NET ZERO+
Building Climate
and Economic Resilience

Climate change adaptation: Policies for a resilient future

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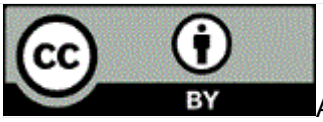
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Abstract

With average global temperatures nearly 1.5°C above pre-industrial levels in 2023 and extreme weather events becoming more frequent and intense, governments need to urgently act to accelerate climate change adaptation. This paper highlights the need for a four-step, iterative process for effective climate adaptation policymaking, including 1) climate risk assessment, 2) policy planning and design, 3) implementation, and 4) measurement and evaluation. Effective adaptation requires measurable objectives, whole-of-government co-ordination, stakeholder engagement, sufficient funding, and sound mechanisms to monitor progress and evaluate the effectiveness of policies. Data and methodological limitations are key challenges for sound measurement and evaluation. Specific attention is paid in this paper to the role of multi-level governance and policies for building resilience in food systems due to their vulnerability to climate change.

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Table of contents

Abstract 3

Acknowledgments 4

Executive summary 6

1 The adaptation imperative 8

2 Effective policy making for climate adaptation 12
- 2.1 Assessing climate risks and identifying priorities 13
- 2.2 Developing targets, strategies and measures through a whole-of-government approach 14
- 2.3 Measuring implementation progress and evaluating effectiveness 18
- 2.4.The role of multiple levels of government 19

3 Summary and conclusion 22

References 24

FIGURES

Figure 1. Population exposure to extreme heat is increasing across OECD and OECD partner countries 9
Figure 2. Determinants of climate impacts 10
Figure 3. The adaptation policy cycle 12

TABLES

Table 1. Adaptation measures 15
Table 2. Local standards or regulations targeting climate adaptation 20

Executive summary

As the impacts of climate change become increasingly visible, actions to enhance the resilience of people, economies, and ecosystems must accompany efforts to achieve net-zero greenhouse gas emissions by 2050. This paper outlines four key steps for effective policymaking for climate change adaptation, highlighting the role of multiple levels of government. Specific attention is paid to building resilience in food systems, given their unique vulnerability to climate change. A separate paper on finance for climate adaptation will also be published as part of the Net Zero+ policy paper series.

The paper builds on the work of several OECD committees, including (in alphabetical order): the Committee for Agriculture, Fisheries Committee, Employment, Labour and Social Affairs Committee, Economic Policy Committee, Environment Policy Committee, Health Committee, Investment Committee, Public Governance Committee and Regional Development Policy Committee.

Key messages

- Global average temperatures are approaching 1.5°C above pre-industrial levels, exacerbating the frequency and severity of extreme weather events. Governments need to act urgently to promote adaptation to climate change impacts.
- Countries recognise the importance of identifying and measuring targets to accelerate action: the 2023 United Nations Conference of the Parties of the UNFCCC (COP28), adpted adaptation targets to help assess progress on the Global Goal on Adaptation.
- Effective policy making for adaptation entails a four-step, iterative process: 1) climate risk assessment, 2) policy planning and design (including through the adoption of National Adaptation Strategies (NAS) and National Adaptation Plans (NAP)), 3) implementation, and 4) measurement and evaluation. Policies and plans should be updated regularly based on the results of measurement and evaluation.
- Evidence suggests that countries are increasingly implementing climate risk assessments (CRAs), although challenges persist in assessing exposure and vulnerabilities because of data and methodological limitations.
- Developing effective National Adaptation Strategies (NAS) and National Adaptation Plans (NAP) requires setting measurable and time-bound objectives based on the results of CRAs; ensuring a whole-of-government approach to co-ordinate efforts across sectors and levels of government; fostering strong stakeholder engagement; prioritising flexible adaptation actions; and ensuring sufficient funding and technical capacity for policy implementation.
- Governments should move beyond planning and urgently advance implementation. Policy packages combining multiple policy levers are often needed to drive effective adaptation, including economic incentives, regulatory measures, information provision, and direct provision of public goods such as coastal protection infrastructure.
- A significant gap remains in measurement and evaluation of adaptation actions. Legislation requiring measurement and evaluation of measures, using indicators to assess progress against

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objectives, and enhancing data collection are instrumental to advance measurement and evaluation capacity.

- Food systems are particularly vulnerable to the impacts of climate change and play a significant role in national adaptation strategies and plans. Climate change can impact crop yields, animal productivity, and fisheries due to increased heat, drought, pest outbreaks, and increases risks to food storage and transport posed by extreme weather events. Promoting innovation and reforming price support and other distortive measures are key no-regret measures to increase food system resilience.
- Regional disparities in exposure to climate risks require "place-based" adaptation strategies. Subnational authorities play a crucial role in climate adaptation by overseeing local policies and accounting for a large share of investment in key infrastructure, yet they face challenges including resource constraints and skills gaps. Effective national-local co-ordination, strengthening local technical capabilities, innovative financing mechanisms, and improved access to climate finance play important roles in ensuring that climate policies work for all regions.

The Net Zero+ project

The OECD's Horizontal Project "*Net Zero+: Building Climate and Economic Resilience*" harnesses the multidisciplinary reach of the OECD to support governments in driving the swift transformational change needed to tackle climate change. The project provides analysis and insights for governments to accelerate and scale up climate action: driving a rapid and resilient transition to net-zero while building economic and societal resilience to impacts of climate change.

