

Development of Adaptation Indicators



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1. Introduction

A major contemporary issue for policy and decision-makers is to understand and respond to the impacts of climate change on environmental, social, and economic systems. Adaptation policies, measures and actions are required to increase the resilience of those systems that are vulnerable to climate change. Within this context, adaptation indicators are needed to:

- Monitor the implementation of adaptation policies, measures and actions.
- Target, justify and monitor funding for adaptation programmes.
- Mainstream adaptation through links between sectors (e.g. biodiversity, water) and related indicators (e.g. climate change impact indicators).
- Communicate adaptation to policy and decision-makers and other stakeholders.
- Compare adaptation achievements across sectors, regions and countries.
- Inform climate change negotiations in the international political arena.

Indicators simplify, quantify, standardise and communicate complex and often disparate data and information. They should be based on assessment frameworks and robust scientific observations or statistical measures. The following considerations are important in their development:

- Availability - do appropriate data and indicators already exist?
- Potential availability - is reliable data available where indicators have not yet been developed?
- Representativeness - are indicators available to measure progress on important or determining factors, rather than less significant issues?
- Continuity - are indicators readily, rather than intermittently, available?

The purpose of this Technical Paper is to present a theoretical and practical framework for the development of adaptation indicators. The paper also aims to apply the framework in the development of indicators for the biodiversity sector and (i) the vulnerability of European biodiversity to climate change and (ii) regions being the interface between high-level national/European policy and local implementation. The studies are used to exemplify how adaptation indicators might be developed to monitor the implementation of adaptation policies, measures and actions. They also illustrate an approach that could be applied in a wider range of policy settings and sectors across Europe.

2. Background

The EEA convened a first *Expert meeting on climate change vulnerability and adaptation indicators* in Szentendre, Hungary in September 2008, where some fundamental concepts surrounding the development and delineation of adaptation indicators were rehearsed (Harley *et al.*, 2008). A second *Adaptation indicators expert meeting* was held at EEA, Copenhagen in July 2009, to discuss in more detail the utility of the conceptual framework for adaptation indicators that was established in Szentendre and develop it further for wider application. The meeting focussed on the two case studies (i.e. the development of adaptation indicators for the biodiversity sector and to support regional adaptation strategies).

3. Framework for developing adaptation indicators

The concepts and issues discussed in Harley *et al.* (2008) provide a framework for the development of adaptation indicators in the context of planned adaptation to climate change impacts (Figure 1). It does not consider autonomous adaptation.

The framework captures the ‘processes’ associated with the development of adaptation policies and delivery of adaptation measures, and the ‘outcomes’ of adaptation actions. It shows the relationship between adaptation indicators that are process-based (i.e. indicators for monitoring the development of adaptation policies and measures) and those that are outcome-based (i.e. indicators for measuring the effectiveness of adaptation actions, which are themselves determined by policies and measures). Process-based indicators can be differentiated into ‘adaptation policy indicators’ and ‘adaptation measure indicators’. As adaptation has only recently become politically significant, 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.

