Adapting to the impacts of climate change

POLICY PERSPECTIVES

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About the OECD

The Organisation for Economic Cooperation and Development (OECD) is a multi-disciplinary intergovernmental organisation, tracing its roots back to the post-World War II Marshall Plan. Today, it comprises 34 member countries that are committed to democratic government and the market economy and the European Commission, with the major emerging economies increasingly engaged directly in the work. The OECD provides a unique forum and the analytical capacity to assist governments to compare and exchange policy experiences, and to identify and promote good practices through policy decisions and recommendations.

Adapting to the impacts of climate change

Our climate is changing and this will affect every sector of the global economy, in both developed and developing economies. Significant reductions in greenhouse gas emissions need to be complemented with adaptation policies. By preparing for a changing climate, policy makers can better protect communities, businesses and natural assets.

The OECD is working with countries to put in place the right policies in order to assess and prepare for climate change. This brochure provides the key lessons learnt as countries move from planning to implementing adaptation. It includes challenges and recommendations for climate adaptation, with a focus on OECD member countries.

Inside

1 CLIMATE IMPACTS

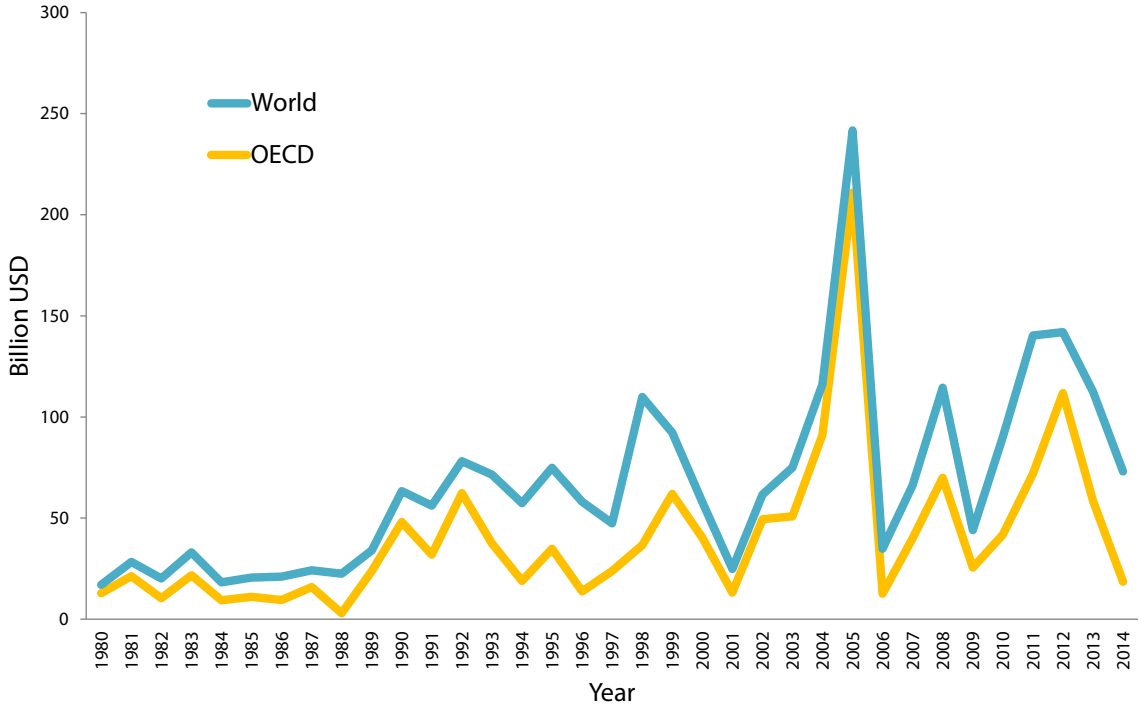
Impacts from climate change are increasingly being felt

Our climate is already changing: the global average of land and ocean surface temperatures has increased by 0.85° C since pre-industrial times, while ocean acidity increased by 26%. Some types of extreme weather events have become more frequent and severe (IPCC, 2014). These changes are **exacerbating existing risks** to societies and economies, including pressures on food production due to changes in agricultural yields, or the risks of cities being flooded due to more extreme rainfall. Climate change could also lead to the **emergence of new risks**, such as the spread of vector-borne diseases to areas that had previously been free of them.