1 The adaptation imperative

Governments face an adaptation imperative. With global average temperatures already almost 1.5°C above pre-industrial levels in 2023[1], and the window for meeting the Paris Agreement target rapidly closing[2], governments need to act now to address not only the causes, but equally the consequences, of climate change.

The intensity and unpredictability of extreme weather events are increasing (OECD, 2023[1]). Globally, drought intensity, extreme precipitation and floods increased sharply between 2002 and 2022 (Rodell and Li, 2023[2]). Drought has also become more commonplace across OECD Member and partner countries over the period 2018-2022 compared to 1981-2010. The duration of the fire weather season grew by 27% between 1979 and 2019 (OECD, 2023[3]), and the number of people exposed to days with maximum temperatures exceeding 35°C increased by 11.3% over the same period (Figure 1) (OECD, 2023[1]). While significant geographical differences exist, and in some regions the frequency and intensity of extreme weather events may even decrease, future projections under different climate scenarios point to a further intensification of extreme events in many regions.

The consequences of climate variability and extremes are profound, extending across social, environmental, and economic systems. In addition to severe implications for human health (Box 2), these events damage physical assets and inflict significant indirect impacts (see Box 1. Determinants of climate impactsfor determinants of climate impacts). In the United States alone, the economic toll of wildfires ranges from USD 63.5 billion to USD 285 billion every year[3] (OECD, 2023[3]) (Thomas et al., 2017[4]). Water-related disasters such as floods and droughts account for over 20% of the country's annual economic losses from extreme weather events, amounting to USD 4.5 billion and USD 8 billion respectively (NOAA National Centers for Environmental Information, 2024[5]). Similarly, flooding in Germany and Belgium in 2021 led to a total loss of EUR 44 billion, and the compound drought and heat events that affected Europe in 2022 cost approximately EUR 40 billion (European Environment Agency, 2023[6]).

The impacts of slow onset events[4] can be equally dramatic. For example, sea-level rise could reach one metre before the end of this century, multiplying risks for coastal areas (OECD, 2019[7]). Without climate adaptation, the cost of flood damage from a sea-level rise of 1.3 metres (higher end of the projection) would reach USD 50 trillion every year by 2100, equivalent to 4% of the world's annual gross domestic product (GDP) (OECD, 2019[7]).

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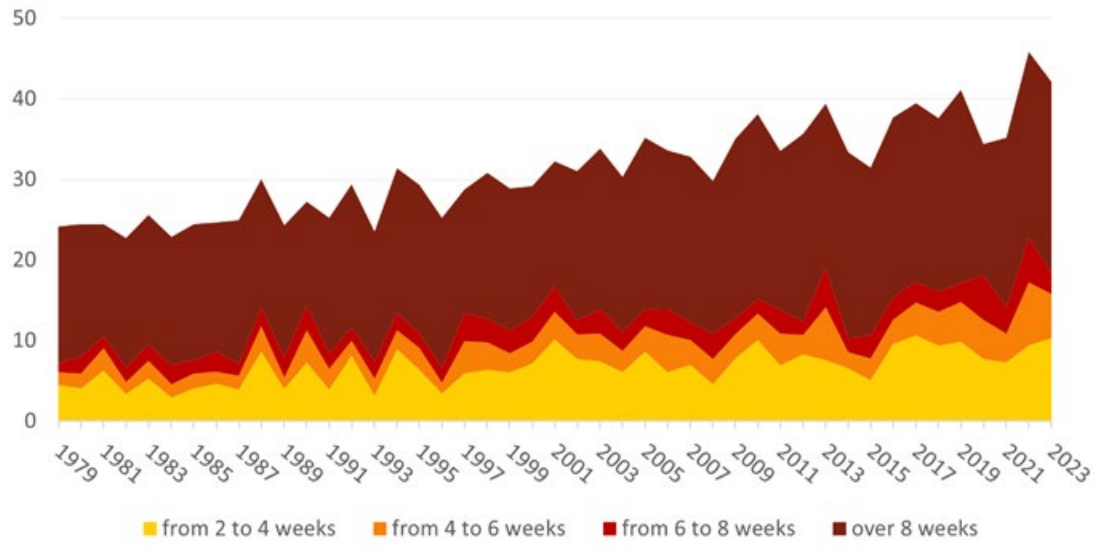
Figure 1. Population exposure to extreme heat is increasing across OECD and OECD partner countries

Percentage of population exposed to more than two weeks of temperatures exceeding 35°C, OECD and OECD partner countries, 1979-2023



Note: Over- or under-estimations of the estimated exposure to extreme temperature are possible due to the spatial resolution of gridded data, particularly for smaller countries or regions. A variety of indicators has been developed that estimate exposure to extreme temperatures; these should be consulted for more detailed analysis of individual countries.
Source: (OECD, 2023[1]).

Climate change impacts disproportionately affect vulnerable communities, such as lower-income households, indigenous peoples, women, children and the elderly, intensifying existing inequalities (IPCC, 2022[8]). For example, low-income population groups often live in areas with low-cost housing that is prone to climate change hazards and poorly adapted to climate risks (OECD, 2023[9]). At the same time, socio-economic factors and gender norms increase the vulnerability of women (OECD, 2021[10]). Climate change will also contribute to forced displacement, forcing more people to migrate and altering migration routes and settlement sites. Displaced populations are ill-prepared to adapt to climate change, as they often live in remote locations, informal settlements, with limited access to basic services and infrastructure (UNHCR, n.d.[11]).

