# Chapter 3
# How Is Uncertainty Addressed in the Knowledge Base for National Adaptation Planning?

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**Key Messages**

Fourteen European countries have provided information on the consideration of uncertainty in their knowledge base for adaptation planning, and there are substantial differences across countries and jurisdictions. Some key features are as follows:

- Almost all national-level climate change projections consider uncertainties related to emission scenarios, global climate models and downscaling methods.
- Many countries have established web portals that provide access to climate projections; their functionality and the presentation of uncertainty vary widely across them.
- Only a few countries have developed non-climatic (e.g. socio-economic, demographic and environmental) scenarios for use in climate change impact, vulnerability and risk assessments.

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(continued)

- All countries have conducted climate impact, vulnerability or risk assessments. The consideration of uncertainty within these varies widely, from a generic qualitative discussion to a probabilistic assessment based on a comprehensive modelling exercise.
- As adaptation activities expand, an increasing demand for more spatially and temporally detailed and varied climate scenarios brings uncertainties to the forefront.
- Most countries have developed guidance material for decision-makers concerned with adaptation. Such guidelines generally explain key sources of uncertainty in climate and climate impact projections but only few guidelines provide practical guidance on adaptation decision-making under uncertainty.
- Substantial efforts are needed to improve the appreciation of uncertainties in climate and climate impact projections by decision-makers and the public at large.

Dynamic interactive tools in web portals can be an important part of the tool box for those who are confronted with adapting to climate change. In addition, targeted guidance is needed that explains the relevance of key uncertainties and how they can be addressed by appropriate adaptation strategies in a specific adaptation context.

## 3.1 Introduction

In this chapter we provide an overview of national climate change adaptation planning in Europe with a special focus on the consideration and communication of uncertainties. This provides a context for the consideration of case studies in Chap. 4, which presents 12 adaptation case studies from 10 countries. The link between the national level information presented in this chapter and the case studies for those 6 countries covered in both chapters is briefly discussed in Sect. 3.3.

The chapter is mostly descriptive, highlighting large differences across countries in the information base available to decision-makers concerned with adaptation. It also shows that those countries which are more advanced in the development of adaptation strategies generally pay more attention to the assessment and communication of key uncertainties and to their consideration in policy development. This finding is relevant for countries that are developing or updating their knowledge base for adaptation. In this context, examples from more advanced countries can serve as an inspiration to other countries.

Section 3.2 presents a brief review of national adaptation strategies and action plans. This review is based on information collected by the European Environment Agency (EEA) through the European Climate Adaptation Platform (Climate-ADAPT[1])

[1] http://climate-adapt.eea.europa.eu

complemented by two independent scientific studies (see Table 3.1 for details). Section 3.3 reviews the consideration of uncertainties in key information sources for adaptation (climate projections, non-climatic scenarios, climate impact projections and guidance material). This review covers those 14 EEA member countries that have provided pertinent information to the EEA through a questionnaire (see Sects. 3.2 and 3.3 for details).

## 3.2 Overview of National Adaptation Activities

Most countries in Europe have begun to respond to the impacts of climate change. This is evidenced in:

- The undertaking of research projects related to climate impacts, vulnerability and adaptation,
- The development of climate projections,
- The preparation of climate change impact, vulnerability and risk (CCIV) assessments,
- The increasing availability of web portals related to climate change adaptation, and
- The development of national adaptation strategies and/or action plans.

Adaptation activities differ considerably across countries. This is due to a number of factors, including the following (see also EEA 2013):

- Current and projected future exposure of systems and assets at risk to climatic hazards (e.g. proportion of the population living in coastal zones),
- Existing governance arrangements for climate-sensitive sectors,
- Awareness among the different categories of stakeholders, and
- Available financial and human resources.

There are also considerable differences in the extent of adaptation activities across sectors as well as differences in earmarking certain activities as adaptation. Comprehensive information on the state of adaptation in Europe at European, national, and subnational levels is provided in the recent EEA report *Adaptation in Europe* (EEA 2013) and in Climate-ADAPT. Additional information on national and regional adaptation research efforts is available in the CIRCLE-2 Climate Adaptation INFOBASE.[2]

Table 3.1 provides a summary of national-level adaptation efforts across 28 European countries (all EU member states except for Croatia and Luxemburg, plus Norway and Switzerland, which are EEA member countries) based on a number of sources.[3] The 14 countries marked in grey in the left-most column are those included

[2] http://infobase.circle-era.eu

[3] The table includes information from those 27 EEA member countries that have provided information on the country pages in Climate-ADAPT at the end of 2012. The EEA member countries include all EU Member States and additionally Iceland, Liechtenstein, Norway, Switzerland and Turkey.

**Table 3.1** Overview of national-level adaptation activities

| | Stage of selected national activities | | | Advancement of adaptation | | Uncertainty communication in NAS |
|---|---|---|---|---|---|---|
| | CCIV | NAS | NAAP | Policy cycle | Uncertainty | Total score |
| Country | 0: no activity; 1: in preparation; 2: finalized/adopted | | | 1: assessing risks; 2: identifying options; 3: assessing options; 4: implementation; 5: monitoring and evaluation | 1: not mentioned; 2: presented as unreliability; 3: hidden or presented as barrier to adaptation; 4: embracing | 0: lowest score; 2: highest score |
| AT - Austria* | **2** | **2** | **2** | **3** | **3** | |
| BE - Belgium | **1+2** | **2** | **1+2** | | | **1** |
| BG - Bulgaria | 1 | 1 | 1+2 | | | |
| CH - Switzerland | **2** | **2** | **1** | | | |
| CY - Cyprus | 1 | 1 | 1 | | | |
| CZ - Czech Republic | **1+2** | **1** | **0** | | | |
| DE - Germany* | **1+2** | **2** | **2** | | | **1.75** |
| DK - Denmark | 2 | 2 | 2 | | | 1 |
| EE - Estonia | 1 | 1 | 1 | | | |
| ES - Spain | **2** | **2** | **2** | **4** | **3** | |
| FI - Finland | **2** | **2** | **2** | **4** | **3** | **2** |
| FR - France* | **1+2** | **2** | **1+2** | **3** | **3** | **1.5** |
| GR - Greece | 1 | 1 | 1 | | | |
| HU - Hungary* | **1+2** | **2** | **1+2** | | | **0.75** |
| IE - Ireland* | **1** | **2** | **1** | | | |
| IT - Italy | 1 | 1 | 1 | 1 | 1 | |
| LT - Lithuania | 2 | 2 | 1+2 | | | |
| LV - Latvia | 1 | 1 | 1 | | | |
| MT - Malta | 0 | 2 | 0 | | | |
| NL - Netherlands* | **2** | **2** | **2** | | | **0** |
| NO - Norway | **2** | **1** | **2** | | | |
| PL- Poland | **1** | **1** | **1+2** | **1** | **1** | |
| PT - Portugal* | 2 | 2 | 1 | | | |
| RO - Romania | 2 | 1 | 0 | 2 | 2 | |
| SE - Sweden | 2 | 2[a] | 2 | | | |
| SI - Slovenia | 1 | 1 | 1 | | | |
| SK - Slovakia | 1 | 1 | 1 | | | |
| UK - United Kingdom* | **2** | **2** | **1+2** | **4** | **4** | |
| Status | March 2013 | | | 2010 | | 2012 |
| Source | EEA (2013, Table 3.1), based on Climate ADAPT | | | Hanger et al. (2013), based on Pfenninger et al. (2010) | | Lorenz et al. (2013) |