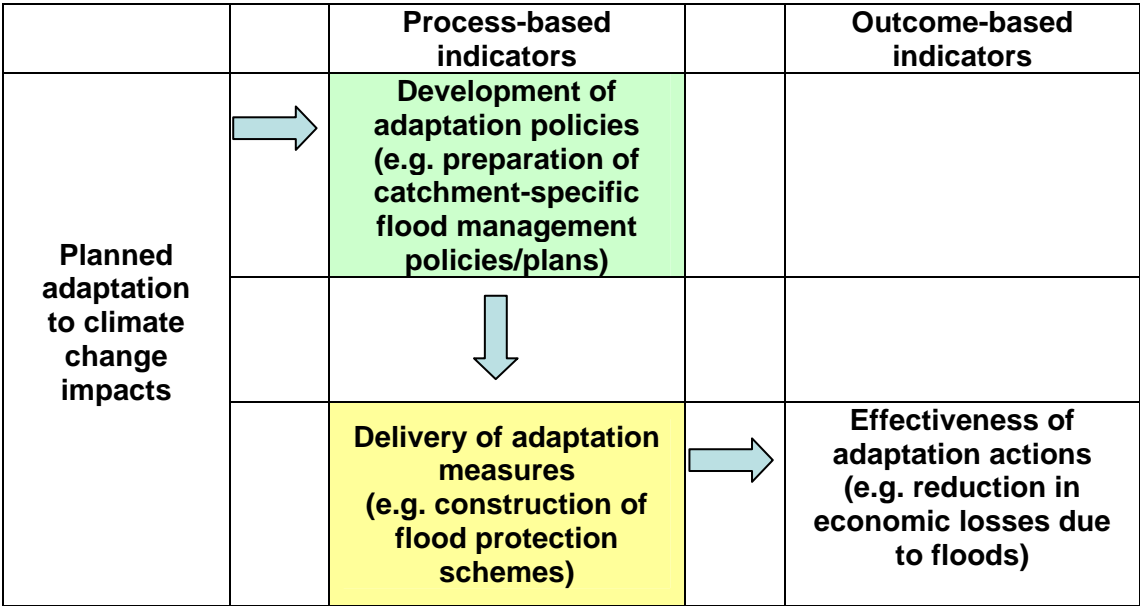


Figure 1: Conceptual framework for adaptation indicators

The principle objective of adaptation indicators is to show whether adaptation policies and measures were implemented and whether vulnerability was reduced through effective actions. In theory, adaptation indicators can also help in assessing why policies and measures were successful (or not) and why vulnerability was reduced (or not).

Whilst the specific purpose of adaptation indicators is to monitor the implementation of adaptation policies, measures and actions, it is also necessary to consider other factors that might contribute to or hinder the adaptation process and its outcomes (Figure 2). Clearly, indicators of other drivers and barriers to the implementation of adaptation and of other developments that decrease or increase vulnerability are also desirable. By monitoring these factors, it should be possible to more objectively measure the success of adaptation and to

learn from adaptation experiences so that policies, measures and actions might be improved in the future.

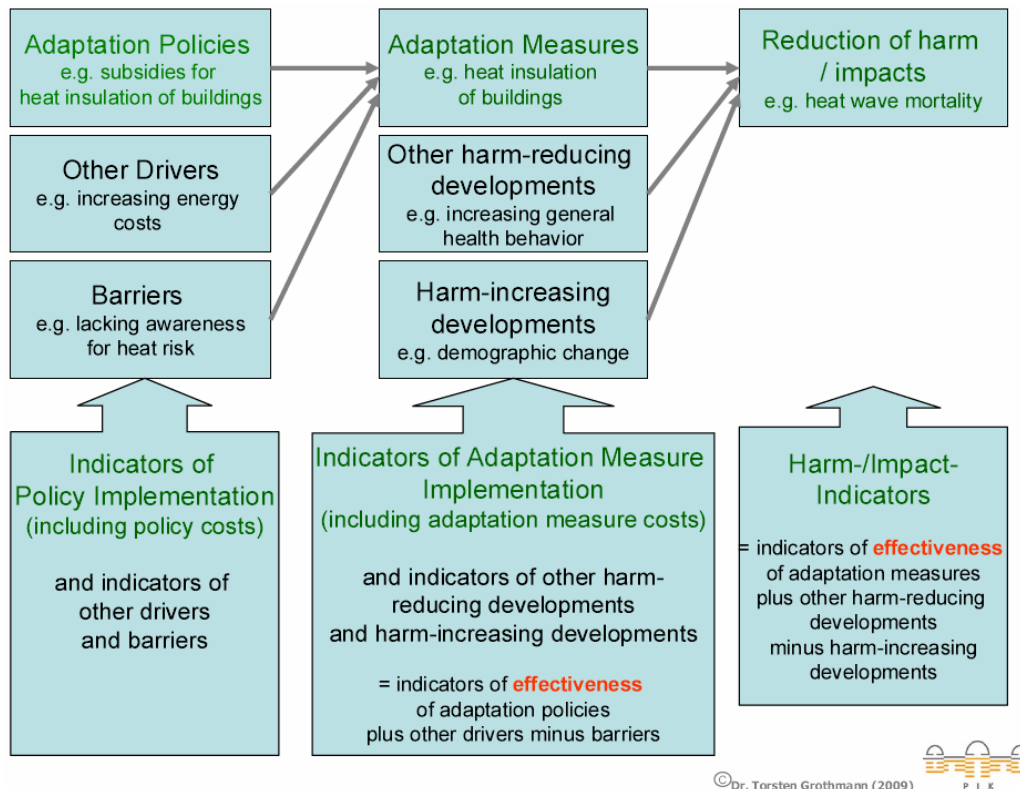


Figure 2: Adaptation indicators in relation to other drivers; note the concept of “harm” is synonymous with that of vulnerability (Grothmann, pers. comm.)

