regime to ensure those benefits are realised. This makes conventional CBA more challenging, i.e. benefits often involve the value of information. Nonetheless, there are CBA studies (e.g. Mechler, 2005) which report good B/C ratios (e.g. 2.5:1).

Ecosystem Based Adaptation

One of the main interventions associated with addressing current climate variability and future climate change (especially as part of IWRM), and an early low-regret option, is ecosystem based adaptation and upstream watershed management. This includes the conservation (or enhanced conservation) and restoration of wetlands[7] and forests (including afforestation) - noting these schemes can be linked to payment for ecosystem service schemes, and for forestry, to avoided deforestation and afforestation.

These upstream water catchment management options primarily address current climate variability, though these also have potential to increase resilience against future changes in trends and extremes. They have multiple benefits, i.e.:

- Capturing and regulating water flows, i.e. releasing to maintain flows downstream;
- Reducing soil erosion and sedimentation;
- Reducing flood risks from high run-off.

They also address existing problems of habitat degradation or loss (e.g. draining wetlands or deforestation) and thus conserve the wider services that these ecosystems provide (see box). This includes benefits from the provision of food, fibre, material, and broader livelihood generation. Many of these ecosystems also have potential benefits in reducing carbon emissions, e.g. through forest, biota or soil sequestration. These options therefore have high low-regret potential, though while these economic benefits are large, assessing them is challenging as they involve non-market sectors.

It is also highlighted that the costs of ecosystem based management (Naido et al ,2006) involve the direct costs (acquisition costs for land, management costs including establishment and maintenance) but also transaction and opportunity costs (the latter including foregone opportunities for land and all user groups). As a result, the costs of schemes may be higher than anticipated, though lower than hard (construction-orientated) measures, and they have much broader benefits, and it is important to consider these issues otherwise this may affect scheme success. There are also additional activities associated with governance/enforcement, which are essential for the success of these schemes. There is therefore a need to ensure community based adaptation (e.g. community based forestry)

[7] Wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

or measures to ensure areas are maintained, which involve governance and socio-institutional elements.

Additional discussion of natural flood plain management, sustainable urban water management and coastal ecosystem based adaptation, are included in later sections.

Box 13. Ecosystem Services and Ecosystem Based Adaptation

Ecosystem services. Ecosystems provide many benefits to society, which in turn have multiple economic benefits that are rarely captured by markets. These are known as 'ecosystem services'. These 'ecosystem services' can be divided into:

- Provisioning (e.g. agriculture, fisheries, timber, water),
- Supporting (soil formation, nutrient recycling),
- Regulating (climate regulation, flood protection, water quality regulation),
- Cultural services (recreational, educational and cultural benefits).

They play a key role in local livelihoods as well as broader development, and the loss of ecosystems and their services can have high economic costs and affect the achievement of development goals. However, as traditional economic models and analysis ignore these benefits, the economic, social and environmental benefits and services that natural resources provide are generally undervalued and overlooked in policy making.

Ecosystem Based Adaptation. There is now a move to combine the principles of adaptation and the consideration of ecosystem services under the concept of Ecosystem-based Adaptation (EbA). This relates to the management of ecosystems within interlinked social-ecological systems. The aim is to enhance ecological processes and services that are essential for resilience to multiple pressures, including climate change. EbA therefore integrates the management of ecosystems and biodiversity into an overall strategy to help people and ecosystems adapt to the adverse impacts of global change, such as population pressures or changing climate conditions. An optimal overall ecosystem-based strategy will seek to maintain ecological functions at the landscape scale in combination with multi-functional land uses and multi-scale benefits. At the core is the recognition of dynamic interactions and feedbacks between human and ecological systems and the need to understand these to enhance benefits, and to ensure sustainable management of natural resources. One of the major themes is to manage ecosystems as part of a larger landscape, of which human activities are a part. This involves multiple land-use and conservation of natural capital, to provide the flexibility to allow the ecological and social systems to adapt to many stresses, including climate change.

Improved Water and Sanitation (Health)

Numerous studies have highlighted the high existing impacts and economic costs of climate variability on health (McMichael et al, 2004) especially from water-borne disease. This includes a range of diseases, noting these may be associated with floods (from contamination of water) and droughts (from switching to contaminated water). These existing impacts have the potential to increase with future climate change due to changes in water availability (ODI, 2014) including from decreased rainfall and water availability, increased flood or drought extremes, and changes in disease prevalence or incidence, e.g. due to temperature increases: as a result, some studies project large increases in future impacts and economic costs (Ebi, 2008: Markandya and Chiabai, 2009).

These studies also highlight there are no-regret options to address these current and future water-related health risks, centred on existing public health options, e.g. low cost prevention, enhanced surveillance. Many of these options centre on improved water, sewerage and sanitation (WSS) / Water, Sanitation and Hygiene (WASH) options. As an example, Ebi (2008) identified the main low-regret options for water-borne disease as improvement of water supply and sanitation, and treating diarrhoeal diseases in children through breastfeeding promotion, rotavirus immunization, cholera immunization, and measles immunization.

In the health domain, an early low-regret option is therefore for enhanced WASH options, as these will address existing water related issues and build resilience to future climate change.

There are a number of studies that report high benefit: cost ratios from improved WASH (see Hunt, 2011 for a review). These studies also report that availability of finance is the limiting factor in determining investment. As an example, Hutton et al (2007) assessed the benefits of achieving the water MDG by 2015, with universal basic access to water supply and sanitation; universal basic access plus water purification at point-of-use; regulated piped water supply and sewer connection. He found all of these were cost-beneficial, with BC ratios of 5 to 46 in developing regions.

In practice there are a range of options for delivering enhanced water supply: and these individual options need to be assessed, especially given the site and context specificity (e.g. boreholes vs rainwater harvesting, etc. types of pumps, whether filters are included, combined interventions of boreholes and vaccinations, etc.). ODI (2014) summarises a number of the potential options and available literature.

However, there are some issues as most studies omit wider health service provision and health infrastructure costs, and again there are often policy or transaction costs associated with setting up and running programmes which can be significant.

Enhanced public health and surveillance for vector borne disease

Alongside water-borne disease, previous studies of the health impacts of climate change (McMichael et al, 2004) identify mal-nutrition and vector borne diseases, noting these also are relevant in terms of current climate variability.

The issue of mal-nutrition is strongly linked to agriculture – though (Ebi, 2008) identify breastfeeding promotion, child survival programs (with a nutritional component), nutritional programs, and growth monitoring and counselling as additional low cost measures.

The other main issue identified is vector borne disease, notably malaria, which has links to climate through prevalence ranges and linkages to water. Again, low cost, low-regret options are identified, which build on existing public health programmes, such as (Ebi, 2008) insecticide-treated bed-nets plus case management plus intermittent presumptive treatment in pregnancy; and indoor residual spraying. With respect to future climate change, a key issue is the enhanced monitoring of disease, so that changes in geographical area of the disease (including at higher elevation in existing areas) are identified. It is highlighted that there are a large number of climate sensitive diseases which could be affected by climate change (see Smith et al, 2014), though again these can be addressed by improved monitoring and surveillance and building on existing public health programmes.

Risk transfer including insurance;

These are discussed in the next section, under extremes.

Low-cost over-design and flexibility

These are primarily discussed in the next section. In summary, there may be adaptation measures for which the costs are relatively low and where the benefits, although mainly delivered under future climate change, may be relatively large. For example, constructing drainage systems with a higher capacity than required by current climatic conditions often has limited additional costs, but can help to cope with increased run-off as a result of expected climate change impacts;

Similarly, there may be potential for more flexible adaptation options – measures which are designed with the capacity to be modified at a future date as climate changes. Influencing the design of a reservoir so that its capacity can be increased at a future date, if necessary, would be an example of flexible adaptation.

Climate risk screening

Another options that has low-regret characteristics, is the use of climate risk screening in project and policy development.

The application of climate risk screening into project portfolios, e.g. for infrastructure, is relatively well advanced, at least in development partners and international financial institutions, and there a range of climate risk screening tools (e.g. such as the African Development Bank Climate Safeguard System (CSS)[8] and similar systems are being tested within LDC governments. These are low cost, and have potentially high benefits by avoiding major risks, both in related to current climate variability and future climate change. They form the early basis for more detailed project appraisal and adaptation resilience, particularly by highlighting potentially high risk project (e.g. see figure below).

Figure 14. Scorecard results and classification for the Afdb Climate Safeguard system

Category 1	Projects may be very vulnerable to climate risk. Requires a detailed evaluation of climate change risks and adaptation measures. Comprehensive, practical risk management and adaptation measures should be integrated into the project design and implementation plans.
Category 2	Projects may be vulnerable to climate risk. Requires a review of climate change risks and adaptation measures. Practical risk management and adaptation options should be integrated into the project design and implementation plans.
Category 3	Projects are not vulnerable to climate risk. A voluntary consideration of low cost risk management and adaptation measures is recommended, but no further action is required.

However, there is also the potential for climate risk screening for development and sectoral policies or master plans, i.e. in climate sensitive sectors.

Iterative adaptive management

A key option for addressing the long-term challenge of climate change is for the early development of iterative adaptation plans.

These are more challenging for agriculture and cross-sectoral water demand, than for other more defined risks (such as sea level rise), due to the large number of climatic and socio-economic factors involved. Recent applications to the agricultural sector (Watkiss et al, 2014) are more complex, but can be advanced by focusing on major risks. This was illustrated in the case study in Figure 5 – and in the example for coffee production in Box 12.

[8] http://www.climateadaptation.cc/files/7213/5602/5312/CSS_Basics-En.pdf

While there are a large number of potential areas to investigate, the early priorities are shaped by the importance of the future impact, the length of time to develop a response, and the degree of irreversibility involved. As examples, this would include issues related to major shifts in agro-ecological zones, the development of new varieties (which can take many years to develop and roll-out) or land-use change (which tends to be irreversible), and along with the iterative plans themselves, an early low-regret priority is to start the monitoring programmes to investigate these types of issues.

Discussion of Higher Regret Options

There are a number of major options for these risks which are frequently cited as low-regret options, but which may in some cases be high regret. These include irrigation and fertilizer use.

Irrigation systems increase productivity, and allow continuity of production, especially in the dry season or during periods of variability, reducing variability of output, and enabling a shift to higher-value crops. There is a very large literature on the costs and benefit of irrigation. Studies often report irrigation increases net gross margin for farmers, and benefit to cost ratios of 3 to 5 are common, though other studies highlight lower values (Watkiss et al, 2013). The measure is technical and outcome focused, and costs can be easily costed, through the increase in irrigated water delivered and the cost per unit of delivery ($/m3 or $/hectare).

Irrigation is also a potential response to existing climate variability and many classic studies identify irrigation as an adaptation measure for future climate change (e.g. World Bank EACC, 2009: 2010; IPCC SREX). However, other assessment question whether irrigation is really low regret and some actually define it as a high regret option.

The reason for these differences is due to the framework and models used. Studies which identify irrigation positively often use crop simulation models, looking at defined future climate projections, assuming perfect foresight and ignoring uncertainty, i.e. they do not align with the framework highlighted in this Toolkit. In contrast, some studies highlight that irrigation can be a high-regret option when climate uncertainty is factored in, and at the very least there are likely to be low and high regret outcomes. Hallegatte (2009) highlights that while additional irrigation infrastructure is an interesting measure in some regions in the current climate, the high investment costs that are needed, and issues with future climate change, mean that irrigation can be a low-regret strategy only in some regions. Ranger and Garbett-Shiels (2011: 2012) identify irrigation as a higher-regret measure, because it is relatively expensive, involves sunk-costs (i.e. some irreversibility) and has benefits that depend on future rainfall.

A number of additional issues are relevant.

- Irrigation is a focus of many countries agricultural development plans, though this is rarely advanced within an integrated framework of water resource management, thus the potential availability of water does not factor in total future demand from economic growth, let alone future water availability with climate change.

- If climate change leads to a decrease in precipitation, the pressure on water resources will increase from all sectors, including agriculture. Under such conditions, using irrigation as a short-term adaptation response may lock-in the agricultural sector to competition for declining water resource, increasing problems or costs. While there is uncertainty, the IPCC (2013) identifies that climate change could reduce renewable surface water and groundwater resources significantly in most dry subtropical regions.

- There are a range of other costs and benefits that can be involved. In some cases, there is an energy penalty from irrigation, from energy used in abstraction and water pumping, as well as issues with the environmental impacts on land. Depending on the manner in which irrigation is expanded, it can also result in the drying out of wetlands which can have negative impacts on overall water resource management or increase risks of salinization and soil degradation.

As a result, irrigation is not always a low-regret option. However, there are a wide range of options for irrigation, including small, medium and large-scale, and variations in level and type of technology, e.g. from local structure to irrigation systems, including mini-sprinkler and drip systems. Some of these options may have lower regrets than others, as they involve lower capital costs or have shorter time-scales which reduce the risks of lock-in. For example, small-scale irrigation (using rainwater harvesting) may be a low-regret early option, focused on smoothing current climate variability. Furthermore, when irrigation is already in place, increasing the efficiency can be a no-regret option, i.e. many studies highlight the benefits of drip irrigation, as this is more efficient (e.g. ECA, 2009). Many national adaptation plans also highlight the option of rehabilitation of older, small-scale irrigation, and also highlight the broader linkages with water conservation.

Another common adaptation option identified in crop modelling studies is the use of additional inputs or more efficient use of inputs, notably fertiliser to compensate for the yield losses from climate change. It is highlighted that the use of conventional fertilisers does increase GHG emissions, and can lead to disperse water pollution, thus the alternatives of organic manure or other organic residues, and more sustainable agriculture may be preferable.

Summary of Low-Regret / Value for Money Options

A summary of the low-regret options, split according to the iterative framework, is presented below. It is stressed that the short-list of options should not be seen as alternatives, but as complementary options. Indeed, several of the most promising options provide largest benefits (i.e. they are most effective) when they are implemented as portfolios of actions, rather than as a single action. As an example, soil conservation, water harvesting technology and crop switching work best when implemented together.

A number of important issues are highlighted.

First, the options listed in the top left (i.e. low-regret options to address the deficit) tend to be more risk specific. These options are therefore more site-specific, i.e. there are greater issues in the transferability of these options.

Second, many of these options have important opportunity or policy/transaction costs, and their benefits maybe more difficult to quantify (e.g. involving the value of information or non-market benefits), thus these factors need to be taken into account when subsequently appraising options.

Finally, many of these options - especially those on the left hand side - will already be part of existing programmes and plans. As highlighted in the previous step, and key part of early adaptation strategy will be to consider the existing baseline and identify where there are gaps, or where additional interventions are needed to scale up and implement promising options.

Table 2. Promising Low-Regret/VFM options for variability and future trends

Low-Regret Options to Address the Deficit	Early resilience	Addressing future challenges
Addressing variability	**Low cost resilience**	**Iterative adaptation**
• Farm level climate related good development (crop switching/management, pest/disease control). • Climate smart agriculture (SALM, conservation agriculture, soil and water conservation, agro-forestry). • Water efficiency use and leakage control. • Ecosystem based adaptation for watershed management (enhanced conservation and restoration). • Improved water and sanitation, and strengthened public health responses. • Enhanced public health and surveillance (vector borne disease). • Early warning systems. • Risk transfer including insurance	• Low-cost over-design. • Low-cost flexibility.	• Iterative adaptive management. • Enhanced early monitoring programmes.
Capacity building	**Capacity and information**	**Transformation**
• Enhanced meteorological data, information and monitoring. • Institutional strengthening and awareness raising. • Integrated water resource management.	• Climate risk screening in projects. • Climate risk screening (mainstreaming) into development plans.	

Note that there are strong linkages with the section below on extremes (floods and droughts), and options should be considered in combination.

Strategic Priority VfM Adaptation for Extreme Events

As highlighted in the introductory chapter, current extreme events, notably from floods, droughts, heat-waves and windstorms, already have major impacts and economic costs in developing countries. These affect multiple sectors, and include direct losses and damages (e.g. to property), impacts on non-market sectors or intangibles (e.g. health) and indirect effects such as disruption (transport, industrial) and even macro-economic effects. However, the impacts of these events are determined by multiple factors.

Future climate change has the potential to increase these changes, affecting the intensity and severity of extreme events, e.g. affecting the frequency of high impact events, or changing the areas that experience major extremes. These may therefore increase the impacts of extreme events in the future, though these need to be seen against the changing baseline of socio-economic vulnerability (population levels, assets at risk, development). However, there is high uncertainty on the exact changes in future climate change and extremes, and effects are likely to vary with location and over time. Moreover, these changes will not always be negative: in cases there is the potential for reductions in future extremes due to climate change. More information is presented in the box.

Box 14. Climate Change and Extreme Events

Heavy precipitation (and floods)
Floods can include river (fluvial) and surface water/run-off floods (pluvial). These events are caused by heavy precipitation and surface run-off leading to extreme river flow or surface water flow. Projections of future climate change suggest that there might be an increase in the intensity of high rainfall events (Allan et al, 2010): as a warmer atmosphere can hold more water, so more will be available for a given rainfall event. Where future rainfall intensity increases, or where heavy rainfall days become more frequent (or both) then this translates into potentially higher flood risks. However, analysis of individual countries or regions indicates a wide range of possible futures. The 5th Assessment report (IPCC, 2013) reports that extreme precipitation events over most of the mid-latitude land masses and over wet tropical regions will very likely become more intense and more frequent by the end of this century, as global mean surface temperature increases. Further, while monsoon winds are likely to weaken, monsoon precipitation is likely to intensify due to the increase in atmospheric moisture. It also reports that due to the increase in moisture availability, ENSO-related precipitation variability will likely intensify. However, there is low agreement on this evidence, and thus low confidence at the global scale regarding these changes.

Heat extremes
It is virtually certain that there will be more frequent hot and fewer cold temperature extremes with climate change, on daily and seasonal timescales as global mean temperatures increase. It is very likely that heat waves will occur with a higher frequency and duration.

Wind-storms and coastal inundation storm-surge
The IPCC (2013) reports that an increase in intense tropical cyclone activity is more likely than not in the Western North Pacific and North Atlantic.