Countries marked in grey in the left-most column (and with numerical scores in bold face) are included in the detailed analysis in the following section

The traffic-light colours (green, yellow and red) illustrate the numerical values to aid visual comparison

Blank fields in the three right-most columns indicate that a country was not included in the underlying study

Countries marked by an asterisk (*) are represented by one or more case studies in Chap. 4

*CCIV* climate change impact, vulnerability and risk assessment, *NAS* National Adaptation Strategy, *NAAP* National Adaptation Action Plan

[a]Sweden does not have a specific document called National Adaptation Strategy. Instead Sweden has a set of delegated tasks to national and regional authorities, to produce information useful in adaptation decisions, to provide knowledge and spread knowledge on adaptation, and to regionally coordinate adaptation

in the analysis in Sect. 3.3 because they have provided sufficient information on uncertainties to the EEA through a questionnaire. These 14 countries include the 3 countries with the highest scores according to Hanger et al. (2013) as well as all but one country considered in Lorenz et al. (2013).

The first three columns (from the left) reflect information provided by EEA member countries to Climate-ADAPT and are summarised in a recent EEA report (EEA 2013).[4] The table shows the status of completed and on-going CCIV assessments[5] as well as the status of National Adaptation Strategies (NAS) and National Adaptation Action Plans (NAAP). A NAS is understood here to be a broad policy document that outlines the direction of action in which a country intends to move in order to adapt to climate change. While a NAS shows some political commitment towards climate change adaptation, it does not always imply that adaptation activities are occurring. NAAPs are more detailed documents giving guidance on specific adaptation actions that are being planned. Out of 28 countries included in this table, 17 countries have finalized a CCIV assessment, with several of them already working on a new one. Sixteen countries have adopted a NAS and 15 a NAAP. In most cases, a comprehensive CCIV assessment precedes the adoption of a NAS or NAAP.

The next two columns summarise an assessment of the advancement of adaptation in general and the treatment of uncertainties specifically for a subset of eight countries from a study by Hanger et al. (2013). The study assessed available policy documents and conducted semi-structured interviews with 30 stakeholders. The advancement of adaptation is assessed according to the policy cycle underlying the Adaptation Support Tool in Climate-ADAPT.[6] The same stages are used in the *Guidelines on developing adaptation strategies* (EC 2013) that were published by the European Commission in connection with the EU Adaptation Strategy. The numerical codes cannot be directly compared across columns as they are taken directly from the underlying studies. Comparison across different sources is facilitated by a standardised colour code, which reveals a general agreement between the stage within the policy cycle and the development of an NAS and/or NAAP.[7]

The study authors identified close links between the stage within the policy cycle and the perception of uncertainties: "*the way uncertainty is perceived seems to change with the progression of adaptation policy-making*" (Hanger et al. 2013, pp. 98–99).

[4] No information was available for the EEA member countries Liechtenstein, Luxembourg, Iceland and Turkey. Information for Denmark was updated compared to (EEA 2013) following the adoption of the *Action plan for a climate-proof Denmark* (http://en.klimatilpasning.dk/media/590075/action_plan.pdf).

[5] The terms climate impact, vulnerability and risk assessment, as used in different countries, show substantial overlaps. In the context of this study, no further distinction is made within this group of assessments. For a discussion of the evolution of these kinds of assessments, see Füssel and Klein (2006). For a discussion of the use of the terms vulnerability and risk in the climate change context, see the Glossary and EEA (2012, Section 1.7).

[6] http://climate-adapt.eea.europa.eu/web/guest/adaptation-support-tool/step-1

[7] The most noticeable difference between the two sources is related to Poland. The assessment for Poland in Hanger et al. (2013) is based on Pfenninger et al. (2010) and did not consider more recent information available in Climate-ADAPT.

They conclude that "*the farther ahead countries appear to be in adaptation planning and implementation, the better developed is the science-policy interface and the more refined and specific are both the expressed needs for information and the handling of uncertainty. Policy-makers in these countries simply understand the problem better*" (p. 100).

We note that similarities in the relationship between the availability of relevant information and the stage of adaptation policy were found in the EEA Report *Adaptation in Europe* (EEA 2013). It must be considered that the fact that some countries are ahead in adaptation planning could be *because* the science-policy interface has been more refined. For example in Finland, which produced the first NAS in Europe, the whole process started from research activities that were rapidly adopted and transformed into policy documents by the administration and policy-makers.

An independent desk study analysed how uncertainties were represented in the NAS of seven European countries and of three devolved regions of the United Kingdom (Lorenz et al. 2013). The final (right-most) column presents the summary score for the seven countries. Considering that only two countries were included in both studies represented in the two right-most columns, it is not possible to compare the assessments of how uncertainty is addressed between the two studies.[8]

The EEA has led a survey, described more fully in Sect. 3.3, which provides information that is complementary to Lorenz et al. (2013). The restriction to NAS in the Lorenz et al. study provides a well-defined basis for a cross-country comparison, but it excludes a rich variety of information that can be highly relevant for adaptation decision-makers in the country. In contrast, the EEA survey assesses the consideration of uncertainties in the larger knowledge base available for adaptation decision-makers.

## 3.3 Consideration of Uncertainty in the Knowledge Base for Adaptation

In this section we focus on key information sources intended to support adaptation to climate change in Europe and the way they consider uncertainty. This review encompasses publications and websites dealing with climate change and climate impact scenarios and documents providing guidance for the use of these scenarios in adaptation decision-making. These information sources cover several of the nine essential components for adaptation implementation by governments identified by Smith et al. (2009).

The planning and implementation of activities to adapt to future climate change face substantial uncertainties related to the future development of the climate

[8] The very low score for the Netherlands in Lorenz et al. (2013) is due to the fact that this study assessed the National Programme on Climate Adaptation and Spatial Planning from 2007 rather than the more recent Delta Programme.

system and society. Uncertainties generally increase from global emission scenarios through changes in radiative forcing, the global temperature response and changes in regional climate parameters to the range of possible regional impacts (Wilby and Dessai 2010). Uncertainties related to future changes in societal factors (including demography, economy, technology and governance) and in environmental factors (including land use) are crucial for determining social impacts of climate change and adaptation needs.

