Review of international experience in adaptation indicators

Customer:
Adaptation Sub-Committee

Customer reference:
Review of international experience in adaptation indicators

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Executive summary

The Adaptation Sub-Committee (ASC) is developing a framework for monitoring and evaluating progress in adaptation, and is interested to see how this framework compares with some recent global adaptation (or vulnerability) indices. The ASC is also keen to understand how other countries have developed, or are in the process of developing, their own approaches for monitoring and evaluating adaptation, to inform, challenge, and improve its own efforts in this regard.

This report considers three recent, high profile, published, and publicly accessible, global indices of vulnerability or adaptation. These are the Global Adaptation Index (GaIn), the Climate Vulnerability Monitor, and the Climate Change Vulnerability Index. The report also identifies key messages from a review of other country-level experiences and approaches to adaptation monitoring, in the UK, Europe and beyond. Two country case studies were used to examine alternative approaches to the challenge of measuring progress in preparedness for climate change (Germany and Australia).

There are synergies between the methodology used by the ASC and the approach being developed in Germany, with the methodology employed by Schönthaler et al. (2010) using the DPSIR framework as the basis for indicator development. However, indicator development in Germany is closely aligned to the DAS (German Strategy for the Adaptation to Climate Change) which provides the contextual anchor for the development of indicators. There has been a strong emphasis on the development of the methodological framework and in articulating a transparent selection process, including a detailed consideration of data constraints and stakeholders have played an important role in the process.

In Australia, efforts to develop national level adaptation indicators have been reenergised by the planned publication of the Climate Futures Reports in 2013 which will require an effective means of quantifying adaptation progress. As is the case in Germany, work on measurement of adaptation is closely aligned to national-level adaptation planning processes. Experience in Australia has also illustrated the potential for drawing from other disciplines, in this case the international development community.

A number of conclusions have been drawn.

- There seems to be no single “best practice” framework for the construction of vulnerability or adaptation metrics, but common concepts can be useful.
- There is no single, consistent definition of the key terms, such as “vulnerability”, “adaptation” “capacity”, involved in the construction of these indices.
- Understanding the purpose of the monitoring / evaluation exercise is essential. A clear purpose has driven the design of each index reviewed. The authors of each index are clear about the action they wish to provoke by the existence of their metric, and this has significantly determined their selection of methods, presentation, data, etc.
- All of these indices confirm the necessity to approach the problem by considering multiple sectors, though not all sectors exhaustively. In fact, a relatively small number of sectors seems to be sufficient. All of the indices provide the ability to look at sectoral results separately, though they provide a composite measure too. There is no consensus over the definition of sectors, and each index includes several individual indicators within each sector. There is almost no discussion in any of the methodology documentation over the selection of sectors: in some cases these seem to have been largely pragmatic choices over data availability.

1 Driving Forces-Pressures-State-Impacts-Responses
• Each index has made different choices about the quality and nature of the datasets used. All three indices rely to an extent on World Bank data. However, the data challenges for adaptation indices are significant.

• Stakeholder engagement is important in many stages of the development of indicators. However, on the basis of the information reviewed, little of the current practice in adaptation indices fully recognises the extent to which normative choices are taken in the selection and aggregation of indicators.

• There are limitations of indicators in measuring adaptation and therefore indicators need to be set in a broader context.

• By their nature, all of the global metrics offer the possibility of cross-country comparison. But despite the global or national nature of the indices considered, there is a recognition that adaptation is first and foremost a local issue.
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Acknowledgements

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We also wish to thank the participants at the workshop held on 23 March 2012 for their considered engagement in discussions on this topic.

We are also grateful for the additional information and context provided by Helen Wilson and John Higgins of Australia’s Department of Climate Change and Energy Efficiency, which enhanced the Australia case study chapter.
1 Introduction

1.1 Purpose of this review

The Adaptation Sub-Committee (ASC) is developing a framework for monitoring and evaluating progress in adaptation. In order to gain insight to approaches for creating adaptation indicators, the ASC is interested to see how this framework compares with some recent global adaptation (or vulnerability) indices. The ASC is also keen to see whether any of the components of these indices might translate into the UK setting, and whether any of the underlying datasets could potentially be used in the ASC’s indicator suite. The ASC is keen to understand how other countries have developed, or are in the process of developing, their own approaches for monitoring and evaluating adaptation, to inform, challenge, and improve its own efforts in this regard. The purpose of this review, therefore, is:

- To describe the purposes, frameworks, methodologies and datasets used to compile, up to 3 different global adaptation metrics;
- To compare/contrast these with the ASC’s approach, and to identify methodological points to learn, and data that might be relevant to the development of adaptation indicators in the UK;
- To review a number of other country approaches to national adaptation monitoring;
- To help preparations for and facilitate at the ASC’s workshop on monitoring and evaluation on 23 March 2012, and to provide a workshop report.

1.2 Indices considered in this review

Many indices at global or multi-national levels related to adaptation or vulnerability have been created over the last decade. Most of these have been the result of academic studies, while some have been in response to policy developments or commercial opportunities. This review considers three recent, high profile, published, and publicly accessible, global indices of vulnerability or adaptation. We have also drawn out key messages from a review of country-level experiences and approaches to adaptation monitoring, in the UK, Europe and beyond. Two country case studies have been used to examine alternative approaches to the challenge of measuring progress in preparedness for climate change (Germany and Australia).

For this report, we have reviewed the key sources of publicly available documentation of the methodologies and data used in the global indices in question. This information was accessed at dedicated websites during January 2012 (Table 1).

| Table 1 Global indices considered in this review |
|-----------------|-----------------|-----------------|
| **Index**       | **Produced by**  | **Website**     |
| Global Adaptation Index (GaIn) | Global Adaptation Institute | [http://gain.globalai.org/](http://gain.globalai.org/) |
| Climate Change Vulnerability Index (CCVI) | Center for Global Development (David Wheeler) | [http://www.cgdev.org/content/publications/detail/1424759](http://www.cgdev.org/content/publications/detail/1424759) |
1.2.1 Global Adaptation Index (GaIn)

The Global Adaptation Index™ (GaIn) is an open data browser that provides national level scores (and access to the underlying data) of current vulnerability to climate change and readiness to adapt for 192 countries. It aims to help businesses and the public sector better prioritize adaptation investments for a more efficient response to the immediate global challenges ahead. GaIn offers information on a country’s vulnerability in four sectors (water, food, health and infrastructure), and on its readiness to undertake adaptive actions supported by these much-needed investments.

1.2.2 Climate Vulnerability Monitor (CVM)

The Climate Vulnerability Monitor (CVM) aims to advance understanding of the impacts of climate change on human society and the actions needed to address these effects. It combines measures in four areas of impact (human health, weather disasters, habitat loss and economic stress). These indicators are provided for 184 countries, and on two timescales, today (2010) and 2030 (in contrast to many climate vulnerability assessments that focus on 2050 to 2100 timeframes). The CVM also highlights over 50 effective adaptation measures.

1.2.3 Climate Change Vulnerability Index (CCVI)

The Climate Change Vulnerability Index (CCVI) quantifies the vulnerability of 233 countries to three major effects of climate change (weather-related disasters, sea-level rise, and reduced agricultural productivity). It develops risk indicators for these impacts and embeds these into a methodology for cost-effective allocation of adaptation assistance.

1.3 Layout

Following this introduction section, the report explores key features of each of the global indices, side-by side. Section 2 considers the contexts in which each index has been developed, and their stated purposes. Section 3 reviews the frameworks, concepts and methodologies used to construct each index. In section 4, we identify the underlying datasets used to populate the indicators included in each index.

In section 5, we turn to other country experiences in adaptation monitoring, and present key messages. Sections 6 and 7 are the case study reviews of the Germany and Australia approaches. The final section offers some conclusions relevant to the ASC’s work on indicators to monitor and evaluate progress in adaptation for the UK.

A separate Appendix 1 provides a copy of some of the publicly available global index data for the UK (as an excel file). Appendix 2 is an example indicator fact sheet from the Germany case study. The report on the ASC’s international workshop on monitoring and evaluation of adaptation is provided in Appendix 3.
2 Contexts and purposes – global indices

This section describes the contexts which have led to the creation of the three global indices considered, including their ownership and provenance. It also identifies the stated purposes of these indices, where available, and the nature of the products which have been generated in each case.

2.1 GaIn

The GaIn was conceived and developed by the Global Adaptation Institute during 2010-2011, as a navigation tool to help prioritize and measure progress in adaptation. It is targeted at the private sector and national governments, as well as international institutions and NGOs.

Despite expanding resource commitments from international institutions, public funding alone is unable to provide the full response to increasing adaptation needs around the world, particularly in the poorest countries. The private sector must play a significant role in contributing additional resources and innovative solutions, but requires appropriate information and enabling environments. It is hoped that GaIn will be the tool which can illuminate the challenges, and identify the most promising areas for action, to guide opportunities for private sector investment in adaptation. Concurrently, GaIn can assist governments, NGOs and international institutions in determining what actions and policies will promote and facilitate these investments.

Global Adaptation Institute

The Global Adaptation Institute\(^2\) is a non-profit organization guided by a vision of building resilience to climate change and other global forces as a key component to sustainable development. Launched in late 2010, its stated mission is to enhance the world’s understanding of the urgency for adaptation to climate change and other global forces and the support needed through private and public investments for developing countries. The Institute aims to raise awareness, and to help to mobilize the private sector. Central to this is the development of metrics, indicators, and other tools to help produce the greatest positive impact from available resources used. The Institute also looks to fund pilot projects in adaptation directly, and to assist other private and public donors to do the same.

All countries face the challenges of adaptation but some, due to geographical location or socio-economic conditions, are more vulnerable to the impacts of climate change than others. In addition, some countries are more ready to address adaptation, as a result of government action, community awareness and the ability to facilitate private sector responses. GaIn seeks to measure both vulnerability and readiness.

GaIn is fully accessible via the internet, and interactive products currently offered include global maps, rankings and underlying datasets, for GaIn itself and the corresponding vulnerability and readiness scores. Users are able to display different combinations of data, to view time-series, and to compare different countries, for example. The website invites feedback and provides access to a consultation. The “Readiness Matrix™” is offered as a simple visual summary of the comparative vulnerability and readiness of countries (Table 2).

\(^2\) [http://globalai.org](http://globalai.org)
Table 2 Global Adaptation Institute’s “Readiness Matrix”

<table>
<thead>
<tr>
<th>Position in matrix</th>
<th>Interpretation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>The Readiness Matrix retains the distinction between the two dimensions of the GaIn – vulnerability and readiness, and arguably this presentation is more informative than the combined GaIn score. The vertical axis measures the relative vulnerability of countries. The horizontal axis measures relative “readiness”. Divisions for the quadrants correspond to the median Vulnerability and Readiness of the world.</td>
</tr>
<tr>
<td></td>
<td>Countries with a high vulnerability to climate impacts, but a low level of readiness, have both a great urgency for action and a great need to improve readiness. Unless the government, international organizations and the private sector move quickly to improve the ability to adapt, significant human suffering will result. Initially these countries are more likely to receive investment from the government or NGOs than from the private sector looking for financial returns.</td>
</tr>
<tr>
<td></td>
<td>Countries in this quadrant are highly vulnerable but are also ready to accept adaptation investment. There is strong urgency to act and the private sector is more likely to invest in adaptation for countries in this quadrant, than in the red or yellow quadrants.</td>
</tr>
<tr>
<td></td>
<td>The yellow quadrant distinguishes countries that are neither highly vulnerable, nor very ready for investment in adaptation. These countries will likely have time to prepare for relatively few climate challenges. While private investment towards adaptation will be low, few people should be at risk.</td>
</tr>
<tr>
<td></td>
<td>These countries have both low vulnerability and are ready and open for investments. They require little help and have few adaptation challenges.</td>
</tr>
</tbody>
</table>

The GaIn website stands alone, but can also be accessed via the main Global Adaptation Institute website, which sets it at the heart of the Institute’s mission. GaIn is currently the flagship project and product, but the Institute is also active in a number of other activities, including outreach and engagement at highest levels with governments and private sector, fundraising, and the development of case studies (demonstration projects).

The GaIn is expected to be improved and refined, both in terms of data and methodology over future years, but the aspiration is for it to become a widely-known and respected standard of reference.

2.2 CVM

The CVM was built to assess the vulnerability of our world to the many effects of climate change, and launched in December 2010 at the UN Climate Conference in Cancun. It was developed by DARA and the Climate Vulnerable Forum with critical input from leading scientists and policy specialists from the fields of climate change, the environment, development assistance and humanitarian relief. The CVM aims to help “keep watch on current and expected impacts caused by climate change and to promote understanding and
debate around its growing dangers and how to deal with them”. It claims that it provided the first comprehensive overview of vulnerability to climate change in an internationally comparable form.

**DARA and the Climate Vulnerable Forum**

DARA\(^3\) is an independent international organization committed to improving the quality and effectiveness of aid for vulnerable populations suffering from conflict, disasters and climate change. It carries out this mandate through research, evaluations, technical assistance and knowledge sharing.

The Climate Vulnerable Forum\(^4\) convenes governments from Africa, Asia, the Americas, and the Pacific, representing some of those countries most vulnerable to the adverse impacts of climate change. The Forum first convened in the Maldives in November 2009 and adopted a declaration that expressed alarm at the pace of change to the Earth caused by climate change and committed to demonstrating leadership aimed at tackling what for some nations is becoming an existential challenge.

The CVM was commissioned as an independent effort to provide guidance on vulnerabilities to climate change and to pinpoint who faces them, when, where and to what degree, highlighting climate vulnerability in a way that could aid in the design of actions to avert harm to communities. It is a work in progress, subject to refinements and review driven by ongoing scientific and data developments.

CVM measures the impact of climate change on human health, weather, habitat loss, and economic stress and combines these into an aggregate index to gauge overall vulnerability on a national, regional, or global level. It also looks at pre-existing characteristics of society that are knowingly affected by climate change, such as exposed coastlines, populations living in arid regions, and climate-sensitive diseases. The level of vulnerability and expected impacts are determined by the scale of the effect that real or projected changes in the climate will have on those characteristics.

The DARA website which hosts the CVM provides a number of entry points into the set of downloadable documents containing the published results. These are available country by country, or aggregated by region, and also arranged by climate impact (sector). Alongside the CVM results, there are links to adaptation actions by sector. The main visual communication device shows CVM results in the four distinct impact areas (sectors) for each country for the two timeframes, with an overarching assessment of vulnerability level (factor) (Figure 1). The available information is not customisable, and it is not possible to gain direct access to the underlying datasets, although contact points for feedback are provided on the website.

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\(^3\) [http://daraint.org/](http://daraint.org/)
In exposing the scale and breadth of the impacts already being faced, the CVM emphasises the case for urgent international action to curb global greenhouse gas emissions. The way in which the CVM is presented also demonstrates that each country is vulnerable to a different combination of climate challenges. The CVM promotes the increasing need for adaptation, not least by the 2010 Adaptation Performance Review which highlights over 50 effective measures that can reduce the identified impacts of climate change.

2.3 CCVI

The CCVI was developed by David Wheeler, senior fellow at the Center for Global Development (CGD). The workstream leading to publication of the CCVI was driven by the immediate, practical objective to provide comprehensive information for donor institutions that provide financial assistance for adaptation to climate change. The CCVI aims to help determine which countries should be prioritized when larger volumes of adaptation finance start to flow. It enables comparison of cross-country vulnerability to some of the most extreme climate threats. Indicators within the CCVI incorporate factors related to climate change risk, vulnerability to climate change, and aid project economics. Climate change risk is described in three categories of extreme weather, sea level rise and agricultural productivity loss.

Center for Global Development

According to its website, the Center for Global Development (CGD) is an independent, nonpartisan and nonprofit policy research organization. It works to reduce global poverty and inequality through rigorous research and active engagement with the policy community to make the world a more prosperous, just, and safe place for us all. CGD combines world-

http://www.cgdev.org
class research with policy analysis and innovative communications to turn ideas into action on a range of topics related to how rich country policies impact people in the developing world. Topics include aid effectiveness, education, globalization, health, migration and trade. Since its founding in 2001, CGD has earned a reputation as a “think and do” tank, where independent research is channelled into practical policy proposals that help to shape decisions in Washington and other rich country capitals.

The CCVI is not an end in itself: it provides the underlying evidence supporting a methodology for cost-effective allocation of international adaptation assistance. The accompanying working paper\textsuperscript{6} (Wheeler, 2011) develops several resource allocation formulas (derived for different scenarios which might be controlled by different institutional perspectives and priorities). Thus, this index is thoroughly grounded within a purpose to improve the efficiency and effectiveness of the distribution of financial assistance to the most climate-vulnerable countries in the world. Primarily, the focus is on public funds (i.e. from multilateral and bilateral donor agencies and banks, and specific climate funds, such as distributed under the UNFCCC). The CCVI is aimed squarely at practitioners in the field of international aid / financing, with data for 233 states provided in a downloadable spreadsheet\textsuperscript{7} for their use.

The CCVI contributes to two research threads. It provides quantitative analysis of the impact of climate change that controls for the concurrent influence of other factors. This strengthens arguments for international action to curb carbon emissions. It also provides specific knowledge about where, when, and how much climate change will affect communities. This facilitates rational decision-making about the allocation of scarce resources for adaptation.

The results of the CCVI have been plotted on an interactive map\textsuperscript{8} (such as Figure 2), available on the CGD website, and the underlying data are freely accessible.

\textit{Figure 2 Map of CCVI results for overall vulnerability} (from www.cgdev.org)


\textsuperscript{7}The data behind the analysis are available for download as: http://www.cgdev.org/doc/Data/Quantifying_Vulnerability_DB.xls

\textsuperscript{8}http://www.cgdev.org/section/topics/climate_change/mapping_the_impacts_of_climate_change
2.4 Summary

The three indices have arisen out of quite distinct contexts, and have been designed for different purposes. The authors of each index have been clear about the action they wish to provoke through the publication of their metrics, and this has steered the methods, presentational and data choices they have made. From the literature, Hinkel (2011) identified a number of potential purposes for vulnerability indicators, including identification of vulnerable regions, raising awareness, allocation of adaptation funds, and monitoring of adaptation policy, although he suggests that vulnerability indicators are the appropriate tool only in a very limited set of circumstances. Clarity about primary purpose is crucial in designing and constructing adaptation/vulnerability indices.

The GaIn is the most “operational” of the three, supported by an organisation with a clear mission, for which this index is a key tool. Its purpose is to provide some degree of comparison between countries both in terms of their vulnerability and their readiness to invest in adaptation, based on transparent methodology and publicly accessible data. The aim is that it can be used to provoke and catalyse more rapid action by national governments to create conditions suitable for adaptation investment, and higher levels of investment and involvement in adaptation by private sector. Because the aspiration is for the GaIn to be accepted as a common standard, choices about transparency, accessibility, and interactivity have been made to encourage “hands-on” involvement in the issue. The GaIn is unique among the three indices in its inclusion of the concept of “readiness”, but this is closely linked to its purpose of leveraging investment.

The CVM is largely a communication tool, aiming to promote understanding and debate on climate impacts, the scale of the climate challenge and how to address it, and this has led to particular effort in the design of appropriate presentational devices. Unlike the other two indices, the underlying data and numerical scores are not immediately publicly accessible. The CVM is the only index among the three reviewed to provide assessment and guidance on adaptation actions.

Both the CVM and the GaIn are presented as works in progress, anticipating refinements and revisions as methods, models and data are improved. There is a clear ambition for the GaIn to be maintained, refined and updated over future years.