Process-based indicators - adaptation policy

There are two clearly defined pathways for the development of adaptation policies (Figure 3). These should be considered when developing indicators to monitor the quality of adaptation policy implementation by sectors and institutions:

- Top down - policies that are closely related to available national adaptation strategies (these are advanced in some EU Member States and do not exist in others – see <http://www.eea.europa.eu/themes/climate/national-adaptation-strategies>). A suitable adaptation policy indicator might be the availability of a national strategy.
- Bottom up - policies that bring together local knowledge and experience. Despite considerable variation in the availability of national strategies, local experiences can inform local policies where no such guidance exists. Suitable adaptation policy indicators might relate to local experiences informing policies within and across sectors.

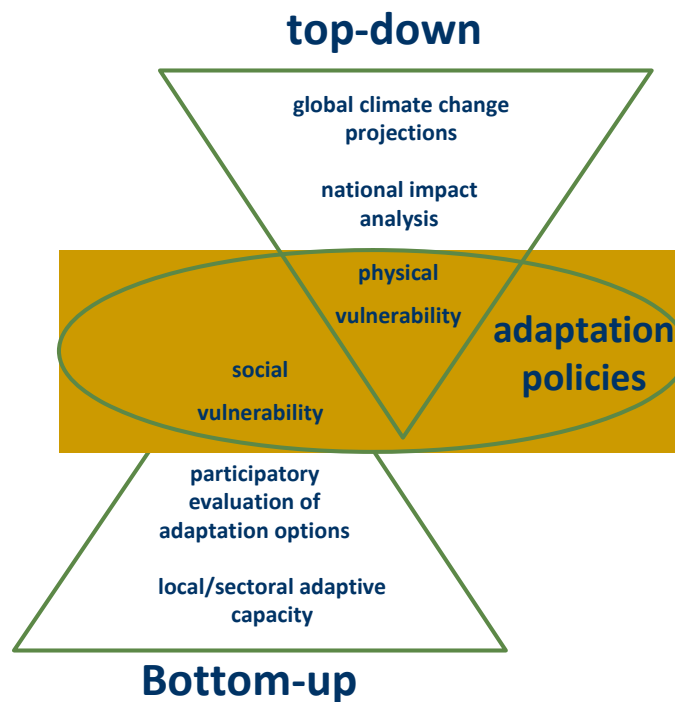


Figure 3: Pathways for adaptation policy development (based on Dessai and Hulme, 2004)

Process-based indicators - adaptation measures

Adaptation measure indicators should not only provide data from which to monitor and review progress in delivering adaptation measures, but also link to indicators for adaptation policy (above) and adaptation actions (below). Where possible, adaptation indicators should relate to the adaptive management cycle (Figure 4). Adaptive management aims to accommodate the uncertainties in multi-decadal planning for climate change. It is applicable across all spatial scales and, through a process on continual evaluation and review, should be effective in progressively increasing resilience and reducing vulnerability to climate change impacts. Adaptation measure indicators can be used to evaluate progress through the adaptive management cycle, in accord with the specific objectives set at each stage in the cycle. These indicators should provide the evidence needed to re-assess measures and the long-term vision and should be revised as the process enters successive cycles.

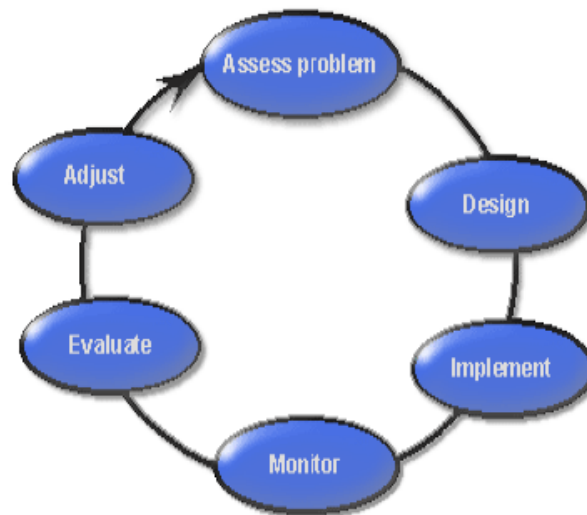


Figure 4: Adaptive management cycle (based on Pesnik, 2009: http://ec.europa.eu/environment/nature/biodiversity/conference/index_en.htm)