Numerous typologies have been developed to distinguish different sources and types of uncertainty relevant for adaptation planning (see also Sect. 2.3). A fundamental distinction of sources of uncertainty relevant for future projections is between decision uncertainty (e.g., related to human decisions that determine future greenhouse gases and aerosol particle emissions), natural variability (e.g., related to the internal variability of the climate system), and scientific uncertainty (e.g., related to data gaps, incomplete understanding or insufficient computing power of climate and climate impact models). For further information, see Chap. 2.

For the purpose of this assessment, the EEA has developed a questionnaire that addresses three broad aspects of uncertainty and adaptation:

- The provision of quantitative scenarios (further distinguished into climate projections, non-climatic projections, and climate impact/vulnerability/risk assessments),
- The provision of guidance material, and
- Legal requirements.

A first set of responses was collected by the EEA through the Interest Group on 'Climate Change and Adaptation' of the Network of European Environmental Protection Agencies (EPA IG Adaptation). An updated version of the questionnaire was later sent to the National References Centres (NRCs) on Climate Change Impact, Vulnerability and Adaptation of those EEA member countries from which no response was received through the EPA IG on adaptation. NRCs are typically either the Ministry in charge of Environment and Climate or the Environmental Agency in an EEA member country. The information reported through the questionnaire has been complemented by us based on various publicly available information sources.

Responses from 14 countries are included in this analysis (see the grey shading in Table 3.1). These are from countries that provided, as a minimum, links to publicly available climate change projections.[9]

[9] Further responses were received from Croatia, Lithuania and Slovenia. Croatia and Slovenia were not included in this analysis because their responses contained very limited information on climate projections and the consideration of uncertainties. Lithuania was not included because publicly available information on climate and climate impact projections was largely restricted to National Communications under the United Nations Framework Convention on Climate Change (UNFCCC). Note that information for "Belgium" was reported separately for the Flemish and the Walloon region, and some information is only available for one of these regions. One member of the EPA IG on Adaptation provided a response for the Basque Autonomous Region in Spain. This response was excluded considering that comprehensive information for Spain was available separately.

### 3.3.1 Sources of Uncertainty in Climate Change Projections

Uncertainty about future climate change is a key consideration for planning adaptation to climate change. In Chap. 2 we discussed key sources of uncertainty along the chain from global climate projections to regional climate change impacts and adaptation needs. Table 3.2a gives an overview of the sources of uncertainty (emissions scenarios, global climate models [GCMs] and regional climate models [RCMs]) that were considered in climate change projections provided or authorised by national governments in the 14 countries in this survey.[10]

#### Status

The column titled "Status" reveals that the use and official status of climate projections varies widely across countries. In Switzerland, use of an optimistic and a pessimistic climate projection is mandatory for federal offices in the context of the development of the Swiss action plan. The UKCP09 projections for the United Kingdom also have a strong status as their use is recommended in the preparation of climate change risk assessments as required by the Climate Change Act 2008. In several other countries, the climate projections reviewed here are mentioned in official documents or are the de facto standard due to the absence of alternative projections of comparable quality.

#### Time Horizon

Most climate projections included in Table 3.2a cover the period until 2100, which corresponds to the time horizon of Special Report on Emissions Scenarios (SRES) emissions scenarios (Nakicenovic and Swart 2000) and of the ENSEMBLES project (see below). The current *reclip:century* project scenarios for Austria have a time horizon until 2050, which will be extended to 2100 in phase 2 of the project. The KNMI'06 climate scenarios for the Netherlands extend until 2050, but the scenarios used in the *Klimaateffectatlas* (Climate Impact Atlas) and the Dutch Delta Programme include projections of sea-level rise and water-related climate variables until 2100 (Delta Programme 2011).

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[10] The table contains two different sets of climate scenarios for Germany, denoted as Deutscher Klimaatlas (German climate atlas, by the German Weather Service) and Regionaler Klimaatlas Deutschland (Regional climate atlas Germany, by the Regional Climate Offices of the Helmholtz Association). Another set of climate projections for Germany is being provided on the Kompass website of the Umweltbundesamt (Federal Environment Agency). The Kompass projections are not considered here as they are older than the two projections included in Table 2. Spain has published regional climate change scenarios in 2009 and is currently compiling new scenarios from different sources. The Netherlands have also published two sets of climate projections.

**Table 3.2a** Climate change projections: status and consideration of uncertainties

| Country[a] | Name of projection (or portal)[b] | Date | Web link[c] | Status | Time horizon | No. of emission scenarios used | No. of GCMs used | No. of RCMs used |
|---|---|---|---|---|---|---|---|---|
| AT | reclip:century | 2011 | http://tiny.cc/ccp-at | 1 | 2050[d] | 2 | 2 | 2 |
| BE | Regional projections (Walloon region) | 2011 | http://tiny.cc/ccp-be1 | 2 | 2100[e] | 1[d] | 3 | 3** |
| | CCI-HYDR & INBO (Flemish region) | 2009 | http://tiny.cc/ccp-be2 http://tiny.cc/ccp-be3 | 2 | 2100 | 3[d] | 3 | 3** |
| CH | CH2011 | 2011 | http://tiny.cc/ccp-ch1 http://tiny.cc/ccp-ch2 | 4[f] | 2100 | 3 | 4* | 9 |
| CZ | Projekt VaV 2007-2011 | 2011 | http://tiny.cc/ccp-cz1 http://tiny.cc/ccp-cz2 | 1 | 2100 | 1[d] | 1[d] | 1[d] |
| DE | Deutscher Klimaatlas | 2011 | http://tiny.cc/ccp-de1 | 2 | 2100 | 5 | 4* | 11 |
| | Regionaler Klimaatlas | ? | http://tiny.cc/ccp-de2 | 1 | 2100 | 4 | 3* | 3 |
| ES | Escenarios regionalizados de cambio climático | 2009 | http://tiny.cc/ccp-es1 | 1 | 2100 | 2 | 3 | 9** |
| | PNACC 2012 | 2013 | http://tiny.cc/ccp-es2 http://tiny.cc/ccp-es3 http://tiny.cc/ccp-es4 http://tiny.cc/ccp-es5 | 3[g] | 2100 | 3 | 3 | 3** |
| FI | ACCLIM | 2009 | http://tiny.cc/ccp-fi1 http://tiny.cc/ccp-fi2 http://tiny.cc/ccp-fi3 | 2[h] | 2100 | 3 | 19* | 9 |
| FR | Climat de la France au XXIe siècle | 2012 | http://tiny.cc/ccp-fr1 http://tiny.cc/ccp-fr2 | 2 | 2100 | 3 | 3 | 2** |
| HU | OMSZ 2008[i] | 2008 | http://tiny.cc/ccp-hu | 1 | 2100 | 1[d] | 2[d] | 2[d] |
| IE | C4I | 2008 | http://tiny.cc/ccp-ie | 1 | 2100 | 4 | 5 | 2** |
| NL | KNMI'06 | 2006, 2009 | http://tiny.cc/ccp-nl1 http://tiny.cc/ccp-nl2 http://tiny.cc/ccp-nl3 | 3[j] | 2050[d] | n.a.[d] | 5 | 10 |
| | Klimaateffectatlas | 2009 | http://tiny.cc/ccp-nl4 | 2 | 2100 | n.a.[d] | Not specified | |
| NO | Klima i Norge 2100 | 2009 | http://tiny.cc/ccp-no1 http://tiny.cc/ccp-no2 | 2 | 2100 | 3 | 6 | 10** |
| PL | Projekcje klimatu | ? | http://tiny.cc/ccp-pl | 1 | 2100 | 1 | 4 | 7 |
| UK | UKCP09 | 2009 | http://tiny.cc/ccp-uk1 http://tiny.cc/ccp-uk2 | 3[k] | 2100 | 3 | 1[d]* | 1** |