Droughts
In terms of future projections, there is very high uncertainty in the future drought signals, with potential increases or decreases possible in many areas that are currently affected. Drought is one of the most difficult parameters to model and forecasting drought is at the cutting edge of current research. Furthermore, even if meteorological drought is projected, there is still then a complex impact chain to assess the potential impact of this on the relevant livelihoods, crops, etc. i.e. whether this will be associated with hydrological, agricultural or socio-economic drought.

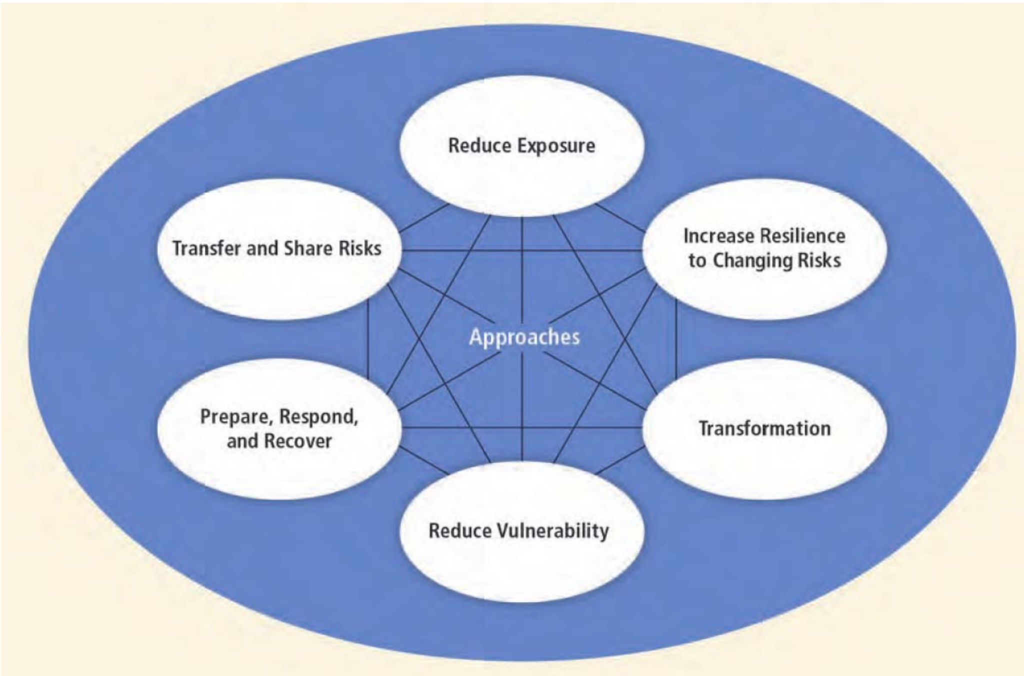
Literature Review on Promising Low-Regret/VfM Adaptation

The responses to address current extreme events are essentially focused around disaster risk reduction / management[9]. However, in the climate change adaptation context, there are some differences, because of the effects on future extremes, the nature of uncertainty, and the cross-cutting linkages with changing trends. Nevertheless, most of the early adaptation options recommended are forms of DRM, and this includes a large number of no- and low-regret options, i.e. which address current extremes. DRR/DRM is one of the more comprehensively assessed areas, though there are relatively low numbers of cost-benefit studies (Mechler, 2011) and many of the available quantitative studies have focused on hard defences, e.g. as a response to flood risks, although the DRM literature is now advancing a greater focus on soft, non-technical and green options.

The recent IPCC SREX report (2012) set out the potential adaptation and DRM approaches for reducing and managing disaster risk in a changing climate, shown below.

Figure 15. Adaptation and disaster risk management approaches

for reducing and managing disaster risk in a changing climate



Source IPCC SREX (2012).

These include a mix of disaster prevention (e.g. reducing risks before events, such as with physical structures), preparation (to reduce risks during events, e.g. with evacuation) and risk financing (risk transfer including insurance, reserve funds).

[9] The terms DRM and DRR are often used inter-changeably, though there are differences, and DRM is more focused on practical (operational) implementation of initiatives. Key definitions are outlined below.
Disaster Risk Reduction aims to reduce the damage caused by natural hazards like earthquakes, floods, droughts and cyclones, through an ethic of prevention. (UNISDR)
Disaster risk reduction (DRR) denotes both a policy goal or objective, and the strategic and instrumental measures employed for anticipating future disaster risk; reducing existing exposure, hazard, or vulnerability; and improving resilience (IPCC SREX).
Disaster risk management (DRM) are processes for designing, implementing, and evaluating strategies, policies, and measures to improve the understanding of disaster risk, foster disaster risk reduction and transfer, and promote continuous improvement in disaster preparedness, response, and recovery practices, with the explicit purpose of increasing human security, well-being, quality of life, and sustainable development (IPCC SREX).

From a review of the existing literature, including the IPCC report above, a number of interventions has been highlighted which tend to be low-regret in nature, and therefore have the potential to deliver value for money. These include:

- Enhanced meteorological data, information and monitoring (see variability);
- Disaster risk management plans, institutional strengthening;
- Awareness raising (capacity building);
- Early warning systems;
- Information and risk mapping
- Soil and water conservation (see variability);
- Ecosystem based adaptation;
- Social protection;
- Risk transfer including insurance;
- Integrated (sustainable) land-use planning;
- Integrated water resource management (see variability section);
- Maintenance regimes;
- Low cost overdesign;
- Critical infrastructure protection
- Design flexibility;
- Water efficiency (see variability);
- WASH (see variability);
- Iterative adaptive management.

There are also a number of options which are often recommended, where the literature disagrees, where there is not a consensus on whether these should be considered low-regret or represent early value for money. These include barriers (flood defences/dikes/barriers, i.e. hard measures).

Note that specific analysis of coastal flood options is discussed in the later coastal section.

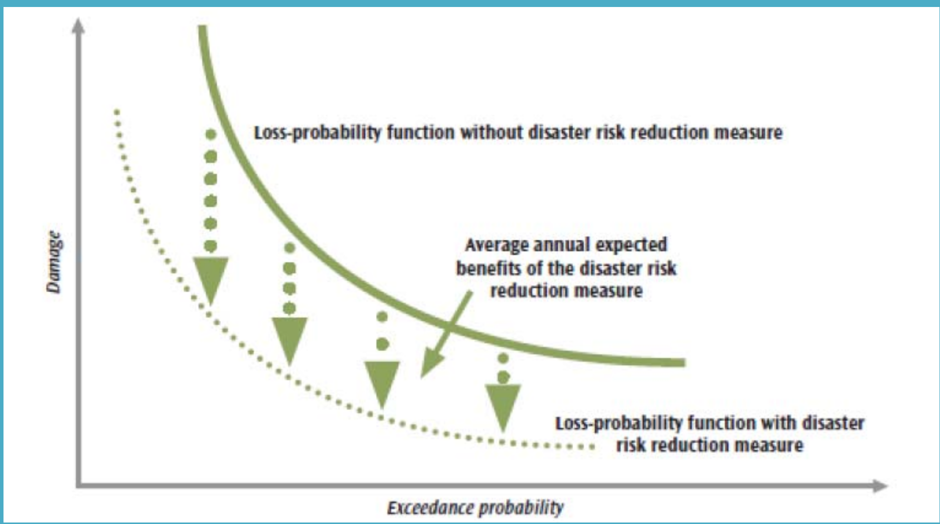
It is highlighted that the analysis of benefits of DRM measures is challenging DRR (see box), as these events are probabilistic. It is possible to assess these events robustly by building up detailed probability loss-damage curves, but this requires large resources and expertise. In many cases such data or assessments are not available. Furthermore, the effect of climate change on extremes is not well represented in the climate projections, and there is high uncertainty over most future changes. This increases the uncertainty of future impacts and adaptation benefits. Finally, disasters have direct and indirect consequences, and are cross-cutting in nature. This makes the analysis of risks (and baseline costs) much more difficult. The analysis of some impacts (e.g. droughts) involves extremely complex causal chains that are dictated by local vulnerability, socio-economic conditions and multiple factors.

For these reasons, a focus on early low-regret options can be particularly helpful in advancing early strategic priorities. A number of promising options have been assessed below. Details of a number of the options are included in the Appendix.

Box 15. Measuring the costs and benefits of DRR interventions

There are a number of steps in the analysis of DRR interventions, including (Mechler, 2012):
1. The risk in terms of potential impacts without risk management has to be estimated, by estimating and combining hazard(s), exposure and vulnerability.
2. Risk management measures and associated costs are identified:
3. The analysis of risk reduction is undertaken, as benefits are the risks avoided. The core benefits generated by disaster risk management are reductions in future impacts and losses.
4. The economic efficiency is assessed by comparing benefits and costs using different metrics.

Disasters are low probability-high impact events, and follow extreme event distributions, and this ideally requires probabilistic analysis for assessment of baseline risks and the benefits of interventions. These are often captured using loss-exceedance curves, as below, which give the probability of an event not exceeding (exceedance probability) a certain level of damages. These show the recurrence of events (i.e. an event that will happen on average 1 every ten years (a 1 in 10 year event), 1 in 100 year event, etc.) and associated damages. Note that the sum of all damages weighted by probability give the expected annual damages (note sometimes these curves are presented with probability on the y axis and losses on the x).



Estimating the benefits of DRM. Source Mechler, 2012.

Estimating such benefits is challening in relation to measuring risk, because of need for probabilistic analysis of complex events, and both direct and indirect losses, but also estimating avoided or reduced risks due to interventions. This is because costs are deterministic, while benefits are probabilistic, and in many cases it is difficult to know the effectiveness of interventions across the curve (above). These challenges are made more difficult by the influence of climate change, because of the change in events, e.g. return periods. Climate change therefore shifts the loss-probability function, and the additional benefits of the DRR measure on top of this changed baseline must then be estimated. .

Discussion of Low-Regret Options

A discussion of some of the promising low-regret options is summarised below. More details of individual options are presented in the Appendix.

Meteorological and hydrological information and services

This options was discussed in the section on variability above, however, there are some more specific aspects in the context of floods and droughts, and the focus of information needs and in particular the connection to early warning systems, which form one of the main areas of benefits, shown in the Table below. It is stressed that the information for drought is more complex, as this is not an instantaneous hazard, and because it involves different elements (meteorological, hydrological, agricultural or socio-economic droughts) which will require different information sets.

Table 3. Information requirements for selected disaster risk management and adaptation to climate change activities.

	Activities	Example of Information needs
Flood risk management	Early warning systems for fluvial, glacial, and tidal hazards	Real-time meteorology and water-level telemetry; rainfall, stream flow, and storm surge; remotely sensed snow, ice, and lake areas; rainfall-runoff model and time series; probabilistic information on extreme wind velocities and storm surges
	Flooding hot spots, and structural and non-structural flood controls	Rainfall data, rainfall-runoff, stream flow, floods, and flood inundation maps Inventories of pumps, stream gauges, drainage and defense works; land use maps for hazard zoning; post-disaster plan; climate change allowances for structures; flood plain elevations
Drought management	Traditional rain and groundwater harvesting, and storage systems	Inventories of system properties including condition, reliable yield, economics, ownership; soil and geological maps of areas suitable for enhanced groundwater recharge; water quality monitoring; evidence of deep-well impacts
	Long-range reservoir inflow forecasts	Seasonal climate forecast model; sea surface temperatures; remotely sensed snow cover; in situ snow depths; multi-decadal rainfall-runoff series
	Water demand management and efficiency measures	Integrated climate and river basin water monitoring; data on existing systems' water use efficiency; data on current and future demand metering and survey effectiveness of demand management
Cross-cutting	Hazard zoning and 'hot spot' mapping	Geo-referenced inventories of landslide, flood, drought, and cyclone occurrence and impacts at local, sub-national and national levels
	Human development indicators	Geospatial distribution of poverty, livelihood sources, access to water and sanitation
	A system of risk indicators reflecting macro and financial health of nation, social and environmental risks, human vulnerability conditions, and strength of governance (Cardona et al., 2010)	Macroeconomic and financial indicators (Disaster Deficit Index) Measures of social and environmental risks Measures of vulnerability conditions reflected by exposure in disaster-prone areas, socioeconomic fragility, and lack of social resilience in general Measures of organizational, development, and institutional strengths
	Climate change modelling	Time series information on climate variables – air and sea surface temperatures, rainfall and precipitation measures, wind, air circulation patterns, and greenhouse gas levels
	Seasonal outlooks for preparedness planning	Seasonal climate forecasts; sea surface temperatures; remotely sensed and in situ measurements of snow cover/depth, soil moisture, and vegetation growth; rainfall-runoff; crop yields; epidemiology

Source IPCC (2012) adapted from Wilby (2009).

Disaster risk prevention and management plans and emergency response

A standard DRM tool, and a key low-regret option, is the creation of disaster risk prevention and management plans. These include flood management and drought management plans. Previous studies, e.g. Cartwright et al (2013) have found such plans have very high BC ratios and are among the highest priority parts of DRM-adaptation options.

Linked to these are the low-cost, no-regret DRM options, such as shelters, sandbags (and response plans) and community based DRM interventions, e.g. escape road, provision of boats for evacuation, installation of pumps, etc. These are well studied in the DRM literature and are primarily an existing DRM option. Such options have high benefit to cost ratios.

Capacity building and institutional strengthening

A large number of the early priorities for disaster risk management and adaptation are around building adaptive capacity. This involves developing the institutional and organisational capacity to respond effectively to climate extremes and future climate change. It includes the information needed and the necessary regulatory, institutional and managerial conditions for adaptation actions to be undertaken.

As highlighted by the World Bank (2011): countries with well-performing institutions are better able to prevent disasters, including reducing the likelihood of disaster-related conflict. Furthermore, preventing disasters requires many public and private agencies to work well together, and there is a role for governments to play an institutional role in this.

In terms of institutional strengthening and building, a broad range of areas are relevant, which includes the potential for new or expanded institutions, including the architecture for DRM-climate change. Given the complex challenges faced, which span many disciplines, and the trans-regional nature, networking alliance and partnership can be established to help ensure more efficient use of resources, better public relations and resource mobilization. It also relates to the policy framework and governance: sound legal, institutional and policy frameworks at all levels are required to achieve effective DRM, to create an enabling environment investments.

Of course these aspects are non-technical in nature and are difficult to appraise. They include the provision and communication of information (see other sections) but also the governance and institutional organisation to plan and respond to risks. These softer options are, however, essential as they are key to the successful uptake of any subsequent resilience plans or options.

Early warning systems (EWS)

Early warning systems involve the broad set of systems and capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities, and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss (IPCC, 2012). Early warning systems have been recommended as a low-regret option by many studies (e.g. Hallegatte, 2009: 2012; World Bank, 2011; ECA, 2009, IPCC SREX, 2012).

These warnings allow individuals to take actions to reduce risks to life, but also to reduce property damage or assets loss. They help avoid unnecessary exposure (e.g. reducing risks of injury, reducing transport and disruption, etc.) and provide information to allow people or organisations to protect homes or other assets when wind-storms or floods are coming (e.g. preparing houses or public buildings for storms, putting out sandbags, or even evacuation).

While the focus here is on flood early warning, these systems will usually be part of a multi-hazard risk management system, though the hazards will vary with location.

These systems are closely linked to the meteorological and hydrological data/information/ services discussed above, indeed, these are a necessary pre-requisite for EWS.

In the context of the EWS themselves, there are a variety of options, which depend on whether an existing system in place. An effective early warning system comprises of a number of parts (World Bank, 2011) including: i) detecting, monitoring, and forecasting hazards; ii) analyzing risks iii) issuing timely warnings, and iv) activating community-based emergency plans to respond to the warnings, iv) coordination across many agencies from national to community levels.

Even in cases where an existing system exists, there can be a need for enhanced information and analysis, including access to data and analytical capacity, as there is often insufficient expertise or capacity.

There is also a need for enhancing communication and dissemination to end-users. This often requires a coordinated government response, and the benefits of existing systems are often reduced by poor communication, the inability to communicate extreme weather to the public, the lack of consistent planning tools, and the inability to leverage the appropriate resources at the local level. This again implies capacity building and institutional strengthening, coupled with public awareness-raising develop the appropriate response measures.

Of course there are many aspects to EWS. Two aspects that have emerged more recently are the use of community based early warning, and also the introduction of mobile communication technology, e.g. SMS technology for the rapid transfer of information to community level in a timely manner.

In the context of climate change, it is important to consider the nature of changing risks (e.g. increases in severity or intensity) of flood events, and thus the potential for risks to arise in new areas, or with a severity that exceeds historical coping capacity.

EWS address current climate variability and lead to benefits from the reduction in risks to life, property, buildings, etc. They also provides enhanced resilience to future climate change, in the form of a low-cost option to address the potential changes in extreme events though they have limits (i.e. they are not a complete substitution for longer-term prevention).

They generally have high benefit:cost ratios, though the costs need to factor in data provision, ICT, training, and institutional co-ordination, as well as awareness raising (on the warming and preventative actions). There are also costs when these systems are triggered, which can include high resource costs (e.g. from a large-scale government response) or the costs of action (e.g. opportunity costs of time for people from disruption, resource costs of protection material, such as sandbags, etc.). The review as part of the toolkit development identified around 10 LDC studies: these had a large range, though in most case BC ratios were high. A further general finding is that EWS options (as a soft option) have much lower costs than large-scale infrastructure. However, the effectiveness of systems very much depend on the level of engagement and dissemination/communication effectiveness that the forecasting organisation with potential stakeholders and users, i.e. for the forecasting team to provide timely and accurate warnings of severe weather. As an example, the Risk to Resilience study (2009) found an EWS in Pakistan was over-designed and had a benefit cost ratio of less than one, because the warning time was not sufficient to allow removal of household contents and commercial stock. It highlighted that a simpler system based on less dedicated infrastructure and more on already operational cell phone/sms could have been just as effective in saving lives at a much lower cost.

Integrated water resource management

See variability section above.

Climate smart agriculture including soil and water conservation

See variability section above.

Climate risk screening

This was discussed in the variability section.

Risk information and risk mapping

The World Bank Economics of Effective Prevention Study (2011) reports that governments can and should make information more easily accessible, as people are often guided in their prevention decisions by information on hazards.

There are therefore high benefits for countries that collect and archive their hazard data (if this is done consistently and comprehensively). It is stressed that this involves additional data to meteorological and hydrological information (above), because it involves hazard data, i.e. on the probability and severity of extreme events (such as floods), and thus moves to broader physical and impact datasets.