In addition, the more global average temperatures increase, the greater the likelihood of encountering catastrophic changes. These pervasive and irreversible impacts could include the collapse of the Greenland ice sheet, the melting of the Himalayan icecap glaciers, and the die back of the Amazon rainforest (Dow et al., 2013).

Extreme weather events provide a vivid illustration of the potential consequences of climate change. Figure 1 shows the **upward trend of economic losses** from climatological (e.g. heat waves), meteorological (e.g. storms) and hydrological (e.g. floods) events. The trend to date is in large part due to the increasing exposure of people and economic assets to weather- and climate-related risks, but climate change is projected to become a more important driver for future losses. These loss estimates only represent a subset of the full costs of weather events, as they do not include non-market impacts such as the loss of ecosystem services and long-term health effects (OECD, 2015a).

Figure 1. **Economic losses from climatological, meteorological and hydrological disasters, 1980-2014**



Source: EM-DAT (Emergency Event Database) (n.d.), "The International Disaster Database", Centre for Research on the Epidemiology of Disasters, www.emdat.be/ (accessed 27 February 2015).

The burden of climate risks will not be borne equally. Characteristics such as age, health, income and mobility, affect people's vulnerability and their capacity to respond. Disproportionate impacts on vulnerable communities are a challenge even in countries with high average levels of economic development.

2 COSTS AND BENEFITS OF CLIMATE CHANGE

Information on climate risks is improving, but major gaps remain

The Economic Consequences of Climate Change (OECD, 2015b) investigates the consequences of a range of climate impacts on the different sectors and regions of the global economy. In the vast majority of regions, market consequences from climate change are projected to be negative. These include agriculture (changes in crop yields), coastal zones (capital and land losses from sea level rise), some extreme events (incl. capital losses from hurricanes), health (labour productivity losses from heat stress; costs of diseases; health expenditures) and energy and tourism demand. Significant non-market impacts are projected to occur, and risks may develop exponentially, particularly once certain tipping points in the climate system have been reached. Net economic consequences are projected to be particularly large in Africa and Asia, where the regional economies are vulnerable to a range of different climate impacts, such as heat stress and crop yield losses. Macroeconomic costs in most countries in these regions are projected to be between 1.5% and 6.5% of GDP by 2060; the **global average costs are equivalent to a 1.0%-3.3 reduction in GDP.** In Canada and Russia, the modelled net economic benefits are projected to outweigh the negative impacts, at least in the coming decades.

Action on climate mitigation and adaptation both have the potential to reduce these impacts and risks, and bring down the macroeconomic costs from selected market impacts (Table 1).

Table 1. **Projected macroeconomic costs of selected climate impacts depending on the implementation of new climate policies**

Type of climate policies	Annual global GDP losses in 2100
None	2-10%
Both adaptation and mitigation policies	1-3%

Once greenhouse gases are emitted, they will have unavoidable effects on the climate and economy for a century or more, and lock the world into higher impacts and a worse risk profile.

Ambitious adaptation and mitigation policies can not only reduce future costs of climate change, but – perhaps more importantly – also limit the **increasing downside risks associated with higher warming**. Despite the capacity of mitigation to limit impacts, however, significant impacts from climate change are projected to persist in vulnerable regions, such as in most countries in Africa and Asia. Even with optimal mitigation and adaptation policies in place, there will still be some remaining market impacts.

Modelling of climate impacts helps us to understand some of the processes by which climate change will affect societies, the relative importance of the different impacts modelled and their regional distribution. However, they only include some of the potential costs of climate change.

Even the most sophisticated models only include a subset of the potential risks and opportunities arising from a changing climate. One of the underlying challenges is the lack of evidence on new and potentially catastrophic changes (e.g. collapse of Greenland ice sheet), meaning they are rarely included in the headline results. Action to mitigate and adapt to climate change is motivated by the desire to manage the impacts that are likely to happen, but is also insurance against the risk of catastrophic change.

At the sectoral level, knowledge about climate risks and the ensuing costs and benefits of adaptation is improving, but coverage is uneven and some risks remain inherently difficult to model. Table 2 provides an overview of the current state of the literature. Historically, the best known climate risks have been the impact of sea-level rise on coastal zones, coastal storms and flooding. Over the last decade, knowledge of freshwater management, adaptation of agriculture and the built environment have all increased substantially. The largest remaining data gaps are climate impacts on biodiversity and ecosystems services, as well as businesses and industry.