**Status**: 1: No official status; 2: Reference in official documents/de facto standard; 3: Use officially recommended; 4: Use officially required

**No. of GCMs used**: An asterisk (*) denotes that a perturbed physics ensemble was produced by at least one of the GCMs

**No. of RCMs used**: A double asterisk (**) denotes that empirical-statistical downscaling models were applied in addition to RCMs

[a]See Table 3.1 for abbreviations of countries

[b]Projections highlighted in grey were used in case studies described in Chap. 4

[c]This document uses dynamic short links ("tiny URLs") in order to improve the readability of the web link and to allow for an update if an URL changes. Please report broken links to the first author of this book chapter

[d]See text for details

[e]The text states 2085, which is the central year of the period 2071–2100. For consistency with references to the same period in other projections, this is denoted here as 2100

[f]For the development of the Swiss action plan, the federal offices are to consider an "optimistic" scenario and a "pessimistic" scenario

[g]Scenarios-PNACC 2012 is intended to become the official information platform for regionalised climate change scenarios for Spain

[h]Consideration of uncertainty is implicitly required by water managers and electric utility companies

[i]Not an official name

[j]The *Nationaal Bestuursakkoord Water* provides advice on which of the KNMI'06 climate scenarios to use for a specific application

[k]Use of UKCP09 scenarios (and quantification of uncertainties, where appropriate) is recommended in the preparation of Climate Change Risk Assessments (CCRAs) as required by the Climate Change Act 2008

**Table 3.2b** Climate change projections: communication of uncertainties

| Country[a] | Name of projection (or portal) | Climate variables[b] | Data download | Interactive maps | Uncertainty in maps | Uncertainty in graphs (e.g. time series) |
|---|---|---|---|---|---|---|
| AT | reclip:century | 2 | ✓ | ✓ | Individual simulations | – |
| BE | Regional projections (Walloon region) | 2 | – | – | Not applicable, because detailed projections are available on request only | |
| | CCI-HYDR & INBO (Flemish region) | 4 | – | – | Individual simulations | Individual simulations |
| CH | CH2011 | 6 | ✓ | – | Multi-model mean | Individual simulations; 3 percentiles (2.5th, median, 97.5th); uncertainty range |
| CZ | Projekt VaV 2007–2011 | 4 | – | – | Individual simulations; mean; robustness of sign (for ENSEMBLE projections) | Individual simulations; percentiles (quartiles, for ENSEMBLE projections) |
| DE | Deutscher Klimaatlas | 9 | – | ✓ | 3 percentiles (15th, median, 85th) | Individual simulations |
| | Regionaler Klimaatlas | 23 | – | ✓ | Individual simulations; uncertainty range (min, max); robustness of sign | – |
| ES | Escenarios regionalizados de cambio climático | 8 | – | – | Individual simulations;multi-model mean | Individual simulations; multi-model mean; uncertainty range (±1 standard deviation) |
| | PNACC 2012 | 3 | ✓ | – | – | 5 percentiles (min, 25th, median, 75th, max) |
| FI | ACCLIM | 7 | – | ✓ | Multi-model mean | Multi-model mean; 2 percentiles (5th and 95th) |

| | | | | | | |
|---|---|---|---|---|---|---|
| FR | Climat de la France au XXIe siècle | 21 | ✓ | ✓ | Individual simulations | 2 percentiles (2.5th and 97.5th) |
| HU | OMSZ 2008 | 2 | – | – | Individual simulations | – |
| IE | C4I | 12 | – | – | Individual simulations; multi-model mean | – |
| NL | KNMI'06 | 4 | – | – | Best guess for each of the 4 scenarios | Uncertainty range (not exactly specified) |
| | Klimaateffect-atlas | 47 | – | ✓ | Best guess for each of the 4 scenarios | – |
| NO | Klima i Norge 2100 | 13 | – | – | Individual simulations; multi-model/scenario mean; 3 percentiles (5th, median, 95th) | Multi-model/scenario mean; 3 percentiles (10th, median, 90th); uncertainty range (±1 standard deviation); individual simulations |
| PL | Projekcje klimatu | 2 | – | ✓ | Multi-model mean; 5 percentiles (minimum, 10th, median, 90th, maximum) | – |
| UK | UKCP09 | 9 | ✓ | ✓ | Separately for 3 emissions scenarios: 3 percentiles (10th, median, 90th), multi-model mean | Multi-model mean; probability/cumulative density function; joint probability plot |

[a]See Table 3.1 for abbreviations of countries

[b]This information is only indicative because counting the number of climate variables involves several challenges. First, different portals have different approaches in presenting different statistics (e.g., seasonal information) for the "same" climate variable. Second, some portals also include variables that could be described more appropriately as climate impact variables. Note that projections for some emission scenarios may not be available for all variables

### Emissions Scenarios

Most climate projections consider simulations forced by 2–5 different emissions scenarios. The approach applied by the Netherlands differs from those of the other countries. Instead of sampling the forcing uncertainty from different emissions scenarios and the climate response from different climate models separately, four climate projections were produced that capture a large range of the variation of those factors that are considered most relevant for the Dutch climate: change in global temperature and change in circulation patterns. A similar approach was used for the climate projections for the Walloon and Flemish regions of Belgium.

The climate projections for the Czech Republic, Hungary and Poland consider only one emissions scenario (SRES A1B); those for the Czech Republic and Poland are furthermore based on a single projection of an RCM (regional climate model) nested in a GCM (general circulation model, also translated as global climate model). However, the Czech projections have been validated and compared with ensemble-based projections based on the EU projects ENSEMBLES[11] and CECILIA.[12] The "Vahava Report" for Hungary (see Table 3.4) used more comprehensive climate scenarios from the PRUDENCE[13] project that are based on 2 emissions scenarios, 3 GCMs and 18 GCM/RCM combinations.