The CCVI has an explicit purpose to provide a more robust basis on which financial assistance for adaptation can be allocated. It places a strong emphasis on how vulnerability scores can be used in other formulae. However, it appears to be the outcome of a one-off project at the CGD, culminating in the working paper and dataset. There is little evidence that this index will be maintained or updated, and there seems to be no strategy for moving it beyond a think-piece and into operation among financial institutions and donors (who appear to be the target audience).

Both the CCVI and the CVM have to some extent been communicated as relevant evidence for arguments around mitigation, as well as in support of adaptation, while the GaIn is entirely focused on adaptation.

On the basis of the information reviewed, none of the indices have fully recognised the extent to which normative choices have been taken in the selection and aggregation of indicators: none appear to have undergone any significant participatory process with multiple stakeholders. The GaIn has undertaken some consultation activity, and informal feedback via the Institute’s outreach activities; the development of the CVM was initiated by a key group of vulnerable country stakeholders. As far as it is possible to tell from the available information, the CCVI has been developed as a desk-based exercise with no engagement with stakeholders from national governments or the financial institutions to which it claims to be offering guidance.
3 Frameworks and methodologies – global indices

In this section, we explore the frameworks and methodologies used to compile the global metrics.

3.1 GaIn

3.1.1 Framework

The GaIn provides an overall measure of a country’s vulnerability to climate-related hazards and its readiness to adapt to the challenges posed by climate change and other global forces. It is measured in two dimensions: vulnerability and readiness, which in turn are constructed from a number of individual quantitative indicators. The index reflects the current situation in countries across the world, and provides historical trend data where possible.

Based on stakeholder feedback during the design process, GaIn measures are intended to be:

- Consistent with current knowledge and best practice;
- Transparent and conceptually clear;
- Based on data that are accessible, quality checked, and comprehensive in national coverage;
- Potentially scalable from national to regional and local;
- Focused on variables that are directly representative of the sector and the components of vulnerability; they should avoid directly incorporating broad socio-economic measures, such as GDP/capita;
- Inclusive of as many (UN) countries as possible given the availability of data.

Two additional aspirations set the GaIn apart from other indices: the measures selected should:

- point to actionable and measurable improvements in adapting to climate risks;
- have time series of data available, so that national progress over the past decade can be tracked and future changes compared.

The GaIn has a modular structure which is easily substitutable and expandable. Future revisions may add additional sectors such as ecosystem services to the Vulnerability Axis, or substitute measures of human capital in the Readiness Axis.

3.1.2 Vulnerability Axis

Following IPCC terminology, vulnerability is defined in the GaIn as: “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." The GaIn vulnerability index has two dimensions:

- three components of vulnerability (exposure to climate-related hazards, sensitivity to their impacts and capacity to cope with those impacts);
- four key sectors (water, food, health and infrastructure, with infrastructure further subdivided into coastal, energy and transport).

For water, food and health, indicators to cover both quantity and quality are included. For the infrastructure subsectors, only quantity indicators are included.

**Figure 3 Indicators in the GaIn vulnerability axis**

<table>
<thead>
<tr>
<th>Sectors</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Capacity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Water</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Projected change in precipitation</td>
<td>Internal and external freshwater extracted for all uses</td>
<td>Population with access to improved water supply</td>
</tr>
<tr>
<td>Quality</td>
<td>Projected change in temperature</td>
<td>Mortality among under 5 yr.-olds due to water-borne diseases</td>
<td>Population with access to improved sanitation</td>
</tr>
<tr>
<td><strong>Food</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Projected change in agricultural (cereal) yield</td>
<td>Population living in rural areas</td>
<td>Agricultural capacity</td>
</tr>
<tr>
<td>Quality</td>
<td>Coefficient of variation in cereal crop yields</td>
<td>Food import dependency</td>
<td>Children under 5 suffering from malnutrition</td>
</tr>
<tr>
<td><strong>Health</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Quantity</td>
<td>Estimated impact of future climate change on deaths from disease</td>
<td>Health workers per capita</td>
<td>Longevity</td>
</tr>
<tr>
<td>Quality</td>
<td>Mortality due to communicable (infectious) diseases</td>
<td>Health expenditure derived from external resources</td>
<td>Maternal mortality</td>
</tr>
<tr>
<td><strong>Infrastructure</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coast</td>
<td>Quantity</td>
<td>Population living less than 10 m above sea-level</td>
<td>Measured on the Readiness Axis</td>
</tr>
<tr>
<td>Energy</td>
<td>Quantity</td>
<td>Population with access to reliable electricity</td>
<td>Energy at risk</td>
</tr>
<tr>
<td>Transport</td>
<td>Quantity</td>
<td>Frequency of floods per unit area</td>
<td>Roads paved</td>
</tr>
</tbody>
</table>

3.1.3 Readiness Axis

Readiness in the GaIn is defined as “a measurement of the ability of a country’s private and public sectors to absorb resources effectively toward increasing resiliency to climate change and other global forces.” 13

10 Measuring what matters report (Global Adaptation Institute, Washington DC, 2011)
11 Quantity measures focus on amounts, how much is used and how many people have access.
12 Quality measures consider factors such as exposure to poor quality, impacts on people and access to quality management measures.
13 Measuring what matters report (Global Adaptation Institute, Washington DC, 2011)
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3.1.4 Determination of composite GaIn

The primary purpose of GaIn is to encourage actions both to reduce vulnerability and to enhance readiness: scores in the composite index are calculated so that they increase as either, or both, of these goals are achieved. Thus, GaIn is simply the composite score on the Readiness Axis minus the composite score on the Vulnerability Axis, rescaled to give values in the range of approximately 0 to 100 for communication purposes (Figure 5).

Figure 4 Indicators in the GaIn readiness axis

<table>
<thead>
<tr>
<th>Components</th>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>Business freedom</td>
</tr>
<tr>
<td></td>
<td>Trade freedom</td>
</tr>
<tr>
<td></td>
<td>Fiscal Freedom</td>
</tr>
<tr>
<td></td>
<td>Government Spending</td>
</tr>
<tr>
<td></td>
<td>Monetary Freedom</td>
</tr>
<tr>
<td></td>
<td>Investment Freedom</td>
</tr>
<tr>
<td></td>
<td>Financial Freedom</td>
</tr>
<tr>
<td>Governance</td>
<td>Voice &amp; Accountability</td>
</tr>
<tr>
<td></td>
<td>Political Stability &amp; Non-Violence</td>
</tr>
<tr>
<td></td>
<td>Control of Corruption</td>
</tr>
<tr>
<td>Social</td>
<td>Mobiles per 100 persons</td>
</tr>
<tr>
<td></td>
<td>Labor Freedom</td>
</tr>
<tr>
<td></td>
<td>Tertiary Education</td>
</tr>
<tr>
<td></td>
<td>Rule of Law</td>
</tr>
</tbody>
</table>

Figure 5 Formula for calculation of GaIn

\[
\text{GaIn}^\text{TM} = (\text{Readiness Indicators} - \text{Vulnerability Indicators} + 1) \times 50
\]

0 - 1 Higher is Better  0 - 1 Lower is Better  0 - 100 Higher is Better

The determination of indicator scores involves four steps (as described by the GaIn methodology documentation), and corresponding files for each step are downloadable from the website.

Step 1: Sourced data

Raw data values are copied directly from the data sources, without any modification or augmentation.

Step 2: Safe assumptions

Data are augmented according to safe assumptions. For example, since Austria has no coastline, the data files for coastal population and area have scores of "0" inserted for Austria.
Step 3: Interpolations and extrapolations

Not all measures are reported for every country in every year. Blank cells are filled by either interpolating or extrapolating from the values present in the raw data files. Interpolation between points uses a linear function for the intermediate values. Extrapolation beyond the most recent data point, and before the earliest data point, is undertaken without variation. If raw data files contain no values for a given country, then no input values are estimated and no indicator score values are available for that measure.

Step 4: Indicator scores

Data are converted into indicator scores normalized within a 0 - 1 range. Since the units and range of each component vary, a general function converts every input value to a score between 0 and 1. Each measure has threshold limits on the input values, giving every instance of input values above or below these thresholds automatically a score of "1" or "0". The thresholds accommodate for extreme outliers that would otherwise dramatically skew the conversion function. The website provides full details of the thresholds and limits for each indicator dataset used.

Vulnerability score

The overall vulnerability score is calculated as the mean of the four sector scores. Each sector and component score is calculated as the mean of its respective indicator scores. In the current vulnerability structure, each measure is given equal weight.14

Readiness score

Readiness scores are calculated by summing component scores on the following weighted scale: 40% economic, 30% governance and 30% social.

Missing data

The website gives details for how missing data are treated. Some countries are missing data for every year for a given measure. The percentage of measures reported for each year, for the full 38 indicators is tracked and reported. A country receives no sector score if any of its components is missing. Up to 4 out of 24 measures in the vulnerability index are allowed to be missing. In these cases, the vulnerability score is calculated with all available measures. If more than 4 measures are absent for a country, vulnerability score is not calculated, and neither is the composite GaIn score. Earlier analysis has shown that the broad ranking of countries is maintained with as many as a third of the measures missing. For readiness, if one or more of the 14 measures are missing, the country receives no readiness score and no GaIn score.

Optional corrections for GDP

Because there are significant correlations of both vulnerability and readiness with GDP, GDP-adjusted scores for GaIn (and its subcomponents) are available. The web interface allows for users to investigate both sets of scores.

3.1.5 “Adaptometer”

Recognizing that many of the impacts of climate change and solutions to building resilience exist at the local level, The Global Adaptation Institute also intends to develop an additional input, the “Adaptometer”, to complement the measures used in GaIn. The goal is to provide information on the awareness of national and local governments and the private sector to the sensitivity to climate change of their jurisdictions and operations. The Adaptometer is expected to follow a subjective, multi-criteria approach, using field information (polling / questionnaires) describing the level of knowledge, the policies in place, the allocation of

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14 Measuring What Matters report (Global Adaptation Institute Washington, DC)
budgets, and the overall commitment of society to adapt to climate change and other global trends. Ultimately, this component may be included within one of the dimensions of the GaIn or as a third, independent axis.

### 3.2 CVM

#### 3.2.1 Climate Vulnerability Monitor (CVM)

Most existing indices of climate vulnerability employ some combination of socio-economic capacity set against meteorological and/or hydrological change\(^\text{15}\). The CVM does not focus directly on capacity, nor directly on climate variables, since these do not pinpoint the impacts that might occur, such as mortality linked to climate-sensitive diseases, or desertification aggravated by local climate shifts. Instead, the CVM is built around four “Impact Areas” that attempt to capture the majority of the consequences of climate change (Figure 6). These Impact Areas are:

- human health (termed: “Health Impact”),
- extreme weather (“Weather Disasters”),
- desertification and sea-level rise (“Habitat Loss”),
- stresses on the economic sectors of agriculture and natural resources (“Economic Stress”).

![Figure 6 Model for construction of the CVM (CVM, 2010)](source: Commons analysis)

CVM measures 5 different levels of impacts, termed vulnerability Factors, from Low to Acute, which are comparable across nations.

\(^{15}\) See reviews of literature in Füssel (2009); Moss et al (2001); Brooks et al (2005)
There are many aspects of human development (such as community access to education, water, sanitation, energy, and clean cooking environments), for which the impact of climate change has not been projected in a way that can be applied to a global model. These are therefore not included in CVM. Also, unlike the GaIn, it does not include such aspects of development as good governance, peace and stability, displacement, and gender issues. Finally, CVM does not take into account the level of domestic/international resources available to a country to deal with climate challenges. (This leads to the US, for example, having a similar vulnerability score to Gabon or Tonga, despite significantly different financial and other capacity available to address impacts.)

The aggregate index on climate vulnerability comprises four sub-indices, each made up by a number of indicators (Figure 7). A country’s sub-index scores are summarized in an aggregate index score, which provides an indication of the overall impact of climate change.

**Figure 7 Composition of the aggregate CVM index**

<table>
<thead>
<tr>
<th>Index on Climate Vulnerability</th>
<th>Sub-Index</th>
<th>Indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Impact</td>
<td>Malnutrition, Malaria, Diarrhea, Dengue, Cardiovascular diseases, Respiratory diseases</td>
<td></td>
</tr>
<tr>
<td>Overall Index</td>
<td>Weather Disasters, Flooding, Storms, Wildfires</td>
<td></td>
</tr>
<tr>
<td>Habitat Loss</td>
<td>Desertification, Sea-level rise</td>
<td></td>
</tr>
<tr>
<td>Economic Stress</td>
<td>Agriculture, Forestry, Water resources, Ecosystems, Fisheries</td>
<td></td>
</tr>
</tbody>
</table>

Indicator scores are reported for Now/2010 and Near Term/2030, although data sources may use different baseline years for their projections. The intention is that new data can be assimilated in future, and that improvements in climate models can also be incorporated.

**Table 3 Main data sources and frequency of updates**

<table>
<thead>
<tr>
<th>Sub-index</th>
<th>Main Sources</th>
<th>Frequency of updates</th>
</tr>
</thead>
<tbody>
<tr>
<td>Health Impact</td>
<td>• WHO (2004), Global Climate Change</td>
<td>• New WHO estimates expected in 2011</td>
</tr>
<tr>
<td></td>
<td>• WHO (2009), Global Health Observatory – Global Burden of Disease Data</td>
<td>• Disease burden updates expected every other year</td>
</tr>
<tr>
<td>Weather Disasters</td>
<td>• CRED (2010), Center for Research of the Epidemiology of Disasters</td>
<td>• Annual updates</td>
</tr>
<tr>
<td></td>
<td>• Munich Re (2010), NatCatSERVICE, Statistics on National Disasters</td>
<td></td>
</tr>
<tr>
<td>Habitat Loss</td>
<td>• DIVA (2003) Dynamic Interactive Vulnerability Assessment</td>
<td>• DIVA – no update expected</td>
</tr>
<tr>
<td></td>
<td>• PLACE (2010), The Place II Model: Population, Landscape, and Climate Estimates</td>
<td>• PLACE – regular data updates</td>
</tr>
</tbody>
</table>
Based on the information in the methodology document, it seems that the aggregate CVM index is built up on three levels of analysis:

**Step 1:**

The climate effect (CE) represented in each dataset, for each country, is determined in order to convert the data into an indicator (column 3 in Figure 7). The methodology document is rather confusing on this point, but it seems that calculations are done to create indicators (e.g. malnutrition, floods, wildfires) from the original data – this effectively uncovers the climate-related element of a particular dataset.

CVM draws on established scientific models or expert estimates to ascertain a probable CE in one of two ways:

- By attributing a climate impact factor to baseline data derived from peer-reviewed scientific literature
- By using existing complex models that calculate the climate effect

The CE can be calculated based on observed values of social and economic variables and the effects of climate change. The extent climate change contributes to the development of a given variable is expressed as a climate impact factor (CIF). The indicator’s climate effect is calculated as follows:

\[ CE = CIF \times \text{variable} \]

Variables are expressed in proportional terms to compare scores between countries: per GDP or per capita.

The other approach to indexing climate effect is using existing models. The two models used in the index are:

- FUND2.8n model, which estimates economic losses in various sectors of the economy
- Dynamic Interactive Vulnerability Assessment (DIVA), which estimates economic losses due to sea-level rise

This approach uses the medium-range climate scenarios in the sub-indices to calculate projections, except in the sea-level rise indicator where a high-emission scenario is used.

**Step 2:**

The indicators are normalised in order to create the composite sub-index for each of the four impact areas (that is, column 2 in Figure 7).

In order to create this sub-index score, the indicator is transformed to allow for cross-comparison with other indicators. The methodology document states that the mean absolute deviation (MAD) is used in this transformation, because it weighs in extreme observations to some degree.

For the sub-index, countries are categorised in bands made in steps of $\frac{1}{2} \times \text{MAD}$ from 100. The construction of the scoring means that one MAD of the 2010 score equals 10, resulting in category bands of low, Moderate, High -, High +, Severe -, Severe +, Acute -, and Acute +.

**Step 3:**
The aggregate index is then calculated based on the sub-indices. The purpose of the aggregate index score is to ensure that outliers in one of the sub-indices are not reflected disproportionately in the overall index, and also to reflect highly impacted countries in one or more of the sub-indices.

To achieve the aggregate index score, each category band on each sub-index is given a number:

- Below 100 = 1
- 100 – 104.99 = 2
- 105 – 109.99 = 3
- …
- 135 and above = 9

The countries’ average score on the sub-indices is calculated and the countries are categorised according to Figure 8.

**Figure 8 Legend for attribution of impact factors in CVM**

<table>
<thead>
<tr>
<th>CATEGORY</th>
<th>LOW</th>
<th>HIGH</th>
</tr>
</thead>
<tbody>
<tr>
<td>ACUTE</td>
<td>&gt;5</td>
<td></td>
</tr>
<tr>
<td>SEVERE</td>
<td>&gt;4</td>
<td>&lt;=5</td>
</tr>
<tr>
<td>HIGH</td>
<td>&gt;3</td>
<td>&lt;=4</td>
</tr>
<tr>
<td>MODERATE</td>
<td>&gt;2</td>
<td>&lt;=3</td>
</tr>
<tr>
<td>LOW</td>
<td></td>
<td>&lt;=2</td>
</tr>
</tbody>
</table>

### 3.2.2 Adaptation Performance Review

The Adaptation Performance Review is a rating system on adaptive effectiveness that assesses measures already proven to function (or already being implemented) in vulnerable regions of the world to limit the impacts of climate change. The 2010 CVM assessed over 50 key actions by climate Impact Area against a uniform set of criteria covering cost-effectiveness, co-benefits, scalability and feasibility (Table 4). Half or more of the actions reviewed for each Impact Area received a rating of High or Very High demonstrating that actions can be taken against even the most challenging climate stresses.

**Table 4 Criteria used in the CVM’s Adaptation Performance Review**

<table>
<thead>
<tr>
<th>Criteria:</th>
<th>Operational Questions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cost-effectiveness</td>
<td>● Cost-effectiveness rating</td>
</tr>
<tr>
<td></td>
<td>● Time horizon (from implementation to impact)</td>
</tr>
<tr>
<td></td>
<td>● Variability</td>
</tr>
<tr>
<td>Co-benefits</td>
<td>● Co-benefits rating</td>
</tr>
<tr>
<td></td>
<td>● Equity</td>
</tr>
<tr>
<td></td>
<td>● Variability</td>
</tr>
<tr>
<td>Feasibility</td>
<td>● Implementation risks</td>
</tr>
<tr>
<td></td>
<td>● Sensitivity to exogenous factors</td>
</tr>
<tr>
<td></td>
<td>● Variability</td>
</tr>
<tr>
<td>Scalability</td>
<td>● Technical specifications and guidelines</td>
</tr>
<tr>
<td></td>
<td>● Training programmes</td>
</tr>
<tr>
<td></td>
<td>● LDC relevance</td>
</tr>
</tbody>
</table>
3.3 CCVI

The CCVI is a composite vulnerability index that assigns weight to both climate risks and the determinants of resilience. Its construction involves statistical analysis to separate the possible role of climate change from the effects of changes in other variables, such as income, governance, urbanization, that influence the felt impacts. It spans 233 states (or nations) and draws on available evidence to provide country-level impact indicators for three dimensions of climate change:

- more extreme weather;
- sea level rise;
- loss of agricultural productivity.

After the impact indicators are constructed, they can be incorporated into a methodology for cost-effective allocation of adaptation assistance.

3.3.1 Vulnerability to changes in extreme weather

This involved new econometric work to separate the effects of climate change, income and governance, and to estimate the effect of income and governance on vulnerability to climate change.

Method

To assess the vulnerability to changes in extreme weather, the CCVI’s core model specifies climate impact risk as a function of radiative forcing from atmospheric accumulation of CO₂. Climate impact risk in a specific year is defined as the probability that an individual will be affected by an extreme weather event in that year.