Box 1. Determinants of climate impacts

Hazard: The potential occurrence of a natural or human-induced physical event or trend that may cause loss of life, injury, or other health impacts, as well as damage and loss to property, infrastructure, livelihoods, service provision, ecosystems, and environmental resources.

Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be affected by hazards.

Risk: The results of dynamic interactions between climate-related hazards with the exposure and vulnerability of the affected human or ecological system to the hazards.

Impact: The consequences of realised risks on natural and human systems, where risks result from the interactions of climate-related hazards, exposure, and vulnerability. Impact generally refers to effects on lives, livelihoods, health and well-being, ecosystems and species, economic, social, and cultural assets, services, and infrastructure. Impacts can be adverse or beneficial.

Figure 2. Determinants of climate impacts

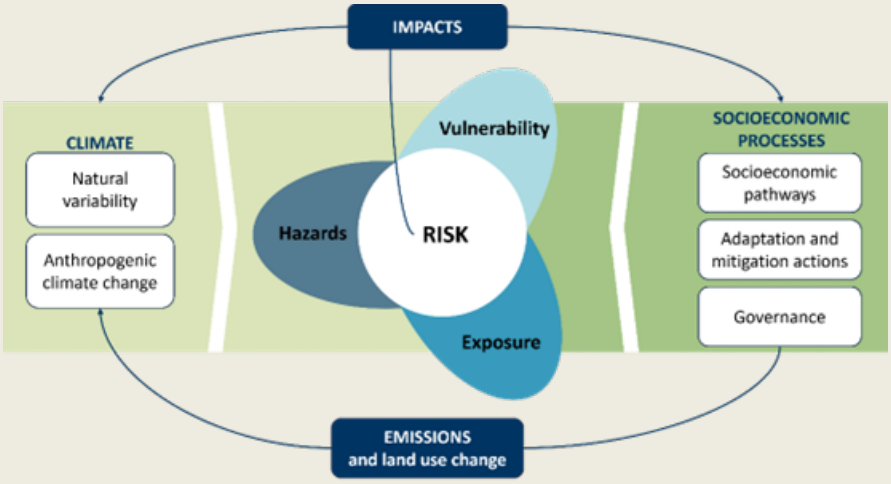


Figure source: Authors based on (IPCC, 2012[12]).

Source: Definitions from (IPCC, 2023[13]).

Climate adaptation calls for multiple approaches and government co-ordination. Certain adaptation measures can provide rapid relief, such as planting vegetation (ideally native plants that are well-suited to the local environment and support local biodiversity) to reduce heat stress in cities, unsealing soil within urban areas to reduce flood risk, and removing excess wildland fuel to reduce wildfire risk (see section 2.2 for more on nature-based solutions). Other measures, such as building climate-resilient infrastructure or relocating exposed communities,[5] require longer implementation timeframes and larger financial investments. In many cases, adaptation action also requires cross-level, cross-boundary, and cross-sectoral co-ordination, which can represent a challenge to timely action. While governments are increasingly introducing adaptation plans, policies and measures (OECD, 2023[14]) gaps remain in implementation and understanding of the effectiveness of policy actions (OECD, 2024[15]).

Box 2. Climate change impacts on human health and well-being

Heat stress is one of the primary causes of weather-related fatalities and can worsen pre-existing conditions such as cardiovascular disease, diabetes, asthma, and mental health issues, and facilitate

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the transmission of certain infectious diseases. Heatstroke has a high fatality rate: for example, the heatwave that hit Europe in the summer of 2003 resulted in approximately 80,000 deaths (though estimates vary widely), and it is estimated that more than 60,000 heat-related excess deaths occurred in the summer of 2022 in Europe. Extreme heat adversely affects pregnant women by increasing the risk of stillbirth, low birth weight, reduced gestational age, and neo-natal stress. Children, the elderly, and people from lower socio-economic backgrounds are also particularly vulnerable to heat stress. For example, in 2013-2022, heat-related deaths of people older than 65 years increased globally by 85% compared with 1990-2000. Moreover, heatwaves degrade air quality, leading to subsequent impacts on human health, ecosystems, agriculture, and everyday activities.

Additional direct and indirect health impacts from climate change encompass water-, food-, and vector-borne diseases, fatalities, injuries, shifts in air pollution and allergens, consequences stemming from changes in agricultural production and food insecurity, and implications for conflict. These can be caused by both slow onset events and extreme weather events. For instance, sea-level rise can cause direct fatalities from coastal flooding and pose risks to vital infrastructure such as hospitals, potentially causing knock-on effects and impacting health outcomes even for those who were not initially affected by the event. Meanwhile, droughts reduce water quality and availability and, in extreme cases, can lead to malnutrition. Long-term health impacts caused by particulate matter emissions ($PM_{2.5}$, PM_{10}) emitted during wildfires include increased respiratory and cardiovascular diseases, neurological and psychological disorders, skin and eye issues, and adverse birth outcomes. Overall, exposure to wildfire smoke alone is responsible for approximately 340,000 premature deaths annually worldwide.

Climate change impacts can magnify mental health risks, both through exposure to traumatic events and by exacerbating pre-existing conditions such as poverty, unemployment, and social marginalisation. For example, in the aftermath of extreme wildfires, higher rates of insomnia, depression, post-traumatic stress disorder (PTSD), and other psychological conditions have been observed among affected populations. Recent evidence also suggests that new forms of mental anguish linked to climate change are emerging, such as eco-anxiety, eco-paralysis, ecological grief, and solastalgia (i.e. environmentally induced distress).