### Climate Models

All but two climate projections are based on a multi-model ensemble of 2–19 different GCMs. Several projections also consider different versions of the same GCM or perturbed-physics ensembles in which alternative variants of a single GCM are created by altering the values of uncertain model parameters (Meehl et al. 2007, Section 10.5.4.2). The UKCP09 probabilistic climate projections were produced in a different way. They are based on a large perturbed-physics ensemble of a single GCM but 12 additional GCMs participating in the Cloud Feedback Model Intercomparison Project (CFMIP[14]) were used in the estimation of structural errors.

All climate projections applied RCMs to downscale the coarse GCM projections to a higher resolution; most of them employed several (up to 11) different RCMs. The UKCP09 projections for the United Kingdom employed only one RCM due to the large number of simulations required for the probabilistic projections. Seven climate projections additionally employed empirical-statistical downscaling methods (ESDMs).

[11] http://ensembles-eu.metoffice.com
[12] http://www.cecilia-eu.org
[13] http://prudence.dmi.dk
[14] http://cfmip.metoffice.com

## Discussion

While there are notable differences in the national climate change projections covered in this analysis, almost all projections share the following characteristics:

- Consideration of different emissions scenarios (see the note above for the Netherlands and for Belgium),
- Use of different GCMs, and
- Downscaling of GCM outputs by different dynamical and sometimes also statistical models.

As can be seen therefore, almost all of the climate projections address the major sources of uncertainty to some degree. This degree of coherence is not surprising considering that the EU-funded projects PRUDENCE (2001–2004) and in particular ENSEMBLES (2006–2009) have been crucial sources for regionalised climate change projections in many countries.[15] An analysis of how national climate scenarios differ from those developed for the whole Europe would be interesting but is beyond the scope of this chapter.

Six countries included in this uncertainty analysis are also covered by adaptation case studies in Chap. 4:

- Case studies in three of these countries (Austria: case 4.2.9, the Netherlands: cases 4.2.5 and 4.2.12 and United Kingdom: case 4.2.2) applied national-level climate scenarios included in Table 3.2a.
- Case studies from two other countries used tailor-made climate change scenarios at the national scale (Ireland: case 4.2.6) or regional scale (Germany: case 4.2.10).
- The French case study (case 4.2.7) did not specify the specific source of climate projections considered, if any.

The case study for the United Kingdom (case 4.2.2) describes the national-level CCIV assessment but none of the other case studies directly uses information from the national-level CCIV assessment (see Table 3.4).

This observation suggests that the current generation of national-level CCIV assessments generally is not well suited to support concrete adaptation planning. It would be interesting to investigate further whether the gap between the information provided in current national-level CCIV assessments and the information needs of local and regional adaptation actors is primarily related to insufficient detail in science-based projections (which could, in principle, be overcome by improved

[15] The latest initiative to generate regional climate change projections based on a multi-model ensemble is the CORDEX (http://cordex.dmi.dk/joomla/index.php) project coordinated by the World Climate Research Programme (WCRP). EURO-CORDEX (http://www.euro-cordex.net/) is the European branch of the CORDEX initiative and will produce ensemble climate simulations based on multiple dynamical and empirical-statistical downscaling models forced by multiple GCMs from the Coupled Model Intercomparison Project Phase 5 (CMIP5).

national-level CCIV assessments) or to the insufficient consideration of the specific decision context (which can only be addressed in local or regional-scale assessments involving relevant stakeholders).

### *3.3.2 Communication of Uncertainty in Climate Change Projections*

The discussion above revealed that almost all climate change projections reviewed here consider the main sources of uncertainty to some degree. We noted in Chap. 2 that projections and their associated uncertainties need to be communicated to climate impact researchers from diverse sectors and/or to decision-makers involved in adaptation and risk reduction. They need to understand the robustness of projections relevant for their activities and decisions. Uncertainty generally increases along the impact chain, but it may be possible to find robust adaptation measures even when impact projections are very uncertain.

The consistent, accurate and understandable communication of uncertainties has been the focus of climate scientists, communication psychologists, and others (Budescu et al. 2009; Moser 2010; Fischhoff 2011; Pidgeon and Fischhoff 2011; Lemos et al. 2012; Rabinovich and Morton 2012). The IPCC has made an unprecedented effort to accurately assess uncertainties and consistently communicate the robustness of specific statements in its assessment reports (Moss and Schneider 2000; IPCC 2005; Mastrandrea et al. 2010). At the same time, decision-makers are not always able to make use of the complex information base due to cognitive, institutional, legal, and other reasons.

A clear conclusion from the pertinent literature is that the communication of climate information with its associated uncertainties needs to be audience-specific. For example, Tang and Dessai (2012) found that the saliency of the (probabilistic) UKCP09 projections was dependent on the scientific competence of its users; furthermore, they claim that "*the use of Bayesian probabilistic projections* [...] *improved the credibility and legitimacy of UKCP09*'*s science but reduced the saliency for decision-making*" (p. 300). A one-size-fit-all approach for the communication of climate projections is unlikely to be successful. This is because of the large differences in the information needs of potential users as well as their ability to comprehend complex, and potentially ambiguous, scientific information. Furthermore, knowledge providers also have different ways of framing and communicating uncertainties, e.g. dependent on their disciplinary background (Swart et al. 2009).

**Comprehensiveness**

Table 3.2a shows the status of all climate projections and Table 3.2b summarises how their results are presented graphically. The column "Variables" shows that some climate change projections are significantly more comprehensive than others. Some of them provide projections for annual and seasonal temperature and precipitation only, whereas others comprise statistics for dozens of climate variables. A detailed assessment of these differences is beyond the scope of this chapter.

#### Availability of Data and Maps

Five out of 18 climate change portals enable download of the raw data for use in climate impact research and adaptation planning. Eight portals allow for the interactive creation of maps, although with considerable differences in the specific features. The majority of national climate projections are currently only available as static maps and/or graphs. Evidence from one of the case studies ("Communication of large numbers of climate scenarios in Dutch climate adaptation workshops", case 4.2.12) suggests that the presentation of climate projections through interactive maps is very effective in communicating key aspects of future climate change to decision-makers. Hence, the development of interactive web portals could be an important part of developing and sharing the knowledge base for adaptation.

#### Uncertainty Communication in Graphs and Maps

There are large differences in the presentation of different sources of uncertainty in maps and graphs. Maps focus on *spatial* variations of *one* climate statistic. Many maps present the results from individual model simulations separately. Some maps show climate statistics, including (ensemble) mean, median, various other percentiles and robustness of sign. In most cases, the statistics were calculated across all GCM/RCM combinations for *one* emission scenario. One exception is the *Regionaler Klimaatlas* (regional climate atlas, Germany) where maps depicting the robustness of projections are based on a multi-model ensemble that comprises *all* emissions scenarios. Similarly, map-based projections for Norway are based on a multi-model ensemble forced by different emissions scenarios. The percentiles used to depict "low" and "high" projections vary widely (e.g. "low" projections are based on the minimum as well as the 2.5th, 5th, 10th and 15th percentile).