Outcome-based indicators - adaptation actions

Outcome-based indicators assess the effectiveness of adaptation actions in reducing vulnerability. Where possible, they should be linked with equivalent impact indicators. They should also be considered alongside data about other developments that decrease or increase vulnerability. Without this, it would be impossible to attribute the success or failure of an adaptation action to the effectiveness or ineffectiveness of that action or to other developments.

4. Case studies

In this section, the conceptual framework for adaptation indicators is applied in both the biodiversity sector and two European regions. These case studies draw on the presentations, discussions and outputs of the *Expert meeting on climate change vulnerability and adaptation indicators* (Szentendre, 2008) and the *Adaptation indicators expert meeting* (Copenhagen, 2009). As stated above, adaptation has only recently become politically significant and, in consequence, work on the development of adaptation indicators has only just started. The current focus is, therefore, on process-based indicators, as these are likely to be of greater importance in the short term. Outcome-based indicators will increase in prominence in the longer term and more will then be developed.

4.1. Development of adaptation indicators for the biodiversity sector

Recent debate in the biodiversity sector has shown increasing importance being attached to the role of biodiversity in both climate change adaptation and mitigation. Examples include the outputs of CBD's *Ad hoc* Technical Expert Group on Biodiversity and Climate Change (<http://www.cbd.int/doc/?meeting=AHTEG-BDCC-02-02>) and the EU's 2009 Athens meeting (http://ec.europa.eu/environment/nature/biodiversity/conference/index_en.htm), and the discussion paper *Towards a strategy on climate change, ecosystem services and biodiversity* prepared by the EU *Ad Hoc* Expert Working Group on Biodiversity and Climate Change (2009).

Impact indicators for the biodiversity sector

A commonly used approach for developing and structuring indicators and for describing the interactions between society and the environment is the DPSIR (Drivers, Pressures, State, Impacts, Response) model. From the biodiversity perspective, the DPSIR indicator categories include: drivers (e.g. agriculture, forestry, fisheries), pressures (e.g. human appropriated, net primary productivity), state (e.g. species distribution, habitat quality, ecosystem goods and services), impacts (e.g. species loss, habitat loss, ecosystem collapse) and responses (e.g. nature directives, 2010 target, Common Agricultural Policy).

The SEBI 2010 (Streamlining European 2010 Biodiversity Indicators) process (<http://biodiversity-chm.eea.europa.eu/information/indicator/F1090245995>) adopted the DPSIR model to select a set of biodiversity indicators to monitor progress towards the EU 2010 target of halting biodiversity loss and to help achieve that target. SEBI 2010 has defined the indicator 'Climate impacts on effect on bird populations in Europe' to assess the impacts of climate change on biodiversity. In addition, new indicators are under development (e.g. impacts on Alpine plant species - linked to the GLORIA project, impacts on butterfly species - linked to the ALARM project). Currently, none of these consider adaptation. However, the European Topic Centres working on impact and adaptation indicators have agreed to collaborate in the development of new 'post-2010' indicators. This should ensure that additional indicators to monitor the impacts of climate change on Europe's biodiversity are identified and that these are linked with complementary adaptation indicators.

Adaptation principles for the biodiversity sector

A number of reviews of existing international and national guidance on adaptation to climate change have recently been carried out. These have identified principles to guide the development of adaptation policies, measures and actions to conserve species, habitats and ecosystems (e.g. Harley & Hodgson, 2008; Smithers *et al.*, 2008). Harley & Hodgson identified seven overarching adaptation principles for biodiversity and its conservation:

- **Take action now** - uncertainties surrounding the precise nature of future climate change and its impacts on biodiversity should not delay practical conservation action.
- **Maintain and increase ecosystem resilience** - the ability of ecosystems to absorb and recover from change should be enhanced to enable the widest range of biodiversity to survive and adapt to climate change.
- **Accommodate the impacts of climate change** - an increasingly dynamic and innovative approach to biodiversity conservation is needed to address the impacts of both gradual changes in climate and extreme weather events.
- **Facilitate knowledge transfer and action between partners, sectors and countries** - successful adaptation requires biodiversity conservation to be integrated with other land and water management activities across relevant sectors and the wider ecosystem service benefits to be recognised.
- **Develop the knowledge/evidence base and plan strategically** - the best available evidence should be used to make decisions that will allow biodiversity to adapt in an uncertain future.
- **Use adaptive conservation management** - effective conservation in a changing climate requires continual evaluation and review to progressively increase resilience and reduce vulnerability.
- **Undertake monitoring and identify indicators** - monitoring using robust indicators will provide essential knowledge of impacts, help shape adaptive management and measure outcomes.

These principles can be used in the development of adaptation indicators and to identify activities from which process-based and outcome-based indicators might emerge.

Towards adaptation indicators for biodiversity and its conservation

The adaptation principles described above are linked with a range of generic conservation activities. These relate to policies, measures and actions from which it is possible to exemplify how both process-based indicators and outcome-based indicators can be derived.

Process-based indicators for biodiversity - adaptation policy

Adaptation policies are likely to be principally focussed on increasing adaptive capacity in a sectoral, cross-sectoral and institutional sense, and at spatial scales ranging from the EU, to Member States, regional and local. A corresponding set of adaptation policy indicators should be developed, with consideration also being given to other drivers of and barriers to implementation (see section 3, above). The following examples illustrate the types of policies from which suitable indicators might be derived:

- Conserve the range and variability of species, habitats and ecosystems.
- Deliver existing biodiversity policy and legislative commitments and agreements.
- Amend biodiversity policy, legislation and agreements to reflect climate change.
- Work with ecological succession and not against it.
- Integrate adaptation into sectoral, regional and cross-border plans.
- Reassess adaptation policies, measures and actions as new evidence emerges.
- Communicate good practice and exchange information on successful adaptation.
- Coordinate adaptation and mitigation to avoid mal-adaptation (i.e. adaptation in the biodiversity sector should not compromise adaptation elsewhere or exacerbate the causes or consequences of climate change).

Process-based indicators for biodiversity - adaptation measures

Adaptation measures will be determined by adaptation policies and should ideally accord with the adaptive management cycle (Figure 4). Adaptation measure indicators should reflect to the delivery of these measures and the specific objectives set for each stage in the cycle. They should also give consideration to other developments that might reduce or increase vulnerability (see section 3, above). Examples of the types of measures from which suitable indicators might be derived include:

- Assessing climate change impacts on species, habitats and ecosystems.
- Maintaining existing conservation activities in protected areas and intervening habitats.
- Planning future conservation areas to protect vulnerable species, habitats and ecosystems.
- Avoiding development to allow the configuration of coasts and rivers to change naturally.
- Removing spatial barriers to increase natural adaptive capacity.
- Monitoring the occurrence and dispersal of 'potential native' species.
- Controlling the succession of invasive species.
- Considering translocation and *ex-situ* conservation of threatened species.

Outcome-based indicators for biodiversity - adaptation actions

The effectiveness of adaptation policies and measures will ultimately be reflected in the outcomes of adaptation actions. Robust adaptation actions will reduce vulnerability. Outcome-based indicators should be developed to assess the effectiveness of these actions (i.e. to measure the reduction in vulnerability). These should complement impact indicators and be considered alongside data about other developments that might decrease or increase

vulnerability. Examples of the types of actions from which outcome-based indicators might be derived include:

- Maintenance, restoration and recreation of habitats and ecosystems.
- Establishment of buffer zones around conservation areas.
- Establishment of interconnected networks of protected areas and intervening habitat.
- Reduction in stress and vulnerability not directly linked to climate change.

Application of adaptation indicators - an example

Enhancing species dispersal capacity and facilitating species movement is seen as an appropriate response to reduce climate change impacts. Policies to achieve this may be initiated at EU and national levels. Process-based indicators are needed to monitor the implementation of these policies. These policies can then lead to the delivery of national or regional measures to establish ecological networks. The delivery of these measures will be monitored with suitable process-based indicators. This in turn could drive local actions (e.g. through changing spatial plans) to improve habitat connectivity and therefore the ability of species to move. The outcome of these actions is increased resilience of those species most vulnerable to climate change. The effectiveness of these actions, and therefore of the associated policies and measures, will be monitored and measured by outcome indicators.