The health consequences of extreme temperatures also have implications for the labour market. Heat stress has significant effects on workers' productivity and health, as it impairs both physical and cognitive performance, increasing absenteeism and elevating the risk of work-related accidents and machinery malfunctions. Data from the International Labour Organization (ILO) shows that, at 33–34°C, a worker operating at moderate work intensity loses 50% of their work capacity. In European OECD countries and the United States, 13% of workers, particularly those employed in outdoor and heavy industries, experience significant heat discomfort. Education is also affected, as heat stress is associated with lower performance in high-stakes school examinations.

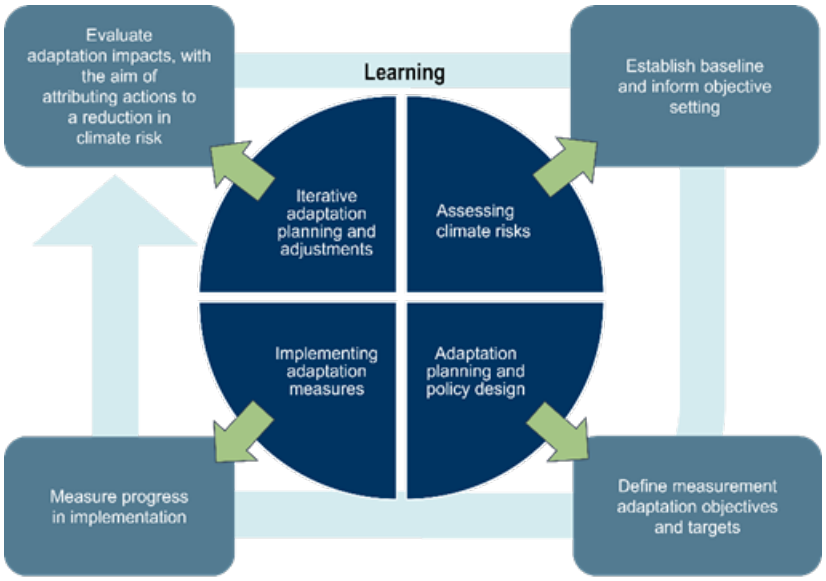
Source: (OECD, 2023[16]); (OECD, 2023[3]); (OECD, 2024[17]); (OECD, 2021[10]); (OECD, 2023[18]); (ILO, 2019[19]); (OECD, 2015[20]); (Lancet Countdown, 2023[21]); (WHO, 2024[22]); (WMO, 2023[23]), (WHO, 2023[24]).

2 Effective policy making for climate adaptation

Building resilience and adapting to climate change entails changes in both human and natural systems. In human systems, it involves adapting to current or anticipated climate conditions and their impacts, aiming to mitigate harm and capitalise on opportunities. This may encompass various strategies, from retrofitting infrastructure to altering land use practices or ecosystem restoration. In natural systems, if climate adaptation does not occur naturally, human intervention (e.g. removing excess wildland fuel from wildfire-prone areas) may help to anticipate and improve ecosystem resilience (IPCC, 2022[25]).

Effective policymaking for climate adaptation entails a four-step, iterative process (Figure 3). The first step is climate risk assessment, which integrates knowledge of climate change hazards, exposures, and vulnerabilities across different geographies and timescales to identify and prioritise areas for adaptation efforts. Second, governments need to develop strategies and measures to address identified risks in collaboration with key stakeholders. The third and fourth steps are implementation – which should include strong mechanisms to monitor progress – and evaluation, which is crucial to assess the effectiveness of implemented measures and make necessary adjustments to continuously evolving climate conditions (OECD, 2024[26]); (OECD, 2024[15]). The following sections outline the key elements of these steps for effective policymaking for climate adaptation.

Figure 3. The adaptation policy cycle



Source: (OECD, 2024[15]).

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2.1 Assessing climate risks and identifying priorities

The first step of the adaptation policy cycle is conducting and regularly updating climate risk assessments (CRAs). CRAs are a critical tool for identifying adaptation gaps and prioritising investment in resilience-building measures. CRAs typically begin by identifying climate hazards, taking into consideration various climate scenarios to assess their potential severity and probability of recurrence. By integrating hazard knowledge with exposure data (e.g. location of assets, infrastructure, ecosystems, and communities) and vulnerability data, CRAs allow policy makers to make informed decisions about where and how to allocate adaptation resources (OECD, 2024[15]). Establishing mechanisms to collect and regularly update data on hazards, exposure, and vulnerability is crucial for effective risk assessment. Ideally, these should include spatial microdata on households' socio-economic characteristics (e.g. gender, income, age, migration background), as social and gender inequalities are often exacerbated by climate change. For example, Chile is developing gender-responsive adaptation indicators by collecting gender-disaggregated data across various sectors to better understand women's exposure, sensitivity, and adaptive capacity to climate change (OECD, 2024[15]). Importantly, as governments must often manage competing urgent priorities with limited resources, assessment of climate change risks should be part of a broader assessment of all emerging critical risks, with prioritisation based on likelihood and severity rather than risk categories (Box 3) (OECD, 2024[26]).

CRAs are increasingly becoming standard practice within countries, reflecting growing recognition of the importance of proactive climate-related risk management. According to a 2023 survey, a significant majority of OECD countries had developed national or sectoral CRAs, many updated every five years (OECD, 2024[15]). Nevertheless, the extent to which countries measure different elements of climate risk varies. While hazard assessment is common, fewer countries comprehensively evaluate exposure to climate change impacts. Assessing vulnerability also remains challenging due to data limitations, with only 16 out of 22 countries conducting vulnerability assessments that include socio-economic factors such as age, income, and employment status (OECD, 2024[15]).