Presentations of climate projections in graphs often show time series for one climate variable in a particular region. Others show projections for several regions and/or seasons for one time period. In many cases several individual simulations and/or several statistics (e.g. different percentiles) are shown together. UKCP09 offers the widest variety of map and graph-based presentations. Its probabilistic climate projections are presented, among others, as probability density functions, cumulative density functions and joint probability plots for two climate variables.

#### Summary on Communication of Uncertainties in Climate Projections

The communication of uncertainties in climate projections differs substantially across countries. In some countries, the only available projections are averages of the most important climate variables provided in reports. Such information may serve some general educational purpose but can be misleading when trying to make specific adaptation decisions involving uncertainties, for example, in the level of flood defence required. In other countries, sophisticated web portals provide access to a wide range of user-defined maps and graphs as well as to the underlying data. Such detailed and sophisticated information can provide support for decisions related to risk management. However, its correct interpretation may require specialists, and a general user may lose the wider picture.

The climate information available in some countries is clearly insufficient to fulfil the information needs of many (potential) users. An improvement of this situation requires a dialogue between information providers and key users and careful consideration of user needs already in the design phase of communication tools for climate projections (e.g. reports and web portals).

Most likely, a tiered set of communication material will be required. In such an approach, highly aggregated projections can support initial coarse vulnerability assessments and provide relevant background information for stakeholders whose activities are only moderately sensitive to climate change. More detailed projections, including quantitative uncertainty assessments, provide further information for stakeholders with more detailed information requirements.

### *3.3.3 Non-climatic Scenarios*

Planned adaptation is driven by projected changes in climate, but, like any long-term planning, anticipated changes in other social, economic, and environmental factors also need to be considered. Some projected changes in non-climatic factors can be considered rather certain (e.g. an increasing share of elderly people in most countries in Europe) whereas others are partly speculative (e.g. technological development or the future role of biomass as an energy carrier).

Table 3.3 summarises the availability of non-climatic scenarios for CCIV assessments. Only Finland, the Netherlands and the UK have developed quantitative scenarios for non-climatic variables specifically for CCIV assessments. The Finnish FINADAPT scenarios comprise several variables related to population, economy and environment that are consistent with 3 out of 4 SRES scenario families. The Dutch WLO and IC11 scenarios comprise 26 variables that also cover energy, transport and agriculture. Within the Dutch Delta programme integrated scenarios have been developed that combine the KNMI06 climate scenarios and the WLO socio-economic scenarios in a coherent way (Deltaprogramma 2011). The UK SES scenarios (from 2001) provide quantitative projections for 12 variables and qualitative projections for further topics from similar topic areas as the Dutch scenarios. Switzerland is currently developing socio-economic scenarios for climate change impact assessment.

The Flemish region of Belgium has published socio-economic scenarios for environmental policy planning, which have been considered in the Flemish Adaptation Plan, and Germany has published land use change scenarios (see Table 3.3 for details).

**Table 3.3** Availability of non-climatic scenarios for CCIV assessments

| Country[a] | Date | Name | Web link | Comment |
|---|---|---|---|---|
| BE | 2009 | Environment Outlook 2030 – Flanders | http://tiny.cc/ncs-be | A single scenario for demography, economic development, employment and energy prices |
| DE | 2012 | Trends der Siedlungsflächenentwicklung – Status quo und Projektion 2030 | http://tiny.cc/ncs_de | Regionalised scenarios for changes in land use |
| FI | 2005 | FINADAPT scenarios for the twenty-first century | http://tiny.cc/ncs-fi1 | Downscaled scenarios of population, sector-specific GDP, household consumption, nitrogen deposition and land use consistent with 3 out of 4 SRES scenario families |
| | 2007 | Assessing the adaptive capacity of the Finnish environment and society under a changing climate: FINADAPT | http://tiny.cc/ncs-fi2 | |
| NL | 2006 | Welfare, Prosperity and Quality of the Living Environment (WLO) | http://tiny.cc/ncs-nl1 | The 4 WLO scenarios comprise 26 variables related to demography, economy, housing, industrial areas, mobility, energy, agriculture and environment. They were re-evaluated in 2010 and they provide the basis for the IC11 scenarios. |
| | 2010 | Bestendigheid van de WLO-scenario's | http://tiny.cc/ncs-nl2 | |
| | 2011 | Socio-economic Scenarios in Climate Assessments (IC11) | http://tiny.cc/ncs-nl3 | |
| UK | 2001 | Socio-economic scenarios for climate change impact assessment (SES) | http://tiny.cc/ncs-uk | The 4 SES scenarios aligned with the 4 SRES scenario families provide quantitative projections up to 2050 for 12 variables related to economic development, population and land use. Further qualitative scenarios are given for those thematic areas as well as for values and policy, agriculture, water, biodiversity, coastal zone management and built environment. The SES scenarios were critically reviewed in 2009. |

[a]See Table 3.1 for abbreviations of countries

However, these socio-economic scenarios are not necessarily consistent with the scenarios underlying the climate change projections, and it is not clear whether they have been used in CCIV assessments. Similar projections may also be available in other countries, but they have not been reported.

In summary, most countries lack readily available long-term scenarios of key non-climatic variables that could be used together with climate scenarios to assess potential climate change impacts.

### *3.3.4 Climate Impact, Vulnerability, and Risk Assessments*

Most decision-makers involved in adapting to climate change are less interested in future changes in climate than in the environmental, social, economic, and health risks (and opportunities) associated with them. CCIV assessments aim to provide such information. Table 3.4 gives an overview of national-level CCIV assessments in the 14 countries covered by our analysis. All 14 countries have published CCIV assessments covering key climate-sensitive sectors and systems, and several countries are currently updating them. For a recent overview of CCIV assessments in 7 European countries, see Steinemann and Füssler (2012).

The multi-sector CCIV assessments shown in the table differ considerably in their method, scope, extent, level of quantification and consideration of uncertainties. Many CCIV assessments comprehensively cover a whole country or region whereas others are restricted to individual sectors or systems. About half of them can be categorised as predominantly quantitative and the other half as predominantly qualitative. Some assessments are literature reviews of existing studies whereas others build on consistent multi-sector modelling exercises. Several assessments present quantitative information on uncertainty derived from different climate projections. However, uncertainty arising from non-climatic projections or from impact models is rarely explicitly considered, which may result in maladaptation. Decision-makers are generally well aware of the main non-climate-related uncertainties relevant for their decisions. However, inclusion of such experience-based knowledge in adaptation decisions may be impaired if CCIV assessments present projected impacts of climate change without consideration of other changes and related uncertainties. Therefore, CCIV assessments should ideally consider multiple plausible scenarios for relevant non-climatic developments. Furthermore, they should either be based on multiple climate impact models or discuss how limitations of a given impact model could affect its results.