As highlighted in Step 1, there are existing country data sets on disasters (e.g. EM-DAT). While these are useful starting points, they do not have sufficient detail for local decisions, which requires mapping of hazard and risk data, i.e. in relation to the probability of hazards and return periods.

A potential low-regret option is therefore around better information and access to information. This involves, for example, maps of flood plains or flood risk levels. These can be used for climate risk screening.

This can include open source software (e.g. GeoNode) to make collecting and sharing information easier. The sharing of information on hazards is low cost, once (Government) agencies collect and analyse data on hazard risks, though in practice there may be a need to overcome information barriers (e.g. on security, commercial confidence) or in some locations, because of the risk of property blight.

It is noted that this information in itself can address existing market failures, and help to ensure property and commercial values reflect hazard risks: it helps people to make decisions on where to live and what prevention measures to take (World Bank, 2011).

Clearly, information on hazards and risks is important for rapidly developing areas, i.e. to consider in siting decisions for future settlements, industrial zones, infrastructure, etc. In this case, risk maps and hazard information can provide critical information on avoiding current risks (i.e. reducing exposure) associated with climate variability.

However, it is perhaps even more important as an adaptation option for building resilience (i.e. risk mapping) as well as addressing future climate change. This is particularly the case because of the long-life time and generally irreversible nature of planning decisions, which lead to exposure to future climate change, though the problem is that these future projections are uncertain.

Land-use planning (integrated land-use management)

An extension of the risk mapping and information above is the subsequent use in exposure reduction, i.e. in risk screening and land-use planning.

This includes intuitional and capacity options, notably the consideration of climate risk screening tools. It also leads to the implementation of risk information in decisions such as land-use planning.

This involves a number of more complex aspects, which affect the low-regret and VfM characteristics of this option.

The potential benefits of land-use planning and constrains (or set-back) reduce future risks. A general finding is that land use planning produces benefits of considerable value, but the cost of producing these benefits is high also, especially when there is a restrictive regulatory regime. This is because although the generation of information (e.g. risk maps above) are low cost, the use of this involves additional elements, especially in the context of future climate change (i.e. future risk maps). The implementation of land-use planning constraints or set-back, e.g. in high risk areas, can be costly, in the form of increased land and/or housing costs from restrictions on the availability of developable land. There may therefore be high opportunity costs, e.g. from the foregone opportunity of the use of the land, especially if large areas are included or high protection levels are put in place due to future risk profiles with climate change (though it is possible to use these areas as open space, which has high amenity benefits (recreation, landscape), as well as other potential benefits).

As well as the decisions to introduce these planning constraints, these options have a strong linkage to institutional capacity, and especially enforcement (which adds to costs, and determines effectiveness).

Nonetheless, a low-regret option is to focus on key hot-spots (e.g. the wards at most risk) and try to tackle these through awareness raising and planning policy, and to also focus on the use of risk mapping and land-use plans for critical infrastructure (e.g. water and sanitation plant, hospitals, major road and rail networks, etc.), where a degree of over-protection is a priority.

Ecosystem based adaptation

There are additional ecosystem based adaptation options for flood risks that are additional the upstream water management discussed earlier. These include a broad suite of options that help to manage water resources and reduce water induced disasters and flood risks, including:

- Natural flood plain management, including water flow regulation and controlled flooding;
- Natural protection structures (e.g. as an alternative to concrete);
- Sustainable urban water management (i.e. urban drainage) to reduce urban flood risks.

Flood plain management, such as through the restoration of flood plains is an option that has emerged in Europe in recent years (through concepts such as ‘room for the river’) and uses natural floodplains for controlled flooding to reduce downstream flood flows and to reduce the focus on hard engineered structural protection. While similar schemes are possible in developing countries, and could lead to high benefits, they do involve challenges in relation to local livelihoods and encroachment, i.e. there are significant socio-institutional challenges and enforcement issues for these managed flood measures.

Sustainable urban water management aims to help address the risks of urban flooding through ecosystem based approaches. This is potentially highly relevant as many developing countries cities have landscapes that are vulnerable to climate extremes, with steep slopes, river valleys, wetlands and rocky hills. They also have inadequate drainage for heavy rainfall and floods. This options therefore uses natural (or artificial) ecosystems to help manage water, e.g. in urban contexts, as a green alternative to hard engineering (for water flows and disaster risk reduction). These form an important option to build urban resilience.

These options address current climate variability (floods) and provide added resilience to future climate change, and are generally considered as low-regret options (though they may have limits). They also have the advantage of providing wider ecosystem service benefits, e.g. food, fibre, source of local livelihood, as well as water quality improvements, which would not arise for engineered systems. The open spaces created with these ecosystems can also be used for productive uses during normal rainfall conditions, such as urban agriculture, recreation etc., thus maximizing the utility of the land for environmental and community benefits. There are also some (modest) benefits from ecosystem based carbon sequestration, though given area size, these are low. They also have the potential for added flexibility compared to hard options.

In general, the costs of these schemes are low (especially where they build on existing ecosystems), however, there can be high acquisition, transaction and opportunity costs for areas, which is a particularly issue for urban areas due to higher land prices and land pressure. They also usually take time to implement (and mature). Finally, they also require maintenance and protection/enforcement to ensure the longer term viability of the schemes. These factors can mean that the costs of these ecosystem based adaptation are higher than might be expected, and may offset the generally lower capital costs relative to hard options.

There are a number of cost benefit studies for these schemes, which indicate positive benefit to cost ratios, though these are dependent on capturing the full benefits, including non-market sectors.

Maintenance regimes

A number of studies (World Bank, 2011; ECA, 2009) highlight the role of improved maintenance as a low or no-regret option for climate variability and extremes, highlighting the potentially high economic rate of return (e.g. from infrastructure maintenance on roads and bridges, and maintain/clearing drainage ditches and storm/flood overflows), but also that because maintenance can be postponed, it gets deferred.

The benefit cost ratios for these interventions are high (e.g. 4:1 is cited by the Bank for road maintenance in Africa), and the ECA (2009) study reports high benefit to cost ratios for drainage system maintenance (in Guyana).

There is also a related issue with respect to drainage system upgrades, to cope with climate change, considered in the low-cost over-design section below.

Building codes

Enhanced building codes are often cited as a low-regret option for flooding, in the context of future climate change (e.g. the IPCC (2012) highlights that climate-proofing of infrastructure; development and enforcement of building codes are low-regret option).

These options build higher resilience into buildings, e.g. with increased flood resilience, e.g. building properties on plinths/stilts or designing buildings so that flood damages are low. These can be implemented through building codes or building regulations, i.e. for new properties, or by less formal routes (recommendations, awareness-raising, market based incentives, etc.). While the focus of building codes is on new buildings, it is possible to retro-fit the existing housing stock.

In many cases, existing codes are insufficient to address current risks, so it is possible to introduce codes to current extremes, e.g. based on current return periods and severity, but also to increase protection levels for future extremes with climate change. The benefits arise from reduced damages and injury/mortality risk. In developing countries where housing lifetimes are shorter and there is likely to be high levels of new build (especially in urban areas), changes in building codes can filter through quickly to provide benefits against current climate variability.

A number of studies have reported positive benefit:cost ratios for building resilience and building codes. IIASA et al (2009) report flood-proofing brick houses in India and raising houses (by 1 metre) in Jakata, with CB ratios of 7:1 and 4:1 respectively at a 10% discount rate). Similarly, the ECA (2009) study reports high benefit to cost ratios for higher building codes in new construction [7:1] (in Guyana).

However, there is balance in relation to the degree of resilience and the costs, so that low-cost resilience measures, translated into codes, are likely to be efficient, but more expensive measures may not, especially given the short lifetime of the housing stock in LDCs.

A further issue is the issue of enforcement/uptake. The effectiveness of these options has a strong linkage to institutional capacity, and especially enforcement. This tends to be low in LDCs, and enforcement adds to costs, and determines effectiveness.

Low cost over-design – including critical infrastructure

In looking to future climate change, a low-regret option is to include a degree of low-cost over-design, either for new build (infrastructure or houses), or during retrofit and replacement cycles. This option is also particularly relevant for critical infrastructure.

The options is to factor in a potentially higher risk in the future due to the potential impacts of climate change, i.e. in terms of the intensity of rainfall, future flood return periods and risk zones, where this can be done at low cost.

Examples include increasing the capacity of drainage channels to factor in potentially higher future flows, with a simple over-design on current practice[10]. However, such options do still involve additional costs (e.g. the additional concrete and building costs) and thus there is a degree of trade-off, which makes it important to only include such options were the marginal costs of over-design are low.

It is also clear that in some cases, over-design is not cost effective. An example is for road design: while it makes sense to design a road to cope with the current climate extremes, the lifetime of roads is short. It therefore makes little sense to design the surface of a road for the climate of 2050, when the road will be upgraded in ten years' time.

[10] noting that these need to consider downstream effects, i.e. increasing drainage channel size will increase flood water volume, and can therefore increase erosion and flooding downstream

A more important issue is therefore likely to be the siting of new roads (to avoid high risk flood plain areas), to focus on areas where the costs of over-design are low especially where it might be difficult or expensive to change in the future (e.g. the size of culverts) and to focus resilience on critical nodes, e.g. bridges, where a degree of over-design makes more sense, due to the longer life-time, the importance of these nodes in disaster relief, and the high costs and difficulty of future upgrades.

This highlights that the focus of this option should be when over-design is low cost, where lifetimes are long, or where there are issues of lock-in.

This includes a focus on critical infrastructure, where a low regret option is to include higher than usual margins of safety (World Bank, 2011): critical infrastructure is essential during and after a disaster, and thus ensuring it is well designed, constructed, and maintained is important. This applies to the design of new critical infrastructure to cope with current climate variability, but also the margin included to cope with future climate change. The definition of critical infrastructure varies with risk and location, but will typically include shelters, hospitals, water sanitation and drinking water plants, critical transport nodes (e.g. major bridges). However, as highlighted by World Bank (2011): it is important to keep the list short, as costs rise quickly if too many assets are defined as critical.

Finally, there may be potential for more flexible adaptation options – measures which are designed with the capacity to be modified at a future date as climate changes. Examples would be designing infrastructure so that its capacity can be increased at a future date, if necessary.

Risk transfer including insurance, reserve funds and risk pools/facilities

Risk sharing and transfer mechanisms at local, national, regional, and global scales can increase resilience to climate extremes (IPCC, 2012), for floods and droughts, and such options are often reported as being no-regret (Heltberg et al., 2009).

Mechanisms include informal and traditional risk sharing mechanisms micro-insurance, insurance, reinsurance, and national, regional, and global risk pools. These mechanisms are linked to disaster risk reduction and climate change adaptation by providing means to finance relief, recovery of livelihoods, and reconstruction; reducing vulnerability; and providing knowledge and incentives for reducing risk (IPCC, 2012). However, under certain conditions, however, such mechanisms can provide disincentives for reducing disaster risk. While the concepts of risk transfer are clear, the implementation is challenging in developing countries, whether private or nationally based (see World Bank, Economics of Effective Prevention, 2011).

These options also have potential to increase resilience to future climate change, especially for future extremes, though it is stressed that future risks will be priced into premiums (or need to be factored into risk pooling arrangements), i.e. future insurance is not a zero cost option to address future risks. Furthermore, it is highlighted that insurance only works in relation to extremes and probabilistic major events, it cannot be used to adapt to the effects of changing trends. As an example, a crop or weather-based index insurance scheme can work if it pays out infrequently – however, if climate change increases the frequency to the point where this triggers insurance payments every couple of years in the same location – the model breaks down because premiums become prohibitively expensive.

Social protection and additional resilience

Social protection schemes are an established resilience option, which help vulnerable households and livelihoods exposed and sensitive to climatic risks, particularly those who have weak risk management capacity. These include a broad set of options, from ex-post coping support for climatic shocks to ex-ante weather risk management, and can include community-based adaptation; safety nets for coping with climatic risks and natural disasters; livelihoods programs; microfinance; food or cash transfers, etc. Social protection schemes also offer the potential, through programmes or public works, to implement many of the other low-regret options outlined here, e.g. ecosystem management and restoration, water supply and sanitation, community forestry, coastal zone management, and disaster risk management. As an example, the World Bank Costing Adaptation through Local Institutions (CALI) study in Ethiopia (World Bank, 2011b) identified a number of activities that were part of social protection programmes that had an adaptation focus, including crop selection (more drought resilient crops), terracing, forest restoration and water harvesting.

Social protection schemes are often termed no-regret (Heltberg et al., 2009). They also provide a mechanism for financing small-scale community-based adaptation, particularly to the most vulnerable, thus they complement the more top-down focus of many other adaptation options.

There is existing Guidance for DFID country offices on measuring and maximising value for money in cash transfer programmes (2011). This sets out key concepts and metrics for analysing value for money (VfM) in cash transfer programmes, and includes more detailed guidance on the issues, concepts and approaches used for VfM analysis of cash transfers, as well as a range of examples. These include benefit:cost ratios from previous studies (which reveal BCrs of 1:1 to 6:1), and also set out the issues in cost estimates (including policy and transaction costs) and programme design.

With climate change, social protection could become more of a priority for adaptation. However, some care is needed because a social protection programme in a major drought- or flood-prone area might lead to improved resilience in the current climate, but could actually lock-in major development in areas that are unsuitable in the long-term with climate change.

Conway and Schipper (2011) examined the potential effects of climate change on a major social protection programme in Ethiopia (PSNP). This found that climate change had the potential to significantly increase the costs of the existing social protection programme – at least under some future drier scenarios – but highlight the uncertainty involved. This changing baseline vulnerability makes it difficult to project forward in time and estimate the effects of climate change on numbers of beneficiaries and drought contingency costs. Nonetheless, a key conclusion is that climate change risks need to be considered within the design (and revision) of social protection programmes.

They also examined potential opportunities for low-regrets measures to increase the resilience of programmes. They highlight the need for more real-time monitoring of rainfall and livelihood systems coupled with a facility for periodic review, supported by the ability to implement annual adjustments of beneficiaries and financing (i.e. a form of iterative climate risk management), noting that the costs of these enhanced monitoring programmes would be low relative to programme costs.

Iterative adaptive management

A key option for addressing the long-term challenge of climate change is for the early development of iterative adaptation plans. While there are a large number of potential areas to investigate, the early priorities are shaped by the importance of the future impact, the length of time to develop a response, and the degree of irreversibility involved. As examples, this would include issues related to major shifts in extremes, i.e. beyond current coping capacity, the development of new major responses such as major protection schemes (which can take many years to develop and roll-out) or land-use change (which tends to be irreversible), and along with the iterative plans themselves, an early low-regret priority is to start the monitoring programmes to investigate these types of issues.

Discussion of Higher Regret Options

There are major options for disaster risk reduction which are frequently cited as low-regret options, but which may in some cases be high regret.

The main area of focus relates to high cost and capital intensive disaster risk management options, e.g. structural protection.

Physical barriers to flooding such as dikes flood barriers are a straightforward but costly way to overcome the adverse impacts of current climate variability and future climate change, i.e. to flooding. There are a range of defences, which range from highly engineered structures (such as in Europe), through to other physical structures. Hard defences are more frequently used for flood defences to protect high value land, for instance urban areas.

In the OECD context, these structures have been found to have high benefit:cost ratios (e.g. see Mechler et al, 2012, who reports an average B:C ratio of 5 for flood DRM). These are driven by the high benefits from protecting assets and people. However, there has been a change in recent years to recognise the limits of hard protection, and recent thinking has shifted from infrastructure based hard resilience to preparedness and systemic interventions, as well as planning for floods, with a much greater focus on soft and ecosystem based options (Mechler et al, 2012).

These factors are even more important in LDCs, and in this context, physical (structural) barriers are not necessarily a low-regret option, because of the high up-front capital costs, the long life-times, and the unknown risks of future climate change. They also require additional maintenance (which is costly) otherwise risks can actually increase as they encourage development in at-risk areas behind the protection line. As a result, hard protection is a low-regret option in some but not all cases, as there is the potential for mal-adaptation, and it may not be an early priority for adaptation.

As an example, the World Bank (2011) reports that Bangladesh reduced deaths from cyclones by spending modest sums on shelters, developing accurate weather forecasts, issuing warnings, and arranging for their evacuation. All this cost less than building large-scale embankments that would have been less effective. Similarly, the Risk to Resilience Study (2009) found that interventions that require high initial investments and are targeted at less frequent but more extreme events were found to be less robust: this included case studies (e.g. in Nepal) where hard protection was estimated to give unfavourable benefit:cost ratios, and that embankments (in India) were not economically efficient (and instead favoured people centred interventions, which had higher BC ratios and lower initial investment costs).

Therefore, while hard protection might be appropriate in some cases (e.g. urban areas with high asset values), in many cases the alternatives set out in the sections above are likely to offer more immediate value for money. There is also the potential to build in flexibility to physical defences (e.g. with soft or more flexible/upgradable systems) which can increase their low-regret characteristics (Ranger and Garbett-Shiels, 2011)

There are also some issues related to heat extremes and the built environment, including demand for cooling, which as a strong feedback to energy use and greenhouse gas emissions, though these are more of an issue in middle and high income countries.

Summary of Low-Regret / Value for Money Options

A summary of the low-regret options, split according to the iterative framework, is presented below. It is stressed that this short-list of options should not be seen as alternatives, but as complementary options. Indeed, integrated portfolios of options are usually more effective and have higher benefit to cost ratios when combined. This can relate to integrated flood risk management (e.g. early warning systems, emergency plans, and shelters, as reported by the World Bank, 2011) or drought management (e.g. the combination of groundwater pumping and micro-crop insurance, as reported in the risks to resilience study, 2009). It also relates to the balance between low and high probability events, for which different interventions will deliver value for money.

Table 4. Promising Low-Regret/VFM options for extreme (current and future)

Low-Regret Options to Address the Deficit	Early resilience	Addressing future challenges
Addressing variability	**Low cost resilience**	**Iterative adaptation**
• Early warning systems. • Emergency plan equipment (e.g. shelters, sandbags). • Maintenance regimes. • Climate smart agriculture including soil and water conservation. • Ecosystem based adaptation. • Social protection. • Water efficiency use and leakage control. • Ecosystem based adaptation for watershed management (enhanced conservation and restoration). • Improved water and sanitation, and strengthened public health responses. • Risk transfer including insurance.	• Integrated land-use planning. • Over-design in critical infrastructure. • Low cost over-design or flexibility in infrastructure.	• Iterative adaptive management • Early monitoring programmes
Capacity building	**Capacity and information**	**Transformation**
• Enhanced meteorological and hydrological information and services • Disaster / emergency risk management plans; • Institutional strengthening. • Risk mapping and information.	• Climate risk screening. • Mainstreaming into development plans.	