Few decision makers in the public or private sectors have the full picture of their exposure to the risks of climate change (Agrawala et al, 2011; OECD, 2015a). For example, while some impacts are routinely captured in government budgets, such as payments from catastrophe funds, other indirect costs (such as impacts on tax revenues) are not. In addition, governments are exposed to **contingent liabilities** that can only become apparent once an event occurs. Improving understanding of these impacts and liabilities can help countries' to better manage their exposure to climate risks (OECD, 2012).

Table 2. **Quality of the coverage of the sectors in the adaptation literature**

Risk/Sector	Coverage/Discussion	Cost estimates	Benefit estimates
Coastal zones and coastal storms	Comprehensive coverage (flooding and erosion) at global, national and local levels in impact assessment studies. Good evidence base on early low regret options and iterative adaptive management including policy studies and decision making under uncertainty (real options).	✓✓✓	✓✓✓
Floods, including infrastructure	Growing number of adaptation cost and benefit estimates (impact assessment studies) in a number of countries and local areas, particularly on river flooding. Evidence base emerging on low regret options and non-technical options. Some applications of decision making under uncertainty.	✓✓	✓✓
Water sector management, including cross-sectoral water demand	A recent focus on supply-demand studies at the national level, but a range of global, river basin or local studies available. Focus on supply, engineering measures; less attention to demand, soft, and ecosystem-based measures. Some examples of decision making under uncertainty, particularly robust decision making, with policy relevant studies.	✓✓	✓
Other infrastructure	Several studies on road and rail infrastructure. Examples of wind storm and permafrost.	✓	✓
Agriculture (multi-functionality)	High coverage of the benefits of farm level adaptation (crop models), and some benefits and costs from impact assessment studies at global and national level. Evidence base emerging on potential low regret adaptation, including climate smart agriculture options (soil and water management).	✓✓	✓✓
Overheating (built environment, energy and health)	Good cost information on heat-alert schemes and some cost-benefit studies for future climate change. Increasing coverage of autonomous costs[1] associated with cooling from impact assessment studies (global and national). Growing evidence base on low-regret options for built environment (e.g. passive cooling).	✓✓	✓
Other health risks	Increasing studies of preventative costs for future disease burden (e.g. water, food and vector borne disease), but coverage remains partial.	✓	✓
Biodiversity/ ecosystem services	Low evidence base, with a limited number of studies on restoration costs and costs for management of protected areas for terrestrial ecosystems.	✓	
Business, services and industry	Very few quantitative studies available, except for the electricity sector, oil and gas production and tourism. Some focusing on winter tourism and some on autonomous adaptation from changing summer tourism flows.[1]	✓	

Note: [1] can be considered an impact or as autonomous (i.e. unplanned) adaptation.

Key: ✓✓✓ Comprehensive coverage at different geographical scales and analysis of uncertainty.
✓✓ Medium coverage, with a selection of national or sectoral case studies.
✓ Low coverage with a small number of selected case studies or sectoral studies.The absence of a check indicates extremely limited or no coverage.

Source: Adapted from ECONADAPT (2015), "The Costs and Benefits of Adaptation", results from the ECONADAPT Project, ECONADAPT consortium.