Box 3. OECD Framework on Management of Emerging Critical Risks

The OECD Recommendation on Governance of Critical Risks defines such risks as threats and hazards that pose the most strategically significant risk as a result of 1) their probability or likelihood and of 2) the national significance of their disruptive consequences, including sudden onset events (e.g. earthquakes, industrial accidents, terrorist attacks), gradual onset events (e.g. pandemics), and steady-state risks (notably those related to illicit trade or organised crime). Critical risks differ from traditional risks in their higher likelihood to be of transboundary nature, heightened uncertainty due to lack of historical precedent, and systemic impact.

The OECD Framework on Management of Emerging Critical Risks provides a structured process for identifying, assessing, and managing these risks by emphasising whole-of-society engagement, clear allocation of actors' responsibility, preparedness for uncertainties, and identification of low-cost co-operative benefits. The framework highlights, among other aspects, the importance of techniques such as horizon scanning and strategic foresight, and engagement with scientific communities to inform risk management strategies.

Source: (OECD, 2024[27]).

2.2 Developing targets, strategies and measures through a whole-of-government approach

Once climate risks have been assessed, **National Adaptation Strategies (NAS) and National Adaptation Plans (NAP) should be developed to cope with the impacts of climate change.** NAS can be broadly defined as "*initial strategic or framework documents which commonly set out governmental approaches to adaptation and communicate priorities"* (Sutherland et al., forthcoming[28]). NAP, established under the 2010 Cancun Adaptation Framework and reaffirmed by the Paris Agreement, are detailed planning documents outlining countries' specific adaptation measures and policies. Parties to the Paris Agreement committed to the development and implementation of plans and submitting regular updates in their Nationally Determined Contributions (NDCs) (UNFCCC, n.d.[29]), (Sutherland et al., forthcoming[28]).

NAS, NAP and other adaptation processes should include specific, time-bound, and measurable adaptation objectives based on CRA outcomes. These can be defined at the sectoral and regional level to help allocate responsibility for actions to relevant ministries and agencies, thus increasing accountability for action. For example, if a CRA finds that 50% of low-income population in a specific region is particularly exposed to floods, an objective could be to decrease this share by a given amount during a specific period. Some countries have passed legislation requiring government to introduce strategies with measurable targets to ensure a stronger legal standing, such as the German 2023 Federal Climate Adaptation Act (OECD, 2023[30]); (Federal Ministry for the Environment, 2023[31]); (Sutherland et al., forthcoming[28]).

Adaptation strategies that are flexible and do not rigidly commit to specific pathways are preferable. In this sense, adaptation actions can be categorised into three main types: 1) *no-regret actions* that yield benefits regardless of future climate scenarios; 2) *low-regret actions* that provide benefits under most circumstances while minimising potential negative outcomes; and 3) *win-win measures* that contribute to adaptation while having social, economic and environmental policy co-benefits (Sutherland et al., forthcoming[28]). Overall, actions that provide more flexibility are preferable, as rigid pathways may result in maladaptation due to uncertainty about the severity and impacts of climate change. Adaptation strategies can also be categorised as to whether they improve the capacity to *absorb* (prepare for or recover from a shock in the short run), *adapt* (implement incremental changes in the medium run), or *transform* (create a fundamentally new system in the long run) (Cobourn, 2023[32]).

Establishing interdepartmental taskforces can help to ensure a whole-of-government approach. A whole-of-government approach to adaptation is crucial, as challenges often span multiple administrative boundaries and require policy instruments that are outside the remit of a single ministry or agency (Box 4) (OECD, 2023[33]); (OECD, 2023[30]). Co-ordination across multiple agencies can also help to identify conflicting policies and avoid maladaptation (Canadian Climate Institute, 2022[34]); (McKenzie and Kuehl, 2021[35]). Interdepartmental adaptation task forces can help to ensure a whole-of-government approach by bringing together relevant ministries and agencies (European Commission, 2023[36]). In countries where such units have been established, preliminary evidence suggests that such task forces often face barriers such as limited resources and lack of legal mandate, relying heavily on co-operation rather than enforceable authority over other governmental units. National and subnational governments should also establish information-sharing platforms to identify interdependencies amongst infrastructure, services, and supply chains (OECD, 2024[26]).

Wide stakeholder engagement can contribute to balancing synergies and trade-offs, facilitating communication and fostering greater trust (OECD, forthcoming[37]); (Sutherland et al., forthcoming[28]). Stakeholder engagement efforts should make sure that more vulnerable demographic groups such as indigenous peoples, low-income populations, women, youth, the elderly, and disabled persons are included. This also allows for gathering and building upon traditional and local knowledge in the adaptation process. Involving social partners such as trade unions and employers' organisations is instrumental to address the impact of climate change on working conditions, such as setting safe temperature thresholds

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in the workplace (OECD, 2024[17]). Consultations, workshops, and citizens' assemblies, with transparent processes and early engagement, have proven effective in involving multiple actors in long-term planning (Aguilar Jaber et al., 2020[38]). Importantly, as the risk landscape evolves, consultation processes should be recurring and not "one off" exercises, especially for sectors more exposed to climate change impacts, such as agriculture (OECD, forthcoming[37]).