A number of important issues are highlighted. The different natural hazards (floods, droughts, storms) involve very different characteristics and impacts, and thus adaptation options needs are specific to the type of disaster risk faced by a country or region, e.g. to flood, windstorm, etc. Related to this, many extreme events and disasters are very site specific, thus they vary according to local conditions e.g. local river catchments for floods, specific vulnerability for droughts. This means the identification of specific low regret measures will be also be site-specific and there will be issues of transferability. The high site specific nature of hazards and subsequent impacts affects the transferability of adaptation costs and benefits (including whether some options deliver value for money).

Many studies suggest the highest value for money may be delivered by information, soft and non-technical options, rather than hard adaptation, especially people centred interventions (i.e. household and community level adaptation) for high frequency, low magnitude events, though as highlighted above, there is a need for a balanced portfolio of options that takes account of the risks of more extreme events and future preparation for climate change.

Strategic Priority VfM Adaptation for Coastal Areas / Sea-Level Rise

One of the major risks of current climate variability is associated with wind-storms, particularly in coastal zones, e.g. from the effects of hurricanes and cyclones. These include the direct impacts of wind damage (e.g. on buildings, risk of fatality/injury) but also the associated coastal storm surge and flooding that occurs with these events. These impacts are important because coastal zones contain large human populations and significant socio-economic activities, including in coastal cities.

These events have major economic costs today, especially for small island states (such as in the Caribbean) or highly vulnerable, low lying coastal deltas (such as Bangladesh). As highlighted in the IPCC SREX report (2012), small exposed countries, particularly small island developing states, experience losses from theses natural hazards that exceed 1% of GDP/year on average – and as much as 8% in the most extreme cases (for the period 1970 to 2010).

Alongside these current risks, there is the potential for future climate change to affect coastal wind-storms, which may change storm wind speed or event frequency, though there is high uncertainty on the change in the intensity, frequency, duration and location.

There is also the future impact of sea level rise, which leads to gradual changes (i.e. higher high water levels). The potential impacts of sea-level rise include flooding and loss of low-lying areas, shoreline (coastal) erosion, saltwater intrusion and increased salinity in aquifers and water supplies. The inundation and erosion (flooding and eventually loss of land) may affect human settlements, agricultural land, infrastructure, transport, and water resources within the coastal zone, as well as tourism and provisioning services (fishing, aquaculture and agriculture). While there is more confidence in the direction of future sea-level rise, there is still a wide range, with the global mean sea level rise for 2081−2100 in the range of 0.26 to 0.82 m across low to high emission scenarios, relative to 1986–2005 (IPCC, 2013)[11]. However, these changes need to be seen in the context of other drivers: geological changes (e.g. subsidence) are also important in the overall relative sea-level rise (RSLR), especially in deltas. Finally, sea-level rise also acts in combination with extreme events, i.e. a rise in sea-level creates a higher water level, reducing the return period of extreme storm-surge events.

Against these risks, there are a large number of potential adaptation responses, noting that different options are needed to respond to different elements of coastal risks (e.g. flooding, erosion) for different receptors (property, water).

In general terms, previous studies have tended to break adaptation responses into three generic types of intervention: protect, accommodate or retreat, as shown in the Table below.

In practice, the list of potential responses could run to several hundred options, and includes a strong overlap with the disaster risk reduction literature (and examples outlined earlier). The underlying work for the toolkit has reviewed the options, to identify promising low-regret options.

[11] It is noted that future sea-level rise does involve global variations and there are some places around the world that will experience higher-than-average sea-level rise, whereas others will experience a lower-than-average rise.

Table 5 Major physical impacts and some examples of potential adaptation responses to current climate variability and sea-level rise for coastal zones

Natural System Effect	Possible Adaptation Responses
Inundation, flood and storm damage (includes surge (sea) and backwater effect (river)	Coastal buffer zones [P], Dikes/surge barriers [P], Building codes/floodwise buildings [A], Land use planning/hazard delineation [A/R].
Wetland loss (and change)	Land use planning [A/R], Managed realignment/ forbid hard defences [A/R], Nourishment/sediment management [P].
Erosion (direct and indirect morphological change)	Coast defences [P], Nourishment [P], Building setbacks [R].
Saltwater Intrusion a) surface waters b) ground-water	Saltwater intrusion barriers [P], Change water abstraction [A/R]. Freshwater injection [P], Change water abstraction [A/R].
Rising water tables/ impeded drainage	Upgrade drainage systems [P], Polders [P], Change land use [A], Land use planning/hazard delineation [A/R].

[P] – Protection; [A] – Accommodation; and [R] – Retreat

Source: Brown et al, 2011, updated from Klein et al. 2001; Nicholls and Tol, 2006.

Literature Review on Promising Low-Regret/VfM Adaptation

Coastal adaptation is one of the more comprehensively assessed areas, and there are estimates of the costs and benefits of adaptation from global through to local level (Agrawala et al, 2011). However, most of the available studies have focused on a classical impact-assessment, focusing on hard defences (dikes) as a response to future sea-level rise.

There are a number of studies that consider a broader set of options (e.g. Cartwright et al, 2013, ECA, 2009), including the consideration of non-technical and green options.

From a review of the existing literature, a number of types of interventions have been highlighted which tend to be low-regret in nature, and therefore have the potential to deliver value for money. These include:

- Enhanced meteorological data, information and monitoring;
- Enhanced coastal and marine information and monitoring;
- Disaster risk management plans, forums/institutional strengthening;
- Early warning systems;
- Natural coastal buffer zones (mangroves)/shoreline restoration (green measures);
- Risk transfer including insurance;
- Risk mapping and land-use planning (integrated coastal zone management);
- Set-back (critical infrastructure);
- Set-back zones;
- Iterative adaptive management.

There are also a number of options which are often recommended, where the literature disagrees, where there is not a consensus on whether these should be considered low-regret or represent early value for money. These include:

- Building codes;
- Barriers (coastal defences/dikes/barriers, i.e. hard measures).

Discussion of Low-Regret Options

A discussion of some of the promising low-regret options is summarised below. More details of individual options are presented in the Appendix.

Meteorological information and services

As highlighted earlier, there is a broad set of early low-regret options that fall within meteorological information and services, including oceanographic information (in the marine and coastal environment). This again includes the broad categories highlighted above, e.g. from equipment to staff, and from analysis through to dissemination/communication.

These provide information related to forecasting, e.g. improved hurricane forecasts and warnings, and improved accuracy of landfill, timing, specificity and also provide the basis for early warning systems.

Coastal and marine information and services

As part of meteorological option above, local coastal tide, wind and wave measurements are important for improving local forecasting. However, there are additional parameters that are needed for the analysis of climate change:

- Tide gauge stations, to measure sea level rise and wave heights;
- Sea-surface temperature loggers;
- Bio-physical monitoring (e.g. tidal current, salinity, sedimentation, acidification);
- Ecological monitoring (e.g. coral health, mangrove, sea-grass surveys).

These provide benefits through the value of information, as they capture information on emerging trends, and provide the data for iterative adaptation planning, i.e. to build information for future decisions. As with meteorological information, these involve physical interventions (stations) but also staff and organisational capacity. It is highlighted that these coastal and marine services are usually very under-developed in LDCs (due to the primary focus on meteorological information), and there is often a strong need for institutional strengthening, as information often sits within separate institutes or research organisations, rather than as an integrated part of government. It is stressed that monitoring systems need to be put in place early, to allow sufficient data periods.

Early warning systems

As highlighted above (in the extreme section), early warning systems have been recommended as a low-regret option by many studies. Some of the largest benefits have been found for coastal areas, due to the high risks of storms and storm-surges and the potential for EWS to provide timely warning (and evacuation) to reduce the impacts of these events (see Appendix).

Further information on this option was included in the earlier discussion.

Disaster risk management plans, forums/institutional strengthening

Alongside EWS, there is a need for disaster risk management plans, and the equipment/infrastructure to support these (e.g. shelters, sandbags). It is highlighted that some studies (e.g. Cartwright et al., 2013) found highest BC ratios for disaster risk management plans (contingency, awareness) and institutional strengthening (e.g. a cross-sectoral disaster forum). This highlights the importance of capacity and institutional aspects.

Natural coastal buffer zones (mangroves)/shoreline restoration (green measures)

One of the options frequently referred to as a low-regret option in the coastal context (for current storm-surge risk, and future sea level rise) is ecosystem based adaptation. These often focus on natural buffer zones, though a number of other options also fall within this category. These provide resilience to current climate variability and future climate change, and also ancillary benefits, e.g. in the form of broader ecosystem services, livelihood benefits, etc. The main options include:

- *Coastal buffer zones* (mangroves) provide protection against storms and coastal erosion. They also have wider benefits as natural inter-tidal filters and help prevent saltwater intrusion, and provide other ecosystem services (e.g. wood, fibre and food). The replanting, restoration and/or enhanced conservation of mangroves is therefore a low-regret adaptation option, increasing current resilience, helping to address future sea-level rise, addressing other impacts (deforestation and habitat fragmentation) and providing other benefits, including reduced GHG. In areas where mangroves are not indigenous, other forms of coastal wetlands or forests can have similar function.

- *Shoreline vegetation/sand dunes.* A similar action is planting and reforestation to create a vegetated band to help in shoreline stabilisation and to offer an additional line of protection. This can also be used with sand dunes as a form of natural coastal barrier to provide stabilisation. These (green or non-technical) barriers provide a physical barrier and are an alternative to hard, structural protection (sea walls) and have the advantage of flexibility, in that it is possible to increase dune heights later.

- *Seagrass.* Seagrass meadows stabilise sediments and help reduce coastal erosion, and have large ecosystem benefits through filtering suspended sediments and nutrients, as well as food chain benefits. Enhanced conservation and replanting of these habitats is an important low-regret option.

- *Coral*. Coral reefs have important roles in coastal protection (against waves, storms and erosion), as well as providing ecosystem services through fisheries and tourism. As with the other areas above, a low-regret option for adaptation is to enhanced conservation and restoration.

While the main option is for restoration and enhanced conservation, there is also the potential for artificial construction of coastal wetlands or vegetation zones, or as part of managed retreat policies.

These natural buffer zones address current climate variability and coastal storm risks. They also provide resilience for future climate change. Their low-regret characteristics arise from their wide ranging benefits, through the ecosystem services they provide. They provide a low-regret option that is a substitute for hard engineered solutions, which can be more community and local livelihood focused.

While studies of their costs and benefits are generally highly positive (see Appendix), it is stressed that the costs of schemes vary widely, and for some options there are important opportunity costs: e.g. where prime urban land needs to be purchased for these options. Furthermore, these systems have some limits in relation to extreme scenarios (World Bank

(2010) and there is often a lag between restoration and the realisation of benefits. Finally, these options are only successful if there is effective management (of protected areas) and this requires capacity and resources, including regulation, enforcement activities, as well as boarder awareness raising (in communities). One way to address this is through community based schemes (e.g. CB-forestry).

Risk transfer including insurance

In terms of the risks of major coastal extremes – and disaster risk reduction - it is usual to strike a balance of responses that vary according to the probability and nature of the extreme. This differentiates between low and high probability event, i.e. seeking to use risk reduction to reduce high probability events, and using risk financing (i.e. risk transfer or insurance) for low probability events, because it is economically rationale to address frequency risks and to insure against low probability (but high impact) events. In the coastal context, in LDCs where private insurance may be challenging, this may involve some form or regional risk pooling. It can also involve sovereign risk transfer, though the benefits of such approaches have been shown to vary with the country (e.g. Mechler 2004).

Risk mapping

Risk mapping, and the use of this information in planning, was discussed earlier (extremes). However, there are some specific coastal aspects. There is a fairly obvious risk (hazard) mapping element around current coastal storm surge zones, and how these might change with future sea level rise, and potentially from storm extremes. An early low-regret option is for detailed evaluation/contour mapping to capture current risks and potential future areas, i.e. low elevation coastal zones – noting that while global data are available – higher local resolution is useful.

Land-use planning / integrated coastal zone management and set-back zones

The risk information (above) can be made available, to help private decisions, encourage the uptake of appropriate insurance, etc. It can also be used to inform land-use and development decisions. This includes the potential use in integrated coastal zone management (ICZM).

It also includes the option to use this information in formal planning and enforcement controls through the designation of coastal set-back zones, i.e. areas of no-build within a short distance of the coastline to reduce impacts. Set-back zones are often built around mandatory set-back distances to reduce the risks of storm-surge. In theory this could be contour based, and thus vary with risk, but in most cases a defined distance is set.

The benefits spatial planning or to inform coastal set-back, is through the avoided damage from climate related risks (now and in the future with climate change). These benefits include health (reduction of injuries and fatalities), property and asset damage, as well as avoided emergency response costs and reduced disruption.

Risk mapping and the use of this information in land-use planning, ICZM or set-back zones addresses the issues of current climate variability. In theory, it is an important adaptation option for building resilience (i.e. risk mapping) by addressing future climate change. This is important because of the long-life time and generally irreversible nature of planning decisions, which lead to exposure to future climate change.

Many studies report high benefit:cost ratios for set-back zones (Cartwright et al, 2013: World Bank, 2010 in Samao; ECA, 2009; CCRIF, 2010). It is therefore clear that some form of zoning seems effecting.

However, there are uncertainties involved in the degree of added protection for future sea-level rise, which makes these options more challenging. Furthermore, there may be high opportunity costs associated with land restrictions, thus there is a trade-off on the risk level (and set-back zone) that is set, versus the residual risks. This may mean it is necessary to focus on key spots (e.g. the wards at most risk) and try to tackle these through awareness raising and planning policy, rather than all areas. Finally, as well as the decisions to set-up a zone, these options have a strong linkage to institutional capacity, and especially enforcement (which adds to costs, and determines effectiveness).

Nonetheless, a low-regret option is therefore to focus on key spots (e.g. the wards at most risk) and try to tackle these through awareness raising and planning policy, and to focus set-back of critical infrastructure (e.g. water and sanitation plant, hospitals, major road and rail networks, etc.).

Iterative Coastal Adaptation

A key option for addressing the long-term challenge of climate change is for the development of iterative coastal adaptation plans. These have been applied (in the European context) at the National level, e.g. the Dutch Delta Plan and roadmaps (Delta Plan; Haasnoot et al, 2013) and at the project level, e, g. the Thames Estuary study in London (EA 2009: 2011). Their applicability in general terms in LDC context seems strong (Watkiss et al, 2014, for Zanzibar) – however, there is a practical issue in advancing more complex route maps because of data limitations.

The most recent applications identify possible risk or impact thresholds (and accompanying indicators) and assess options that can respond to these threshold levels. These are accompanied by monitoring plans that track key indicators, and through a cycle of evaluation and learning, allows the adjustment of plans over time.

Therefore along with the plans themselves, an early low-regret priority is to start the monitoring programmes (e.g. sea level rise, coastal erosion, storm surge heights and inundation areas).

Discussion of Higher Regret Options

There are two major options for coastal risks which are frequently cited as low-regret options, but which may in some cases be high regret.

Building Codes

Enhanced building codes are often cited as a low-regret option for tropical wind storm risk or coastal flooding, in the context of future climate change (e.g. the IPCC SREX (2012) highlights that climate-proofing of infrastructure; development and enforcement of building codes are low-regret option).

These options build higher resilience into buildings, e.g. with increased wind resistance of houses by requiring roofs are secured more firmly, or building coastal properties on plinths or stilts to address coastal flooding. These can be implemented through building codes or building regulations, i.e. for new properties, or by less formal routes (recommendations, awareness-raising, market based incentives, etc.). While the focus of building codes is on new buildings, it is possible to retro-fit the existing housing stock.

In many cases, existing codes are insufficient to address current risks (e.g. EACC, 2010), so it is possible to introduce codes to current extremes, e.g. based on current return periods and severity, but also to increase protection levels for future extremes with climate change. The benefits arise from reduced damages and injury/mortality risk. In developing countries where housing lifetimes are shorter and there is likely to be high levels of new build (especially in urban areas), changes in building codes can filter through quickly to provide benefits against current climate variability.

While some studies find high benefit to cost ratios (e.g. EACC, 2010 in Samoa), other studies contradict these findings and suggest that at best, these options are low-regret under some but not all cases, especially in relation to future climate change, for example CCRIF (2010) found low BC ratios and Hochrainer-Stigler et al. (2010) found codes were only efficient under certain circumstances and for specific locations.

There are two reasons for this. First, there is a trade-off between future design levels and the marginal costs of higher-design standards. As an example, in the US, very high building codes can be justified because of the high value of property and long residential home lifetime. In contrast, in developing countries the economics are different, and high cost measure may not be justified given the value of property and the shorter life-time of buildings. Second, there is the issue of uncertainty around future risks (e.g. future levels of category 4 and 5 hurricanes) and the potential mal-adaptation from over- or under-design. For this reason, there are issues about whether options or building codes should be prescriptive, or try and build in flexibility and robustness.

Finally, these options have a strong linkage to institutional capacity, and especially enforcement (which adds to costs, and determines effectiveness).

This may mean that higher building/design codes offer low-regrets in some but not all cases, and this may mean the early focus should be on critical infrastructure, or high capital infrastructure with long life-times.

Barriers (Coastal Defences/Dikes)

Coastal protection, e.g. physical barriers to flooding and coastal erosion such as dikes, sea-walls and flood barriers, is a straightforward but costly way to overcome the adverse impacts of current climate variability and future climate change, i.e. for both storm surges and rising sea-levels.

There are a range of sea defences. These range from highly engineered structures (such as in Europe), through to other physical structures, such as sea walls and dikes. Hard defences are more frequently used for flood and coastal defences over soft measures to protect high value land, for instance urban areas or agriculture land from inundation. Note also that there are also some more natural alternatives (to concrete) that involve reshaping sandbanks around coastlines (though this tends to be more expensive) or building on existing dune structures or other forms of beach nourishment. In some areas, a mix of hard and soft protection measures are applied, e.g. rock groynes and beach nourishment.