The UK Climate Change Risk Assessment (CCRA) stands out in many ways: it is the only legally mandated CCIV assessment; it builds on the most comprehensive climate projections (UKCP09); it is the only probabilistic CCIV assessment, providing the 10th, 50th and 90th percentile of projected impacts; and it is the most comprehensive example, comprising several thousand pages. This assessment is described in case study 4.2.2.

**Table 3.4** National climate change impact, vulnerability and risk (CCIV) assessments

| Country[a] | Date | Name | Web link | Comment |
|---|---|---|---|---|
| AT | 2010 | Klimaänderungsszenarien und Vulnerabilität | http://tiny.cc/civ-at | Qualitative; part of the NAS |
| BE | 2011 | L'adaptation au changement climatique en région wallonne (Walloon region) | http://tiny.cc/civ-be1 | Mostly qualitative; the reporting of sector-specific impacts distinguishes five levels of probability and five levels of quality of the knowledge base |
| | 2010 | Bouwstenen om te komen tot een coherent en efficiënt adaptatieplan voor Vlaanderen (Flemish region) | http://tiny.cc/civ-be2 | Mostly qualitative; quantitative impact projections are available from some of the underlying research projects |
| CH | 2007 | Climate Change and Switzerland 2050: Expected Impacts on Environment, Society and Economy | http://tiny.cc/civ-ch | Mostly qualitative; uncertainty is discussed qualitatively[b] |
| CZ | 2011 | Zpřesnění dosavadních odhadů dopadů klimatické změny v sektorech vodního hospodářství, zemědělství a lesnictví a návrhy adaptačních opatření (in Czech) | http://tiny.cc/civ-cz | Quantitative; restricted to water management, agriculture and forestry |
| DE | 2005 | Climate Change in Germany. Vulnerability and Adaptation of climate sensitive Sectors | http://tiny.cc/civ-de1 | Quantitative; uncertainty resulting from different emissions scenarios and climate models[c] |
| | 2008 | Deutsche Anpassungsstrategie an den Klimawandel | http://tiny.cc/civ-de2 | Qualitative; part of the NAS |
| ES | 2005 | ECCE – A preliminary General Assessment of the Impacts in Spain Due to the Effects of Climate Change | http://tiny.cc/civ-es | Quantitative; based on a comprehensive review of available studies; uncertainty is addressed differently depending on the underlying study[d] |
| FI | 2012 | Miten väistämättömään ilmastonmuutokseen voidaan varautua (ISTO) | http://tiny.cc/civ-fi | Mostly qualitative[e] |
| FR | 2009 | Climate change: costs of impacts and lines of adaptation | http://tiny.cc/civ-fr | Quantitative; based on a comprehensive review of available studies and specific assessments; uncertainty is addressed by considering a low and a high emission scenario |
| HU | 2010 | Climate Change and Hungary: Mitigating the Hazard and Preparing for the Impacts (The "Vahava" Report) | http://tiny.cc/civ-hu | Qualitative; the underlying reports were not available for further analysis |

(continued)

**Table 3.4** (continued)

| Country[a] | Date | Name | Web link | Comment |
|---|---|---|---|---|
| IE | 2008 | Climate Change: Refining the Impacts for Ireland | http://tiny.cc/civ-ie1 | Quantitative; many uncertainties are presented quantitatively[f] |
| | 2009 | A Summary of the State of Knowledge on Climate Change Impacts for Ireland | http://tiny.cc/civ-ie2 | Qualitative; based on a literature review |
| NL | 2012 | Effecten van klimaatverandering in Nederland 2012 | http://tiny.cc/civ-nl | Quantitative; uncertainties covered by 4 KNMI'06 scenarios |
| NO | 2010 | Adapting to a changing climate: Norway's vulnerability and the need to adapt to the impacts of climate change | http://tiny.cc/civ-no | Mostly qualitative; uncertainties are mentioned in the text |
| PL | 2010 | Opracowanie wskaźników wrażliwości sektora transportu na zmiany klimatu | http://tiny.cc/civ-pl1 | Semi-qualitative; consideration of uncertainties not known; only one sector (transport) |
| | 2012 | Strategiczny plan adaptacji dla sektorów i obszarów wrażliwych na zmiany klimatu do roku 2020 | http://tiny.cc/civ-pl2 | Semi-qualitative; consideration of uncertainties not known (due to inavailability of English translation) |
| UK | 2012 | The first UK Climate Change Risk Assessment | http://tiny.cc/civ-uk | Comprehensive; quantitative; probabilistic (results for 10th/50th/90th percentile); legally mandated every 5 years |

[a]See Table 3.1 for abbreviations of countries
[b]A follow-up project is currently under development (http://www.wsl.ch/fe/wisoz/projekte/klimarisiken/index_DE)
[c]Currently two projects are working at a consistent and cross-sectorial vulnerability assessment for Germany in support of the German Adaptation Strategy
[d]Between 2008 and 2011, CCIV assessments were conducted for the following sectors and systems: biodiversity, water resources, forests, coasts, desertification, and tourism
[e]New studies are currently being undertaken within the Finnish Research Programme on Climate Change (FICCA, http://www.aka.fi/en-GB/A/Programmes-and-cooperation/Research-programmes/Ongoing/FICCA/)
[f]A new national CCIV assessment has been completed but the results have not been published to date

### 3.3.5 Guidance for Adaptation Planning Under Uncertainty

Climate projections and CCIV assessments provide crucial information for adaptation planning, but this information is often presented in a way that is difficult to understand for adaptation decision-makers (Lemos et al. 2012). Uncertainties in projections present particular challenges for decision-makers as they may be difficult to comprehend or current decision-making criteria may be based on the use of a single "best" value. Therefore, most adaptation decision-makers need help to make best use of available climate and climate impact projections. This section presents a brief overview how uncertainties in climate and climate impact projections are addressed in written guidance material and web-based tools targeted at adaptation decision-makers. A wider analysis of the available guidance material is beyond the scope of this chapter.

Table 3.5 provides an overview of how uncertainties are addressed in guidance documents and websites for adaptation decision-makers across different countries.[16] Apart from the Netherlands, these guidance documents are only available in the national language. Only four countries (Germany, the Netherlands, Norway and United Kingdom) currently explicitly address climate uncertainties in their guidance material for adaptation decision-makers. Finland has published relevant guidance documents for specific sectors, and Spain is developing a user guide where climate uncertainties are addressed. The most comprehensive effort at assisting public and private adaptation decision-makers has been made in the United Kingdom.

The lack of guidance in some countries is surprising. For example, the CCIV assessment for Ireland provides substantial information on uncertainties in climate and climate impact projections but there are no documents helping adaptation decision-makers to address these uncertainties. In addition, while Austria is relatively advanced in terms of adaptation policy (see Table 3.1) and has included several sources of uncertainties in its national climate change projections (see Table 3.2a), information on addressing uncertainties is very difficult to find on its web site.