Multiple policy levers are often necessary to drive effective adaptation and implement strategies Table 1; Box 4). These include economic incentives (e.g. taxes, subsidies), regulatory measures (e.g. more stringent building codes and zoning regulations), and information provision (e.g. campaigns to raise awareness of water scarcity risks) (Sutherland et al., forthcoming[28]).

A key challenge for adaptation action is evaluating the costs and benefits of various strategies due to uncertainty around climate impacts, long time horizons for pay-offs and often large upfront costs. Several tools can be used to this end, including common economic decision-making approaches such as cost-benefit analysis, cost-effectiveness analyses, and multi-criteria analysis, and approaches designed to support economic decision-making under uncertainty, such as robust decision making, real options analysis, and rule-based decision making (Sutherland et al., forthcoming[28]); (OECD, 2024[26]). Notably, assessments should include the triple dividend of resilience (i.e. avoided losses, induced economic or development benefits, and additional social and environmental benefits), as well as the long-term operations and maintenance costs of infrastructure (in addition to their upfront capital costs). (World Resources Institute, 2022[39]); (Sutherland et al., forthcoming[28]).

Table 1. Adaptation measures

Policy instrument		Example	Main barrier that the policy instrument addresses
Economic instruments		Tax credits for wildfire mitigation practices, grants to strengthen resilience of buildings	Financial constraints and behavioural obstacles (in case of subsidies); Externalities, behavioural obstacles, and moral hazard in case of taxes
Regulations		Building codes, zoning	Moral hazard, imperfect information, co-ordination failures
Information provision		Flood risk maps, early warning systems, educational programmes	Asymmetric and imperfect information; uncertainty and ambiguity due to missing information
Infrastructure provision		Traditional infrastructure (e.g., sea walls), Nature-based solution (e.g., restoring wetlands)	Positive externality from the provision of public protective infrastructure; financial constraints of firms and individual

Source: based on (Sutherland et al., forthcoming[28]).

Box 4. The need for a whole-of-government approach: the case of wildfires

Addressing the complex challenge of wildfires requires a multi-faceted approach, utilising various policy tools to enhance resilience. Key strategies include restoring degraded forests and peatlands, managing vegetation in wildland-urban interfaces, and mitigating risks associated with the abandonment of rural and agricultural areas. Additionally, improving monitoring capabilities for early wildfire detection and suppression is critical for a timely response.

A whole-of-government effort is essential to co-ordinate these diverse initiatives effectively. Ministries and agencies responsible for rural, environment and agricultural policies, together with spatial planning agencies, meteorological services, local governments, and private property owners play a critical role. The creation of central co-ordinating bodies, such as Portugal's Agency for the Integrated Management of Rural Fires, can be effective in increasing co-ordination and knowledge exchange across sectors and levels of government.

Source: (OECD, 2023[3]).

Nature-based solutions (NbS) are a particular form of infrastructure that can generate additional social, economic, and environmental co-benefits. NbS are measures that protect, sustainably manage, or restore nature, and in doing so aim to maintain or enhance ecosystem services to address a variety of social, environmental, and economic challenges (OECD, 2024[26]). NbS can be used as a substitute, complement, or safeguard to traditional "grey" engineered solutions, i.e. built structures and mechanical solutions. It is estimated that replacing around 11% of global infrastructure with NbS instead of grey infrastructure would save USD 248 billion annually from the USD 4.29 trillion needed for infrastructure each year (Bassi et al., 2021[40]). In addition to cost savings, NbS offer further benefits compared to grey options, such as improving biodiversity and ecosystem services. Numerous barriers to their implementation exist, however, including technical capacity gaps and low awareness among decision makers (see Box 5 for more on NbS) (OECD, 2024[26]).

Box 5. Examples of nature-based solutions

Bari, Italy: Fostering urban green solutions

Four neighbourhoods in Bari, Italy, including the city centre, are currently divided by a railway line. The Nodo Verde project aims to reconnect and redevelop the 160,000 square meter urban area by 2026, with key components including a wide pedestrian passage above the railway line, an artificial hill or green roof over the station, two new parks, and the rehabilitation of the city's abandoned Caserma Rossani barracks. This initiative will increase green spaces, enhance urban mobility with pedestrian and bike paths, and reduce the urban heat island effect, contributing to climate adaptation and flood risk management. The project, supported by EUR 143 million from Italy's National Recovery and Resilience Plan, aligns with strict sustainability criteria and aims to improve air quality, urban biodiversity, and overall liveability. Collaboration among multiple governmental and private stakeholders has been essential since the project's inception in 2004, emphasising the importance of green infrastructure and NbS in urban regeneration.

Budapest, Hungary: NbS for flood protection in highly populated areas

High population density in Budapest, Hungary leaves many inhabitants exposed to flood risks. The city has implemented a rainwater management strategy that includes adjusting building codes to mandate a minimum green area ratio for residential properties, as well as NbS such as swales (landscaped channels to manage water runoff), permeable surfaces, rain gardens, small reservoirs, and sludge traps (pre-treatments for rainwater or wastewater). By contrast, other Hungarian cities, particularly those along the Danube and Tisa rivers, face more frequent and severe flood risks due to less robust protection measures.

Challenges to use of NbS in the Philippines

An October 2023 policy dialogue held as part of the OECD's Sustainable Infrastructure Programme in Asia (SIPA) project found that although nature-based solutions have gained significant attention in the Philippines in recent years as measures to enhance the climate resilience of infrastructure assets, implementation challenges persist due to difficulties in assessing benefits and resistance to paradigm shifts favouring grey infrastructure, as well as technical and organisational hurdles. The dialogue evidenced that enhanced co-ordination between agencies is crucial for promoting NbS in infrastructure planning.