3 ADAPTATION PLANNING

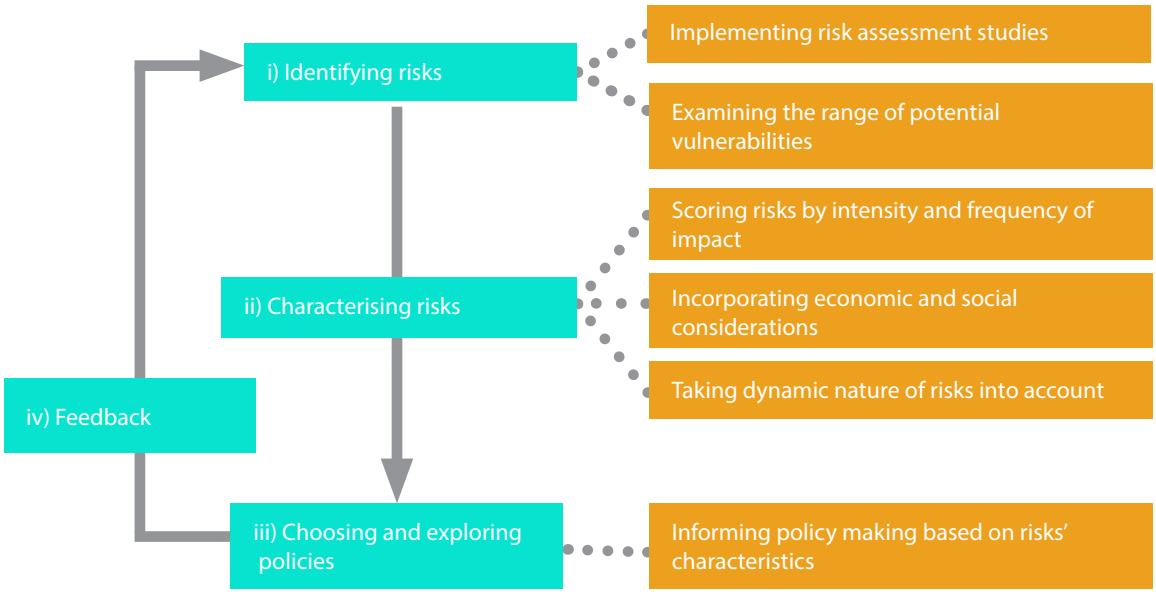
Adaptation planning should be flexible and integrated into policy making

Uncertainty about the future need not be a barrier to preparing for the effects of climate change. Some aspects of the climate (e.g. rising temperatures) are better understood than others (e.g. changes in precipitation) but all are subject to some uncertainty (IPCC, 2014). Moreover, climate risks are the result of complex, and often unpredictable, interactions between climate and economic, social and environmental systems. For example, whether prolonged high temperatures lead to excess mortality will be affected by other factors, including urban planning, building design and the effectiveness of emergency planning.

As the characteristics of risks are increasingly difficult to predict over long time-horizons, the policy response should involve a proportionate, flexible and iterative risk management approach in adaptation planning (Figure 2). This includes:

- **Improving knowledge about the risks** from climate change through national assessments.
- Using these assessments to **plan for a range of possible outcomes**, and not one 'most likely' projection.
- Accepting that zero risk is unrealistic, and **preparing the response and recovery systems** to cope with the remaining risk.

Figure 2. **The four steps of a risk-based approach to adaptation**



Climate risks, and the measures to address them, are inherently linked with other policy measures. The efficiency and effectiveness of adaptation planning can be increased by integrating it with the relevant policy processes and decision cycles, for instance regarding land use planning and resource management. By recognising that adaptation is one of many policy objectives, not necessarily the dominant one, **mainstreaming ensures that adaptation priorities are aligned with policy priorities**. This avoids some potential misalignments with climate adaptation, such as: regulatory regimes for infrastructure that deter investment in resilience; planning policies that encourage development in vulnerable areas; and under-pricing of natural resources (OECD, 2015c).

Countries are increasingly taking a national, strategic approach to preparing for climate change. Currently, **24 OECD countries have published national adaptation strategies** and 7 are in the process of developing them. Under the UNFCCC National Adaptation Plan (NAP) process, 52 developing countries, mostly Least Developed Countries, have submitted or are developing strategies on their mid- to long-term adaptation needs (UNFCCC, 2015). In parallel, regional and city-level plans have steadily grown in importance, spurred by organisations like ICLEI, C40 and World Mayor Council on Climate Change. Policy makers at all levels of development should exchange and learn from one another, to make the most of the resources invested in adaptation.

This progress is encouraging but there is still room for improvement. OECD countries' adaptation strategies are all based on impact assessments, often based on historic trends and climate scenarios, and most have identified adaptation options, but few have incorporated adaptation into projects, or established institutional response mechanisms (Table 3). Only two of the NAPs submitted to the UNFCCC have undertaken comprehensive risk and vulnerability assessments (UNFCCC, 2015).