The level of benefits is driven by risk levels, i.e. there is more justification of defences where there are more people and greater assets. In some locations, especially coastal cities, building sea walls is economically justified by storm surge risks today with the current sea level, and sea level rise will make these walls more socially beneficial (Nicholls et al 2007; Hallegatte, 2009). There is also a large literature that reports high benefit:cost ratios when applied to address future risks of sea-level (e.g. Agrawala et al, 2011), but these assume perfect foresight (i.e. they optimise dike height to assumed future sea levels) and thus do not take account of uncertainty, and in many cases, these studies assume a high degree of existing protection (i.e. they only consider additional costs of increasing existing dike heights).

However, physical (structural) barriers are not necessarily a low-regret option, because of the high up-front capital costs, the unknown risks of future climate change and also because these structures can lead to the risk of enhanced coastal squeeze. They also require additional maintenance (which is costly) otherwise risks can actually increase as they encourage development in at-risk areas behind the protection line.

As a result, hard coastal protection is considered a low-regret option in some but not all cases, as there is the potential for mal-adaptation. It is most likely to be applicable for urban coastal areas, where there are major populations or assets, and as part of future iterative options.

Summary of Low-Regret / Value for Money Options

A summary of the low-regret options, split according to the iterative framework, is presented below. It is stressed that the short-list of options should not be seen as alternatives, but as complementary options.

Table 6. Promising Low-Regret/VFM options for coastal risks (extreme and SLR)

Low-Regret Options to Address the Deficit	Early resilience	Addressing future challenges
Addressing variability	**Low cost resilience**	**Iterative adaptation**
• Early warning systems • Natural coastal buffer zones • Risk transfer including insurance	• Land-use planning integrated coastal zone management • Set-back zones • Low-cost over-design in critical infrastructure.	• Iterative adaptive management • Early monitoring programmes
Capacity building	**Capacity and information**	**Transformation**
• Enhanced meteorological data, information and monitoring • Enhanced coastal and marine information and monitoring • Disaster risk management plans, forums/institutional strengthening	• Risk mapping. • Climate risk screening. • Mainstreaming into development plans.	

Case Study: Prioritising Adaptation in National Action Plans

To test the concepts of iterative frameworks, the focus on value-for-money adaptation, and their use in sequencing and prioritising early VfM adaptation, a field-based case study was undertaken in Zanzibar, one of the two countries that comprise the United Republic of Tanzania. This case study was linked to ongoing technical support to the Revolutionary Government of Zanzibar as part of the development of the *Climate Change Strategy and Action Plan for Zanzibar*.

The case study applied the iterative framework and VfM thinking to help identify, sequence and the initial prioritisation of adaptation, as part of an adaptation action plan. This provides a real, practical example and has high relevance for the development of National Adaptation Plans (NAPs).

Context, Existing Climate Variability and Future Climate Change

Zanzibar's economy, employment and livelihoods are associated with highly climate sensitive activities, notably agriculture, tourism and coastal zone activities. Furthermore, as a small developing island, it is highly vulnerable to sea-level rise, with around 25% of the land and over 45% of the population in the low elevation coastal zone. The islands are already experiencing the impacts of rising water and wave heights, acting with socio-economic change (e.g. mangrove loss), which is leading to increased erosion and large areas of salt-water intrusion. Looking forward, there are potentially large impacts from climate change, from a combination of sea level rise, storm surges and increased wind speeds, as well as sea surface temperature and ocean acidification. These could be very significant given the low-lying nature of the islands. There are also risks to the agricultural sector from changes in future rainfall and temperature, and potential risks to the tourism sector. However, all of these areas are characterised by high uncertainty, e.g. in relation to the level of sea-level projected, or the shifts in the terrestrial climate.

Application of the Iterative Framework and VfM Adaptation Sequencing

An iterative framework was applied to help develop the framing of the risks in the Strategy, starting with current climate variability and then looking at long-term climate change (including uncertainty).

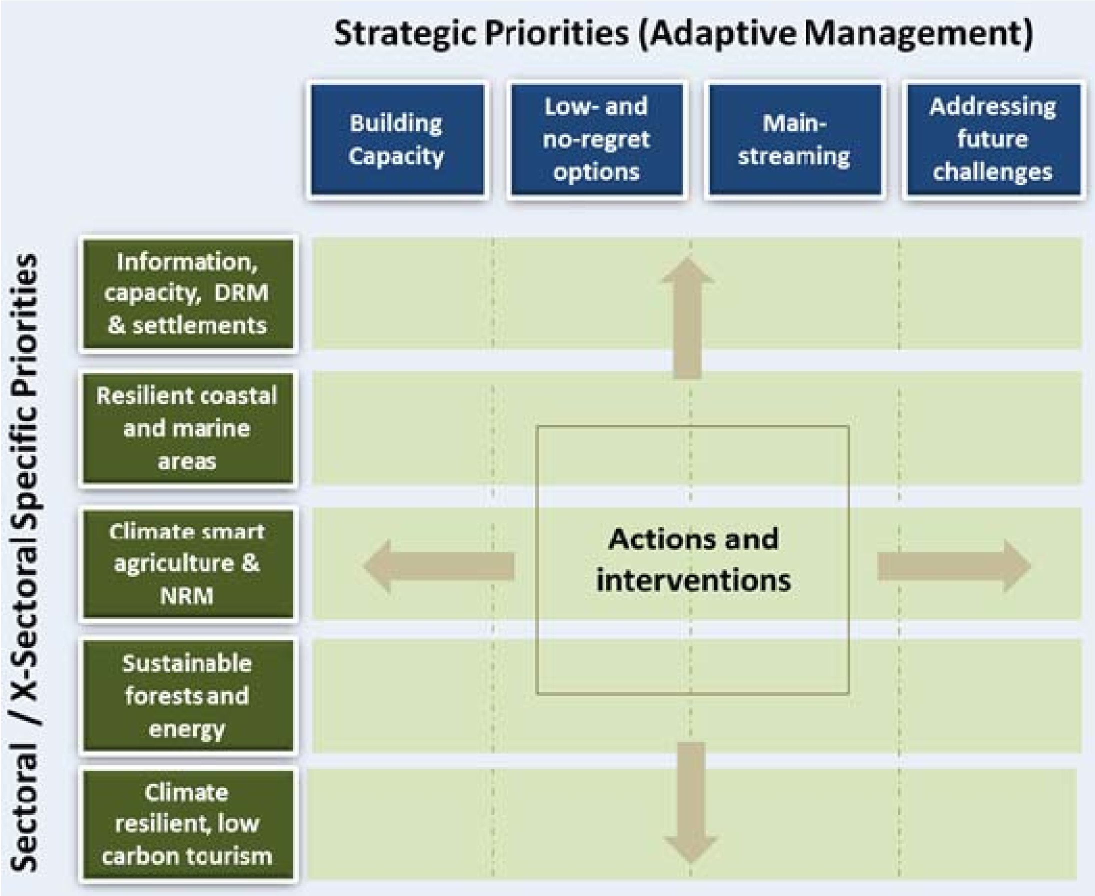
In turn, this led to the identification of a large number of possible risks and associated adaptation responses. A key lesson from the case study was the need to prioritise this long-list, as the large number of options was a barrier to progressing the strategy and action plan. At the same time, there was a need to align adaptation options within the existing institutional and policy landscape, taking account of existing government programmes and development partner assistance.

To address this, the Strategy developed an adaptation action plan that was based on the iterative framework outlined in this report. This included the three complementary areas of adaptation (as outlined in Step 3), i.e.:

- Addressing the adaptation deficit, though in the action plan, capacity building and low and no-regret options were included as separate interventions;
- Mainstreaming climate change;
- Early actions to address future challenges.

These early VfM adaptation areas were then mapped against sectoral/cross-sectoral priorities for the islands, shown below.

Figure 16 Matrix used for mapping out early VfM adaptation



This matrix was then used to identify and sequence early adaptation, and to identify early priorities for the prioritised action plan, focusing on those areas likely to deliver greatest value for money.

This applied the approach outlined in Step 4 of the toolkit – focusing on promising value-for-money options.

The results were used to build up the priority action plan – i.e. to identify the immediate focus and highest priority areas for early programming/financing. This is shown in the figure below.

This followed the typology advanced in this report, with a mixture of immediate economic benefits (from addressing the existing adaptation deficit), mainstreaming climate change and the value of information, and early action to start preparing for future major change.

Many of the promising options identified in this chapter are included in the prioritised action plan. Examples include option of enhanced meteorological information and services, improved early warning systems, climate smart agriculture, ecosystem based adaptation, and early research and monitoring.

Figure 17 Strategic Priorities, using the Typology of Early VfM Adaptation

	Building capacity	Low- and no-regret options	Main-Streaming	Addressing future challenges
Climate information, capacity, DRM and Sustainable Settlements	-Enhanced capacity & co-ordination (including community level). -Investment plans, climate finance & M&E. -Awareness raising. -Governance. -Education (+curriculum). -Enhanced met services.	-Enhanced communication. -Enhanced forecasting. -Strengthening of DRM. -Enhanced EWS (including community level).	-Enhanced climate risk screening. -Risk mapping & spatial planning including Zanzibar land-use plan. -Sector mainstreaming.	-Enhanced research with linkages to URT, regional, SIDS and global.
Resilient coastal and marine areas & ecosystem services	-Enhanced coastal and marine monitoring (data, physical, ecosystems). -Capacity and awareness (including community groups, policy makers).	-Salt water intrusion programme. -Mangrove & shoreline restoration (inc COFM) -Enhanced conservation & fishery resource management (inc. community level).	-Enhanced climate risk screening. -Strengthening Integrated coastal zone management / Community ICZ.	-High resolution risk elevation mapping. -Research and pilot studies (e.g. cage-culture, livelihood diversification). -Study on blue carbon.
Climate-smart agriculture and natural resource management	-Information support and awareness raising (e.g. extension service, indigenous knowledge, etc.).	-Good practice (value chain). -SALM (e.g. soil management, agro-forestry, rain-water harvesting).	-Sustainable land use planning. Integrated water management.	-Research and pilots (e.g. new varieties, new practices, future risks such as cloves).
Climate resilient, low carbon tourism	Survey/ assessment/pilots -Awareness raising. -Analysis of sustainability criteria. -Capacity inc. community empowerment.	-Energy and water efficiency programs. -Enhanced awareness and enforcement.	-Investment and development planning controls. -Risk screening.	-Long-term sustainable tourism planning. -Research on tourism development & climate change.

Source: Zanzibar Climate Change Strategy (to be published, 2014).

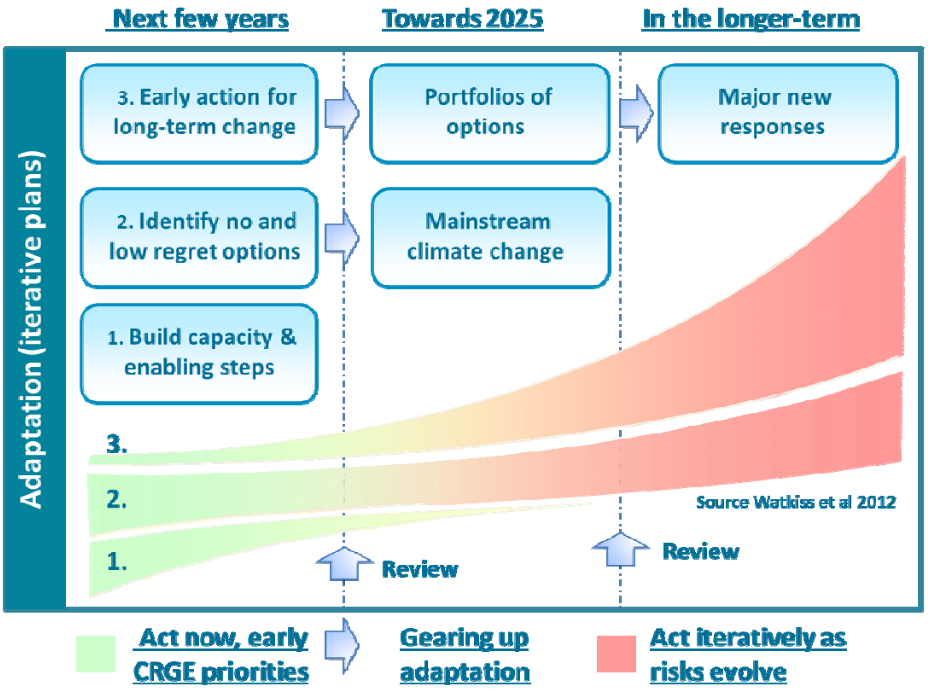
The case study provides important evidence that iterative frameworks are practical to implement, and that they can be used in the early identification, sequencing and prioritisation of adaptation within a real policy setting.

Case Study: Prioritising Adaptation in Sector Action Plans

An additional desk based review of a sectoral adaptation strategy was undertaken, looking at the Ethiopian (FDRE) Climate Resilience Strategy for Agriculture (Watkiss et al, 2013). The earlier steps in this strategy were presented earlier (in Step 1). This section extends that case study to apply the iterative framework to the early prioritisation of adaptation, working towards the development of sector adaptation investment plans, which are a likely focus for development partner support.

The iterative framework used in the adaptation plan was aligned to the Ethiopian development and growth planning windows, thus the mainstreaming objective was aligned to the FRDE Growth and Transformation Plan, with the 5 year cycles and the Vision date of 2025.

Figure 18 The Iterative framework used in the CR Strategy



As highlighted in Step 1, the analysis first used a vulnerability and risk analysis to identify and quantify key current risks of climate variability, notably around floods, droughts, rainfall variability and soil erosion. These were identified as the priority for early capacity and early low-regret (VfM) options, i.e. to deliver value-for-money by addressing the existing adaptation deficit.

The study then used the framework outlined in Step 3 and 4 to build up a short-list of adaptation options.

Table 7. Short-list of promising adaptation options

Strategy Area 1. Establish capacity for managing change and sectoral resilience	
Capacity building and institutional coordination (staff, training)	
	Climate information, research and enhanced co-ordination
	Institutional strengthening and building
Information and awareness (climate, agro-met services, R&D)	
	Meteorological and agro-metrological data
	Agricultural research and development
	Enhanced extension services
Strategy Area 2. Build on existing good practice (no-regret and robust options)	
Crop and water management on-farm (e.g. crop switching, smallholder irrigation)	
	Crop switching and new varieties
	Fertiliser use
	Farm management and technology
	Pests and disease (including post-harvest losses)
	Irrigation
	Water infrastructure, allocation and transfers
Livestock	
	General animal and value chain improvements
	Herd diversification
	Breeding programmes
	Improved animal health
	Fodder and feed improvement and resilience
	Resilient animal housing
Value chain and market development (i.e. exports (coffee, sugar), roads)	
	Coffee (Monitoring (yield, quality, pests), capacity building, new varieties, shade trees, conservation, new plantations.)
	Irrigated sugar plantations (irrigation efficiency, changes to practice, integrated basin management, upstream catchment rehabilitation, climate risk screening).
	Roads (new roads, paving, design standards)
Sustainable agriculture and land management (SWC, SLM, climate smart)	
	Conservation agriculture (zero or low tillage, cover crops, crop residues)
	Soil and water conservation (SWC) structures (bunds, trees, grass strips, contour levelling, terraces, shade trees, waterways).
	SWC cover crops
	SWC water harvesting (tied ridges, RWH, local structures).
	Soil management
	Agroforestry.
	Rangeland rehabilitation and management
Forestry, conservation and biodiversity (including ecosystem based adaptation)	
	Using forests for adaptation
	Resilience measures for forests
	Conservation and rehabilitation
	Promoting biodiversity in agriculture
	Payment of ecosystem services
Strategy Area 3. Protect the most vulnerable	
Disaster Risk Reduction	
	Early warning systems
	Disaster risk management planning
	Insurance
	Structural protection
Social protection for high priority groups including women and children	
	Safety nets
	Asset creation and protection
	Access to credit
	Livelihood diversification

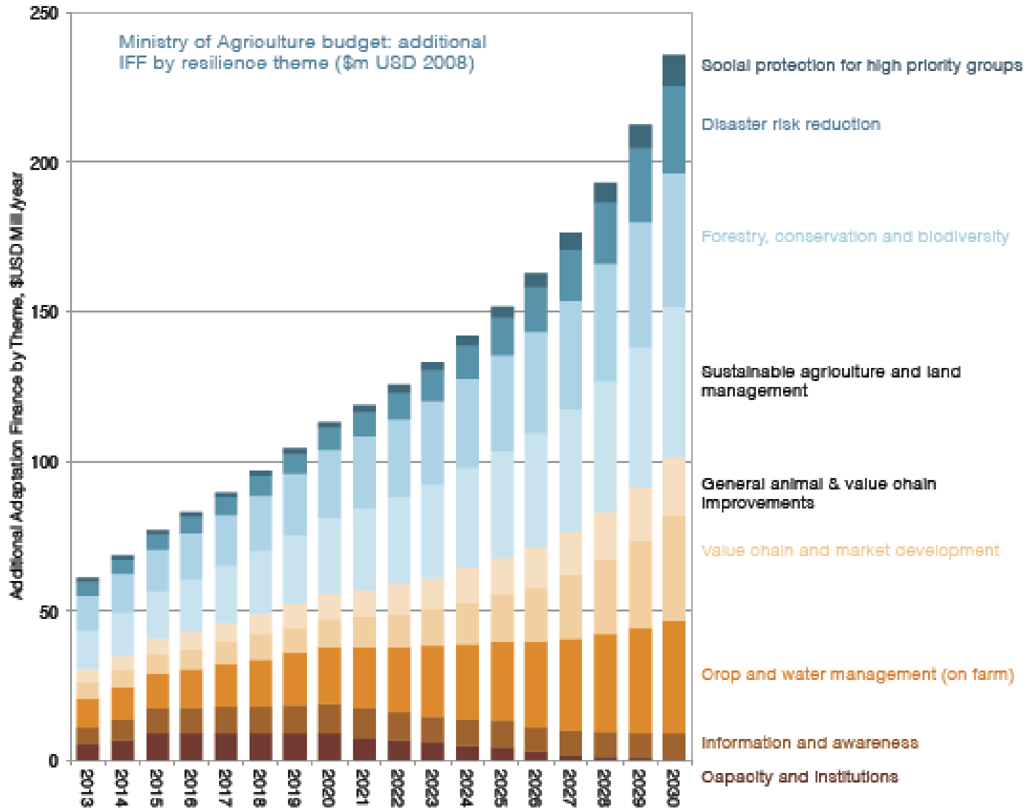
Subsequently, the study moved towards developing these priorities into sector plans.