Source: (OECD, 2023[41]); (OECD, 2023[42]); (OECD, 2024[43]).

Effective adaptation planning and implementation may require upskilling for public officials. The cross-cutting nature of adaptation and complex data call for a diverse set of skills. These include technical skills to grasp the scientific complexities of climate change (e.g., understanding vulnerability and risk

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assessments), participatory skills to foster co-operation, and management skills (UNITAR, 2017[44]). Investment in training and upskilling may therefore be needed, especially across levels of government (European Commission, 2023[36]).

Finally, **development of NAP/NAS should include an assessment of investment needs and possible funding strategies** (European Commission, 2023[36]). Medium- and long-term adaptation objectives should be linked to budget resources to ensure that adequate funding is available to finance adaptation measures, including infrastructure provision.[6] While direct government investment is vital, capital markets and private investment also have a role to play. Importantly, countries should establish principles for fair and equitable financing of adaptation measures by apportioning costs among relevant parties (e.g. national and subnational governments, private investors, citizens and other parties), acknowledging varying financial capabilities, and incorporating mechanisms for beneficiary contributions, cross-subsidisation, equity, and appropriate risk management (OECD, 2024[26]).

The next subsection focusses on the example of adaptation in food systems, which are particularly vulnerable to the impacts of climate change and play a central role in national adaptation strategies and plans. Climate change poses severe threats to food systems, impacting crop yields, animal productivity, and fisheries due to increased heat, drought, pest outbreaks, and risks to food storage and transport posed by extreme weather events. Some studies also suggest that as levels of warming progress, current agricultural systems may become untenable in certain regions (IPCC, 2019[45]) (OECD, forthcoming[46]). At the same time, rising sea surface temperatures are projected to reduce global fisheries catches by between 3% to 24% by the end of the century under the IPCC's scenarios of warming of 1.6 °C and 4.3 C by 2100, respectively (OECD, 2023[47]).

In focus: Planning for resilient food systems through transformative strategies

The importance of incorporating food systems into wider adaptation planning and strategies is increasingly recognised. At the 2023 United Nations Conference of the Parties of the UNFCCC (COP28), countries committed to integrating agriculture and food systems into NAP, NDCs, long-term strategies, and related frameworks through inclusive and transparent engagement before COP30 in 2025 (COP28, 2023[48]).

Food system adaptation strategies must consider the triple challenge characterising the sector: providing food security and nutrition, ensuring livelihoods along the supply chain, and ensuring environmental sustainability. These challenges present many synergies and trade-offs. For instance, charging farmers for water use would likely lead to a more efficient use of a scarce resource, but could also raise food prices, as farmers could potentially pass the cost on to consumers (Deconinck et al., 2023[49]).

Shocks can affect food systems at different stages of the supply chain (e.g. extreme weather disrupting transportation) **and propagate throughout it** (Deconinck et al., 2023[49]). These disruptions can lead to cascading effects, including reduced food availability, price volatility, and increased vulnerability for consumers and businesses reliant on timely food delivery.

Evidence suggests that existing efforts to increase food system resilience have largely focused on developing absorptive and adaptive capacity. In agriculture, short-run absorptive measures could include early warning systems or insurance mechanisms, while medium-run adaptive measures might include changes to planting dates or crop mixes. Climate change may necessitate more fundamental long-term changes, however, including exiting agriculture in some cases. Recent analysis of UNFCCC reports shows that investments in agricultural climate adaptation programmes mostly emphasise adaptive capacity – a recognition that short-run absorptive capacity is insufficient to address growing climate risks. Actions to increase long-run transformative capacity are emerging, but lag behind short- and medium-run measures (Cobourn, 2023[50]).

Barriers at both personal and institutional levels hinder the development of transformative capacity. Individual aversion to change, which can be caused by limited financial resources and importance of traditional culture for national identities, poses significant challenges. At the institutional level, policies that reward specific production practices or that shield farmers from risk can form an obstacle to transformation. For instance, producer support that is tied to the production of specific commodities or the use of specific inputs reinforces existing production systems and limits the flexibility of farmers to experiment with new practices. Policy uncertainty and discontinuity also can hamper transformative action (Wreford, Ignaciuk and Gruère, 2017[51]); (OECD, forthcoming[46]).

Phasing out measures that hinder production adjustments is a no-regret measure for helping food systems adapt to climate change. Preparing food systems for the impacts of climate change entails encouraging agility and responsiveness to a changing environment. In this context, subsidies that discourage changes in production systems and are economically inefficient, such as price support and other harmful subsidies, should be reformed (OECD, 2023[14]). Instead, policies should offer multiple adaptation pathways for farm households: supporting sustainable productivity improvements, diversifying income sources among household members, and, when necessary, facilitating the transition away from agriculture. Investments in research and development, extension services, entrepreneurial skills, human capital, and the uptake of resilience-enhancing technologies can build farm resilience capacity and reduce farmers' risk exposure to climate change over the long term. Policies should aim to facilitate structural adjustment and support new and diverse income sources as complements to revenue from traditional crop and livestock production. Examples include payments for biodiversity conservation and other ecosystem services, or targeted support programmes to facilitate structural adjustment in affected communities (OECD, 2023[14]); (OECD, 2023[47]).