Table 3. **Coverage of adaptation in National Communications**

		Adaptation options and policy responses		
		Establishment of institutional mechanisms for adaptation responses	Formulation of adaptation policies	Explicit incorporation of adaptation in projects
No adaptation strategy published	Canada	●*	●	●*
	Czech Republic – planned for 2016		●*	●*
	Estonia – aplanned for 2016	○	○*	
	Greece – under development	○*	○	○*
	Iceland			
	Israel – under development	○	●	
	Italy – under development		○	○
	Japan – planned for 2015		○	
	New Zealand	○	●	
	Slovenia – under development		○	
Aadaptation strategy published	Australia	●	●	●*
	Austria	○*	●*	○
	Belgium	●*	●	
	Chile	○*	○	
	Denmark	○	●	●
	Finland	○	●	○
	France	●*	●	
	Germany	○*	●	○
	Hungary	○*	○	○
	Ireland	●*	○	
	Korea		●	
	Luxembourg		●*	
	Mexico	○	●	
	Netherlands (new NAS in 2016)	○*	●	●*
	Norway	●	●*	
	Poland	○*	●*	
	Portugal	●*	●	
	Slovak Republic	*	●*	○*
	Spain	●*	●	
	Sweden	●*	○	
	Switzerland	●	●*	●
	Turkey	○*	●*	●*
	United Kingdom	●	●*	●*
	United States	●*	●*	●*

Coverage in NCs:

- Extensive discussion
- Some mention/limited discussion
- No mention of discussion

* Changes that occurred since last National Communication published

Quality of discussion in NCs:

- ● Discussed in detail, i.e. for more than one sector or ecosystem, and/or providing examples of policies implemented, and/or based on sectoral/national scenarios
- ○ Discussed in generic terms, i.e. based on IPCC or regional assessments, and/or providing limited details/no examples/only examples of planned measures as opposed to measures implemented

Note: The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

Source: OECD (2015), Climate Change Risks and Adaptation: Linking Policy and Economics, OECD Publishing, Paris, DOI: http://dx.doi.org/10.1787/9789264234611-en.

4 IMPLEMENTING ADAPTATION AT THE SECTORAL LEVEL

Adaptation challenges, opportunities and constraints vary by sector

Water and water-related hazards have a significant effect on economic growth (Sadoff et al., 2015). To increase their water security, the majority of countries' efforts to date have focused on building the evidence base and developing information-based instruments, such as flood risk maps and adaptation guidance for local governments. Some countries are also revising laws and regulations such as sustainable water abstraction limits, building codes and land-use planning. They are also adjusting economic instruments such as water tariffs, water-related environmental taxes, and flood insurance schemes to reduce baseline stress on water systems, raise financing and address increasing flood risks (OECD, 2013).