First the study undertook a climate risk review of existing policies and programmes. This placed the analysis of impacts and adaptation within the institutional structure of Government, and took account of the existing programmes and policies. Second, the study undertook an investment and financial flow analysis (IFF) – a form of Public Financial Management assessment. This provided baseline information on the likely sector development plans and investment levels (on and off budget, public and private) now and through to 2025. The aim was to assess the level of 'climate readiness' of the current policy framework and to identify opportunities for mainstreaming, as well as finance gaps to deliver this.

The mainstreaming analysis provided some critical lessons, which help inform the evidence base on the application of iterative frameworks. Again, it found that the iterative approach was useful in building up a prioritised plan for adaptation. However, it also found there was a substantial overlap between existing activities (currently financed under the Federal Ministry of Agriculture (MoA) budget) and the promising early VfM adaptation options identified in the Strategy analysis. The analysis indicated that over the period 2007-2013, approximately 63% of the MoA budget was already undertaking resilience-oriented activities.

Nevertheless, this still meant there were major gaps for adaptation, and the analysis estimated that the investment needed to fill this was around $130 million per year in 2013-14, rising to $240 million per year by 2020 and more than $500m per year by 2030, as shown in the figure below. The size of the gap was estimated up by identifying early VfM adaptation and the phasing of options over time, e.g. with more capacity building and information and awareness in early years, then the subsequent scale- up later on.

Figure 19 Additional investment needs for mainstreaming in Ethiopia (agriculture)



It is stressed that the low value attached to social protection and DRR in the figure is due to the fact these areas are already heavily funded and have climate resilience already factored into future budget profiles.

At the current time, these sector plans are being translated through into detailed programmatic sector plans for adaptation finance.

Finally, for the longer-term challenges, a combination of existing information (climate projections and modelling studies) and qualitative narratives were used, to identify the major future challenges (shown in Step 1). For each of these, an iterative framework was developed; identifying early actions to start preparing for these long-term but uncertain risks. An example for coffee was presented in the previous chapter. Detailed programmes for early action and for adaptation finance are being develop for the most important of these early areas.

STEP 5

Theory of Change (Part 2)

Key Messages in this Section

- This step looks at how to develop a theory of change for the adaptation programme intervention, including how to develop the logical framework and design the monitoring and evaluation framework.
-

Identify inputs, outputs, outcomes and expected impacts of options

Steps 3 and 4 of this guidance series recommended that the design team use context analysis to create a 'long list' of potential adaptation options, and then use the adaptation pathway framework to categorise and prioritise options into a shortlist. The result should be a table similar to below, which maps potential options against programme priorities and early VFM characteristics.

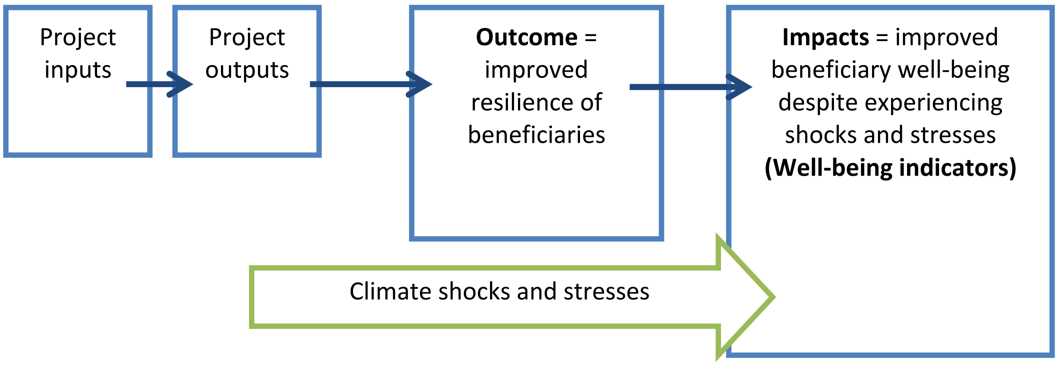
Table 8 Prioritisation Table

Prioritisation table			
Strategic priorities (based on theory of change)	Actions to address the current adaptation deficit	Risk screening, resilience and mainstreaming	Addressing future climate change
Agriculture	*Option a…*	….	….
Water	….	….	….
Social safety nets	….	….	… *Option z.*

The options appraisal of the short list of adaptation options will require data on the costs and benefits of the various options. To generate this data (and to form the backbone of the logical framework), the design team can identify the inputs, expected outputs, expected outcomes and expected impacts of each option. This is demonstrated in the subsequent Table below. **For a selection of readymade output and outcome indicators, see the adaptation supporting indicators toolkit.**

The logical sequence from inputs to impacts should be in line with the figure below. We recommend that DFID projects develop some indicators of 'improved resilience' at the outcome level in order to track the effectiveness of programme outputs during the project lifetime. Changes in impact indicators may also be observed (though changes in impact indicators might not be directly attributable to the programme). For further discussion see the PEAKS study: assessing the impact of ICF programmes on resilience..

Figure 20 Logical sequence from inputs to impacts



Theory of change (ToC): without the programme beneficiaries would have been less resilient to climate related shocks and stresses and therefore performance of well-being indicators (e.g. income, deaths) would be worse than in the with programme scenario

Table 9 Example of options mapped against expected inputs, outputs, outcomes and impacts

Option	Inputs	Outputs	Outcomes	Impact
Cash transfers to households	*Includes of - for example, set up costs, human resources, physical resources needed*	*Indicators of - for example number of HHs with increased monthly income*	*Indicators of improvements in resilience of beneficiaries to climate shocks/stresses*	*Indicators of beneficiary welfare, reduced poverty*
Early warning systems and support to local government to design emergency response plan	…	…	…	…
Improved seeds and irrigations systems to farmers	…	…	…	…

The information generated in this table can help advisers to write the Value for Money section of the Business Case. The information can be used to compare economy, efficiency and effectiveness of different options.

- Economy analysis will focus on the input indicators – to consider whether we are purchasing inputs at the right quantity and price;
- Efficiency analysis will look at the output and outcome indicators – to consider how and why we expect the programme outputs to lead to programme outcomes
- Effectiveness analysis will look at how the programme outcomes (improved resilience) are expected to lead to impacts (welfare improvements, reduced number of deaths, or reduced poverty relative to the counterfactual scenario).

STEP 6

Appraisal of Adaptation

Key Messages in this Section

- This section provides guidance on the economic appraisal of adaptation options.
- It provides information of potential use for business cases, including on:
  - The rationale for options (in addressing market failures);
  - Appraisal and Decision Support / Analysis of Uncertainty;
  - Costs and benefits (including existing B:C ratios) of promising options;
  - The analysis of value for money.
- It includes worked examples for promising options and further information sources.

Introduction

As highlighted in the Step 3, the prioritisation and appraisal of adaptation is challenging, because:

- There are no simple common metrics to compare and prioritise adaptation interventions.
- Baseline risks – and adaptation benefits – are highly site and context specific, and also change over time.
- There is high uncertainty associated with future climate change and thus with future adaptation benefits.
- Many promising early adaptation options are non-technical in nature, or involve qualitative, ancillary or non-market sector benefits.
- The identification of outcomes and outcome based indicators are made difficult by underlying climate variability and the long life-times involved.
- There is a strong overlap between adaptation activities and existing development.

As highlighted in previous sections, the use of iterative frameworks and the focus on low-regret adaptation can help in early identification and prioritisation towards the delivery of value for money. This allows the identification of strategic priorities for intervention and promising adaptation options (see Step 4).

However, for more formal economic appraisal, additional detail is needed. The final step in the toolkit therefore provides information to help for this more in-depth analysis, e.g. in relation to business case submissions. It provides relevant context in key areas, outlines key issues to consider, provides useful sources of information e.g. on cost:benefit ratios for promising options.

The section follows the general format of business case submissions, as follows:

- The potential market failures that adaptation options address.
- Appraisal and decision support techniques for adaptation, including addressing uncertainty.
- The costs and benefits of options, including a review of benefit:cost ratios for promising early options.
- The analysis of value for money.

It also includes worked examples and further information sources.

Addressing Market Failures

Some of the principal issues in the adaptation appraisal process are to make the justification for adaptation intervention, and to examine the potential role of Government in the proposed intervention. These issues are often quite complex for adaptation since they frequently involve consideration of non-market benefits and costs, and the existence of public goods.

There is Government guidance on this, (Defra, 2010), which recognises that people and businesses will take action to adapt when it is in their interest and power to do so; that is, they will take measures where the benefits outweigh the costs to them. However, the guidance also stresses that there are a number of information, market and policy failures that act to prevent such action, and this is borne out by the lack of autonomous, proactive adaptation seen to date in a number of sectors (Berrang-Ford. et al 2011).

The Defra report highlights that there are a range of barriers that make it challenging for people and businesses to choose the right adaptation strategy, including:

- Market failures. These include lack of information or awareness of climate impacts, misaligned incentives and the public good nature of some adaptation measures.
- Adaptive capacity. Some people lack the ability to respond to climate change because of financial or other constraints.
- Natural capacity. Natural systems might be unable to adapt because of the natural pace of their adaptive capacity, their resilience to frequent stresses, and the surrounding environment.
- Behavioural barriers. Adaptation decisions are complex, and involve dealing with long time horizons and uncertainty. Taking into account climate change in decisions made today – such as how and where to build new infrastructure – will have long-term benefits, but may entail additional near-term costs. There is a tendency for people to demonstrate inertia, procrastinate, and have implicitly high discount rates that place little weight on the future consequences of their decisions.

An extended discussion of the role of public intervention for adaptation is set out in the box below.

There is therefore a role for DFID in supporting Government, people and businesses to overcome some of these barriers and create an environment for (appropriate) adaptation decisions. However, it is important to consider and understand the barriers for motivation and the justification for intervention.

Box 16. The role of public intervention for adaptation

Berkout et al., (2007) set out a series of information, market and policy failures which affect efficient private adaptation. In response, they outline a role of Government in:

- Providing information, knowledge and learning;
- Early-warning and disaster response;
- Facilitating adaptation in market transactions, in the case of 'public good' arguments for investing in adaptation, and the risk of externalities. This can include standards and regulations to give private actors the freedom and incentives to adapt (facilitating adaptation or enhancing adaptive capacity).
- Tackling non-market sectors, such as in ecosystem management, due to the need to encourage efficient adaptation in sectors where goods are not traded, and where government has a clear role in encouraging adaptation.
- Mainstreaming climate-resilience, especially in areas of public policy that dominate climate-vulnerable sectors, for collective goods or because the state has a role through regulation.
- Enabling cross-sectoral linkages not captured by private sectoral interventions.
- Tackling infrastructure planning and development, and the role of Government in including climate resilience.
- Compensating (or considering) the unequal distribution of climate impacts (inequality and distributional impacts), especially where these aspects are not captured by existing markets.
- Preventing mal-adaptation, through co-ordination across areas and regions, and ensuring the potential for mal-adaptation is prevented through shifting of vulnerability.
- Reversing trends that increase vulnerability.
- Recognising and facilitating ancillary benefits, either in relation to current climate resilience, or wider sustainability or socio-economic benefits, to achieve optimal social adaptation, including for non-market areas, for knowledge and experience spill-overs, and where benefits occur to other agents (than those taking action).
- Addressing trans-regional or trans-boundary aspects that cannot be satisfactorily covered by private, local or regional or country (devolved administration) planning. Similarly, where local action would conflict with the overall country objectives, or where actions of sectors or regions act in ways that conflict with wider national objectives.
- Areas where national budget and spending programmes are important.
- In cases of capital resources (constraints), where potential adaptation responses may be so costly that only centralised funding from national funds will enable the action to occur.
- Where the greater size of national action (co-ordinated action) can leverage greater results.
- Where barriers to adaptation require some form of facilitation, enhancing the adaptive capacity of a sector, region or country, The fact that many no-regret measures have not been taken yet indicates the presence of barriers, and a role for Government role in removing these.
- Because of uncertainty, because the benefits of adaptation are uncertain, and this leads to a potential lack of action from individuals or organisations affected by climate change, especially where it constraining market sectors from fully undertaking adaptation.
- Because of discounting, as the present value of future adaptation benefits is dependent on the discount rate, and industry discount rates will significantly reduce the future benefits of adaptation and lead to less action than with the use of Government social discount rates.

To address this, the options identified in Step 4 have been considered in terms of the market and policy failures they address. These are discussed below:

Capacity building

As highlighted in Step 4, many of the promising low-regret/VFM options are centred on capacity building (e.g. information, awareness raising, institutional strengthening), and provide benefits in the form of the value of information. These involve public good aspects, and public investment in capacity building and institutional strengthening can also be justified on the basis of merit good characteristics, i.e. the benefits of its provision recognised by the state above those that the individual may recognise, and in terms of addressing existing information failures (and the consequences of these).

Enhanced meteorological and hydrological data, information and monitoring. Meteorological information and services provide services that have public good characteristics. The key market failure relates to the under-investment in public goods by private producers, which lead to allocatively inefficient decisions by potential users and those affected (e.g. farmers, or those affected by extreme events, against which they might otherwise be prepared). Similar issues are relevant for enhanced bio-physical monitoring.

Capacity building including institutional strengthening and awareness raising. Public investment in capacity building and institutional strengthening is likely to be justified on the basis of its merit good characteristics (see earlier). There are also public good aspects to its provision. Awareness raising is likely to be limited through private provision as a result of its public good characteristics. The negligible cost of re-production of an awareness raising service suggests that it is best provided as a public service.

Information and risk mapping. These provide information that has public good characteristics, addressing insufficient private investment or inefficient decisions (mis-allocation) relative to risks or risk transfer. It also address information failures, which can often be best provided as a public service in developing countries due to access to finance/transaction cost constrains, as well as the lack of private risk information providers.

Early interventions to address climate variability and extremes

A major strand of low-regret options in Step 4 are centred on addressing current climate variability and extreme events. These address the existing market failures associated with extreme events (such as flood), and often involve public good aspects, due to insufficient private investment relative to economic risks, and/or inadequate risk transfer mechanisms, noting these market failures may be exacerbated by underinvestment in the capacity building highlighted above.

Disaster risk prevention and management plans and emergency responses. There are usually market failures associated with flood risks and existing protection levels with insufficient private investment relative to economic risks, and inadequate risk transfer mechanisms. Risk management options also have a public good aspect, necessitating public intervention.

Farm level measure to encourage good development and climate resilience. These options involve high transaction costs, and access to finance can prevent the economically efficient level of up-take of these practices, thus there is a role for government, including addressing the information failures and barriers to uptake.

Climate smart agriculture (e.g. conservation agriculture, soil and water conservation, agroforestry). These options address specific variability problems, and also address many of the externalities associated with conventional agriculture, e.g. soil erosion and degradation, GHG externalities (carbon emissions). There are often high transaction and/or opportunity costs, and access to finance limits the economically efficient level of up-take of these options, which is exacerbated on information failures on their benefit. All of these elements highlight a potential role for public intervention.

Early warning systems. In general terms, there are market failures associated with flood risks and existing protection levels, and there is a public good aspect with insufficient private investment relative to economic risks, and inadequate risk transfer mechanisms. This issue may be compounded by a lack of information on basic data and forecasting that have public good characteristics. EWS have public good characteristics, and are unlikely to be provided by private organisations, thus highlighting the role for intervention.

Integrated water resource management. The primary market failure is that water is not adequately priced in most developing countries - as a result of the social benefits being greater than the private benefits - which therefore leads to inefficient and inequitable allocation of water resources. This is usually compounded by the absence of an effective institutional and regulatory framework for water management. There is often insufficient protection and conservation of upstream water catchments, which lead to downstream externalities (floods, reduced electricity generation from hydro-electricity), alongside poor enforcement (e.g. abstraction licences, water source encroachment and illegal abstraction) reducing economic and social welfare. IWRM acts to address these market failures.

Water efficiency use and leakage control. As with IWRM, water efficiency may be limited under private provision because the private value differs from the social value of water provision.

Integrated (sustainable) land-use planning. Private market decisions, in relation to land-use, are often made with a lack of information on public good characteristics and do not take account the wider societal benefits of land-use decisions and externalities (e.g. the reduction in amenity or welfare value, reduction in green space, increase in flood risks, from poor land-use decisions). Integrated land-use planning addresses these aspects and also addresses potential mal-adaptation.

Ecosystem based adaptation. These options help to address the existing market failures associated with water variability and extremes (droughts, floods, storm-surge), in the context of existing action, as there is a public good aspect. They also address underlying market failures in relation to the loss and degradation of ecosystems, noting the high externalities involved from the loss of ecosystem services. There is therefore a strong argument for public action, given public good characteristics and transaction cost constraints. This may be particularly important as ecosystem based adaptation is often undertaken at a community, where such constraints are high.

Social protection. There are market failures associated with climate risks and existing protection levels where there is a public good aspect with insufficient private investment relative to economic risks, and inadequate risk transfer mechanisms, especially where access to finance prevents the economically efficient level of up-take of measures.

Improved water and sanitation (water quality and health). There are market failures associated with insufficient investment in basic water and sanitation, and access to finance prevents the economically efficient level of up-take of preventative measures. These also have public good characteristics, especially when integrated water management aspects/externalities are taken into account, thus highlighting the role for intervention.

Maintenance regimes. The key failure relates to the under investment in maintenance and the higher subsequent impacts and externalities this leads to, i.e. inefficient resource allocation, as a result of failures (delays or reassignment in resource allocation), or information failures.

Building codes, set-back zones, critical infrastructure protection. There address existing market failures associated with flood risks and existing protection levels due to insufficient private investment relative to economic risks, inadequate risk transfer mechanisms, or inefficient allocation decisions (information failures). These options also have a public good aspect.