The equation for a standard approximation to the relationship between radiative forcing and CO₂ accumulation is embedded in an estimating equation that also incorporates income per capita and various confounding factors (including population, percentage of the population in urban areas, a measure of regulation quality, as well as terms to account for unobserved country- and region-specific effects, and random error).

The total number of people affected in the five disaster categories is divided by total population in order to calculate reported risk for country \( i \) in year \( t \).

Output

The results relate changes in risk to changes in variables including the CO₂ concentration. Controlling for other factors, the results indicate that a 1% increase in the atmospheric CO₂ concentration has been associated with an increase in extreme weather risk of about 30%. Holding other factors constant, the actual increase in CO₂ concentration from 1995 to 2008 is associated with a 9.6-fold increase in risk.

This approach can be used to help answer several questions that have complicated the policy dialogue on adaptation assistance:
Review of international experience in adaptation indicators

- Where will significant impacts occur, how large will they be, and how quickly will they emerge? (Important for allocating assistance aid.)
- How can problems attributable to historical weather patterns be distinguished from problems caused by climate change? (Without this, any additional component of assistance beyond standard development aid cannot be determined.)
- Should adaptation assistance distinguish between exogenous vulnerability attributable to weather changes and endogenous vulnerability that can be affected by policy? (The results indicate that countries with successful economic growth strategies become far less climate vulnerable than their less-successful counterparts over time. The results suggest that vulnerability also decreases markedly in countries whose urban development strategies incorporate effective control of land use in high-risk areas. Ignoring endogenous vulnerability will introduce perverse incentives for aid recipients, because countries whose policies reduce vulnerability will receive significantly less adaptation assistance than countries with ineffective policies.)

3.3.2 Vulnerability to sea level rise

The sea level rise (SLR) component is built on previous work for a subset of developing countries (Dasgupta, et al., 2009a,b).

**Method**

The approach accounts for the fact that climate change will increase coastal risk for two reasons, 1) thermal expansion and ice cap disintegration will contribute to coastal inundation and storm surges; 2) a warmer ocean is likely to intensify cyclone activity and storm surges. In addition, population increase and migration means that there could be an increase in vulnerable populations in the coastal regions of many countries. Risk indices for 2008 and 2050 are calculated in a multi-stage exercise that sequentially estimates the areas of low-elevation coastal zones (LECZs); areas of storm surge zones within LECZs; and populations within the storm surge zones.

As in the extreme-weather approach, risk from sea level rise (SLR) is defined as the probability that an individual resides in a zone threatened by storm surges. To estimate SLR risk in 2008, LECZ population density in 2008 is multiplied by storm surge zone area. This is then divided by national population to obtain the probability of residence in a threatened area in 2008.

For the future estimate, changes by 2050 are assumed to be half those forecast for 2100 by Dasgupta, et al. (2009b). National population forecasts for 2050 from the US Census Bureau (2010) and the UN (2010) are used. For countries without forecasts, average population growth rates for their regions are applied. Future LECZ population densities are computed and the calculations described above are used to obtain vulnerability estimates for 2050.

**Output**

Results are provided for the top 20 countries ranked by risk (probability of residence in a threatened zone) and population at risk. Twelve of the 20 highest-risk countries are small island states or principalities; four are small Persian Gulf states; 2 are in Europe (Denmark, Monaco); and 2 are in Africa (Guinea-Bissau, Tunisia).

The calculated future risk incorporates projected SLR as well as project population change. Kuwait is the only country amongst the 20 which has a projected population decrease sufficient to offset the effect of a larger storm surge zone.

Summarising the results for all 192 coastal states and principalities, the total vulnerable populations increase from 156.4 million in 2008 to 266.9 million in 2050.
3.3.3 Agricultural Productivity Loss

The agricultural productivity component is based on the work of Cline (2007), extended to the full set of 233 states.

Method

The results on extreme weather and sea level rise are supplemented with estimates of future agricultural productivity change. The Cline (2007) dataset includes single estimates with and without carbon fertilisation for many countries, and estimates for multiple regions in large countries. For large countries, median regional values are used (without carbon fertilisation).

After drawing agricultural productivity change forecasts for 113 countries from the Cline dataset, the 233-state dataset is completed as follows: median agricultural productivity changes are calculated for the 24 geographic sub-regions list. Wherever possible, these median values are used to replace missing country values within sub-regions. Cline’s results are broadly distributed geographically, so this procedure provides estimates for an additional 84 states. The remaining 36 states are all islands in the Atlantic, Indian and Pacific Oceans that have no natural comparators. For those states, the global median agricultural productivity loss forecast by Cline (20.5%) is used.

Output

The main output is the median forecasts of agricultural productivity loss through 2050, by sub-region. The implications for many developing countries are serious, with predicted losses greater than 10% in all developing regions outside of Asia and significant losses in all Asian regions except China.

3.3.4 Vulnerability Indicators

The output described in sections 3.3.1, 3.3.2, and 3.3.3 is used to construct risk indicators for 233 states that combine short- and long-term factors: changes in extreme weather risks from 2008 to 2015 \(W\), and risks associated with storm surges \(R\) and agricultural productivity loss \(A\) from 2008 to 2050.

Actual vulnerability to climate change depends on the interaction of these risks with determinants of resilience: economic development, demographic change, and governance. This approach achieves this by constructing a composite vulnerability indicator that assigns weight to both climate risks and the determinants of resilience. This would allow institutions financing adaptation to allocate funds to countries in proportion to their indicator values, with adjustments for country differences in average project costs and the likelihood of project success.

Each of the three indicators – \(W, R, A\) – can be used for separate allocation if a funding organisation wants to focus on one problem. For combined exercises, each indicator is weighted proportionally to the size of the affected groups: the national population for extreme weather, the population of the coastal storm surge zone for sea level rise, and the rural population for agricultural productivity change.

Calculating the change in vulnerability is also driven by a change in environmental conditions attributable to carbon emissions, modified by income per capita and regulatory quality factors.

For climate vulnerability, then, the full formula for country scoring is given by:

\[
\text{Per-capita vulnerability} \times \frac{\text{Project concerns}}{\text{Average project costs}}
\]

Or separating this into its three components, a country’s score is given by:

- Per-capita vulnerability
- Project concerns
3.4 Summary

Because there is no single, consistent definition of the key terms and concepts, such as “vulnerability”, “adaptation”, and “capacity”, central to these indices, each metric has a different construction, driven by its particular purpose, and modified by the limitations of the methods and data available. All of the indices use the term “vulnerability” in one way or another, but in their supporting documentation, none recognise that it is misleading to speak of “measuring” vulnerability, as this is impossible (Hinkel, 2011).

Both GaIn and CVM focus on outcome vulnerability, the GaIn explicitly so, in the construction of its vulnerability axis following IPCC categories (exposure, sensitivity, adaptive capacity, though it may be arguable the extent to which their chosen indicators truly represent these categories). The CVM is more heavily focussed on impacts (potential or realised) than the GaIn. The GaIn introduces the concept of “readiness”, which is less clearly defined: it may be closely related to some interpretations of “adaptive capacity”, though in practice it uses different metrics from those included in the adaptive capacity part of the GaIn vulnerability axis. Nevertheless, there is a correlation of both vulnerability and readiness scores with GDP, illustrating the complexity of this topic and the interplay between climate vulnerability and broader contextual factors.

The CCVI seems to include several types of vulnerability within its overall framing: a climate change vulnerability term (which in practice seems a measure of climate impact or sensitivity) optionally modified by other factors to provide a measure of outcome vulnerability.

Given the lack of consensus around terms and concepts, the ASC has put considerable effort into structuring a clear framework for the development of its indicators. The ASC’s framework covers aspects of both contextual vulnerability and outcome vulnerability. Table 5 provides a summary of how the global indices map to the components of the ASC’s framework.

<table>
<thead>
<tr>
<th>ASC component</th>
<th>GaIn</th>
<th>CVM</th>
<th>CCVI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Risk factors (exposure and (contextual) vulnerability)</td>
<td>Exposure, sensitivity and adaptive capacity are included in the GaIn vulnerability score.</td>
<td>Underlying risk factors including socio-economic data and exposure are necessary input components in the modelling, but are not recorded separately.</td>
<td>Underlying risk factors including socio-economic data and exposure are necessary input components in the modelling, but are not recorded separately.</td>
</tr>
<tr>
<td>Adaptation actions</td>
<td>Actions are not explicitly measured in GaIn, though there is an intention to develop a bottom-up measure of actions (“adaptometer”).</td>
<td>The Adaptation Performance Review assessed the potential effectiveness of particular adaptation actions. This is not a measure of the level of implementation of actions.</td>
<td>The CCVI does not include indicators of the implementation of adaptation actions – its end aim is to facilitate allocation of resources for adaptation</td>
</tr>
<tr>
<td>Impacts (residual risk and realised)</td>
<td>Not distinguished in the GaIn. However, some of</td>
<td>The overall impacts cores are essentially an</td>
<td>The outputs from the CCVI include forecasts of</td>
</tr>
</tbody>
</table>

Table 5 Mapping of the global indices to the ASC’s framework
impacts) – emphasise outcome vulnerability

| the individual metrics used in the vulnerability score could be considered to be measures of realised impacts (e.g. children suffering from malnutrition; frequency of floods per unit area). | aggregate representation of outcomes (or potential outcomes). The focus of the CVM is on impacts. | risk (e.g. probability of residence in zones threatened by SLR) and of impacts (e.g. agricultural productivity loss). |
4 Datasets used in global indices

This section identifies the data sources used to populate each of the indices. Where possible, we have included hyperlinks to the underlying datasets where these were available on the internet\textsuperscript{16}.

4.1 Galn

The Galn contains data for 192 UN countries (as of December 2010) for 15 years, from 1995 to 2010. It uses publicly available datasets, predominantly from international bodies.

4.1.1 Vulnerability

In order to calculate a country’s vulnerability to climate change, Galn relies heavily on three sources of information: the World Bank, the Climatic Research Unit/Tyndall Centre and World Health Organisation (WHO). Out of the 24 metrics used in this index, more than half are quantified by data collated by the World Bank.

Table 6 summarises the datasets used in the Galn vulnerability indicators. With the exception of one source, the datasets provide one number at national level, and for the majority of the data on an annual basis. The exception is the ‘Population with access to reliable energy (%)’\textsuperscript{17}; here a global figure is used in the index, and no breakdown by country was provided.

\textbf{Table 6 Datasets used for Galn vulnerability indicators}

\begin{tabular}{|l|l|l|l|}
\hline
\textbf{Sector} & \textbf{Metric} & \textbf{Data Sources} & \textbf{Additional Information} \\
\hline
Water & Projected change in precipitation & Climatic research unit/ Tyndall Centre & Multiple data sources incorporated in this measure, based on modelled and observed data. \\
- & \% internal and external freshwater water extracted for all uses & Food and Agriculture organisation of the United Nations & Level of data for each country varies significantly. For example Uruguay only has one data point for 2000, compared to Cyprus who has data points spanning from 1990 to 2009. Data last updated in 2009 (for some countries). Modelled data. \\
- & \% Population with access to improved water supply & World Bank & Dataset was last updated in 2008. The observed data is collected as part of a joint partnership between WHO and UN Children’s fund. \\
- & Projected change in temperature & Climatic research unit/ Tyndall Centre & Multiple data sources incorporated in this measure, based on modelled and observed data. \\
\hline
\end{tabular}

\textsuperscript{16}Web-links were all active and maintained at the time of writing (January – March 2012), but if the URLs are changed by data providers, the links in this report may no longer work.

\textsuperscript{17}WHO (2011) The Energy Access Situation in Developing Countries http://content.undp.org/go/cms-service/stream/asset/?asset_id=2205620
### Review of international experience in adaptation indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Source</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Projected change in agricultural (cereal) yield</td>
<td>Centre for Global Development</td>
<td>Dataset from the Quantifying Vulnerability to Climate Change: Implications for Adaptation Assistance paper (CCV Index).</td>
</tr>
<tr>
<td>% of population living in rural areas</td>
<td>World Bank</td>
<td>The data on urban population shares used to estimate rural population come from the United Nations, World Urbanization Prospects. Total population figures are World Bank estimates. Data updated annually from 2006 – 2010.</td>
</tr>
<tr>
<td>Agricultural capacity:</td>
<td>World Bank</td>
<td>Three sets of data are used to make up this measure. Datasets have been collated by the Food and Agriculture Organisation. Fertiliser consumption and agricultural machinery data updated annually (2006 – 2008). Irrigated land updated annually (2006 – 2009). No further updates since these dates.</td>
</tr>
<tr>
<td>(1) Fertilizer consumption (kilograms per hectare of arable land)</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>(2) Agricultural machinery, tractors per 100 sq. km of arable land</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>(3) Agricultural irrigated land (% of total agricultural land)</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>Food import dependency</td>
<td>Food and Agriculture organisation of the United Nations</td>
<td>Data updated annually until 2009.</td>
</tr>
<tr>
<td>Children under 5 suffering from malnutrition (%)</td>
<td>World Bank</td>
<td>Data from World Health Organization, Global Database on Child Growth and Malnutrition. Very limited dataset. Many countries do not have any information recorded. And where data is recorded – only one historic figure is present. No data for the UK.</td>
</tr>
<tr>
<td>Estimated impact of future climate change on deaths from disease</td>
<td>Globalisation and Health Journal</td>
<td>Data from an academic paper forecast.</td>
</tr>
<tr>
<td>(1) Physicians (per 1000)</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>(2) Nurses and midwives (per 1000)</td>
<td>World Bank</td>
<td></td>
</tr>
<tr>
<td>Longevity</td>
<td>World Bank</td>
<td>Annually updated figures from 2006 – 2009. Derived from male and female life</td>
</tr>
<tr>
<td>-------------------------------------------------</td>
<td>--------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td><strong>Health expenditure derived from external resources (%)</strong></td>
<td>World Bank</td>
<td>Annual updated from 2006 – 2009. Data from World Health Organization National Health Account database.</td>
</tr>
<tr>
<td><strong>Infrastructure: Coast</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Land less than 5 m above sea-level (%)</strong></td>
<td>The Socioeconomic data and application centre</td>
<td>Academic paper – data is estimated.</td>
</tr>
<tr>
<td><strong>Population living less than 5 m above sea-level (%)</strong></td>
<td>The Socioeconomic data and application centre</td>
<td>Academic paper – data is estimated.</td>
</tr>
<tr>
<td><strong>Infrastructure: Energy</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Population with access to reliable electricity (%)</strong></td>
<td>World Health Organisation</td>
<td>Only 2008 figure available. Global figure, no breakdown per country provided.</td>
</tr>
<tr>
<td><strong>Infrastructure: Transport</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Frequency of floods per unit area</strong></td>
<td>World Bank</td>
<td>Data collated by the Food and Agriculture Organization. Updated annually (2006-2010) no change in data.</td>
</tr>
<tr>
<td><strong>% of roads paved</strong></td>
<td>World Bank</td>
<td>Data collated by International Road Federation, World Road Statistics. Most countries are missing data.</td>
</tr>
</tbody>
</table>
4.1.2 Readiness

In order to calculate a country’s readiness to adapt to climate change, the GaIn relies on two data sources: the Heritage Foundation and the World Bank, as shown in Table 7.

The Heritage Foundation, in partnership with the Wall Street Journal, has tracked the movement of economic freedom in 184 countries\(^{18}\) across the world since 1995 in the Index of Economic Freedom\(^{19}\) (IEF). It measures 10 components of economic freedom (property rights, freedom from corruption, fiscal freedom, government spending, business freedom, labour freedom, monetary freedom, trade freedom, investment freedom and financial freedom) to rank the world’s economies annually.

**Table 7 Datasets used for GaIn Readiness indicators**

(Table source: Global Adaptation Index Website\(^9\)) Please follow hyperlinks to data sources.

<table>
<thead>
<tr>
<th>Category</th>
<th>Metric</th>
<th>Data Source</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic</td>
<td>IEF Business freedom</td>
<td>The Heritage Foundation</td>
<td>Data updated on an annual basis in the IEF</td>
</tr>
<tr>
<td></td>
<td>IEF Trade freedom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEF Fiscal freedom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEF Government Spending</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEF Monetary freedom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>IEF Investment freedom</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Financial freedom</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Governance</td>
<td>WGI Voice &amp; Accountability</td>
<td>World Bank</td>
<td>Data updated on an annual basis (until 2010)</td>
</tr>
<tr>
<td></td>
<td>WGI Political Stability &amp; Non-Violence</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WGI Control of Corruption</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social</td>
<td>Mobiles per 100 persons</td>
<td>The Heritage Foundation and World Bank</td>
<td>World Bank data: updated annually until 2010</td>
</tr>
<tr>
<td></td>
<td>Labour freedom</td>
<td></td>
<td>The Heritage Foundation data: updated on an annual basis</td>
</tr>
<tr>
<td></td>
<td>Tertiary Education</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>WGI Rule of Law</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IEF = Index of Economic Freedom  
WGI = World Governance Indicators

The readiness indicators incorporate datasets drawn from other indices.

4.2 CVM

The CVM reports scores for now (2010) and projected ‘near term’ (2030). Data sources include true datasets based on monitoring and observations, academic studies, and various model outputs.

Models used in the CVM include:

1. Dynamic Interactive Vulnerability Assessment (DIVA)
2. The Climate Framework for Uncertainty, Negotiation, and Distribution, version 2.8 (FUND2.8n)

\(^{18}\) The IEF covers 184 countries, while the GaIn covers 192. Assumptions have been used to interpolate missing data.

\(^{19}\) The Index of Economic Freedom: [http://www.heritage.org/index](http://www.heritage.org/index)
3. IMAGE 2.2 Carbon Cycle Analysis (IMAGE 2.2)
4. HadCM2global, IPCC

In contrast to the GaIn, the CVM does not have a strong dependency on any single data source or data provider. Table 8 summarises the datasets used to create the CVM.

**Table 8 Datasets used for CVM Indicators**
(Table source: The Climate Vulnerability Monitor Report)

<table>
<thead>
<tr>
<th>Impact Area</th>
<th>Measures</th>
<th>Data Source</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>- WHO (2009) Global Health Observatory—Global Burden of Disease Data</td>
<td>Global Burden of Disease Data updated every other year. Multiple data sources for the</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>multiple sub measures used to quantify the indicator</td>
</tr>
<tr>
<td>Weather Disasters</td>
<td>Additional Deaths and Damage Costs from Floods, Storms, and Wildfires</td>
<td>- CRED (2010) Centre for Research of the Epidemiology of Disasters</td>
<td>Data base year 1990-2009. Multiple data sources for the multiple sub measures used to</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Munich Re (2010) NatCatService, Stats on Natural Disasters</td>
<td>quantify the indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Toth et al. (2005) Millennium Ecosystems Assessment Report</td>
<td>Multiple data sources for the multiple sub measures used to quantify the indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Multiple data sources for the multiple sub measures used to quantify the indicator</td>
</tr>
<tr>
<td></td>
<td>resources, - Ecosystems)</td>
<td></td>
<td>indicators are updated less frequently. Multiple data sources for the multiple sub</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>measures used to quantify the indicator</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>sources for the</td>
</tr>
</tbody>
</table>
4.3 CCVI

The CCVI relies heavily on the results of studies, rather than true datasets, to quantify the indicators that it uses. Table 9 summarises the sources used in the CCVI.