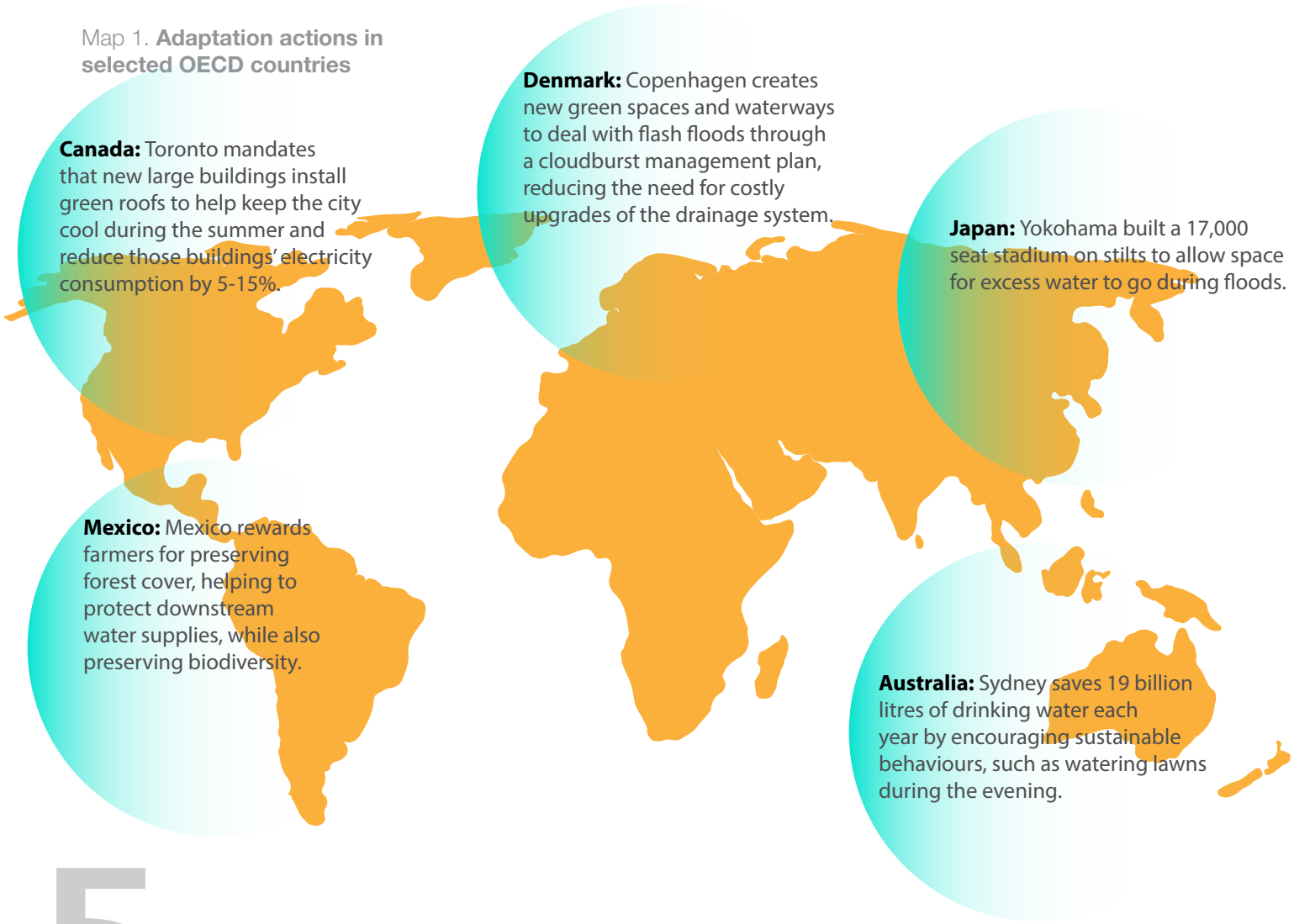
Climate change will affect the yields and prices of most **agricultural commodities**. By modelling the regional effects of different climate scenarios in the future, and the impact of different adaptation strategies, the OECD has found that autonomous adaptation may not be sufficient to avoid all losses. A range of diversified measures are required to reduce risks, such as the adoption of drought resistant crops or improved irrigation efficiency (Ignaciuk and Mason-D'Croz, 2014). Relevant and up-to-date business advice, training and extension are key to stimulate an uptake of innovative technologies that support farmers' adaptive capacity (Ignaciuk, 2015).

Cities have a unique ability to address global climate change challenges, but they need to be supported by national and regional policies, legislative framework and economic incentives, as well as private sector financing. Enabling cities to access financial support from other public authorities or the private sector is key to removing their barriers to adaptation (OECD, 2014a).

Climate change will affect **energy sector** infrastructure, may cause energy supply disruptions and alter energy demand patterns. The International Energy Agency (IEA) sees building climate change resilience as one of the key tasks in enhancing energy security. Various approaches are needed, including risk assessment, technological solutions, adapted flexible management practices as well as emergency preparedness measures, governmental policies and fiscal instruments, including insurance. The IEA's annual Nexus Forum brings together governments and businesses across the energy sector, and other stakeholders to share knowledge and experience on these issues (IEA, 2014a). Several IEA flagship reports, including World Energy Outlook have been integrating the issue of the energy sector resilience to climate change in their analysis and key messages (IEA 2012, IEA 2013, IEA 2014b).

The **nuclear power** sector is an example of an energy sector that is paying great attention to climate change and the issue of resilience. Indeed, given the long lifetime of nuclear power plants (40 to 60 years), the sector has become increasingly aware of the impact that changes in the climate, including extreme weather events, can have on the operation and safety of its facilities. This has been factored in the design of newer plants, as well as in the regulatory framework, for instance related to siting of new plants that could operate up to the 2080s or beyond. For existing plants, safety requirements require that risks related to external events, including climate events, be mitigated so that safety is not compromised. The Nuclear Energy Agency (NEA, 2015) recommends that governments put in place an investment framework for long-term adaptation and ensure that regulations are conducive to climate change adaptation.