Risk transfer including insurance. The existing market failures may be around the lack of developed insurance market and access to finance (individuals). There may also be information failures, e.g. in relation to data on the frequencies and intensities of hazards and assets among those affected. It may also relate to incorrect risk premiums (e.g. where these are too low and encourage activities in hazard-prone areas, noting this may be an issue with future climate change). Furthermore, while individuals are risk-averse, there are good reasons for governments acting on their behalf to be risk neutral. At the national to regional level, there may be a role for intervention in addressing market failures (e.g. the provision of affordable insurance) through risk pooling.

Mainstreaming

In considering near-term decisions that have long life-times, there is high potential for allocatively inefficient decisions by potential users, especially given information failures. These failures can be addressed by **climate risk screening, low-cost over-design, and flexibility**.

The information barriers involved (noting the uncertainty over future climate change), and the potential for mal-adaptation, highlights the potential role for intervention, especially as these decisions will often by associated with public infrastructure or addressing non-market sectors.

Early actions to address future challenges

Iterative adaptive management plans address a number of market and information failures, and capture many of the elements highlighted above. They have benefits through the value of information (addressing information failures), and encourage more efficient allocations and decisions through the focus on decision making under uncertainty and option values. They also have strong elements of capacity building, thus public good and merit good characteristics. The long-time scales involved in these plans means that they are unlikely to be provided by private organisations, thus highlighting the role for intervention.

Appraisal and Decision Support / Analysis of Uncertainty

A key part of the adaptation policy cycle is the appraisal of options. As highlighted in Step 2, this is challenging, due to:

- The uncertainty involved, which cautions against the use of traditional decision support tools, such as cost-benefit analysis.
- The nature of benefits (see Step 3), which are often qualitative or involve elements that are difficult to consider in economic appraisal, such as the value of information, or non-market sectors.

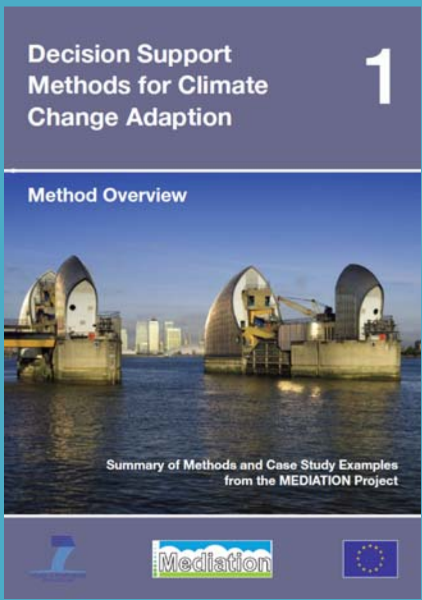
A key resource for helping for adaptation appraisal is provided in the **DFID Topic Guide: Adaptation Decision Making under Uncertainty**, which provides additional information and support. This was summarised in Box 11.

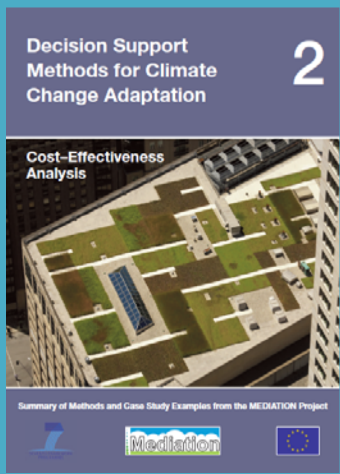
Additional information is also available on a range of individual appraisal tools and their application to adaptation on the Mediation common platform, including case study examples. The information is highlighted in the box below.

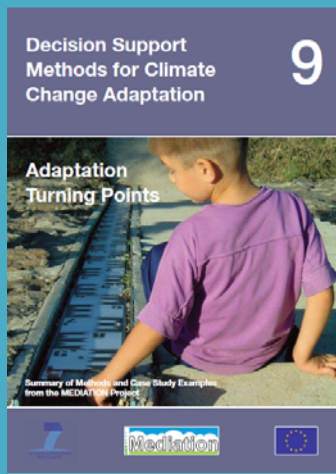
Box 17 Decision support tools for adaptation and uncertainty

The FP7 MEDIATION project has undertaken a detailed review of decision support tools, and has tested them in a series of case studies. It has assessed their applicability for adaptation and analysed how they consider uncertainty.

An overview of support tools – and summaries of individual techniques - are available from the MEDIATION Adaptation Platform.







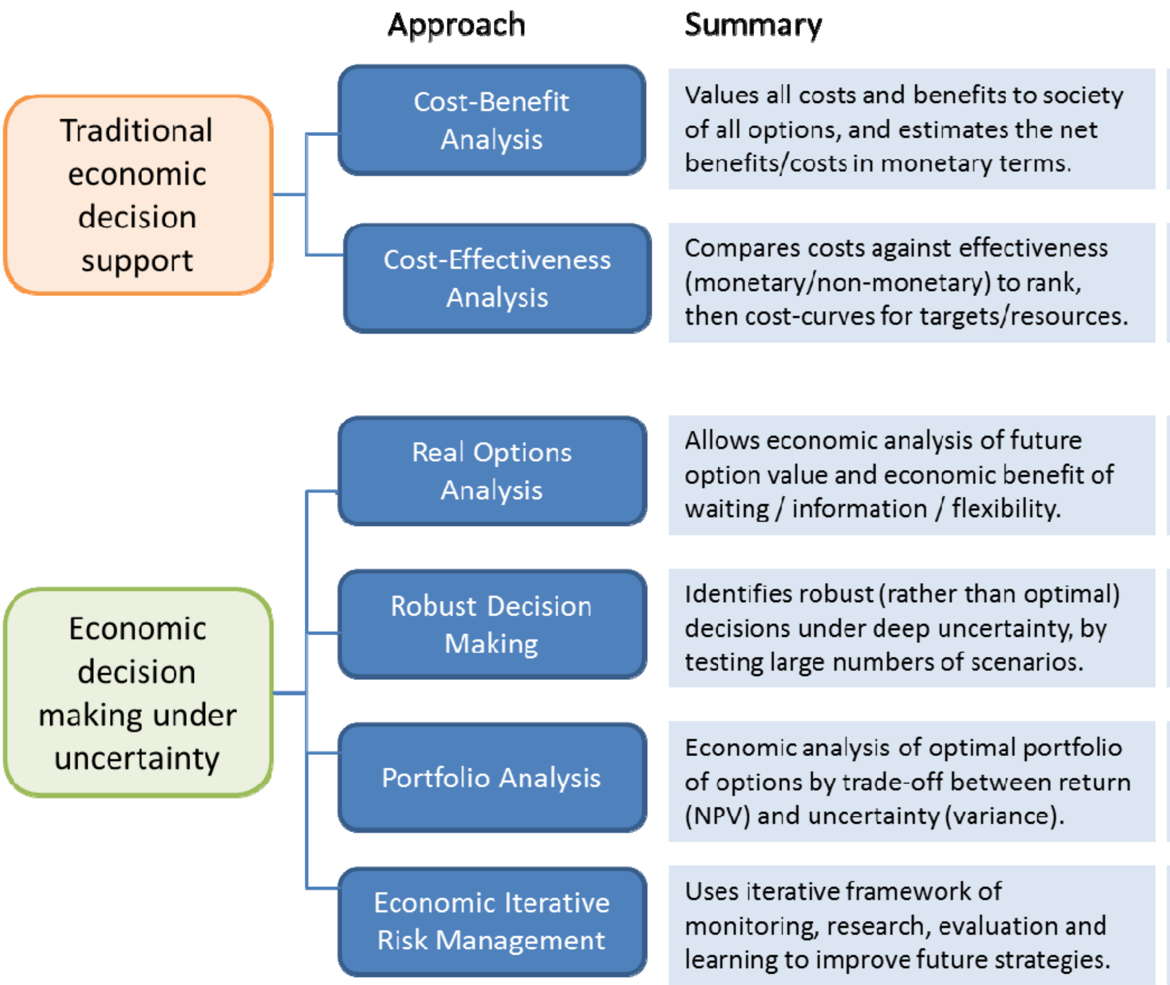
These include:

- Method overview (1):
- Cost-Effectiveness Analysis (2);
- Multi-criteria analysis (3);
- Real Options Analysis (4);
- Robust Decision Making (5);
- Portfolio Analysis (6);
- Iterative Adaptive Management/Adaptation Turning Points (7);
- Analytic Hierarchy Process (8);
- Social Network Analysis (9).

These can be downloaded from:
http://mediation-project.eu/output/technical-policy-briefing-notes

A summary of the various tools and their key attributes is shown in the figure below.

Figure 21. Summary of Adaptation Decision Support and Appraisal Tools



While there are no hard-or-fast rules on which tool to use, it is clear that certain tools lend themselves more to specific contexts or sectors. Furthermore, the level of time and resources available, and the size of the investment decisions, will determine the level of detail needed, and also which support tool might be justified.

The table below highlights the strengths and weaknesses of the tools. The grading of resources and expertise required are relative; most of these tools are resource/expertise-intensive. However, depending on the size of the investments being considered, such resources can be justified by minimising investment resource mis-allocation.

Table 10. Attributes of the Decision Support Tools.

Decision Support Tool	Strengths	Input requirements	Benefits analysis	Resources / expertise	Weaknesses
Cost-Benefit Analysis	Well known and widely applied.	Individual scenario and climate model outputs. Baseline damage costs from scenario-based IA.	Reduction in baseline costs (benefits). Benefits expressed in monetary terms.	Medium.	-Difficulty of monetary valuation for non-market sectors and non-technical options. -Consideration of uncertainty limited to probabilistic risks.
Cost-Effectiveness Analysis	Analysis of benefits in non-monetary terms.	Scenario and climate model outputs and often baseline damage costs. Effectiveness as reduction in impacts (unit / total).	Benefits expressed in quantitative (but not monetary) terms.	Medium	-Single headline effectiveness metric difficult to identify -Common metric makes less suitable for complex or cross-sectoral adaptation. -Consideration of uncertainty
Real Options Analysis	Value of flexibility, information.	Probability or probabilistic assumptions for climate (multiple scenarios). Decision points. Baseline damage costs.	Analysis of benefits of options expressed in monetary terms	High.	-Requires probabilities -Requires decision points -Most relevant where adaptation deficit. -Challenge of valuation-for non-market sectors.
Robust Decision Making	Robustness rather than optimisation.	Multi-model scenario and climate model outputs (more the better). Formal approach requires uncertainty information for all parameters.	Benefits expressed in quantitative or economic terms.	High.	-Often qualitative inputs (stakeholder) -High computational analysis (formal) and large number of runs -Large numbers IA assessment (CC)
Portfolio Analysis	Analysis of portfolios rather than individual options	Probability or probabilistic assumptions for climate (multiple scenarios). Variance and covariance of each option.	Benefits, expressed as physical or monetary inputs / NPV outputs	High.	-Requires probabilities -Issues of inter-dependence between options
Economic Iterative Risk Assessment	Iterative analysis incorporating monitoring, evaluation and learning.	Sets of scenario and climate model outputs, but flexible. Threshold levels for risks.	Benefits expressed in quantitative or economic terms.	Variable.	-Challenging when multiple risks acting together. -Thresholds are not easy to identify.

Source Watkiss et al, 2014.

In comparing the methods, a number of key differences emerge.

- Of the approaches considered, two require economic valuation of benefits (CBA and ROA): the other four (CEA, RDM, PA, IRM) have greater flexibility and can consider economic or physical benefits, increasing their applicability.

- Among the uncertainty tools, two are risk orientated, requiring estimates of probability (ROA and PA), while two are applicable under situations of uncertainty (RDM and IRM) where probabilistic information is low or missing.

- While powerful, all uncertainty-focused tools are technically complex. In their formal application, they are data and resource intensive, requiring a high degree of expert knowledge.

- Finally, the discussion above has focused on climate uncertainty. However, as highlighted earlier, there is additional uncertainty. While this can be included within most approaches, RDM is best structured for addressing multiple sources of uncertainty.

- These differences (in design, but also consideration of uncertainty) mean that these tools are suitable for different types of adaptation problems (noting their application to the same problem can also lead to different decisions).

The type of problem (and objective) will therefore shape the most appropriate tools to use. None of these tools is universally applicable to all adaptation problems and they each have particular strengths for certain types of decisions and/or applications. Drawing on the review, applicability is summarised below. A number of observations are highlighted.

- A number of the methods require probabilistic inputs, but climate uncertainties are rarely characterised in such terms. Even when probabilistic-like projections exist, these provide a probability distribution for individual emission scenarios, rather than a composite probability distribution for all scenario futures and all models together. This is a critical issue, especially for techniques that require probability/expected value (ROA and PA). This tends to favour RDM and IRM tools when climate change uncertainty is large.

- Furthermore, there are differences in the relevant time periods. RDM has broad application for current and future time periods, especially in identification of low- and no-regret options. When investments are nearer term (especially high upfront capital irreversible investments), and where there is an existing adaptation deficit, ROA is a potential useful tool. For long-term investments in conditions of a low current adaptation deficit, IRM may be more applicable.

- Finally, with respect to scale: ROA appears to be more orientated towards projects (investments), while RDM and IRM have greater potential for programme/sector analysis. It is not clear how any of these methods might be used to evaluate transformational adaptation, e.g. when the size of change is structural or non-marginal (e.g. major macro-economic or societal change).

- Finally, while the tools are presented individually, they are not mutually exclusive. Indeed, a tool focussed on economic efficiency may be complemented by one orientated towards robustness; the decision-maker would then be better able to make an informed judgement across these criteria.

Table 11 Applicability of the Different Decision Support Tools.

Tool	Applicability	Usefulness & limitations in climate adaptation context	Potential uses of approach
Cost-Benefit Analysis	Short-term assessment, particularly for market sectors.	Most useful when: -Climate risk probabilities known. -Climate sensitivity small compared to total costs/benefits. -Good data exists for major cost/benefit components.	Low and no regret option appraisal (short-term). As a decision support tool within iterative risk management.
Cost-Effectiveness Analysis	Short-term assessment, for market and non-market sectors. Particularly relevant where clear headline indicator and dominant impact (less applicable cross sectoral and complex risks).	Most useful when: -As for CBA, but for non-monetary metrics (e.g. ecosystems, health). -Agreement on sectoral social objective (e.g. acceptable risks of flooding).	Low and no regret option appraisal (short-term). As a decision support tool within iterative risk management.
Real Options Analysis	Project based analysis Large irreversible capital investment, particularly where existing adaptation deficit. Comparing flexible vs. non flexible options.	Most useful when: -Large irreversible capital decisions -Climate risk probabilities known or good information -Good quality data exists for major cost/benefit components	Economic analysis of major investment decisions, notably major flood defences, water storage. Potential for justifying flexibility within major projects.
Robust Decision Making	Project and strategy analysis. Conditions of high uncertainty. Near-term investment with long life times (e.g. infrastructure).	Most useful when: -High uncertainty in direction of climate change signal. Mix of quantitative and qualitative information. -Non-monetary areas (e.g. ecosystems, health)	Identifying low and no regret options. Testing near -term options or strategies across number of futures or projections (robustness). Comparing technical and non-technical sets of options.
Portfolio Analysis	Analysing combinations of options, including potential for project and strategy formulation.	Most useful when: -A number of adaptation actions likely to be complementary in reducing climate risks. -Climate risk probabilities known or good information.	Project based analysis for future combinations for future scenarios. Designing portfolio mixes as part of iterative pathways.
Economic Iterative Risk Assessment	Project level. Strategy level for framework for planning.	Most useful when: -Clear risk thresholds. -Mix of quantitative and qualitative information. -For non-monetary areas (e.g. ecosystems, health).	Flexible, though very relevant for medium-long-term where potential to learn and react. Applicable as a general framework for adaptation policy development.

Source Watkiss et al, 2014.

The figure below matches the types of low-regret/VFM adaptation to possible types of decision support tools:

Figure 22. Early VfM and Detailed decision support tools for appraisal.

EARLY VFM ADAPTATION	Type of early adaptation	Analysis
1. Low/no regret options to address deficit	a) Good development	Cost-benefit analysis, noting the development context, and the need to consider future climate risks.
	b) Addressing current climate vulnerability	Cost-benefit analysis e possible in some cases, but risk based. Often non-market sectors and qualitative benefit, thus cost-effectiveness or multi-criteria, considering future climate risks.
	c) Capacity Building	Less outcome based and often qualitative. Some potential for CBA when value of information, otherwise multi-criteria analysis.
2. Risk screening, resilience & mainstreaming	a) Low cost, robust and flexible options	Requires future climate information (envelope/range) and given uncertainty, potential for robust decision making, portfolio analysis or real options analysis.
	b) Capacity and information	Less outcome based and often qualitative. Some potential for CBA when value of information, otherwise multi-criteria analysis.
3. Addressing future climate challenges	a) Iterative adaptation pathways	Iterative adaptive management framework, which can include CBA or MCA. Can also extend to real options analysis.

Finally, all of these methods are resource intensive and technically complex, and this is likely to constrain their formal application to large investment decisions or major risks. Given this, there is a focus on 'light-touch' approaches that capture principal conceptual aspects, while maintaining a degree of economic rigour. A number of examples are included in the DFID Topic Guidance on Uncertainty.

Costs and Benefits including Benefit:Cost Ratios

Economists and project developers considering including low regret/VFM options will normally be expected to assess the overall costs and socio-economic benefits of these measures in any appraisal process, and to justify their inclusion against alternatives using cost-benefit or other forms of economic analysis.

The basis for this appraisal will be the standard DFID guidance notes on appraising climate change interventions, together with guidance set out in Green Book (HMT, 2011: creating options, valuing costs and benefits, adjusting valued costs and benefits, discounting, addressing risk and uncertainty, preventing risk and uncertainty, and considered unvalued impacts).

There is also additional supplementary guidance to the Green Book on accounting for the effects of climate change, i.e. adaptation (HMT, 2009) and on intergenerational wealth transfers and social discounting (2008).

As highlighted above, in many cases, the application of a standard CBA for adaptation is challenging, because of the qualitative or non-market aspects, or the future consideration of uncertainty. However, the iterative framework addresses many of these challenges, by focusing on current climate variability and value for money interventions for mainstreaming and addressing future challenges. For the more immediate measures (which address the adaptation deficit), the evidence is more robust, and less weight may be given to issues of long term uncertainty (though this should not be ignored).