**Table 9 Datasets used in the CCVI**

<table>
<thead>
<tr>
<th>Category</th>
<th>Measures</th>
<th>Data Source</th>
<th>Additional Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme weather disasters</td>
<td>Natural disasters (year and type)</td>
<td>EM-DAT database Centre Research on the Epidemiology of the Disasters</td>
<td>Updated on ad hoc basis – i.e. Event of disasters etc.</td>
</tr>
<tr>
<td></td>
<td>Atmospheric CO₂ concentrations</td>
<td>Neftel, et al. (1994) and Keeling, et al. (2007; updated to 2010)</td>
<td>The equations derived in the two academic papers listed combined (along with other sources listed in this table) to derive new equations/models.</td>
</tr>
<tr>
<td></td>
<td>Radiative forcing that incorporates income per capita</td>
<td>Rockström, et al., 2009 IPCC 2001, Table 6.2 Neftel et al., 1994</td>
<td>Equations derived in the academic papers and IPCC table were incorporated into the model</td>
</tr>
<tr>
<td></td>
<td>Population (Annual and % Urban)</td>
<td>World Bank’s World Development Indicators database</td>
<td>Updated annually. Data collated from the UN Population Division.</td>
</tr>
<tr>
<td>Sea level rise</td>
<td>Estimated areas and populations of storm surge zones (in 83 countries)</td>
<td>Dasgupta, et al. (2009b)</td>
<td>Data was not available for all sites from one data source. Risk indices were estimated for 2008-2050 in a multi-stage exercise.</td>
</tr>
</tbody>
</table>
4.4 Summary

Each index has made different choices about the quality and nature of the datasets used. The more “operational” GaIn is more reliant on other existing indicator sets and true quality-assured and maintained datasets than are the other two. The CCVI with its stronger focus on methods can afford a greater dependence on one-off academic studies to support its construction. All three indices rely on World Bank data. The majority of the datasets are collated on an annual basis from various research studies, predominantly by NGOs. Any indicators which are intended to be updated regularly and provide long-term time series information should prioritise the use of true datasets which are well-maintained, above the use of academic research results.

The EM-DAT database

All three indices use data relating to weather disasters from the EM-DAT database. This database is maintained by the Centre for Research on the Epidemiology of Disasters (CRED) at the Université Catholique de Louvain, Brussels.

To be included in the EM-DAT database, a natural disaster must involve: at least 10 people reported killed; 100 people reported affected; the declaration of a state of emergency; or a call for international assistance. Recorded deaths include persons confirmed as dead and persons missing and presumed dead. Total affected persons include people suffering from disaster-related physical injuries, trauma or illness requiring medical treatment; people needing immediate assistance for shelter; or people requiring other forms of immediate assistance, including displaced or evacuated people.

CRED characterizes its methodology and information sources as follows:

“The database is compiled from various sources, including UN agencies, nongovernmental organizations, insurance companies, research institutes and press agencies. Priority is given to data from UN agencies, governments and the International Federation of Red Cross and Red Crescent Societies. …The entries are constantly reviewed for redundancy, inconsistencies and incompleteness. CRED consolidates and updates data on a daily basis. A further check is made at monthly intervals. Revisions are made annually at the end of each calendar year.”

While it is clear that the GaIn is to be updated on a more regular basis than the CVM or the CCVI, none of these indices are entirely explicit about whether their primary purpose is a one-off measurement of state (which might support the initial allocation of investment) and/or ongoing measurement of trend (which is required to evaluate what adaptation investments achieve over time). This distinction has implications for the quality standards of underpinning datasets. For measurements of state, it may be possible to accept a lesser precision in data, so long as it is still possible to distinguish between the measurement units to be compared. For trends, data quality criteria (precision and accuracy) are usually more stringent to enable the detection of change over time with an acceptable signal-to-noise ratio, within each measurement unit.

Several of the indicators from the GaIn (and the underlying data on which they depend) could be investigated further for incorporation into the ASC’s set for drought and flooding. These are:

- Water use (percentage of total internal and external water withdrawn for all uses, and associated data sets)
- Coastal area (percentage of land less than 10 m above sea-level)
- Coastal population (percentage of population living less than 10 m above sea-level)
- Road flooding (frequency of floods calculated as flood disasters per decade per 100,000 km² of land area)
5 Other international experiences of adaptation indicator development

5.1 Introduction

This section draws upon a review of recent work on adaptation-related indicators within and beyond the UK, undertaken by AEA for the Scotland and Northern Ireland Forum for Environmental Research (SNIFFER). The key messages from this study are distilled and considered in the context of the global adaptation indices reviewed earlier in this report, and the ASC’s on-going work on adaptation indicators. Where appropriate, additional research has been considered, drawing upon international good practice.

The research project for SNIFFER has two phases, the first focussing on information gathering, identifying work which has been or is currently being undertaken on adaptation indicator development in the UK, Europe and beyond. The report considers the conceptual development of indicators, their national and regional application, sectoral and policy relevance, links to other monitoring activities and data and stakeholder constraints at different spatial scales (UK, Europe and Global). A second phase is proposed which will focus on the needs of different adaptation indicator user groups in Scotland, examining the implications for future indicator development.

5.2 Key messages

5.2.1 There is no single “best practice” framework but there are some common concepts

In examining the various conceptual approaches to the development of indicators, the SNIFFER Report (Miller et al. 2012) highlights that no single best practice framework emerges from the research. This is perhaps not surprising given the diversity of adaptation objectives and interventions and, consequently, the differing purposes for which indicators are developed. This is acknowledged in the recent World Resources Institute report, ‘Making Adaptation Count: Concepts and Options for Monitoring and Evaluation of Climate Change Adaptation’, which stresses that there is no one-size-fits-all approach and that “no one system will work for all purposes or all players” (Spearman and McGray, 2011, p.50). It also reflects the normative nature of the choices made in selecting indicators. The futility of seeking a universally applicable framework for the development of indicators is also reinforced in recent guidance produced by UKCIP (Pringle, 2011).

5.2.1.1 Experience in applying a Drivers-Impacts-Actions approach

While no single framework can be identified, either for monitoring and evaluation of adaptation interventions more broadly, or specifically in identifying indicators, the SNIFFER study does identify some consistent approaches. For example, the ‘adaptation preparedness ladder’ developed by the ASC applies the Pressure-State-Response (PSR) framework to identify Drivers, Impacts (or risks) and Action (adaptation). Such an approach has also been used by those developing indicators in support of the New York adaptation plan (Jacob et al., 2010; Harvey et al., 2011). The SNIFFER study stresses that this framework allows impacts to be considered as part of a broader system, but also recognises its limitations. For example, the Driver-Impacts-Actions framework “assumes a narrow, linear view of the way
climate impacts arise” which does not necessarily account for more complex relationships within and between sectors in the absence of climate pressures.

### 5.2.1.2 Process and outcome-based indicators

Another concept which appears repeatedly within the SNIFTER study is the distinction between processes and outcomes. Reflecting on concepts and issues discussed by the European Environment Agency’s (EEA) European Topic Centre on Air and Climate Change (ETC ACC), Harley et al. (2008) outline a framework for the development of adaptation-related indicators (see Figure 9). This framework makes a distinction between the ‘processes’ associated with the development of adaptation policies and delivery of adaptation measures, and the ‘outcomes’ of adaptation actions. The process-based indicators are then considered in terms of ‘adaptation policy indicators’ and ‘adaptation measure indicators’.

#### Figure 9 Framework for the development of adaptation-related indicators (Harley et al., 2008)

This approach also recognises how the long term nature of adaptation often means that process-based indicators are likely to be of greater importance in the short term, with outcome-based indicators increasing in prominence in the longer term. To date, it has been applied to the European regions of Andalucía, Spain and North Rhine Westphalia, Germany (Harley & van Minnen, 2009).

UNFCCC (2010) provides a further framework for evaluating projects, policies and programmes. This represents a useful example of how adaptation indicators should be considered within a broader framing of both the adaptation and evaluation processes, in the case using three categories; ‘broader socio-economic and ecological systems’, ‘adaptation policy process’ and ‘monitoring and evaluation systems’. The framework stresses the importance of learning and feedback, characteristics which are emphasised by other recent guidance on adaptation evaluation approaches (Spearman and McGray, 2011, Pringle, 2011).
5.2.1.3 Other criteria for establishing adaptation indicators

The SNIFFER study identifies other ‘common features’ of adaptation indicators at national and regional level, including the need for ‘SMART’ (Specific, Measurable, Achievable, Relevant and Time-bound) indicators (UNFCCC, 2010; Jacob et al., 2010). This is exemplified by the National Climate Change Strategy for Costa Rica which recognises the value of ‘SMART’ indicators, which should be easily measurable, applicable to a range of adaptation outcomes at different spatial and temporal scales, and have a reasonable and justified cost for obtaining data.

Other useful criteria for developing climate change indicators identified in the SNIFFER study include the following suggested by Jacob et al. (2010):

- Policy relevance – incorporates a changing baseline, shows trends over time; allows intra-and inter-city comparison
- Analytical soundness – based on well-founded definitions and scientific terminology; linked to economic models and climate scenarios / projections
- Measurability – based on readily available data or data available at reasonable cost-benefit ratio; data goes back long enough to allow quantitative statistical evaluation; can be updated at regular intervals.

5.2.2 Understanding purpose is essential

The review of the three global adaptation indices found that each index had a clear purpose which drove its design and approach. The importance of understanding the purpose which underpins indicator development is also a consistent thread which runs through the SNIFFER study. In this context, this purpose can refer to the subject of the evaluation (e.g. project, programme or policy), the scope and content (an indicator to monitor what?) or the sectoral or thematic focus (e.g. biodiversity adaptation indicators). It can also include a broader understanding of the objectives which drive the monitoring or evaluation process.

5.2.2.1 Understanding purpose and motivation

The need for those developing monitoring and evaluation processes to understand the purpose and objectives of their work is also emphasised in guidance from UKCIP (Pringle, 2011), which suggests the following reasons for monitoring and evaluation:

- To evaluate effectiveness
- To assess efficiency
- To understand equity
- To provide accountability
- To assess outcomes
- To improve learning
- To improve future activities or interventions
- To compare with other similar activities or interventions

This builds upon the work of Spearman and McGray (2011) which emphasises the need to acknowledge the tensions and synergies which may exist between differing purposes. Understanding purpose for monitoring and evaluation therefore provides a context in which to explore the nature and application of indicators.

The purpose which underpins monitoring and evaluation work is likely to be closely aligned to the motivations to adopt adaptation indicators. This theme is picked up within the SNIFFER study with reference to the work of Smithers et al. (2012) in the application of biodiversity adaptation indicators at European Commission (EC) and Member State (MS) level. Smithers et al. (2012) expose the following motivations for developing indicators in relation to biodiversity and climate change:
Opportunities to understand and quantify links between biodiversity and ecosystem services relevant to policy areas
Establish requirements for monitoring performance at EU, MS, regional and local levels
Informing the development of policy and practice
Reviewing the effectiveness of EU, MS, regional and local policies and outcomes in building resilience.

5.2.2.2 Understanding the subject
The SNIFFER study highlights how the subject being evaluated can raise different challenges for those tasked with developing appropriate adaptation-related indicators. For example, developing indicators to track progress at project level appears to be relatively simple compared to the application of indicators for programmes and policies (UNFCCC 2010) which often can involve multiple actors and cut across traditional sectors. This also has implications for the scale at which indicators will be applied as adaptation policies are usually implemented, monitored and evaluated at national level due to their cross-sectoral, strategic nature, whereas programmes and projects tend to be relevant at sectoral or sub-national (including local and regional) levels (UNFCCC, 2010). The absence of well-defined outcomes and measurable targets at programme and policy level can further hamper the development of useful indicators (Miller et al. 2012).

Reflecting on the international experiences explored in the SNIFFER study, it is apparent that the German, Costa Rican and New York indicator initiatives are closely tied to specific adaptation strategies (the German Federal Government’s Adaptation Strategy, Costa Rica’s Climate Change Strategy, and the New York City Adaptation Plan). This provides a clear context and purpose for the development of indicators and a basis for the stakeholder engagement which characterises all three approaches.

5.2.2.3 Understanding scope and implementation
In addition to understanding the subject of monitoring and evaluation efforts, the SNIFFER study also stresses that the application of adaptation-related indicators will depend on the scope of the indicator i.e. the process or outcome that the indicator is measuring (Miller et al. 2012). Furthermore, it is important to consider who will undertake this work. Monitoring is usually undertaken by the actors involved in the project, policy or programme, whereas evaluation is typically undertaken by an independent expert in light of the results of the monitoring (UNFCCC 2010). This links to the purpose of monitoring and evaluation efforts, for example transparency and independence may be essential where indicators will play a role in determining future funding allocations.

5.2.2.4 Understanding the focus
Best practice guidance on indicator development from OECD (2008) and Hák et al. (2007) emphasises “the need to define clearly the systems of interest that will be the focus for the indicators” (AEA, 2011). This reflects the context-specific nature of adaptation, a trait also identified within the global adaptation indices review in chapters 2 to 5 of this report. It also suggests that adaptation-related indicators may have added value when related to specific sectors and policy areas (e.g. biodiversity and natural environment, built environment, critical infrastructure, farming and forestry, health and well-being). Equally, grouping indicators around a theme or common purpose may facilitate more effective cross-sector consideration of adaptation. For example Smithers et al. (2012) used the high-level biodiversity adaptation indicator (BAI) categories identified by Harley & van Minnen (2010) as the basis for engaging with stakeholders from the biodiversity, agriculture, forestry and water policy areas in the European Commission and Member States.
5.2.3 Stakeholder engagement is important

Drawing upon the international experience of adaptation indicator development considered in the SNIFFER study (Miller et al. 2012), the importance of stakeholder engagement is evident. At national level, SNIFFER (2007) examined the potential impacts of climate change in Northern Ireland and in doing so acknowledged the need to develop targets and indicators in collaboration with relevant stakeholders. Similarly, the study on Indicators for the German Adaptation Strategy (Schönthaler et al., 2010) considered the engagement of a broad range of stakeholders as an essential factor to achieve success in indicator development and consulted with a wide range of sectors and representatives from all departments of the Federal Government (including 13 sectoral action fields and two cross-sectoral fields). A further European example is provided by Spain, where the implementation of measures under the Climate Change Adaptation Strategy is monitored by national authorities and other stakeholders.

The SNIFFER study (Miller et al. 2012) identifies stakeholder acceptance as a key challenge in the development of adaptation indicators and stresses the need for the early engagement of stakeholders in defining:

• The areas of focus
• Methods used
• Data provision
• Development of the conceptual framework

Looking beyond Europe, the New York indicator initiative ensures that the indicators developed are specific to the stakeholders and circumstances in New York City (and is closely linked to the New York City Adaptation Plan). Through this process, those responsible for developing adaptation indicators have engaged widely with stakeholders providing a clear focus for the indicators and the objectives and outcomes that indicators are expected to contribute to (Jacob et al., 2010; Harvey et al., 2011).

5.2.4 There is no single, consistent definition of the key terms

As with the review of global adaptation matrices, the SNIFFER study (Miller et al. 2012) identifies the lack of consistently applied definitions as a particular challenge associated with use of adaptation-related indicators. While this problem cannot be resolved by a single report, the study seeks to clarify certain key terms, such the purpose and role of indicators, based on definitions from other sources. It highlights how indicators can be used to simplify, quantify, standardise and communicate complex and often disparate information and stresses that indicators need to be based on reliable, readily available or accessible data that are both continuous and representative of the factors being measured (Harley & van Minnen 2010).

The SNIFFER study also highlights that differences are also evident in defining a long-term vision of the adaptation outcome and in agreeing on an acceptable level of risk. These issues are potentially much harder to resolve than the consistent use of terminology as they are shaped by the framing and perspective of each stakeholder. For example, a private business may perceive risk very differently from a government department. In such cases establishing effective stakeholder engagement may be a more realistic goal than seeking consensus.
5.2.5 Limitations of indicators

The SNIFFER study (Miller et al. 2012) highlights how the use of indicators may result in unintended negative side effects (UNFCCC, 2010). In doing so, it provides the following example:

“Using ‘percentage of population living in a flood plain’ as an indicator of effective adaptation (where a low percentage would be considered a step towards successful adaptation) could lead governments to adopt policies of resettlement and relocation which, in some cases, may not actually benefit the households concerned. After the floods in Mozambique in 2000, many households were relocated away from the flood plains in which they lived. However, OECD found that many of the people concerned were not provided with new homes, sufficient farmland or adequate alternatives to their original livelihood strategies and have returned to the flood plains (Levina, 2007 in UNFCCC, 2010).

This example emphasises the importance of engaging stakeholders in both the development and application of indicators. It also highlights how adaptation is rarely an objective in itself; therefore adaptation indicators need to relate to broader social, economic and environmental objectives. In the example from Mozambique given above, adaptation indicators might be used alongside development indicators to identify tensions and exploit synergies between adaptation and broader development goals, helping to avoid maladaptation.

5.2.6 Setting indicators in a broader context

The development of adaptation indicators promises to reduce the complexity to a manageable state by identifying and measuring essential components and relationships within the system (ASC, 2011). However, this results in trade-offs in credibility, robustness and legitimacy (Miller et al. 2012). Consequently, those developing and using adaptation indicators need to navigate a path between simplification and quantification on one hand, and developing a rich understanding of the complexities which underpin adaptation on the other.

This process can be managed by viewing adaptation indicators in the context of broader monitoring and evaluation objectives and ensuring that they are used in addition to other information sources. This is recognised in the SNIFFER study (Miller et al. 2012), which states that it is recommended that a mix of quantitative, qualitative and narrative tools as well as a mix of process and outcome indicators, should be used so that results provide the most accurate picture of progress towards adaptation (UNFCCC, 2010). The report also supports the need to link adaptation-related indicators to other climate change monitoring activities, such as the use of impact and vulnerability indicators.

As Harvey et al. (2009) acknowledge, choosing how to develop a single measure of a complex problem is inherently a political decision based on values and particular framings of climate change (Pringle, 2011). This further underlines the need to engage stakeholders effectively, ensuring that a range of values are reflected in the indicators developed.

5.2.7 Data challenges

The SNIFFER study (Miller et al. 2012) highlights the need for adaptation indicators to be supported by robust, high quality, long-term data sets. Finding data that is both relevant and statistically robust remains a challenge; in one study data was only collected for approximately 40% of the proposed indicators across all sectors (Harvey et al. 2011). The availability of data varies depending on the sector/theme and spatial resolution required. For example, in New York data on climate change variables (‘climate driver indicators’) is readily available for at City-level, however indicator data tracking the impacts of climate risks (‘impacts indicators’) proved more difficult to locate. Further challenges include data not
being consistently collected and archived or being publically available (see also Smithers et al., 2012). The time period covered also varies across different data sets, making comparisons across data sets difficult.

The challenges of effective data collection are also identified in an evaluation centred on adaptation measures in Pacific Island Countries. This study identified:

- The need for better record-keeping
- The benefit of specifying a framework for monitoring benefits, enabling comparison of measurable benefits against defined targets
- The importance of continuous monitoring (UNFCCC, 2010: 13)

SNIFFER study (Miller et al. 2012) also provides details of some pragmatic responses to data gaps from developing and transition economies. For example, as part of Guatemala’s vulnerability reduction assessment responses to indicator-based questions (that had been tailored to locally relevant vulnerability issues) were collected at community meetings throughout the lifetime of the project (UNFCCC, 2010). In the Caribbean, a 2009 report of the Mainstreaming Adaptation to Climate Change project stressed the key role of a functioning monitoring and evaluation system but noted the potential benefits of more systematic, less frequent reporting. These findings support the view that linking indicators to carefully targeted datasets (where possible using existing sources) may be more effective than a scattergun approach to data collection. The SNIFFER study views these data challenges through a positive lens, recognising this as an opportunity to forge strong partnerships to contribute to effective monitoring, which will inform future policy and decision-making (Jacob et al., 2010).
6 Case study: Germany

6.1 Introduction

A project entitled *Establishment of an Indicator Concept for the German Strategy on Adaptation to Climate Change* (Schönthaler et al., 2010) was initiated in December 2008 and completed in March 2010. This chapter of the report draws out some of the key messages from this work in terms of purpose, approach, types of indicators and use of datasets in Germany in order to inform ASC’s continuing work on adaptation-related indicators.