Map 1. **Adaptation actions in selected OECD countries**



5 MONITORING AND EVALUATION

Robust monitoring and evaluation is needed to inform policy development

Given the scale of the adaptation challenge, it is essential that effective approaches are being adopted and implemented. Monitoring and evaluation can improve policy learning and strengthen accountability by tracking how resources are spent and whether the policy or project is delivering as expected (OECD, 2015d).

Four key tools for monitoring and evaluation of adaptation are:

1. **Climate change risk and vulnerability assessments** can provide a baseline of domestic vulnerabilities to climate change against which progress on adaptation can be reviewed. If repeated, such assessments can also demonstrate how risks and vulnerabilities are changing over time.
2. **Indicators** facilitate an assessment of progress made in addressing adaptation priorities. However, indicators cannot explain on their own how the change came about. Reporting on, and using indicators, is resource intensive. They must therefore be carefully defined, and when possible, draw on existing data sources.
3. **Project and programme evaluations** can help to identify what approaches to adaptation are effective in achieving agreed adaptation objectives and to understand what some of their enabling factors for success may be.
4. **National audits and climate expenditure reviews** examine if resources allocated for adaptation are appropriately targeted and allocated cost-effectively. This information may be particularly useful when resources are specifically earmarked for adaptation.

The complexity of the monitoring and evaluation approach used should be proportionate and avoid putting undue pressure on administrative capacity. It may not be necessary, for instance, to start collecting new data, as the environmental and socio-economic data that countries already collect on a regular basis can inform the monitoring and evaluation of adaptation. Remaining data gaps can gradually be addressed by, for example, incorporating relevant adaptation questions into established data collection processes such as household surveys. Given the diverse set of data used to monitor and evaluate adaptation, a co-ordination mechanism can usefully link data producers and users.

In the case of developing countries, development co-operation providers can support the development of partner countries' own statistical systems by, to the extent possible, drawing on data collection mechanisms already in place for their own reporting requirements. When data gaps exist, development co-operation providers can support initiatives that will contribute to enhanced capacity of the partner country's statistical system rather than focus on the collection of data for discrete projects and programmes (OECD, 2014b).

Monitoring and evaluation is still in its infancy, and quite a few of the national adaptation plans or strategies put in place by OECD or partner countries still have to develop frameworks. The table below (Table 4) presents examples of existing frameworks.

Table 4. **Emerging country indicators to monitor and evaluate adaptation**

Country	Approach and overview of the proposed indicators
Kenya	The National Performance and Benefits Measurement Framework (2012) tracks both adaptation and mitigation actions under the Kenyan National Climate Change Action Plan. It combines indicators of institutional capacity (top-down) and vulnerability (bottom-up). Both types of indicators comprise national-level indicators (process-based), and county-level indicators (outcome-based), and are closely linked to Kenya's Vision 2030 development strategy.
Philippines	The National Climate Change Action Plan (2011) is monitored yearly and evaluated every three years, against set immediate, intermediate and ultimate outcomes, using mostly process-based indicators.
United Kingdom	Statutory evaluation of the National Adaptation Programme (2014) published in 2015 using detailed indicators on vulnerability, realised impacts and uptake of adaptation action, as well as an analysis of decision-making processes. The evaluation framework has been developed through sectoral assessments over the 2012-2014 period (flooding and water scarcity in the built environment, natural environment, infrastructure, business and public health).
Germany	The Indicator System to evaluate the Strategy for Adaptation to Climate Change (2008) was published in September 2015. It comprises a vulnerability assessment, an indicator-based assessment of the 15 action and cross-sectional fields of the Strategy, and a higher-level evaluation of whether the Strategy is addressing the projected risks and opportunities from climate change.
Australia	A National Adaptation Assessment Framework is under development, with the initial set of 12 indicators identified currently subject of a consultation. These indicators are structured around the social and economic drivers of adaptation the activities expected to take place for a successful adaptation and the outcomes achieved thanks to it.
France	A set of process-based indicators have been developed to reflect the 230 measures identified in the French National Adaptation Plan (2011-15).

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