To advance this, the work underlying the toolkit has undertaken a wide-ranging literature review, to identify existing cost-benefit assessments of relevant early VFM adaptation options. This has identified over a hundred relevant studies.

A summary of the findings of the review are presented below – by option[12] – along with key issues or important notes. More information is provided in the appendices, which include individual results and references for each option analysed in detail. It is therefore possible to draw on the existing economic literature on the costs and benefits of these interventions, as a proxy for their use in early adaptation.

It is stressed that in many cases, options provide largest benefits (i.e. they have highest BC ratios) when they are implemented as portfolios of actions, rather than as a single action.

Table 12 Benefit: Cost Ratios for low regret/VFM adaptation

Low Regret/VFM option	CBA Literature results
Enhanced meteorological and hydrological data, information and monitoring	These studies assess the value of information and the benefits from improved meteorological data, and subsequent use in forecasting, warning, etc. A review of the literature is provided by Clements (2013) and with updates, a total of 39 studies were identified, though there was a bias towards OECD countries and agriculture (seasonal forecasts). The studies indicate benefit-cost ratios of between 2 and 36, though ratios vary according to sector, and whether non-market benefits are quantified. Note that benefits vary strongly with the assumptions about use of information and uptake.
Capacity building including institutional strengthening and awareness raising	Analysis of benefits challenging due to the quantitative nature. Cartwright et al (2013) report high BC ratios for disaster risk management plans (contingency, awareness) and institutional strengthening (e.g. a cross-sectoral disaster forum) – and found these had amongst the highest BC ratios of all options considered. A

[12] The results are presented for the original study papers – they do not undertake a meta-analysis to standardise on discount rates, thus some care should be taken in comparisons between studies.

	number of studies report higher benefit:cost ratios when capacity building/institutional strengthening are combined with outcome orientated adaptation options.
Disaster risk prevention and management plans and emergency response	Evidence from World Bank (2011) also suggest high BC ratios (4: 1) for emergency plans shelters, developing accurate weather forecasts, issuing warnings, and arranging for their evacuation. Williams (2002) highlights that preparing a house before a hurricane (e.g. by covering windows) can reduce damage by up to 50%.
	Earlier studies of disaster risk management cite a benefit :cost value of 8:1, though the evidence for this was weak, drawing on a single paper. More recent review (Mechler, 2012) report that benefits outweigh the costs on average, by about four times the cost (in terms of avoided and reduced losses), with value of 3.9 for wind-storms and 5.0 for floods, based on a review of ex ante and ex post studies.
Farm level good development and climate resilience	Estimates are available from standard agronomic economics literature. Studies report high benefit to cost ratios.
Climate smart agriculture (e.g. conservation agriculture, soil and water conservation, agroforestry)	These options generate yield benefits and have additional environmental or livelihood benefits. Studies generally indicate benefit-cost ratios of >1, though this depends on coverage, and discount rate due to the longer-term nature of benefits (e.g. on soil structure). Review identified around 7 studies, though range of values across different BC ratios with location, even for same individual option. These options also have important opportunity or policy/transaction costs McCarthy et al (2011), which need to be included and can change the BC ratios.
Early warning systems	These systems have low costs and high benefits (World Bank, 2012), though a need to factor in met data, capacity and training, institutional, dissemination and awareness raising. The benefits arise from reduced fatalities and injuries (non-market) and reduced damage, thus benefits depend on health valuation. Review identified 10 studies for flood early warning and 6 studies for coastal wind-storm/storm-surge. Wide range of BC ratios, but values of 2 to 5 are common, with even higher values for highly vulnerable areas (e.g. Bangladesh).
Water efficiency use and leakage control:	Estimates are available from standard economics literature. Studies report high benefit to cost ratios.
Integrated water resource management:	Benefits from value of information, improved water management (downstream users) and reduced flood risks, that arise, which high compared to the costs. One CBA study identified with BC of 2.5.
Information and risk mapping /	Benefits focused around value of information, but no explicit studies identified.
Integrated (sustainable) land-use planning	Benefits from amenity benefits (e.g. public space), reduced externalities (reduced flooding, heat) from land-use planning, though issue of opportunity costs where land-use planning constraints introduced.
Ecosystem based adaptation for watershed and flood management	Benefits from reduced flow/improved water management, and wider ecosystem service benefits (though these often challenging for valuation). Capital costs lower than hard protection, but costs can be high due to acquisition, opportunity costs (especially in urban areas) and maintenance costs, plus policy costs to ensure conservation. 7 economic studies identified, though show high benefits, but all OECD
Ecosystem based adaptation for coastal buffer zones	Benefits are large due to high ecosystem service value, e.g. associated with mangrove, sea-grass, coral, etc. Cost of restoration low, thus high BC ratios. 7 studies found, which generally report high BC ratios though a wide range (2:1 to 50:1), noting Cartwright (2013) reports lower values in Durban due to acquisition costs for land.
Social protection	DFID guidance on measuring and maximising value for money in cash transfer programmes (2011) provides estimates of VFM including CBA ratios.
Improved water and	Hunt (2011) reviews CBA studies, reporting on 7 studies. Wide range

sanitation (water quality and health);	depending on option and context (OECD vs LDC). BC ratios high, with values of 2-3:1 in most studies, but with one study reporting 5 – 12:1 for LDC context.
Maintenance regimes	Highlighted by World Bank (2011) and number of studies focusing on flood/storm drainage maintenance report good BC (3:1, e.g. ECA, 2009).
Building codes	Number of studies in flood context, which indicate high BCrs, e.g. 7:1 in Guyana (ECA, 2009); IIASA et al (2009) report flood-proofing brick houses in India and raising houses (by 1 metre) in Jakata, with BC ratios of 7:1 and 4:1 respectively). Lower BC ratios found in coastal windstorm context (five studies), with 3 studies finding BCs <1, and 2 >1, thus option highly site (and risk) specific, even to individual locations in same country.
Risk transfer including insurance	Benefit to cost ratios available for insurance. Number of estimates in LDC context, reporting favourable BC ratios, e.g. of 2 for drought (index based insurance in India) from the Risk to Resilience Study (2009).
Critical infrastructure protection	Highlighted as highly beneficial by World Bank (2011), though need to ensure list of critical infrastructure highly focused.
Set-back zones	In coastal context (storm-surge), four studies report very high BCrs (e.g. ECA, 2009; Cartwright et al, 2013), with highest values amongst all options considered.

For a number of options, e.g. the more forward looking aspects (e.g. low cost overdesign, design flexibility, climate risk screening and mainstreaming climate change, iterative adaptive management plans) the benefits arise from more complicated benefit elements, e.g. through value of information, option values from flexibility, learning, and thus do not align to the traditional CBA. However, studies that compare these options against standard options find they can deliver higher expected values.

A number of other aspects are highlighted that should be taken in to consideration:

1. *Additionality and baseline development:* In undertaking an assessment of the economic benefits of adaptation, it is important to consider whether the activities are additional to those likely to be undertaken in the absence of the programme. This can involve quite complex decisions, and the attribution rules may depend on the application/context and the boundary of the analysis. It is highlighted that many low-regret/VfM options (as above) are already included in existing government programmes, e.g. measures that fall within traditional sector budgets and build resilience (e.g. social protection, sustainable agriculture, water supply). Therefore, care should be taken to ensure that there is no overlap with existing government plans, and that DFID programming is not simply displacing other funding, or bringing forward activities that would have been funded by other means at a later date. This may mean more robust and detailed analysis about the baseline is needed, though this could have the impact of reducing the overall economic returns from a CBA perspective;
2. *Benchmarking and transferability:* The table above provides examples of Benefit-Cost Ratios and other economic data for low- regret/VfM options. This information is useful for the purposes of benchmarking in the context of an appraisal. However, it should be noted that unlike mitigation costs, adaptation costs and benefits tend to be heavily influenced by local geographic, environmental and economic factors, i.e. they are site and location specific. Costs of labour and materials vary substantially between countries, and even within a given country. Likewise, economic benefits, such as those associated with increased water availability and improvement in agricultural yields will be site specific (dependent on crop choice, soil fertility and market prices), and vary with time. When using economic values drawn from similar projects as part of an appraisal,

the similarities and potential differences of these reference projects to the one under appraisal should be explored and, where appropriate, tested using sensitivity analysis, i.e. to examine the potential for benefits transfer;

3. *Distribution of costs and benefits:* For some types of low-regret/VfM options, the distribution of costs and benefits will not be uniform. Many development-oriented measures targeted at improving resilience are focused on vulnerable populations (agriculture, water supply, sanitation, social protection), and are likely to provide significant benefits to poorer population segments. Where climate change adaptation is only one of a number of development outcomes associated with a project, it might be possible to apply an equity weighting, reflecting the positive distributional effect delivered by no-regrets activities, thereby increasing the expected socio-economic returns;
4. *Ensuring that the full range of benefits are recognised:* When appraising climate mitigation projects, it is possible to use common non-monetary units (e.g. tonne of GHG abated) and to express this in a singly monetary unit (£/tCO_2e abated). For adaptation measures, there are a wide range of benefits, without a single common unit. Many of these benefits are difficult to monetise, particularly for options centred on capacity building or non-market sectors (e.g. ecosystem services, adaptive capacity, and value of information). Where methodologies do exist, these can be complex and resource intensive to apply from an ex-ante perspective during project development. Where these benefits are not monetised, they should nonetheless be quantified to the extent possible, and where not, described in qualitative terms;
5. *Using non CBA appraisal techniques:* As highlighted in the previous section (appraisal), a number of different techniques are available for covering the full range of adaptation options and to consider uncertainty. This may require additional support tools to CBA. As examples, a number of options (particularly in relation to infrastructure, e.g. water supply and or quality) will need to meet national standards - from this perspective, cost effectiveness analysis (finding the least cost option of meeting the standard) can be an appropriate support tool. For qualitative or non-market options, there is the potential to use multi-criteria analysis. Finally, for some of the more forward looking options, it may be appropriate to use robust decision making, real options or iterative management approaches, noting the potential for simpler approaches as illustrated in the DFID Topic Guidance on Uncertainty.

Value for Money

As highlighted earlier, the International Climate Fund (ICF) uses VFM considerations at a strategic level in relation to the allocation of resources and at a project level to improve design and maximise outcomes.

- At a *strategic* level, VFM may be used to support allocation approaches. For example, VFM may inform the balance between capacity building and project investment, or the allocation of resources between countries or sectors on the basis of vulnerability. VFM may be viewed from an operational angle, such as the potential speed of disbursement, absorption capacity of different beneficiaries and delivery channels, and scaling up/leverage potential;

- At an *implementation* level, VFM can drive effective project design through the promotion of **low- and no-regret measures**, the identification of co-benefits (mitigation or poverty reduction), and innovation potential. Results frameworks are used to provide a common set of indicators that can be aggregated.

In the appraisal of adaptation VfM in business cases, some suggestions on possible approaches are included below.

At a project level, DFID guidance supports VFM analysis at three levels:

- *Economy (spending less):* This refers to ensuring lowest cost procurement of goods and services within project design, and focuses on making sure that the unit costs are benchmarked against market norms. For example, from an adaptation perspective, this might involve ensuring that the costs of a water saving technology purchased were in line with international market expectations.

- *Efficiency (spending well):* This refers to ensuring that the choice of goods and services to be procured ensures that the procurement of goods and services results in the envisaged outputs. The input to output ratios are the key consideration. From an adaptation perspective, this might involve ensuring that the technology selected would deliver the desired reduction in volumes used for irrigation compared to similar alternative technologies.

- *Effectiveness (spending wisely):* This refers to the selection of those outputs most likely to result in the desired outcomes (and impacts). From an adaptation perspective, this could be ensuring that the water saving technology selected was the most (cost) effective way of making an agricultural community more resilient. Alternatives to be considered might include, adopting more drought resistant crops, investing in water capture and storage capacity, or diversifying livelihoods away from agriculture.

A more detailed overview of potential questions and approaches to analysis is set out below:

Economy

In terms of analysis the economy component of VFM, it is useful to:

- Set out unit costs associated with the intervention (e.g. £/meteorological station, £/m^3 of for a water saving technology,/£/ha of mangrove restoration etc.) and explain how these benchmark against similar interventions or against other market price data;
- Explain programme management or contractor costs as a % of overall budget and how these benchmark against DFID or other programmes in similar territories and sectors.

Efficiency

In terms of analysis the efficiency component of VFM, it is useful to:

- Highlight the key output indicators that will drive costs (and therefore determine VFM) for this type of intervention (e.g. number of meteorological stations installed and operational, number and extent of early warning systems products developed, area of agroforestry planted);
- Explain the potential barriers to these outputs being delivered (e.g. integration of technology with legacy systems, capacity of staff to interpret and manipulate met data), and show how these are being addressed (e.g. smart procurement, training);
- Show how commercial, management and M&E frameworks will support effective delivery and cost control (e.g. payment by results per monitoring station installed and operational after x years);
- Set out any 3rd party finance or in kind support being leveraged to deliver project outputs (e.g. matching funds from met office, access to WMO resources).

Effectiveness

In terms of analysis the effectiveness component of VFM, it is useful to:

- Set out why the focus on a given (sub-)sector represents the most sensible use of funds (medium term agriculture forecasting vs. short term EWS) based on risk and vulnerability assessment and existing development baselines;
- Provide examples of the relevant logframe outcome indicators for this type of intervention? (e.g. # farmers changing agricultural practices based on medium range forecasts, # pre-emptive response actions based on EWS)
- Explain why the balance, type and volume of no regret activities/outputs represent the most effective route to achieving these outcomes. Do other routes exist to achieve the same goals (e.g. hard protective infrastructure)?
- Indicate if the chosen activities represent a necessary pre-condition for achieving other resilience or development aims (e.g. met services a pre-requisite for longer term agricultural infrastructure planning and land reclamation policy);
- How have potential barriers to no regret outcomes being achieved been addressed (e.g. negotiating private contracts with insurance sector to co-finance maintenance of station network over time, ensuring that information products designed with a clear end user profile based on market demand, training end users in using met data)?
- What are the transformational or indirect network effects expected as a result, particularly those not been modelled in the CBA (e.g. policy mainstreaming of risk data into sector planning, replication and scale up of EWS in neighbouring countries, mobilising additional finance into met services);
- Are the project specific CBA results in line with similar type interventions elsewhere (as demonstrated by the earlier evidence list)? What non-market benefits and equity considerations have not been included in the CBA that might make the case more attractive?
- What specific analysis might be built into the M&E or KM process to strengthen VFM understanding (e.g. user willingness to pay for information)

Finally, a number of quick examples are presented below.

Table 13. Examples of VFM attributes for Low-regret/VfM adaptation

Option	Economy	Efficiency	Effectiveness
Enhanced meteorological and hydrological information/ services	Ensuring lowest cost procurement of goods and services, especially for meteorological equipment.	Ensuring the necessary training, analysis capability and communication/ dissemination means to ensure that benefits reach potential users, i.e. to ensure that investment in MHS results in the envisaged outputs. There is also an efficiency aspect in the choice of areas to focus on, i.e. in the benefits in relative sectors (e.g. agriculture, EWS, etc), noting this will be driven by local risk context and existing baselines.	Choosing the balance of investment between equipment, capacity, institutional strengthening, dissemination, etc. to result in the desired outcomes (and impacts). It is also likely to focus on the areas most likely to deliver cost-effective benefits, noting this should include non-market benefits (e.g. valuation of life) and equity consideration (the most vulnerable).

Water efficiency use and leakage control	Benchmark unit costs for pipe and water regulation device procurement Benchmark irrigation management and contractor costs against similar programmes	Clearly identify cost drivers (number of water flow meters installed) and demonstrate why intended equipment volumes and systems design represents the optimal level to address climate risks Consider payment by results in terms of number of farmers benefiting or # hectares upgraded. Alternatively consider payment on basis of reduced water savings where metering systems exist Demonstrate how operational effectiveness will be monitored ex-post to ensure adequate maintenance regime is followed Set out co-finance by farmers in terms of investment in associated infrastructure, and cooperation with other donor funded initiatives	Explain how improving end use water efficiency links to the underlying climate vulnerability (e.g. increasing trans-evaporation, reduction in river-fed irrigation flows) Explain how the outcome indicators can be used to link performance to value for money (e.g. # litres saved per ha, % in water use per ha) to financial and economic benefits (reduced water charges, increased yield returns) Set out how prevailing water subsidies or distortions in pricing might otherwise distort the financial incentives for farmers involved Set out benefits of demand side water management, and contrast with other potential options (for example, investment in storage, or water catchment improvement), explaining balance between both Explain if investment in irrigation efficiency is a pre-requisite for other adaptation activities, e.g. reclaiming degraded lands and income diversification Explain how potential barriers to long term maintenance and operation have been addressed (e.g. formation of water user groups, introduction of water provision fees) Set out how investment in improved irrigation systems can be used to scale up regional and national level efforts (e.g. farmer training seminars, study visits for policy makers, field level cost benefit analysis to inform policy makers)

Climate-smart agriculture, including conservation agriculture, soil and water conservation, agroforestry.	Consider procurement approach, including low cost community-led service provision vs. higher cost external commercial service contracts Benchmark community level adaptation labour and material costs for specific climate smart activities	Clearly identify cost drivers (e.g. # ha. under terracing) Consider payment structures that reflect implementation progress e.g. payment by # ha upgraded and under sustainable management. Demonstrate how operational effectiveness will be monitored ex-post to ensure adequate maintenance regime is followed (e.g. investment in community level management structures) Set out level of community contribution (both financial and in-kind labour and materials)	Explain how climate smart agriculture addresses potential threats (soil degradation, erosion, soil productivity), and why site and options choice are optimal Explain how the outcome indicators (e.g. increased yield) can result in to financial and economic benefits (e.g. % increase in annual household incomes, improved returns per ha.) Set out how climate smart agriculture can reduce other cost inputs (e.g. reduced fertiliser use) Explore selection of options within climate smart agriculture, and justify against other potential (no regret) options Explain if climate smart agriculture is a necessary pre-condition for other adaptation options or delivers important co-benefits as part of a wider package of resilience measures (e.g. in conjunction with an efficient irrigation programme) Explain how potential barriers to long term support have been addressed – e.g. farmer training Set out how investment in improved climate smart agriculture can be used to scale up regional and national level efforts (e.g. farmer training seminars, study visits for policy makers, field level cost benefit analysis to inform policy makers)

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