6.2 Purpose

This study was taken forward against the backdrop of the adoption of the DAS (German Strategy for the Adaptation to Climate Change, Bundesregierung 2008) in December 2008. The DAS created a framework within which adaptation responses to the consequences of climate change could be developed for Germany and is predominantly focused on the Federal level, but providing guidelines for those working at other levels. It is intended that the DAS will be supported by an Indicator System and a Report on Indicators, informed by the work of Schönthaler et al. (2010).

The key outputs from the study undertaken by Schönthaler et al. (2010) were a methodology for identifying adaptation indicators, an initial set of indicators for adaptation at Federal level and a structure for a Report on Indicators (due to be completed in 2013). Schönthaler et al. identify the requirements of the DAS indicator system as being:

- **Updateability.** The approach must be able to account for new insights emerging from both technical and political spheres and need to ensure data availability for individual indicators into the future.
- **Comprehensible prioritisation.** The Indicator System needs to provide comprehensible prioritisation of themes.
- **Realisability.** The system needs to be implemented largely using existing data sources, whilst recognising the need to identify gaps.
- **Acceptability.** The Government must be willing to make the required data available and the system must be technically acceptable to government departments.

The proposed national level DAS Indicator System also needs to reach upwards to link to EU adaptation activities and downwards to link to subordinate levels of government (Laender).

6.3 Method and Framework

The framework used by Schönthaler et al. (2010) for the development of adaptation indicators can be most easily understood in terms of two key dimensions, the first being the type of indicator (e.g. impact indicator) and the second the ‘field’ i.e. the sectoral architecture within which indicators were selected and prioritised.
6.3.1 Indicator types

The project utilizes the DPSIR framework\(^\text{20}\), with the aim that indicators will provide concise information of Drivers, Pressures and State thus informing an improved understanding of cause and effect of climate change and its consequences. As a result, the basic structure of the indicator system considers three main indicator types:

1) Indicators at **impact and response** level

2) Indicators for describing past or present and future developments and indicators for assessing **sensitivities or vulnerabilities**

3) Indicators for describing **processes** relevant throughout the Federal Republic and indicators for describing problematic issues.

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\(^{20}\) Driving Forces-Pressures-State-Impacts-Responses

6.3.2 Action and Indication Fields

The methodological approach taken to selecting indicators reflects the sectoral nature of the DAS. Consequently, indicators were proposed for the following 13 Action Fields and 2 Cross-sectoral fields upon which the DAS is structured:

- Human Health
- Building Sector
- Water Regime, Water Management, Coastal and Marine Protection
- Soil
- Biodiversity
- Agriculture
- Woodlands and forestry
- Fisheries
- Energy
- Financial services
- Transport and transport infrastructure
- Trade and industry
- Tourism Industry
- Spatial, regional and physical development planning
- Population protection

Through a combination of literature review and consultations with experts, impacts and measures (implemented or proposed) were identified for each Action field and organized into sub-themes then grouped into a series of technical sectors or 'Indication Fields'. The aim of this approach was to produce a manageable number of indicators within each Action Field (e.g. Human Health) which would be classified into Indication Fields (e.g. 'Health effects of UV'). The Indication Fields were then considered in terms of **Impacts and Responses**.

The process of selecting an appropriate number of Indication Fields for impacts involved the application of a weighted set of criteria which included relevance, status of data, strength of the cause-and-effect relationship with climate change, involvement and spatial coverage. However, it was decided not to apply criteria to ‘response’ Indication Fields as the identification of response indicators with suitable data sets proved challenging in itself.
6.4 Indicators

The output from this thorough selection process was a table containing impact and response indicators categorized into Indication Fields for all 15 Action Fields, as exampled in Table 10.

Table 10 Examples of indicators in the Action Field ‘Water regime, water management, coastal and marine protection’ (Schönthaler et al., 2010)

<table>
<thead>
<tr>
<th>Indication field</th>
<th>Sub-theme</th>
<th>Indicators proposed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundwater regeneration / groundwater table</td>
<td>Changes in the groundwater table</td>
<td>WW-I-1: Changes in the amount of groundwater</td>
</tr>
<tr>
<td>Sea level and sea currents</td>
<td>Sea level rise</td>
<td>WW-I-8: Sea level rise</td>
</tr>
<tr>
<td></td>
<td>Eutrophication of water bodies</td>
<td>No indicator proposed</td>
</tr>
<tr>
<td></td>
<td>Adverse effect on bathing-water quality</td>
<td>No indicator proposed</td>
</tr>
<tr>
<td>Communication with / explanations to in-habitants regarding risks and hazards (Inland waters, terrestrial areas)</td>
<td>Educating the inhabitants</td>
<td>No indicator proposed</td>
</tr>
<tr>
<td>Adapting the water-management infrastructure</td>
<td>Safeguarding and enhancing/extending the drainage infrastructure</td>
<td>WW-R-2: Developments regarding the surfaced area (in ha), which is connected to a) mixed systems, b) separate systems</td>
</tr>
<tr>
<td>Adapting the water-management infrastructure</td>
<td>Safeguarding and enhancing/extending the drainage infrastructure</td>
<td>WW-R-2: Developments regarding the surfaced area (in ha), which is connected to a) mixed systems, b) separate systems</td>
</tr>
</tbody>
</table>

6.5 Data Sources

In considering the broader objective of developing an Indicator System for the DAS, the challenges of data availability were acknowledged from the outset and are reflected in the aforementioned requirements for the system to be ‘updateable’, ‘realisable’ and ‘acceptable’. The importance of sound data is a theme also reflected in the weighted criterion used to select the ‘indicator fields’ for impact indicators; indeed the availability of regularly collected data is identified as an essential prerequisite for generating meaningful Indication Fields.

The development of individual indicators was informed by meetings with experts which produced ideas for indicators which warranted further research. For each proposed indicator an Indicator Fact Sheet was developed providing justification of the choice, an unambiguous title and a review of the strengths and weaknesses of the indicator (including data availability). An example of this Fact Sheet can be found in Appendix 2.
In addition, a Data Fact Sheet was also proposed which will draw upon standards for the use and documentation of metadata\(^\text{21}\) which will detail the data source, geographical coverage, collection frequency and methodology, cost and format. Full details of all data sources are not included in the report by Schönthaler et al. (2010).

### 6.6 Conclusions

There are synergies between the methodology used by the ASC and the approach being developed in Germany, with the methodology employed by Schönthaler et al. (2010) using the DPSIR framework\(^\text{22}\) as the basis for indicator development. However, the methodology being developed in Germany is closely aligned to the DAS (German Strategy for the Adaptation to Climate Change) which forms a conceptual anchor for the development of indicators. There has clearly been a great deal of energy put into the methodological framework and in articulating a transparent selection process, including a detailed consideration of data constraints. Stakeholders have clearly played an important role in the process and Schönthaler et al. (2010) often refer to input from ‘experts’; however there is limited discussion of who these experts are and how they have been selected.

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\(^{21}\) EEA standards and the Dublin Core Standard see Schönthaler et al. P.54

\(^{22}\) Driving Forces-Pressures-State-Impacts-Responses
7 Case study: Australia

7.1 Introduction
This section of the report offers a snapshot of progress on the development of adaptation indicators in Australia based on conversations with the Australian Department of Climate Change and Energy Efficiency and a report by CSIRO entitled *Developing National Indicators of Climate Change Adaptive Capacity* (Gardner et al. 2010). It aims to provide an understanding of the prevailing policy context within which indicators are currently being developed and progress that has been made to date on developing metrics for adaptive capacity.

7.2 Policy Context

7.2.1 Links to national policy
In 2010 the Australian Government released a position paper (*Adapting to Climate Change in Australia*) that set out a broad approach to climate change adaptation. The position paper noted that climate change impacts present serious and pervasive risk management challenges to Australia and governments, businesses and communities have a role to play in responding to them.

While most of the assets and activities at risk from climate change impacts are owned or managed by businesses and the communities, governments have an important role to play in adaptation. Specifically, governments should provide information for business and communities to adapt, set the right policy and regulatory conditions for effective adaptation, and ensure that government programs and assets are managed for a changing climate. Six priority sectors for adaptation were identified: water resources, infrastructure, the coastal zone, natural ecosystems of national significance, agriculture, and natural disaster management.

Australia’s Productivity Commission is inquiring into policy and regulatory barriers to effective climate change adaptation and will report on 20 September 2012. A draft report released on 27 April 2012 concludes that there are few systemic barriers to adaptation and most adaptation will take place through normal risk management and the operation of markets. The draft report identifies some potential reforms to promote adaptation, including clarifying legal liabilities of local government, reviewing land-use planning systems, and ensuring the National Construction Code and associated standards take climate change into account.

The Australian Government’s position paper included a commitment to produce a Climate Futures report to track national adaptation progress and test the appropriateness of policy settings.

The Climate Futures Report will:

- raise awareness among Australian governments, business and the community about the need to adapt to the impacts of climate change we cannot avoid;

- assess how well Australia is placed to deal with the risks of climate change impacts; and
Review of international experience in adaptation indicators

- evaluate the effectiveness of policy measures in improving resilience to climate change impacts, including state measures with nationally important social, economic and environmental implications.

The report will be published every five years, with the first report to be published in early 2013. The Minister for Climate Change and Energy Efficiency has appointed an independent expert group (IEG) to advise on preparation of the report. Membership of the IEG is drawn from science, economics and business experts.

7.3 Method and Framework

A monitoring and evaluation framework for the Climate Futures Report is still being developed. A normative approach, based on a model of what a well-adapting Australia would look like, is one possible approach to developing the monitoring and evaluation framework. Given the nature of adaptation, a monitoring and evaluation framework will need to allow assessment of progress on a number of levels, such as adaptive capacity, policy and regulatory settings, governance, on-ground actions, and outcomes. In 2010 the Department of Climate Change and Energy Efficiency commissioned CSIRO to provide advice on possible indicators for monitoring adaptive capacity, one of the ‘levels’ on which adaptation progress may need to be assessed.

7.3.1 Adaptive capacity

Adaptive capacity is an interesting lens through which to view adaptation progress and may yield useful lessons for the work of the ASC. Gardner et al. broadly define adaptive capacity as “the ability of a natural or human system to deal with a stressor” (Gardner et al. 2010, p.19) and recognise that resources and the ability to deploy them are critical aspects of adaptive capacity (Adger et al. 2004). The relationship between adaptation and adaptive capacity is also explored; adaptive capacity can be presented as a reflection of potential adaptation and, conversely, adaptation can be viewed as ‘realisation of adaptive capacity’. The close relationship identified between these two concepts provides the rationale for seeking to measure adaptive capacity as one means of understanding progress in the field of climate adaptation.

7.3.2 Methodology and conceptual framework

In order to determine appropriate measures of adaptive capacity, it is necessary to first identify the constituent elements of adaptive capacity. The methodology employed by Gardner et al. (2010) uses the Sustainable Livelihoods Framework (Ellis, 2000) as a guiding concept. This considers adaptive capacity as the sum of the following five resource types or ‘capitals’:

- Human capital – aspects that enable individuals to improve or maintain standards of living (e.g. education, skills)
- Social capital – interconnections between individuals and groups
- Natural capital – environmental assets (e.g. biodiversity, water resources, land)
- Physical capital – buildings, equipment or infrastructure
- Financial capital – availability and access to finance

The project then undertook a review of previous work using these five capitals to generate assessments of adaptive capacity focusing on the agricultural sector. Types of measures and best practice in metric development were reviewed and barriers and challenges are identified. This material was then used in the formulation of a staged method for metric development illustrated in Table 11.
### Table 11 Five Stage approach to metric development (Gardner et al., 2010)

<table>
<thead>
<tr>
<th>Stage</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stage 1</td>
<td>Establish clear working definitions of each capital (noting that such definitions might need to be adjusted in the future)</td>
</tr>
<tr>
<td>Stage 2</td>
<td>Identify a preferred spatial and temporal resolution of measurement (noting particular issues relating to the aggregation and disaggregation of data)</td>
</tr>
<tr>
<td>Stage 3</td>
<td>Identify multiple potential indicators to reflect each of the capitals (focussing on advantages and disadvantages of different types of measures)</td>
</tr>
<tr>
<td>Stage 4</td>
<td>Reduce the number of potential measures (via the application of specified criteria for the inclusion and exclusion of measures)</td>
</tr>
<tr>
<td>Stage 5</td>
<td>Combine chosen indicators into summary measures (noting the value of interpreting individual measures before they are combined, and noting some specific statistical issues associated with combining diverse measures).</td>
</tr>
</tbody>
</table>

The stage-based approach to metric development identified by Gardner et al. (2010) incorporated a set of best practice principles based upon the review of existing literature. These include:

- The purpose of the assessment must be clear (as different metrics and processes are more or less suited to different purposes)
- Assumptions need to be transparent (allowing the review and potential amendment of the appropriateness of the measures)
- An appropriate scale needs to be chosen (i.e. a consistent and appropriate measurement scale)
- Each metric must allow for validation (the collection of evidence that a metric accurately reflects the aspect of adaptive capacity being considered)

### 7.4 Indicators

#### 7.4.1 Conceptual understanding of adaptive capacity indicators

Gardner et al. (2010) acknowledge that adaptive capacity refers to a system’s potential future response and therefore is impossible to measure directly. The result of this characteristic is that it is necessary to infer adaptive capacity from variables which can be observed and measured (or proxies). The study considers a range of indicators developed in other studies including ‘top-down’ approaches where a mix of socio-economic indicators applied at different spatial scales. ‘Bottom-up’ participatory approaches to indicator development are also illustrated where primary data is gathered, often in conjunction with the local community, an approach which draws heavily upon both literature and experiences from the development community (e.g. Park et al., 2009; Brown et al. 2010). Gardner et al. (2010) also differentiate between:

- Input indicators which reflect an input which can be reasonably expected to influence capital
- Outcome indicators which are measures of the resulting outcome on the capital itself
- Process indicators that reflect the process or the development of capital

For example, increased investment in climate change education could be considered an input indicator while the level of educational attainment achieved or knowledge gained within
a community could be a measure of outcome. A process measure might refer to the quality of teaching at climate change training events.

### 7.4.2 Potential metrics for specific sectors

In addition to discussing the concepts which underpin the development of adaptive capacity metrics, Gardner et al. (2010) attempt to identify metrics for the sectors of Coastal Management, Water, Infrastructure, Natural Systems, Natural Disaster Management, Agriculture and Health. Table 12 illustrates the potential indicators developed for the water sector:

**Table 12 Issues and potential indicators for the five capitals in the water sector (From Gardner et al. 2010)**

<table>
<thead>
<tr>
<th>Capital</th>
<th>Sector-specific issues</th>
<th>Potential indicators</th>
</tr>
</thead>
</table>
| Human     | Human capital relates to a quite narrow group of people – those with immediate responsibility for management of water resources and related services. | - Expertise in climate adaptation amongst people working directly in management of water resources.  
- Rates of vulnerability assessment and adaptation planning in water management entities. |
| Social    | As for other sectors, the quality of linkages within and between groups working in this area is important, especially where such linkages exist for the transfer of information regarding climate change impacts and planning. | - Extent of co-ordinated activity between neighbouring water management groups  
- Quality and quantity of contact between water management groups and centralised bodies. |
| Natural   | Includes both levels of rainfall and quality and extent of catchment areas (positive aspects of capacity) and flood risk (a negative aspect of capacity). | - Level of rainfall and runoff per region per year, with reference to historical trends and future projections.  
- Extent of flood warnings per region over time (a negative measure of adaptive capacity). |
| Physical  | Water-sector infrastructure includes water processing and storage facilities, pumping stations, desalination plants, water recycling plants, as well as reticulated supply and drainage piping. | - The quality and value of this infrastructure  
- Extent to which this infrastructure is exposed to climate impacts (a negative measure of adaptive capacity) |
| Financial | Financial capital in this sector is a fairly narrow field relating to the current and likely future availability of funding for adaptation of water-related infrastructure and supply. | - Per capita funding for water management  
- Extent of incentives for private investment in this area. |

### 7.5 Data Sources

Gardner et al. (2010) identify substantial limitations in both the quality and quantity of appropriate data for the development of adaptive capacity metrics. Limitations associated with secondary data identified include data not being gathered for the purpose of measuring adaptive capacity (proxy measures) hence there may not always be a clear link to the concept being investigated; inaccurate or incomplete data; and data sets being spatially or temporally incompatible. Participatory data is often gathered only for a small sample and therefore may not be applicable at national level. A further challenge is how multiple indicators can be combined effectively i.e. how to pull together several indicators for each
'capital', and then data on the five capitals, into a coherent and comparable measure of adaptive capacity.

Work has been undertaken on data sources for each sector (in an appendix to the report) but this was not available for review at this time. The main body of the report does not seek to connect the potential indicators and measures to specific data sources suggesting that further work may be required in this area. The approach embodied in the work of Gardner et al. (2010) contrasts with the case study from Germany where data availability was a key driver for indicator development from the start.

### 7.6 Conclusions

Efforts to develop national level adaptation indicators appear to have been reenergised by the planned publication of the Climate Futures Reports in 2013 which will require an effective means of quantifying adaptation progress. As is the case in Germany (Schönthaler et al., 2010), this work is closely aligned to national-level adaptation planning processes therefore further thought may need to be given to the objectives of the ASC’s work on indicators vis-à-vis the UK National Adaptation Plan which will also be published in 2013. While acknowledging that adaptive capacity is viewed as one of a number of 'levels' on which adaptation progress may be assessed, the report by CSIRO (Gardner et al. 2010) provides an interesting contrast to the approach outlined by Schönthaler et al. (2010). It also illustrates the potential for drawing upon concepts from other disciplines, in this case the international development community.
8 Summary and conclusions

8.1 From the review of global indices

This short report has explored three recently published global adaptation or vulnerability indices. Table 13 provides a summary of these indices.

Table 13 Summary of the indices reviewed

<table>
<thead>
<tr>
<th>Index</th>
<th>Purpose</th>
<th>Sectors</th>
<th>Data sources</th>
</tr>
</thead>
<tbody>
<tr>
<td>GaIn</td>
<td>Leverage private sector investment in adaptation</td>
<td>Vulnerability: water, food, health, infrastructure, infrastructure Readiness: governance, social, economic</td>
<td>High dependence on World Bank datasets and Heritage Foundation data (pre-existing indicator sets)</td>
</tr>
<tr>
<td>CVM</td>
<td>Promote understanding and debate on climate change impacts</td>
<td>Health, weather disasters, habitat loss, economic stress</td>
<td>A range of datasets and some model data</td>
</tr>
<tr>
<td>CCVI</td>
<td>Facilitate efficient allocation of public funds for adaptation</td>
<td>Extreme weather, sea level rise, agricultural productivity</td>
<td>A range of academic sources / studies; some true datasets</td>
</tr>
</tbody>
</table>

Overall, GaIn seems to be the most relevant and potentially useful in the context of the ASC’s current work, not least because it is entirely transparent in its construction and based on true, maintained and publicly accessible datasets.

We offer the following conclusions on frameworks, methods and data for the ASC to consider in the development of adaptation outcome metrics for the UK.

1. Each of the indices reviewed has been developed in a distinct framework: none of them correspond closely with each other, or with the framework currently proposed by the ASC. There seems to be no single “best practice” framework for the construction of vulnerability or adaptation metrics.