4.2. Regional adaptation strategies and indicators

Information relevant to the development of regional adaptation indicators was derived from recent adaptation initiatives in Andalucía, Spain and North Rhine Westphalia, Germany. Both regions have developed strategies to address climate change impacts, vulnerability and adaptation. The adaptation strategies for both are outlined below and a tabulated list exemplifying the sorts of adaptation indicators that might be applied in these and other regions then follows. Early outputs from the German 'KomPass' project (<http://www.anpassung.net/>) were also considered.

Andalucian Adaptation Strategy

Andalucía is a pioneering region within Spain as it is one of the first to develop a regional climate change strategy, the *Estrategia Andaluza ante el Cambio Climático (EACC)*, 2002 (<http://www.juntadeandalucia.es/EACC>). Three main work streams arose from this strategy: mitigation, adaptation and communication. The mitigation work programme was developed in 2006, whilst the adaptation strategy, the *Plan Andaluz de Adaptación al Cambio Climático (PAACC)*, is currently in draft and unpublished format.

The Climate Change Unit of the Andalucian Department for the Environment is responsible for the development of the adaptation strategy and allowed AEA access to the draft report. The following information is based on the March 09 version.

The aims of the strategy are to:

- Increase knowledge of climate change impacts in the region.
- Develop regional and local adaptation options based on analyses of sectoral impacts.
- Coordinate action on behalf of the regional administration and local stakeholders.
- Encourage education and participation in adaptation.

These aims will be delivered through five work programmes:

1. Immediate action.
2. Sectoral climate change impact analyses.

3. Sectoral adaptation options.
4. R&D and continuous knowledge development.
5. Governance.

The need for immediate action arises from the precautionary principle, the identified costs of inactivity and the process of adaptive management.

North Rhine Westphalian Adaptation Strategy

The German state of North Rhine Westphalia is also one of the first in Europe to launch a regional adaptation strategy (NRW, 2009 www.klimawandel.nrw.de). The work programme presented in the strategy includes commitments to:

- Increase public awareness of climate change and the need for adaptation.
- Improve knowledge of regional and local climate change impacts.
- Identify possible sector- and area-specific adaptation options.
- Increase the adaptive capacity of sectors and areas.
- Facilitate implementation of adaptation options.

In general, adaptation options are:

- Technologically oriented.
- Socio-economically oriented.
- Integrated with reductions in other sources of harm.

The strategy currently considers six key sectors and the urban and industrial environments. A common thread is the need for more rigorous monitoring to inform and review the effectiveness of adaptation. Examples of the options identified for each are outlined below:

- **Agriculture.** The focus is on soils with low water holding capacity, as these will be most affected by decreasing moisture availability. Adaptation options include growing different crop types, changing management practices and insurance regimes, and developing more soil-independent techniques.
- **Forestry.** A major challenge is to relate the long time horizons in forestry plans to climate change. Adaptation options include introducing new tree species (with an emphasis on drought and heat tolerance), and changing management practices to reduce the risk of storm damage and outbreaks of pests and diseases.
- **Nature and biodiversity.** Adaptation options include improving protection of vulnerable areas (e.g. wetlands), increasing connectivity of protected areas, and reducing non-climate stress factors.
- **Public health.** This is one of the most comprehensively described sectors, with the heat wave of 2003 being used to show the urgent need for action. Adaptation options are behavioural (e.g. drinking more water), educational (e.g. providing medical advice), and structural (e.g. using blue-green infrastructure to reduce heat-island effect).
- **Tourism.** Adaptation options include maintaining traditional pursuits (e.g. skiing) in the short term, whilst identifying new recreational opportunities for the longer term.
- **Water resources.** Climate change will have implications for water quality and availability and for flood protection. Adaptation options include increasing the flexibility of water management, improving drainage, and designating specific flood areas.
- **Urban environment.** The planning system can be used to increase resilience to climate change. Adaptation options include increasing green space and water bodies, and changing building regulations and design.

- **Industrial environment.** Adaptation options are concerned mainly with changing management practices.