We conclude that guidance material for addressing uncertainties in adaptation planning is insufficient in most countries. This is even the case in some countries where climate projections or CCIV assessments consider key uncertainties. This means that in most countries, substantial efforts are needed to improve the appreciation of uncertainties in climate and climate impact projections by decision-makers and the public at large. Until the results of these efforts will become available, the reader will have to rely on the sources mentioned in this chapter and additional material available through contacts at the national and local level. Generic understanding of uncertainties at the European (e.g., Climate-ADAPT) and national level (e.g., UKCIP) can be relevant in any adaptation situation in Europe.

[16] When interpreting the information in Table 5, it should be considered that guidance documents can possibly be provided by many institutions. It is thus much more difficult to assemble a complete overview of guidance documents than of national-level climate projections and CCIV assessments.

**Table 3.5** Guidance on dealing with uncertainty in climate or climate impact projections

| Country[a] | Date | Name | Web link | Further information |
|---|---|---|---|---|
| AT | 2011 | Der Zukunft vorgreifen: Klima-wandelanpassung und Unsicherheiten | http://tiny.cc/gdu-at | Some information on sources of uncertainties and implications for adaptation planning[b] |
| DE | 2010 | Klimalotse (Step 3.1) | http://tiny.cc/gdu-de1 | Some recommendations on addressing uncertainties related to emission scenarios, global and regional climate models, and development of society and economy |
| | 2012 | Stadtklimalotse | http://tiny.cc/gdu-de2 | Recommendations on flexible planning under uncertainties |
| FI | 2012 | Hulevesiopas | http://tiny.cc/gdu-fi1 | Guidance documents on water management in a future climate |
| | 2012 | Energialaskennan testivuodet tulevaisuuden ilmastossa | http://tiny.cc/gdu-fi2 | Guidance on future climatic reference conditions for architects |
| NL | 2009 | Klimaatschetsboek Nederland (Sect. 2.3) | http://tiny.cc/gdu-nl1 | Explanation of sources of uncertainty; simultaneous presentation of results for 4 KNMI06 scenarios |
| | 2009 | Socio-economic Scenarios in Climate Assessments | http://tiny.cc/gdu-nl2 | Guidance for the combination of socio-economic scenarios with climate scenarios |
| NO | 2009 | Klima i Norge 2100 (Chap. 6) | http://tiny.cc/gdu-no1 | Explanation of sources of uncertainty in climate projections; very brief discussion on dealing with this uncertainty |
| | 2012 | Klimaprojeksjoner og usikkerhet | http://tiny.cc/gdu-no2 | Guidance on the consideration of climate uncertainties for municipalities |
| UK | 2013 | Climate change: Advise by sector | http://tiny.cc/gdu-uk1 | Comprehensive guidance documents on adapting to climate change, including the consideration of uncertainties, (in the UK and/or England) are available at these web portals |
| | 2013 | UKCIP: Tools | http://tiny.cc/gdu-uk2 | |
| | 2012 | Climate Ready | http://tiny.cc/gdu-uk3 | |

[a]See Table 3.1 for abbreviations of countries
[b]This information is only contained in a news archive and is thus difficult to find on the web site

## 3.4 Conclusions

The national climate policy scene in Europe is rapidly changing. Judging by the number and breadth of national policy documents dealing with the issue, adaptation has become a mainstream activity (see also Massey and Huitema 2012). However, the perceived needs, available resources, and levels of ambition vary significantly across countries (see Table 3.1).

We can foresee a demand from the impact, vulnerability and adaptation community to deliver more sophisticated climate change scenarios. Long-term averages are no longer sufficient when more detailed questions are being asked on the nature and range of possible impacts. Short-term variability within years, the frequency and magnitude of extreme events and intermediate-term projections are gaining importance. The expanding demand for more detailed and varied climate scenarios brings uncertainties to the forefront. In this context, it needs to be emphasized that uncertainties related to non-climatic (e.g., socio-economic and technological) developments and uncertainties resulting from imperfect climate impact models are still not systematically considered in many CCIV assessments. The development of a robust knowledge base for adaptation requires increased consideration of those uncertainties, even though they cannot always be quantified.

Dealing with uncertainty is not only an academic issue but also a very practical question for planners, managers and insurance agents. Targeted guidance is needed that explains the relevance of key uncertainties and how they can be addressed by robust adaptation strategies. Organisations at the boundary between science and policy, such as the EEA, play an important role in providing policy-makers with quality-controlled information that is understandable and relevant for their specific decision context (Hanger et al. 2013). Work at the boundary between science and policy can help turning potentially useful climate information into information that is actually used by decision-makers (Lemos et al. 2012).

Dynamic interactive tools in web portals are likely to be an important part of the tool box for those who are confronted with adapting to climate change. As an example, Climate-ADAPT provides indicators on climate change, climate impacts and related vulnerabilities and a step-by-step Adaptation Support Tool. It also aims to support the learning processes between European countries by providing extensive information on the legal framework for adaptation, on the relevant knowledge base and on actual adaptation actions across Europe. If such tools can be made sufficiently user friendly, they have the advantage of supporting the mainstreaming of adaptation in various planning activities. This is important to ensure successful climate change adaptation.

We feel there is a need to develop a variety of ways of estimating and presenting uncertainties and to turn research findings into conclusions that can be used in practical applications. Addressing uncertainties in adaptation to climate change is challenging, and there is no single strategy that works best in all circumstances. Note in this context that some authors have used the metaphor of a "monster" to distinguish several strategies to cope with scientific uncertainty about climate change (van der Sluijs 2005; Curry and Webster 2011):

- "Hiding" aims at denying the existence or relevance of uncertainties;
- "Exorcism" aims at reducing or eliminating uncertainties, in particular through more research;
- "Adaptation/taming" aims at taming the monster by quantifying uncertainties;
- "Simplification" aims at standardizing the monster, e.g. by formalized IPCC guidelines for characterizing uncertainty; and
- "Assimilation" is about learning to live with the monster by rethinking one's own perspective on it, e.g. through post-normal science and other forms of reflexive science (Funtowicz and Ravetz 1992).

Each of these strategies can be recognized to some degree in the activities of the countries surveyed here. More advanced countries generally pursue several strategies in parallel, as can be shown by the example of the United Kingdom. Fundamental research sponsored by the Natural Environmental Research Council (NERC) aimed at reducing uncertainties through improved data collection and process understanding can be regarded as "monster exorcism"; the development of the probabilistic UKCP09 climate scenarios can be regarded as "taming"; classifying the confidence in specific risk projections according to three categories (low, medium and high) in the *Summary of the Key Findings from the UK Climate Change Risk Assessment 2012* can be regarded as "simplification"; and the provision of comprehensive guidance documents about living with these uncertainties (see Table 3.5) can be regarded as "assimilation".

The survey results presented here indicate that there is still plenty of work in order to convey meaningful messages on uncertainties. Dynamic interactive tools in web portals are likely to be an important part of the tool box of those who are confronted with issues related to adaptation to climate change.

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