2. A clear purpose has driven the design of each index. This is a crucial point. The authors of each index are clear about the action they wish to provoke by the existence of their metric, and this has significantly determined their selection of methods, presentation, data, etc. The GaIn is seeking to be accepted as a common standard at national level (e.g., similar to credit ratings), and this results in imperatives about transparency, accessibility, and interactivity in order to encourage “hands-on” involvement in the issue. The CVM is largely about communication and awareness-raising on the scale of the climate challenge, as can be seen in the choice of presentational devices, and in the fact that the numeric scores and underlying data are less accessible. The CCVI is driving a point about the need for fair and efficient allocation of adaptation finance, and so there is a strong emphasis on how vulnerability scores can be used in other formulae.

It may be worth the ASC articulating clearly what purpose it foresees for the metrics under development: not only the general purpose (such as to deliver statutory duties), but also specifically what action (and by whom) it wishes to provoke by the publication of the indicators. This level of clarity may help refine choices about approach, data, presentation and communication.
3. By their nature, all of the global metrics offer the possibility of cross-country comparison. The GaIn actively encourages this kind of status comparison in order to provoke governments to act. By contrast, the CVM promotes the fact that every country faces a different combination of climate impacts and none is immune, and the qualitative presentation discourages too much neighbourly “peer pressure”.

The ASC might consider the extent to which it wishes to enable comparison, even encourage competition, between sub-national areas, through the publication of its indicators.

4. There is no single, consistent definition of the key terms and concepts, such as “vulnerability”, “adaptation” “capacity”, involved in the construction of these indices. Both GaIn and CVM focus on outcome vulnerability, the GaIn explicitly so, in the construction of its vulnerability axis following IPCC categories (exposure, sensitivity, adaptive capacity, though it may be arguable the extent to which their chosen indicators truly represent these categories). However, the GaIn then introduces the concept of “readiness” which is less clearly defined, seemingly a combination of what some would interpret as adaptive capacity and wider measures of governance and economics. The CCVI seems to include several types of vulnerability within its overall framing: a climate change vulnerability term (which in practice seems a measure of climate impact or sensitivity) optionally modified by other factors to provide a measure of outcome vulnerability.

Given the lack of consensus around terms and concepts, it seems right for the ASC to put effort into defining terms and structuring a clear framework for the development of adaptation indicators. We note that to date, the ASC has emphasised both contextual vulnerability and outcome vulnerability: further clarity about the use of terms, and particularly the ASC’s interpretation of vulnerability may be useful.

5. All of these indices confirm the necessity to approach the problem by considering multiple sectors, though not all sectors exhaustively. In fact, a relatively small number of sectors seems to be sufficient, with GaIn and CVM covering four, and the CCVI only three. All of the indices provide the ability to look at sectoral results separately, though they provide a composite measure too. The CVM seems to emphasise sectoral results, while the GaIn promotes the composite. There is no consensus over the definition of sectors, and each index includes several individual indicators within each sector. There is almost no discussion in any of the methodology documentation over the selection of sectors: in some cases these seem to have been largely pragmatic choices over data availability.

It seems that the ASC could exercise some freedom about which sectors to include, and how those sectors are defined.

6. Each index has made different choices about the quality and nature of the datasets used. Data quality requirements are different depending on whether an index is providing a measure of state and/or of trend. Measurements of state may require less stringent data precision than is needed to enable the detection of trends. The more “operational” GaIn is more reliant on other existing indicator sets and true quality-assured and maintained datasets than are the other two. The CCVI with its stronger focus on methods can afford a greater dependence on one-off academic studies to support its construction. All three indices rely on World Bank data. The majority of the datasets are collated on an annual basis from various research studies, predominantly by NGOs.

If the ASC’s indicators are intended to be updated regularly and provide long-term time series information, then the ASC should continue to prioritise the use of true datasets
which are well-maintained, and offer appropriate levels of accuracy and precision to enable detection of trends. The ASC should also look to capitalise on indices developed and maintained in associated fields.

7. The indices mainly use data reported at national levels only. From the perspective of the ASC’s remit to assess UK preparedness for climate impacts, a single number at UK level may not be very informative.

However, it may be worth exploring the wealth of data maintained by some of the international institutions, including World Bank, WHO and UN programmes, since the trend in some of the available statistics, at UK level, could provide additional insight alongside the more detailed, sub-national indicators which the ASC is collecting. In particular, the datasets assembled by GaIn on water use, coastal vulnerability and road flooding may be useful.

8. Despite the global nature of these indices, there is recognition that adaptation is first and foremost a local issue. The GaIn intends to be supplemented by an “Adaptometer” and the CVM includes an Adaptation Review.

The ASC’s decision to develop of outcome metrics within a much broader monitoring framework seems to chime with these other examples.

9. Across the three indices reviewed, there is a wide range of presentational options, determined by the underlying purpose for each. One common tool is the use of maps to provide a visual overview of results.

The ASC may wish to consider the most effective communication tools to support the purpose of their indicators, and to incorporate some spatial indicators which can be presented in mapped form within their final indicator set.

8.2 From the review of other countries

10. There is no single “best practice” framework for monitoring and evaluating adaptation interventions or the development of indicators, indeed the case studies from Germany and Australia illustrate two very different approaches to the challenge of measuring adaptation. However, there do appear to be some useful and consistent approaches, for example, the use of the DPSIR framework and the closely aligned Pressure-State-Response (PSR) approach. Another concept which appears repeatedly within the SNIFFER study is the clear distinction between process and outcome indicators.

The lack of a universal framework or approach places greater importance on ensuring that the ASC stays up to date with progress elsewhere and engages with those also grappling with the challenges of indicator development. Events such as the ASC’s workshop (see Appendix 3) are beneficial in this regard.

11. Understanding purpose is essential in the development of appropriate indicators. The lack of a single approach to the development of adaptation-related indicators may reflect the fact that indicators are developed for different purposes and applied to different subjects. In order to be able to develop an appropriate conceptual framework, and then effective indicators, thought needs to be given to their purpose.

The focus of the ASC’s work appears to be on developing suitable national level adaptation indicators. As the National Adaptation Programme develops, it will be necessary to consider in greater depth the purpose of such indicators. Further work may
also be required to understand how stakeholders perceive the purpose of national-level indicators.

12. In a number of cases, the development of indicators is clearly connected to an existing or planned national level adaptation policy or plan (examples include Germany, Australia and New York). These plans help to define the purpose of the indicators and anchor them to policy objectives. This may also help provide a focus for stakeholder engagement.

*The ASC may wish to give further consideration to how future adaptation indicators may (or may not) relate to the emerging National Adaptation Programme.*

13. **Stakeholder engagement is an important theme** within the SNIFFER study and a number of examples of stakeholder engagement in the indicator development process are provided.

*Linked to clarity of the purpose and application of indicators, it will be important that stakeholders are fully engaged in the development process. This may help in providing expert judgement on the appropriateness and relevance of indicators and measures for specific sectors, the availability of data and, critically, how the indicators should be used.*

14. **There is no single, consistent definition of the key terms and concepts.**

*As a consequence, the effort made to define key terms by the ASC is valuable. However, it is important to recognise that, in some cases, definitions will be value-driven (e.g. ‘acceptable risk’) therefore consensus may not be a realistic objective. Instead, understanding different values and perceptions through stakeholder engagement may be a more realistic aim.*

15. **Indicators do have limitations.** As the SNIFFER Study illustrates, if used inappropriately or indiscriminately, indicators can lead to maladaptation. A key strength of indicators is that they reduce the complexity to a manageable state by identifying and measuring essential components and relationships within the system (ASC, 2011). Paradoxically, this can also be a weakness if careful thought is not given to how indicators are used, for what and by whom. Those developing and using adaptation indicators need to navigate a path between simplification and quantification on one hand, and developing a rich understanding of the complexities which underpin adaptation on the other.

*Linked to the conclusions regarding both purpose and stakeholders, it may be useful for the ASC to provide guidance on how indicators can be used most effectively, highlighting the need to connect indicators to broader attempts to understand the complex factors which influence adaptation processes and outcomes.*

16. The case study from Germany places a great emphasis on the establishment of a transparent methodology. The approach outlined by Schönthaler et al. (2010) is complex but it does mean that it is possible to trace where assumptions or value judgements have been made during the process.

*The work of Schönthaler et al. (2010) underlines the need to identify where assumptions are made and to map out the logic which underpins the indicator development process. This is particularly important given that data limitations can mean that in some cases the ‘next best’ measure must be chosen. The case study from Australia also reveals the challenges of developing summary or composite indicators.*
17. **Data availability and quality remains a constraint in nearly all cases.** Issues of data availability, access, quality, spatial resolution and temporal coverage were raised in all of the studies reviewed.

   *There is no magic solution to data issues but this does highlight the need to carefully consider the relevance and rigour of datasets when agreeing metrics. The methodical approach to assessment used in the German case study may yield useful lessons.*

18. **Adaptive capacity** provides and interesting lens through which to view adaptation progress. The work of Gardner et al. (2010) provides a new and useful perspective and also highlights how other disciplines and sectors may provide a useful source of conceptual frameworks and ideas (in this case the application of the Sustainable Livelihoods Framework)

   *Further thought could be given to the role of adaptive capacity indicators, in particular, these might be effective when examining specific sectors. This could link to the sectoral approach to adaptation support being developed by the Environment Agency in the UK.*
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Appendices

Appendix 1: UK data tables (as separate excel file)
Appendix 2: Germany Indicator Fact Sheet
Appendix 3: Report from ASC workshop on 23 March 2012
Appendix 1 – Data for the UK

Provided to ASC in separate Excel file
Appendix 2 – Germany Indicator Fact Sheet

Indicator Fact Sheet

<table>
<thead>
<tr>
<th>Fact Sheet Author:</th>
<th>Schönhaler Bosch &amp; Partner</th>
</tr>
</thead>
<tbody>
<tr>
<td>in cooperation with Mini Group Forestry, MLUV MV (S. Grell), DWD (K.-P. Wittich)</td>
<td></td>
</tr>
<tr>
<td>Last update:</td>
<td>22 March 2010</td>
</tr>
<tr>
<td>Next update:</td>
<td></td>
</tr>
</tbody>
</table>

I Description

<table>
<thead>
<tr>
<th>Internal No. FWI.6</th>
<th>Title: Forest fire hazard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit: N days / Forest fire season</td>
<td>Brief description of the indicator: Number of days with forest fire indices (1+2 and 3+4, calculated on the basis of the Canadian FWI) per forest fire season (March to October) for 100 selected DWD stations</td>
</tr>
<tr>
<td>Alternative:</td>
<td>Differentiated as per Federal State</td>
</tr>
<tr>
<td>Required formulae for calculation:</td>
<td></td>
</tr>
<tr>
<td>Sum (N_{days} FWI 3+4) for all stations / N_{stations}</td>
<td></td>
</tr>
<tr>
<td>Sum (N_{days} FWI 1+2) for all stations / N_{stations}</td>
<td></td>
</tr>
<tr>
<td>Interpretation of the indicator value:</td>
<td>The higher the numerical value for the days with forest fire indices of 4 and 5, the greater the potential of forest fire hazards and vice-versa</td>
</tr>
</tbody>
</table>

II Allocation

<table>
<thead>
<tr>
<th>Action Field:</th>
<th>Forestry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Index Field:</td>
<td>Vitality / mortality effects</td>
</tr>
<tr>
<td>Sub-theme:</td>
<td>Damage caused by changes in the abiotic disturbance regime</td>
</tr>
<tr>
<td>DPSIR:</td>
<td>Impact</td>
</tr>
</tbody>
</table>

III Derivation and Rationale

| References: | Adaptation to climate change - a strategy for North-Rhine Westphalia 2009: Spatial distribution of forest fire hazards at municipal level on the basis of the average number of days posing a high or very high level of forest fire hazard (ch. 4.2): p. 70 Specialised Information System 'Adaptation to Climate Change' (FISKA-Fachinformationssystem "Klimaanpassung") within the framework of KomPass UBA (UBA FKZ 206 41 100); "Waldbrandgefährdung nach Bruschek" ("Forest fire hazard according to Bruschek") and "Waldbrandgefährdung nach Käse" ("Forest fire hazard according to Käse") |
| Rationale: | Risk assessments predict an increased risk of forest fires for countries including Germany in the decades ahead. This is due essentially to rising temperatures and declining precipitation in spring, summer and autumn months. Daily updates of forest fire hazards (during the forest fire season from early March until mid-October) is calculated in cooperation with DWD on the basis of a fixed-points system. This will take into account the development of vegetation, air temperature, humidity, precipitation and wind. On the basis of the alert levels laid down for forest fire hazards the forestry authorities initiate surveillance of forests/woodlands regardless of ownership category. Depending on the level of |

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   | The individual Federal States’ own legislation covering forests/woodlands and forest (fire) protection
   | With regard to legislation at Federal State level, administrative districts and municipalities, especially with regard to preventative fire protection, additional federal laws on civil protection or fire protection and emergency services apply. |

| Objectives: | EU KOM: Further elaboration of forest monitoring for the prevention of forest fires in cooperation with EFFIS since formation of Forest Focus, work began under Regulation (EC) No. 2158/92 on “the protection of the Community’s forests against fire.”
   | Legislation in force in individual Federal States, pertaining to forests and woodlands, e.g.:
   | Landeswaldgesetz Mecklenburg-Vorpommern (Section 19 (1)): Forest owners are obliged to take action to prevent significant damage to their forest/woodland from natural events, forest fires and forest pests in the form of plants or animals.
   | Landeswaldgesetz Baden-Württemberg (Section 14 (1)): Careful management signifies, in particular, [...] action to prevent the hazard of significant damage to their forest/woodland from natural events, forest fires, forest pests in the form of plants or animals.
   | Landeswaldgesetz Sachsen-Anhalt (Section 13 (1)): The protection of forests/woodlands encompasses measures to take precautions against, recognise early, combat and mitigate damage caused by [...] forest fires.
   | Legislation in force in individual Federal States, pertaining to emergency management, e.g.:
   | Bayerisches Katastrophenenschutzgesetz (Art. 1 (1)): The authorities responsible for emergency services are obliged to prevent disasters and to take the necessary preparatory measures (emergency management). |

   | Section 4 (1): The German Meteorological Service (DWD) is obliged to [...] 3. publish official warnings regarding weather phenomena which might present hazards to public safety and order, especially with regard to the threat of flooding hazards. |

### IV Technical Data

| Data source: | DWD indices by region
   | EU identification of areas at risk, covering the entire Federal Republic |
| Spatial distribution: | comprehensive cover of all woodland/forest areas
   | NUTS 0
   | Alternative: NUTS 1 |
| Geographical cover: | the whole of Germany |
| Frequency: | annual |
| Restrictions: | none |

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V Qualitative Data

| Strengths and weaknesses: | Strengths: Broad methodical basis for indicator calculation; acceptance of indicators regarded as certain; distinct interface with the current reporting system (including DWD, current fire hazard and weekly forecasting).

Weaknesses: The stations used by DWD for calculating the indicators proposed in this document were not chosen for representing a particularly extensive forest/woodland area. Typically, these stations are located in open ground, often on the edge of settlements. This entails uncertainties in the interpretation of values (especially in those cases where weather stations which represent only a minor woodland, indicate a high forest fire hazard, whereas other stations which represent extensive areas, might indicate only a minor hazard).

The DWD’s forest fire index is a prognostic value used as an aid for setting the alert level for forest fire hazards in line with the forestry regulations in force in any particular Federal State, i.e., the index can vary from the official alert level. There are differences in the way the DVD value is applied spatially in different Federal States. There are, for instance, differences in the statements issued for administrative districts or forestry district offices or municipalities.

Feasibility, development needs: 1 In Germany, the forest fire hazard in the course of a year has been calculated for decades on the basis of various models most of which are based on developments from the 1960s. These are:

- Forest Fire Index according to BRUSCHÉK (annual drought index calculated from the quotient of precipitation amount and the number of summer days = days at maximum temperature > 25°C); so far the model has been validated in Brandenburg only; it is possible that the hazard is overestimated in other Federal States, especially in broadleaf-rich areas;
- Forest Fire Index according to BAUMGARTNER (developed and applied in West Germany, calculated on the basis of the climatic water balance of the preceding 5 days);
- Forest Fire Index M-68 according to KÄSE (used in the GDR and currently applied as operational procedure by the German Meteorological Service for daily updates of forest fire hazard forecasts for Germany; the model refers to mid-day values of air temperature, relative humidity, wind speed and 24-hour precipitation sums, as well as height of snow measurements in the morning during early spring months; the status of vegetation and the phenological development of forest understorey and canopy).

The DWD method (based on Käse or M-68) is currently the most standard of these procedures applied in Germany. The daily fire warning based nationwide on the DWD Forest Fire Index is calculated by this method. In addition, the DWD is currently - in conjunction with the Federal States - running trials for the application of the Canadian Fire Weather Index (FWI). This Canadian Index enjoys worldwide recognition. It is used for evaluating weather data in a different manner from the German M-68. In this method, ground moisture levels are incorporated in the calculations. Days with alert levels of 4 and 5 or 1 and 2 have already been calculated according to the Canadian FWI by DWD (on a trial basis) for the period 1977 until 2008 for 100 meteorological stations. No doubt, it would be possible to continue the time series in line with this methodology.
VI. Supplementary Information

<table>
<thead>
<tr>
<th>Glossary of Terms:</th>
<th></th>
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</table>
Appendix 3 – Report from ASC workshop

The ASC is keen to understand how other countries have developed, or are in the process of developing, their own approaches for monitoring and evaluating adaptation, to inform, challenge, and improve its own efforts in this regard. On March 23, 2012, the ASC convened a small expert workshop with a number of country-level representatives to share knowledge and experience of the approaches being taken by different countries to develop, monitor and evaluate adaptation to climate change.

Overviews of the State of Play reported at the workshop

In advance of the workshop, the ASC received responses to a short questionnaire about current activities on monitoring and evaluation of adaptation at national level. These are summarised in Figure 10, and additional context, based on remarks invited at the workshop, is provided below. All the countries represented at the workshop have the intent to publish (or have already published) a national adaptation strategy of some form, and all are aware of the importance of assessing progress arising from the implementation of those national strategies.

Figure 10 Summary of responses to ASC questionnaire

<table>
<thead>
<tr>
<th>1. Are you considering how to monitor and evaluate the effectiveness of your national adaptation strategy?</th>
<th>Germany</th>
<th>Canada</th>
<th>Australia</th>
<th>France</th>
<th>Netherlands</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes. German Federal Environment Ministry (BMU) is developing a M&amp;E framework for the national adaptation strategy (NAS)</td>
<td>Not yet, but intend to develop these frameworks</td>
<td>Yes. Publishing a Climate Futures Report in 2015 which will establish a M&amp;E framework.</td>
<td>Yes. National Adaptation Plan (2011-2015) has M&amp;E chapter and stipulates yearly progress reports and midterm and final evaluation reviews in 2013 and 2015.</td>
<td>Not yet, but aim to use concept of adaptive monitoring for adaptation monitoring programs.</td>
<td>Federal agency leadership on adaptation planning through the President’s Council on Environmental Quality. A National Climate Assessment is being developed.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Are you developing/ have you developed indicators as part of your monitoring and evaluation framework?</th>
<th>Germany</th>
<th>Canada</th>
<th>Australia</th>
<th>France</th>
<th>Netherlands</th>
<th>USA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes. Aim to complete a preliminary indicator-based report for the adaptation in Germany by the end of 2014.</td>
<td>Yes.</td>
<td>Yes.</td>
<td>Currently considering utility of indicators.</td>
<td>Yes. Monitoring is implemented through specific indicators (mainly process or output-based).</td>
<td>Developing indicators but not ready yet.</td>
<td>Indicators are important components of a monitoring and evaluation framework for adaptation and are currently being developed for the NCA.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. What type of indicators have you developed/ are you developing?</th>
<th>Climate impact</th>
<th>Process</th>
<th>Contextual factors</th>
<th>Exposure</th>
<th>Sensitivity</th>
<th>Vulnerability</th>
<th>Adaptation actions/measures</th>
<th>Overall (residual) risk</th>
<th>Realised impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Germany</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Canada</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Australia</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>France</td>
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<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>Netherlands</td>
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<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
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<td>Yes</td>
<td>Yes</td>
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<tr>
<td>USA</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

| NCA indicators are currently being researched |

Key: red shading indicates the country is developing that type of indicator
Canada

The Federal Government (through Natural Resources Canada), monitors activities on adaptation using process level indicators. These tend to monitor decision-making processes across the decision continuum. Natural Resources Canada is currently concerned to monitor how government-funded climate change impacts and adaptation data and resources are being used and absorbed by others across government, and to an extent in the private sector. The collection of information about this is largely undertaken through a qualitative interview process, rather than by means of a structured quantitative assessment. More progress in monitoring and evaluation of adaptation at national level is expected, with an emphasis from Canada’s Auditor-General on increased collection of data, and drivers from scientific / research perspectives to measure adaptation outcomes, as well as process indicators.