Towards regional adaptation indicators

Whilst a wide range of adaptation options are proposed in both the Andalusian and North Rhine Westphalian adaptation strategies, neither cites any specific adaptation indicators. The following tables suggest, by way of examples, a number of process-based indicators (adaptation policy indicators and adaptation measure indicators) and outcome-based indicators. These have been extrapolated from information in these strategies, whilst drawing also on the German 'KomPass' project and the case study for the biodiversity sector (above).

Regional process-based indicators - adaptation policy

Sector	Indicator	Relevant for:	
		Andalucia	North Rhine Westphalia
General	Delivery of current policy, legislative and regulatory commitments.	X	X
	Amendments to policies, legislation and regulations based on new knowledge etc.	X	X
	Establishment of coordinating authorities and networks (e.g. for health).	X	X
	Use of adaptation scans by municipalities and local authorities.	X	X
	Engagement with stakeholders on adaptation.	X	X
Agriculture	Research into farming techniques that accommodate climate change.	X	X
Biodiversity	Integration of adaptation into regional ecosystem management plans.	X	X
	Research into ecosystem-based adaptation.	X	X
	Facilitation of shifts in species' distributions.	X	X
	Consideration of non-climatic stress factors.	X	X
Health	Development of regional and local strategies for addressing climate change impacts.	X	X
Tourism	Research into the effects of sea level rise on tourist areas.	X	
Water	Development of catchment-specific flood management policies/plans.		X
	Development of catchment-specific drought management policies/plans.	X	

Regional process-based indicators - adaptation measures

Sector	Indicator	Relevant for:	
		Andalucia	North Rhine Westphalia
General	Use of scenarios to inform adaptation options.	X	X
	Identification of cross-sectoral issues/concerns.	X	X
	Production of local adaptation guidance.	X	X
	Production of disaster management plans.	X	X
Agriculture	Implementation of measures to reduce soil erosion and desertification.	X	
	Introduction of drought and heat resistant crops.	X	
	Uptake of insurance to cover weather extremes.	X	X
Biodiversity	Monitoring of climate change indicator species.	X	X
	Removal of spatial barriers to increase natural adaptive capacity.	X	X
	Extension, connection and establishment of buffer zones around protected areas.	X	X
Health	Mapping and control of disease vector species (e.g. mosquitoes).	X	X
	Provision of climate control equipment for vulnerable people.	X	X
Tourism	Modification of recreational facilities to accommodate higher ambient temperatures.	X	X
Water	Construction of flood protection schemes.	X	X
Economy	Upgrade of transport infrastructure.	X	X

Regional outcome-based indicators

Sector	Indicator	Relevant for:	
		Andalucia	North Rhine Westphalia
Biodiversity	Reduction in degraded ecosystems.	X	X
Health	Reduction in deaths during heat waves.	X	X
Water	Reduction in water consumption.	X	
Economy	Reduction in economic losses due to floods.	X	X

5. Summary and next steps

This paper draws on the presentations, discussions and outputs of the *Expert meeting on climate change vulnerability and adaptation indicators* (Szentendre, 2008) and the *Adaptation indicators expert meeting* (Copenhagen, 2009) and builds on the Technical Paper *Climate change vulnerability and adaptation indicators* (Harley *et al.*, 2008). It presents a theoretical and practical basis for the development of adaptation indicators. It also uses case studies to exemplify how indicators to monitor and evaluate the effectiveness of adaptation policies, measures and actions might be defined.

The next step will primarily be to develop specific adaptation indicators for use in the biodiversity sector. Working with those involved in the SEBI process and other experts, the focus will be on determining how the proposals presented here might be translated into an agreed set of process-based and outcome-based indicators. In addition, a number of wider issues will be addressed, including:

- The specific purposes of monitoring and evaluating adaptation (as these influence the types of indicators that will be needed).
- The range of stakeholders likely to be involved in monitoring adaptation (including the role of the EC and EEA).
- The spatial resolution of adaptation indicators and the levels at which these should be focused (EU, Member State, regions, sectors, local stakeholders/institutions).
- The links with existing indicators (particularly impact indicators) and the need for new indicators.
- The relationship with the EC Climate Change Impacts, Vulnerability and Adaptation Clearinghouse Mechanism.

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