At provincial and municipal levels adaptation strategies are now being rolled out, and some of these state that they will include monitoring and evaluation. However, methods of collecting information against provincial plans are fragmented and under-developed. There is some growing interest in monitoring some tangible outcomes such as mortality rates in the city during heatwaves.

France

France has published a national adaptation plan. Indicators are linked to the implementation of the measures (mainly process or impact indicators), and are therefore quite simple. For each measure, there are indicators of outputs and indicators of the outcome of adaptation measures. Currently, there are no national-level indicators of the level of adaptation across France. There will be a mid-term review of the plan in 2013, and a final evaluation at the end, but it is not yet decided how that evaluation and assessment will be undertaken.

Netherlands

Since 1 January 2012, the “Delta Act” has been in place in the Netherlands. This Act focuses on freshwater availability and flood management, and sets up the policy landscape: it positions the Delta Commissioner, and frames the major “Delta Programme” policy programme. There are currently no legal targets, but the Delta Programme must report to parliament every year on progress. By 2015, there is an expectation for a number of “Delta Decisions” in the area of flood safety and security of freshwater availability. These Decisions are then to be implemented after 2015, with the establishment of substantial budgets for investment in actions (around 1bn euro pa from 2020).

At a national policy level there has not been much progress in monitoring and evaluation of adaptation, although some research projects on adaptation strategies and plans have also been considering indicators.

Within the Delta Programme there has been some consideration of policy indicators to follow the implementation of the programme. These indicators are under discussion, and not yet agreed or published, though the first report on the Delta Programme in 2013 may contain further information. The Dutch government is also developing strategic documents on long term adaptation options, and this involves updating impacts indicators which cover climate variables and the natural environment.

USA

Adaptation planning has been underway at State, regional and local level in the US. In 2009, the Obama Administration convened the Interagency Climate Change Adaptation Task Force23 (ICCATF), co-chaired by the White House Council on Environmental Quality, the Office of Science and Technology Policy, and NOAA, along with representatives from more

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23 http://www.whitehouse.gov/administration/eop/ceq/initiatives/adaptation
than 20 Federal agencies. Following the establishment of the ICCATF, President Obama signed Executive Order 13514, “Federal Leadership in Environmental, Energy, and Economic Performance,” directing the ICCATF to recommend how the Federal Government can strengthen policies and programs to better prepare the nation to adapt to the impacts of climate change. The ICCATF activities initially included multiple Workgroups, including Adaptation Science. The Adaptation Science Workgroup was transferred to USGCRP as a new program to improve the Federal Government’s capacity to provide science in support of adaptation decisions at all scales.

The Executive Order 13514 requires that each Federal agency evaluate their agency risks and vulnerabilities as they relate to climate change impacts to manage both the short- and long-term effects of climate change on their agency’s mission and operations. Agencies will eventually need to evaluate how they are progressing with minimizing their risks to climate change, and capture learning from the whole process of developing and implementing adaptation strategies. In 2011, the “Federal Actions for a Climate Resilient Nation” report was released providing a high-level overview of how the US is adapting to the impacts of climate change through adaptation actions.

The USGCRP Adaptation Science Workgroup has been working on an initial framework to evaluate the effectiveness of adaptation actions given the incredible need to identify the costs and benefits of adaptation actions for the long-run. The Workgroup plans to:

1. Continue to mine the literature for examples of strategic planning, indicators, performance measures, and evaluation of climate adaptation actions;
2. Capture the knowledge of practitioners who are engaged in implementing and evaluating climate adaptation activities through interviews; and
3. Provide a suite of products (e.g., example indicators and performance measures for coastal adaptation actions, best management practices, lessons learned, etc.) to help practitioners better evaluate their adaptation planning and implementation efforts.

The evaluation effort of the USGCRP Workgroup supports some broader National Climate Assessment goals, but will also help the Federal agencies evaluate the effectiveness of their adaptation actions in due course. A number of National Action Plans and Adaptation Strategies have been, and are being, published, but the place of monitoring and evaluation, and the design of robust indicators, is still largely unclear. No national level indicators have as yet been identified and published, but the intention is to do so, and efforts are currently in a process of consultation.

**European level – European Environment Agency**

The European Commission’s White Paper on Adaptation established the landscape and some of the priorities for European level Adaptation Strategy. The new European Climate Adaptation Platform web portal24 (“Climate-Adapt”), hosted by the European Environment Agency (EEA), is a key dimension in this strategy. Climate-Adapt provides a one-stop-shop for policy makers on impacts and adaptation information, and includes indicators of impacts (though not yet of adaptation). In March 2013 the comprehensive European Adaptation Strategy will be published.

In 2008, the EEA published an indicator-based assessment of the impacts of climate change across Europe, and there is ongoing work on an update of this report, which should be published later in 2012. The EEA has also undertaken work exploring the concept of indicators for adaptation. EEA reports on vulnerability in coastal and mountain areas, and on adaptation indicators, are publicly available, and initial suggestions of process- and outcome-based indicators have been piloted for the biodiversity sector, in the context of existing biodiversity frameworks.

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Current proposals for the European Monitoring Mechanism Regulation are likely to lead to a requirement for national level monitoring of adaptation. Historically this regulation covered reporting and monitoring of greenhouse gas emissions only, but now the expectation is that it will extend to cover adaptation. Current legal proposals are quite vague on this topic and do not yet specify national level indicators of adaptation.

OECD

The UK is one of the most advanced OECD countries in developing domestic adaptation indicators. OECD has two areas of interest which relate to this topic:

1. Comparing and sharing best practice between member countries. A policy forum scheduled in May 2012 is intended to generate a community of practitioners who can exchange knowledge and experience on adaptation best practice. Within this forum, monitoring and evaluation is a keen area of interest.
2. In 2011, OECD published a review of 6 agency approaches to monitoring and evaluation of individual adaptation projects and investments. Building on this work, the OECD’s member countries are increasingly interested in scaling up M&E from the project level to the national level.

Conclusions from workshop discussions

Efforts to determine how to measure adaptation are necessarily founded on a theoretical framing of what constitutes adaptation. As we search for suitable indicators, our understanding of adaptation, and the underlying concepts and processes, is exposed, clarified and refined. For example, if adaptation is understood primarily as a process, then this process will need to be measured appropriately. If adaptation is understood and defined much more precisely in a set of outcomes, then a different set of indicators would be needed.

The extent to which both the objectives of national adaptation policies and the motivations for the monitoring and evaluation effort can be precisely articulated, is crucial in the definition of indicators. For example, if the objective of a national adaptation policy is to mainstream adaptation into other policies, indicators that can monitor the mainstreaming process would be required. The aspirational goals of an adaptation policy are also critical: an aspiration that “no-one dies in a flood” is very different from “everyone is impacted equally by climate change”, and the outcome indicators selected in these two cases would be quite different. If adaptation strategies can be framed in terms of very practical decisions (such as an adaptation decision which defines average height of sea defences) then outcomes can be fairly easily measured in comparison.

Development of indicators is not driven only, or even mainly, by science. Instead, policy, political, programme and institutional drivers and factors combine to create the landscape which can promote particular types of metric. The importance of institutional structure, policy and political frameworks was evidenced during the workshop discussion. For example, the statutory role (and associated resourcing) of the UK’s ASC has been the driving force for current UK efforts on this topic. The UK has also seen how a change in ideological stance on performance monitoring generally can create or remove the frameworks which might facilitate adaptation monitoring, while in Canada, a new emphasis on government data collection is enhancing opportunities for further development of adaptation monitoring. Where there is a strong element of climate scepticism within administrations, then the kind of indicators that can be developed may be constrained for political reasons.

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25 "a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change"

26 One participant noted that there is still considerable effort needed to define successful adaptation, especially in contexts of adaptive management.

27 The workshop did not provide explicit definitions of “indicator” or “metric”, and it was noted that indicators for adaptation could be quite varied in nature.

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Because adaptation must address multiple hazards (and potential opportunities) across multiple sectors, a large set of indicators will ultimately be needed to provide the big picture. A wealth of information is needed, but this presents challenges for synthesis. Policy priorities may also change over time. So adaptation policy priorities are likely to be dynamic. This reinforces a recommendation to maintain a broad palette of indicators which can be adapted to changes in policy, and still enable long term analysis of evidence.

Outcome-based indicators are necessary, but not sufficient, for measuring progress in adaptation. Narratives, stories and other qualitative information are significant alongside indicators for adaptation. It will never be possible to measure everything, so indicators should be seen as a starting point, which can direct effort for a deeper assessment in specific areas.

Detailed, qualitative information about actions is important for monitoring and evaluating the implementation of a national adaptation programme. Process-based indicators which reveal what actions are being undertaken are needed as well as indicators of the impact of those actions (i.e. the outcomes in terms of preparedness).

It is difficult to identify very precise and robust indicators of preparedness: most outcome indicators are therefore likely to be proxies. However, proxy indicators can be misleading, especially in the absence of contextual information. Detailed analysis across multiple variables may be needed to provide real insights to adaptation. Identifying the counter-factual of no adaptation (or no adaptation policy) is hard. Further research into appropriate analytical methods may be needed.

Multiple or diverse interpretations of one indicator are possible, without accompanying contextual information on social, spatial and temporal factors. For example, an indicator of water consumption would lead to different conclusions about preparedness depending on whether the context was rain-fed or irrigated agriculture. In addition, over time, changing perceptions of what constitutes good or bad adaptation in a particular situation may challenge the robustness of interpretations of the data. The issue of spatial scale is relevant in selecting and interpreting appropriate indicators.

**Ongoing challenges**

It is difficult to match monitoring efforts to final adaptation programme priorities. The selection and definition of indicators depends on the overall objective, or desired end-point of adaptation. This is likely to be dynamic and community-specific, and dependent on spatial scale. Similarly, it is not yet clear how indicators which are feasible and potentially useful at national level can also promote adaptation (and avoid maladaptation) at lower levels. In some cases, it could be more useful to develop indicators at the municipal level rather than nationally (though an issue of ownership, and therefore long term sustainability, may then arise).

Simple metrics often send mixed messages - the underlying reasons for change can be near-opposites. This means that in some cases a level of aggregation, disaggregation, or statistical analysis is required to provide informative monitoring and evaluation. However, there is a tension in national level indicators between the generic and the specific.

Adaptation is multi-hazard and multi-sector, and there is a challenge of scale and prioritisation in attempting to combine or aggregate a large number of different indicator sets to give an overall picture of preparedness. There is considerable complexity involved in monitoring of one hazard in one sector — these complexities are multiplied when scaling up to a full socio-economy where trade-offs, conflicts and synergies must be managed, and questions about the comparability of different indicators in different sectors may arise. Public decision-makers may have short attention span, and a broad suite of indicators is therefore challenging in terms of presentation and communication.

In the real world, data availability is a real issue, and the nature of the indicators that can be developed is severely constrained by data. Data availability and quality also shifts over time,
making monitoring of adaptation over longer-term extremely challenging. The data needed for adaptation monitoring will necessarily need to be sourced from diverse sectors, which presents practical challenges. Given the long-term nature of climate change, sustained data collection is required, but this may challenge current funding arrangements.

Linked to the data issue is that of resources: given the wide-ranging nature of adaptation, any national level M&E programme would ideally involve synthesis of many indicators (such as the Germany example), yet sufficient resources for this scale of effort are not often available. There is therefore a need to be pragmatic and work with proxies rather than first best. There will need to be a prioritisation in data collection due to limits on available resources.

**Learning points**

Informing adaptation through M&E is a necessity.

A combination of indicators is needed to assess adaptation. It is difficult to identify a very precise and robust indicator: most of them are likely to be proxies. Impacts and adaptation are not always separable. It is easier to develop indicators of exposure and actions/process, than it is to define indicators of adaptation outcomes. It is extremely difficult to develop indicators to monitor the quality of decision-making.

A logical framework for the set of indicators is required to show how indicators relate and interact. This framework should include both the contextual information (e.g. population) as well as the climate signals (e.g. flood frequency) providing insight to vulnerability and impacts/consequences in order to establish the relevance of actions for climate change. A surrounding narrative can provide further context. No one indicator should be taken in isolation.

Indicators are only ever a part of a monitoring and evaluation programme (not the whole thing). All indicators have to be contextualised, and presented alongside complementary data that provides “ground-truth” and local qualification. Interpretation of trends may depend on additional information, regional context and/or political goals / priorities. Additionally, the temporal and spatial characteristics of the indicators are important.

Measuring adaptation effectiveness requires a clear definition of the goal of the action, who is doing it and what is their motivation. Indicators that may help regional policy-makers to evaluate their progress may not be useful for comparing progress across (or between) regions. Important to understand why you are monitoring, and then evaluating relative to that objective.

Defining indicators will in itself stimulate adaptation actions: need to be sure that this doesn’t lead to “overadaptation” where it is being measured, or “underadaptation” in areas where indicators are less well-defined. There is danger in relying too heavily on indicators alone – they can obscure important information or maladaptation.

**Workshop materials**

**Workshop agenda**

Figure 11 shows the agenda for the workshop held on 23 March, 2012.
Expert workshop on monitoring & evaluating progress in adaptation

Date: 23rd March | Time: 10:00 – 16:00
Location: Committee on Climate Change, 7 Holbein Place, London SW1W 8NR, UK

Agenda

0930 – 1000
Tea & Coffee

1000 – 1015
Introduction to workshop
Chair: Professor Martin Parry

1015 – 1045
UK Climate Change Risk Assessment: approach and looking to future assessments
Kiran Sura, Adaptation Sub-Committee Secretariat
Professor Rob Wilby, Loughborough University

1045 – 1145
Discussion: current status of national adaptation plans and whether they include monitoring and evaluation
Purpose: each country to set out how they are developing their national adaptation plans and specifically whether the plan includes a monitoring and evaluation element (5 minute description from each delegate, no slides please)

1145 – 1200
Break

1200 – 1230
Adaptation Sub-Committee’s approach to monitoring and evaluating progress in adaptation, followed by Q&A
Dave Thompson, Adaptation-Sub Committee Secretariat

1230 – 1330
Lunch

1330 – 1345
Introduction to aims for the afternoon
Lisa Horrocks, AEA

1345 – 1500
Group exercise to explore the use of indicator approaches for measuring effectiveness of adaptation at national level
Lisa Horrocks, AEA
Purpose: to identify benefits and limitations of indicator approaches in a practical scenario. During the course of discussion we hope that delegates will have ample opportunity to share their own experience of methods, and the indicators used to measure progress.

1500 – 1505
Break

1505 – 1545
Feedback from exercise and plenary discussion
Purpose: to clarify any lessons learned, challenges, next steps.

1545 – 1600
Summation by Chair and close
List of delegates

Delegates at the workshop came from 6 different countries, and the European Environment Agency and the Organisation for Economic Cooperation and Development were also represented. Attendees are listed in Table 14.

**Table 14 List of delegates at ASC workshop**

<table>
<thead>
<tr>
<th>Name</th>
<th>Country</th>
<th>Organisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allen, David</td>
<td>USA</td>
<td>United States Global Change Research Program</td>
</tr>
<tr>
<td>Campbell, Darius</td>
<td>UK</td>
<td>Department for the Environment, Food and Rural Affairs</td>
</tr>
<tr>
<td>Catovsky, Sebastian</td>
<td>UK</td>
<td>Adaptation Sub-Committee Secretariat, Committee on Climate Change</td>
</tr>
<tr>
<td>Fankhauser, Sam</td>
<td>UK</td>
<td>Adaptation Sub-Committee, Committee on Climate Change</td>
</tr>
<tr>
<td>Füssel, Hans-Martin</td>
<td>Europe</td>
<td>European Environment Agency</td>
</tr>
<tr>
<td>Hall, Jim</td>
<td>UK</td>
<td>Adaptation Sub-Committee, Committee on Climate Change</td>
</tr>
<tr>
<td>Horrocks, Lisa</td>
<td>UK</td>
<td>AEA Technology</td>
</tr>
<tr>
<td>Humphrey, Kathryn</td>
<td>UK</td>
<td>Adaptation Sub-Committee Secretariat, Committee on Climate Change</td>
</tr>
<tr>
<td>Krebs, John</td>
<td>UK</td>
<td>Adaptation Sub-Committee, Committee on Climate Change</td>
</tr>
<tr>
<td>Lebechi, Atinuke</td>
<td>UK</td>
<td>Department for the Environment, Food and Rural Affairs</td>
</tr>
<tr>
<td>Leclerc, Liza</td>
<td>Canada</td>
<td>Independent Consultant</td>
</tr>
<tr>
<td>Miller, Kathleen</td>
<td>USA</td>
<td>National Atmospheric Research Centre</td>
</tr>
<tr>
<td>Mullan, Michael</td>
<td>Europe</td>
<td>Organisation for Economic Co-operation and Development</td>
</tr>
<tr>
<td>Parry, Martin</td>
<td>UK</td>
<td>Adaptation Sub-Committee, Committee on Climate Change</td>
</tr>
<tr>
<td>Pinder, Clare</td>
<td>UK</td>
<td>Adaptation Sub-Committee Secretariat, Committee on Climate Change</td>
</tr>
<tr>
<td>Preston, Chris</td>
<td>UK</td>
<td>Department for the Environment, Food and Rural Affairs</td>
</tr>
<tr>
<td>Reyssset, Bertrand</td>
<td>France</td>
<td>National Observatory on the effects of Climate Change</td>
</tr>
<tr>
<td>Street, Roger</td>
<td>UK</td>
<td>Environmental Change Institute</td>
</tr>
<tr>
<td>Sura, Kiran</td>
<td>UK</td>
<td>Adaptation Sub-Committee Secretariat, Committee on Climate Change</td>
</tr>
<tr>
<td>Thompson, David</td>
<td>UK</td>
<td>Adaptation Sub-Committee Secretariat, Committee on Climate Change</td>
</tr>
<tr>
<td>van Minnen, Jelle</td>
<td>Netherlands</td>
<td>Netherlands Environmental Assessment Agency</td>
</tr>
<tr>
<td>van Rüth, Petra</td>
<td>Germany</td>
<td>Climate Impacts and Adaptation, Federal Environment Agency</td>
</tr>
<tr>
<td>Waller, Jamie</td>
<td>UK</td>
<td>Department for the Environment, Food and Rural Affairs</td>
</tr>
<tr>
<td>Wilby, Rob</td>
<td>UK</td>
<td>Loughborough University</td>
</tr>
</tbody>
</table>
Group exercises

Exercise – Scenario 1
You and your colleagues make up the Management Team of a national Environment Agency. You want to develop a set of indicators to monitor national progress in adapting to climate change. Your immediate concern is water availability in the agriculture sector.

The nation is likely to enter its sixth summer drought in the last seven years. Agricultural systems have traditionally been supplemented by extractions from glacier-fed rivers. The south of the country is the key area for agricultural production but recent drought has placed great pressure on the sector to meet export demands. The country launched a sector-based National Adaptation Policy last year which stresses the importance of adaptation interventions which are effective, efficient, equitable and flexible in response to changes in our understanding of climate and non-climate drivers.

For the purpose of the scenario discussion, assume that data availability is not a limitation.

For reference, Handout 1 defines some key terms. Handout 2 suggests some principles of good adaptation.

Task 1: Potential indicators (40 mins)
Share out the A5 indicator cards evenly among the group. Use the large Reporting Sheet to record your discussions.

A) Take 1 minute to think individually about the indicators which you have been given.
B) As a group, discuss each indicator listed on the Reporting Sheet, and decide whether you think it is very useful (☑), partially useful (☐) or not very useful (☒). Indicate this in the second column.
C) Use the third column to provide reasons for your decision. For example, which aspect(s) of the hazard-vulnerability-impact-action system does the indicator shed light on? How would changes in the indicator be linked to changes in impacts and/or adaptation?

Feel free to refine the wording of the indicators, and to add any additional indicators that you think would be useful.

Task 2: Motivations, benefits and limitations (25 mins)
Use the flip chart to record key points from your discussions.

A) In your role as the Management Team, discuss your motivations for developing the indicator set. What actions or changes would you like to stimulate in response to the measurement and publication of these national indicators?
B) You decide to select only around 5 indicators as headline indicators. Which do you choose?
C) What are the benefits of using your chosen indicators to monitor the preparedness of the nation for climate impacts?
D) What are the limitations of using indicators? What other information might you need?

Task 3: Back in the real world (20 mins)
Using the post-it notes:
Review of international experience in adaptation indicators

- Please write down any learning points, or points for consideration, that you will take away to apply in your own context (please put one point per post-it).

- Please write down the big challenges that you face as you develop monitoring and evaluation of adaptation in your own context (please put one point per post-it).

Stick your post-it notes onto the flip chart, placing them alongside any similar points.
As a group, identify any common themes.

Exercise – Scenario 2

You and your colleagues make up a Government Task Force charged with adaptation planning in the built environment. You must develop a set of indicators to monitor national progress in adapting to climate change in urban areas as part of a new programme funded by the Government, insurance companies and six major house builders. Your immediate concern is flooding.

A recent Government study suggests that particular ‘hotspots’ exist in terms of current flood risk; however, little is understood about how climate and non-climate drivers may change over time. In 2010, a major summer flood event affected 25,000 homes, many of which were part of the large stock of social housing owned by the Government. This led to alarm in the media about the poor and elderly being adversely affected by climate change.

For the purpose of the scenario discussion, assume that data availability is not a limitation.
For reference, Handout 1 defines some key terms. Handout 2 suggests some principles of good adaptation.

Task 1: Potential indicators (40 mins)

Share out the A5 indicator cards evenly among the group. Use the large Reporting Sheet to record your discussions.

A) Take 1 minute to think individually about the indicators which you have been given.

B) As a group, discuss each indicator listed on the Reporting Sheet, and decide whether you think it is very useful (😊), partially useful (🍪) or not very useful (😢). Indicate this in the second column.

C) Use the third column to provide reasons for your decision. For example, which aspect(s) of the hazard-vulnerability-impact-action system does the indicator shed light on? How would changes in the indicator be linked to changes in impacts and/or adaptation?

Feel free to refine the wording of the indicators, and to add any additional indicators that you think would be useful.

Task 2: Motivations, benefits and limitations (25 mins)

Use the flip chart to record key points from your discussions.

A) In your role as the Management Team, discuss your motivations for developing the indicator set. What actions or changes would you like to stimulate in response to the measurement and publication of these national indicators?

B) You decide to select only around 5 indicators as headline indicators. Which do you choose?

C) What are the benefits of using your chosen indicators to monitor the preparedness of the nation for climate impacts?

D) What are the limitations of using indicators? What other information might you need?
Task 3: Back in the real world (20 mins)

Using the post-it notes:
- Please write down any learning points, or points for consideration, that you will take away to apply in your own context (please put one point per post-it).
- Please write down the big challenges that you face as you develop monitoring and evaluation of adaptation in your own context (please put one point per post-it).

Stick your post-it notes onto the flip chart, placing them alongside any similar points.
As a group, identify any common themes.

Comments on potential indicators
The group discussions on potential indicators suggested in Scenarios 1 and 2 are summarised in Table 15 and Table 16, respectively.

Table 15 Results from group discussion on Scenario 1

<table>
<thead>
<tr>
<th>Potential Indicator</th>
<th>How useful?</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Water consumption by agricultural users</td>
<td>😊</td>
<td>Would need to control for interacting variables (e.g. temperature, efficiency as well as water availability). Could be an impact or an adaptation. Needed for short-term or long-term plans.</td>
</tr>
<tr>
<td>2. Per capita consumption all sectors/users</td>
<td>😊</td>
<td>V useful, but only works if it is benchmarked against historic trends. Must be measured against efficiency measures such as uptake of metering. Need local data. Is an Exposure/impact indicator. Good to compare sectors (public vs other).</td>
</tr>
<tr>
<td>3. Freshwater abstractions by sector</td>
<td>😊</td>
<td>Similar to no2. Also need supply data.</td>
</tr>
<tr>
<td>4. Reservoir levels and/or capacity</td>
<td>😞</td>
<td>Would need seasonal data. Expected flow (supply) seems like a more important indicator than reservoir storage, which would also depend heavily on rules regarding control of water levels.</td>
</tr>
<tr>
<td>5. Volume of on-site storage reservoirs in agriculture sector</td>
<td>😞</td>
<td>Similar to no4. Would be of interest if measured against supply from glaciers. There is also an upper limit on storage capacity from reservoirs that mean a levelling out of volume at some threshold. Volumes not necessarily driven by adaptation. Don’t want to ignore this data though as is a potentially useful measure of autonomous adaptation. Focussing only on reservoirs could introduce a bias towards this over other measures (leading to potential maladaptation).</td>
</tr>
<tr>
<td>6. Number of drought orders in place</td>
<td>😞</td>
<td>Useful as an adaptation lever- we want to avoid these….or do we, as not having them when we need them would be equally bad for the environment. Area affected by drought orders rather than number would be more useful. Would need a very long-term dataset.</td>
</tr>
<tr>
<td>Indicator</td>
<td>Rating</td>
<td>Description</td>
</tr>
<tr>
<td>--------------------------------------------------------------------------</td>
<td>--------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>7. Percentage of population affected by water supply restrictions</td>
<td>😞</td>
<td>Would want to monitor this as it is politically sensitive. Does this add anything on top of other indicators? Might be useful as a risk indicator, but not as an adaptation.</td>
</tr>
<tr>
<td>8. Water bodies at risk of environmental damage due to abstraction</td>
<td>😊</td>
<td>Useful as an impact indicator. Relevant for sustainable agriculture.</td>
</tr>
<tr>
<td>10. Eutrophication of water bodies</td>
<td>😞</td>
<td>Should be integrated into other indicators looking at environmental quality. Lots of interacting variables, so hard to distinguish any adaptation signal. Will also be monitored elsewhere for pollution studies.</td>
</tr>
<tr>
<td>11. Soil moisture regime (water transport, soil moisture storage)</td>
<td>😊</td>
<td>Useful indicator of risk if not adaptation. Other interacting variables, but may be possible to monitor these.</td>
</tr>
<tr>
<td>12. Uptake of water efficiency measures</td>
<td>😊</td>
<td>Impact of uptake of efficiency measures much more interesting that uptake alone. Would also need water consumption data. Measures efficiency, rather than simple increase/decrease in volume used.</td>
</tr>
<tr>
<td>13. Water savings through demand management measures</td>
<td>😞</td>
<td>If you can measure this, might be useful (the effects of pricing/metering/licensing are hard to attribute). However, potentially a very useful indicator of policy leading to a beneficial response (outcome based indicator).</td>
</tr>
<tr>
<td>14. Use of early-warning systems and climate information services</td>
<td>😞</td>
<td>Seasonal forecasting is fairly unreliable. No link to outcomes/actions.</td>
</tr>
<tr>
<td>15. Education of farmers in understanding climate change</td>
<td>😞</td>
<td>Hard to measure the outcome of this; knowledge doesn’t necessarily lead to action and a socially beneficial outcome. Could monitor action and outcome instead?</td>
</tr>
<tr>
<td>16. Research and development on agricultural water management</td>
<td>😊</td>
<td>As a monetary indicator it’s fairly easy to measure, but hard to see what it really tells us about risk/adaptation. A long-term dataset might be useful.</td>
</tr>
<tr>
<td>17. Number of Environment Agency staff trained in climate adaptation</td>
<td>😞</td>
<td>As an indicator of action, it has a long lead-time and on its own doesn’t measure outcomes. Similar to no15.</td>
</tr>
<tr>
<td>18. Changes in agricultural production (varieties, productivity)</td>
<td>😞</td>
<td>Too vague. Nutrition/productivity per unit of water used might be better.</td>
</tr>
<tr>
<td>20. Changes in market demand for key crops</td>
<td>😞</td>
<td>Not only driven by supply, therefore not that useful as an adaptation indicator.</td>
</tr>
</tbody>
</table>

Many of the indicators were identified as necessary, but insufficient to provide evidence of progress in adaptation at national level. Overall, the exercise showed that a large set of indicators would be needed, and that in some cases combinations and cross-analyses of several indicators might provide more useful information than the individual metrics.

Some additional indicators were also suggested:
- A sampling approach to monitor farm-level use of water for that system
- Land use changes from H2O-intensive to drought resistant varieties (c.f. indicator no 13)
- More environmental indicators for groundwater and wetlands are relevant as wider context.
- Implementation of water-smart measures (e.g. driven by policy such as abstraction reform)

Discussion about the nature of indicators data confirmed that, in this scenario at least, one national number is at best inadequate, and at worst, misleading. Instead there is a need for spatial detail in the indicators. Similarly, temporal detail superimposed on top of a 5 or 10 year reporting set would be important, particularly to capture seasonal trends and changes over years.

It was also considered important to capture a measure of whether relevant stakeholder groups are learning in response to climate information and adaptation experience. This kind of information would likely need to be obtained through interview or other participatory methods.

### Table 16 Results from group discussion on Scenario 2

<table>
<thead>
<tr>
<th>Potential Indicator</th>
<th>How useful?</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Changes in Absolute values of the monthly mean runoff (mMQ) values of selected levels of rivers</td>
<td>😞</td>
<td>There are better indicators of impact. This would measure a lot of noise.</td>
</tr>
<tr>
<td>2. Frequency of floods, as flood disasters per decade per 100,000 km² of land area.</td>
<td>😃</td>
<td>A good long-term impact indicator.</td>
</tr>
<tr>
<td>3. Number of properties within the fluvial and coastal floodplain</td>
<td>😃</td>
<td>Crucial determinants of risk and exposure, but need to be looked at in conjunction with other indicators</td>
</tr>
<tr>
<td>4. Number of properties within surface water flood risk areas</td>
<td>😃</td>
<td></td>
</tr>
<tr>
<td>5. Number of properties in flood risk areas, accounting for flood defences</td>
<td>😃</td>
<td>Useful information for deciding what flood management measures are needed. Better than Indicator 3.</td>
</tr>
<tr>
<td>6. Area of impermeable and permeable surfacing in urban and suburban areas</td>
<td>😞</td>
<td>May encourage over-generalisation. Useful only in conjunction with local information e.g. earth type/ slope</td>
</tr>
<tr>
<td>7. Percentage of population who are over 65 and living in flood risk areas</td>
<td>😞</td>
<td></td>
</tr>
<tr>
<td>8. Location of vulnerable members of the community (care homes, schools, hospitals) in flood risk areas</td>
<td>😃</td>
<td>Measures of sensitivity. Good to measure distributional impacts of flooding to focus policy response and emergency planning. Proportion over 65 only relevant if there is a particularly high number of over 65s in the area.</td>
</tr>
<tr>
<td>9. Number of households in most deprived communities in flood risk areas</td>
<td>😃</td>
<td></td>
</tr>
<tr>
<td>10. Proportion of infrastructure assets at flood risk benefitting from protection measures and are these measures adequate and do they account for climate change</td>
<td>😞</td>
<td>A more interesting question is to look at the type of infrastructure. Some infrastructure (e.g. roads) is naturally more resilient than others.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td><strong>11.</strong> Uptake of sustainable drainage systems in new development, <em>in areas of flood risk where SuDS are cost-beneficial</em></td>
<td>😞</td>
<td>Too broad. Does not capture local complexities.</td>
</tr>
<tr>
<td><strong>12.</strong> Number of properties flooded per year</td>
<td>😊</td>
<td>A good long-term impact indicator.</td>
</tr>
<tr>
<td><strong>13.</strong> Availability <em>Affordability</em> of insurance in flood risk areas</td>
<td>🙁</td>
<td>Indicator of effectiveness of adaptation policy. This indicator would pick up a lot of noise and be difficult to interpret. Insurance can provide the wrong incentives (moral hazard).</td>
</tr>
<tr>
<td><strong>14.</strong> Expected annual damages from flooding, accounting for uptake of resilience measures in new development</td>
<td>😊</td>
<td>Very useful!</td>
</tr>
<tr>
<td><strong>15.</strong> Total insured damage ($) paid under property insurance policies per region <em>Insurance payments as a percentage of insured assets each year</em></td>
<td>🙁</td>
<td>Would pick up the effect of increase in wealth if it was left in absolute terms. Insurance picks up too many factors, makes floods in more wealthy areas look more drastic.</td>
</tr>
<tr>
<td><strong>16.</strong> Number of deaths/injuries/health problems caused by flooding and storms per year</td>
<td>😞</td>
<td>Realised impact indicator, but lots of noise! Unlikely to see clear climate or flood management signal</td>
</tr>
<tr>
<td><strong>17.</strong> Green and blue space in urban areas</td>
<td>🙁</td>
<td>Too generic. Imperfect proxy for SuDS.</td>
</tr>
<tr>
<td><strong>18.</strong> Total annual public investment in flood defences</td>
<td>🙁</td>
<td>Doesn't show effectiveness. It could be a long-sighted policy to reduce spend during recession and increase later for example. Needs to be coupled with asset condition and should reflect number of homes.</td>
</tr>
<tr>
<td><strong>19. (a)</strong> Use Uptake and usefulness of flood warning systems and</td>
<td>😊</td>
<td>Should be split. Needs to reflect whether these measures have any effect, not just uptake. E.g. flood warnings are known to be only 20% effective in some locations.</td>
</tr>
<tr>
<td><strong>19. (b)</strong> Uptake and usefulness of climate information services</td>
<td>😊</td>
<td></td>
</tr>
<tr>
<td><strong>20.</strong> Uptake of community engagement programmes on flood resilience</td>
<td>😊</td>
<td>What type of community engagement? Part of a range of adaptation measures that we should be aiming to monitor.</td>
</tr>
</tbody>
</table>

**Discussion on motivations, benefits and limitations**
Motivations

There is a range of possible motivations for the development of indicators in the scenarios. Headline indicators would be targeted towards national or federal government, with additional indicators needed to provide more relevance for local governance.

Ultimately the indicators are intended to drive more climate resilient behaviour. For example, in scenario 1, the intention is to maximise agricultural production per unit of H2O. The indicators are ultimately driving improvements in resource efficiency, because in scenario 1, this can be identified clearly as a key win-win and no-regret adaptation objective.

In scenario 1, indicators would be directed at Government policy. They can also be used to communicate rationale behind policy, to strengthen markets, and to promote R&D (for adaptation). Indicators may also provide motivation for autonomous adaptation.

Scenario 1 also exposed the importance of social equity as a motivation: adaptation has to protect and provide for everyone. This may mean that it is important to find indicators that can uncover this dimension, and spatially disaggregated indicators may be needed.

Benefits

Indicators can provide an objective and holistic picture of environmental and social change. The indicators considered in the exercise were not just process based, which means it is possible to learn more about the outcomes of adaptation. The indicators are quantitative and evidence based.

The kinds of indicators discussed in the exercise would provide a sense of scale of adaptation which can be viewed relative to other pressures and drivers of change. The development and use of indicators requires an explicit choice of priorities.

A combination of process-based, results-based and outcome-based indicators can give a full picture of the actions that are being undertaken and the impacts that those actions are having. The set of indicators can also be connected to social values.

Limitations

The potential indicators in the scenario did not provide the whole picture. For example, in scenario 1, further information at farm level was needed, and indicators to show the impact of policies were also lacking. Most of the indicators provided a national, top-down assessment of issues which are very locally- and context-specific.

Alongside national level numbers, spatial detail is needed: in scenario 1, the national figures may be misleading. Temporal detail is also important given the seasonal variability that is possible, and perhaps more important in terms of impacts. Human vs monetised indicators may show very different effects.

The outcome indicators are generally affected by a number of confounding factors, making attribution of any changes in the indicators to adaptation very difficult. Many of the indicators discussed are “noisy”. At best, most of the indicators discussed in scenario 1 are proxies. In scenario 2, the indicators would not pick up upstream / downstream effects of adaptation.

Some process-based indicators are also required in order to find out what people are doing. The indicators considered in the scenario do not reveal anything about the adaptation decision-making process. These indicators do not provide any insight to the learning that is occurring as a result of climate information or adaptation experience, nor of the extent to which community or co-operative learning is occurring.
Definitions used in the workshop

Handout 1 – key terms

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Climate hazards</td>
<td>A situation or event resulting from climate trends and extreme weather with the potential to cause harm. A hazard does not necessarily cause harm.</td>
</tr>
<tr>
<td>Contextual factors</td>
<td>Long-term social and economic trends that can influence exposure and sensitivity to climate hazards.</td>
</tr>
<tr>
<td>Exposure</td>
<td>The extent to which a receptor (people, livelihoods, infrastructure, economic, social, cultural and environmental assets) come into contact with a climate hazard.</td>
</tr>
<tr>
<td>Sensitivity</td>
<td>The degree to which a recipient is affected, either adversely or beneficially, by exposure to a climate hazard. Includes the ability of the recipient to prepare, respond and recover from a climate hazard (and conversely to benefit from positive impacts).</td>
</tr>
<tr>
<td>Adaptation action</td>
<td>Adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities. Adaptation actions can directly reduce exposure and/or sensitivity or can minimise bio-physical impacts.</td>
</tr>
<tr>
<td>Residual risk</td>
<td>The risk which remains after adaptation action. Risk combines the likelihood an event will occur with the magnitude of its consequences.</td>
</tr>
<tr>
<td>Realised impact</td>
<td>The consequences of climate hazards to society, the economy and the environment.</td>
</tr>
</tbody>
</table>

Handout 2 – UKCIP Principles of Good Adaptation

- **Work in partnership** – identify and engage your community and keep them well informed.
- **Understand risks and thresholds**, including associated uncertainties.
- **Frame and communicate SMART* objectives/outcomes** before starting out.
- **Manage climate and non-climate risks using a balanced approach** – assess and implement your approach to adaptation in the context of overall sustainability and development objectives.
• **Focus on actions to manage priority climate risks** – identify key climate risks and opportunities.

• **Address risks associated with today’s climate variability and extremes** as a starting point to addressing risks and opportunities associated with longer-term climate change.

• **Use adaptive management to cope with uncertainty** – recognise the value of a phased approach to cope with uncertainty.

• **Recognise the value of no/low regrets and win-win adaptation options** in terms of cost-effectiveness and multiple benefits.

• **Avoid actions that limit future adaptations** or restrict adaptive actions of others.

• **Review the continued effectiveness of adaptation decisions** by monitoring and re-evaluating risks.

*SMART objectives – specific, measurable, achievable, results-oriented, and time-bound objectives.*