Maintaining open borders during climate-related production shortfalls is essential, as trade can reduce the impact on domestic food supply. Trade openness can help to mitigate the adverse impacts of climate change by allowing offsetting domestic production shortfalls while also promoting broader economic prosperity (Adenäuer, Frezal and Chatzopoulos, 2023[52]). However, not all trade-related measures stimulate adaptation.

Innovation is crucial. Experimentation and gradual learning are essential when considering adaptation actions that represent a significant departure from the status quo. To support these activities, it is vital to establish and strengthen institutional support and secure funding for extension services. Ensuring that research priorities are aligned across research and extension agencies is also key. Additionally, partnerships between research institutions and private companies can play a significant role in supporting independent research and facilitating the diffusion and scale-up of innovations. These efforts collectively ensure that innovative solutions are effectively developed and implemented, driving progress and resilience (OECD, forthcoming[46]).

2.3 Measuring implementation progress and evaluating effectiveness

Measuring progress in implementation and evaluating the effectiveness of adaptation policies is essential. All UNFCCC Parties have agreed to establish and operationalise a system for monitoring, evaluation and learning for their national adaptation efforts by 2030 under the UAE-Belém Work Programme (UNFCCC, n.d.[53]).

Data shows that **monitoring is a common practice in adaptation policy cycles in OECD countries.** Within OECD countries, around 70% of surveyed countries reported tracking implementation outputs while 60% of surveyed countries also track resources allocated to adaptation (OECD, 2024[15]). Globally, nearly 40% of the 63 countries that have adopted a national adaptation policy have started to track its implementation.

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Assessing the effectiveness of adaptation policies is challenging, however. Assessing the extent to which an action reduces vulnerability and climate-related risk, increases resilience, and avoids maladaptation can be difficult due to the complexity of estimating actual losses and damages attributable to climate impacts, as well as of attributing changes in these impacts to specific actions or policies. The substantial data requirements for adaptation assessments are another significant hurdle. Indeed, 80% of surveyed OECD countries find measuring the effectiveness of their adaptation policies to be quite or very challenging (OECD, 2024[15]).

Countries can enhance their capacity to monitor progress and evaluate effectiveness by embedding adaptation measurement into national policy and legal frameworks. Most OECD countries are anchoring adaptation measurement in their national adaptation planning processes, using the results to inform subsequent phases of their NAP. Some countries have further institutionalised adaptation measurement through climate legislation that mandates progress tracking and evaluation of the effectiveness of adaptation measures. This approach, exemplified by the 2023 German Federal Climate Adaptation Act, can be effective in engaging responsible actors in the measurement task, enhancing accountability, and ensuring a systematic approach (OECD, 2024[15]).

In addition, **enhanced data collection and better linking of existing datasets is key to ensure accurate and reliable assessments of adaptation policies**. Project-level monitoring and evaluation should take into account the time needed to observe impacts of implemented measures, which in certain cases can take years or even decades for benefits to be fully realised (OECD, 2021[54]). Monitoring and evaluation should also consider impacts for multiple socio-economic characteristics, including gender.

Learning from the progress and effectiveness of existing measures should inform the process of regularly updating strategies and plans, jointly with new information on climate risks. Given the dynamic nature of climate change and its impacts, communities and assets that are resilient now may no longer be so in ten years. The longevity of infrastructure assets further highlights the importance of not considering evaluation a “one-off” exercise. Keeping records on public assets up to date, including on past performance and repairs, and use of new technologies such as big data or remote sensing (already in use in some cases, e.g. in Italy) can help to ensure data on resilience of infrastructure assets are up to date and are fed into the process (OECD, 2023[41]); (OECD, 2024[26]).

2.4.The role of multiple levels of government

Climate risks – and the opportunities available to mitigate them – vary between regions within countries. For instance, urban centres experience more severe heatwaves compared to less densely populated areas due to the urban heat island effect. While this effect varies greatly between cities, some urban centres can be 5-7°C warmer than their surrounding areas (OECD, 2023[9]). Similarly, in 2022, while some Australian states were suffering from extreme droughts, others were experiencing record rainfall and floods (OECD, 2023[9]). A “place-based” approach to understanding and addressing local differences is essential for developing effective adaptation strategies that can mitigate climate change impacts and enhance resilience in communities (OECD, 2023[33]; OECD, 2023[9]).

Recognising the importance of spatial tailoring, in many countries subnational authorities bear primary responsibility for important adaptation policy areas such as delivery and operation of key infrastructure (OECD, 2024[26]). They are directly responsible for setting policies and providing infrastructure and services in sectors related to climate resilience such as water, waste, housing, transportation, and energy. For example, in 2019, local and regional governments accounted for 63% of climate-significant public expenditure and 69% of climate-significant public investment in OECD and European Union (EU) countries (OECD, 2023[9]; OECD, 2022[55]), corresponding to 1.1% and 0.4% respectively of gross domestic product (GDP) across countries surveyed (OECD, 2023[9]). Some larger local authorities have also developed dedicated adaptation plans and strategies to mainstream climate

resilience across all locally led functions, often complemented by targeted plans to address specific risks (OECD, 2023[33]). Many OECD countries have explicitly implicated local governments in their national adaptation strategies: 80% of surveyed countries report that subnational authorities contribute to adaptation measurement (OECD, 2024[15]).

Regional and local governments also carry out regulatory functions (such as land-use planning, project permitting and standard setting) **that can build climate resilience** (OECD, 2024[26]). For instance, subnational governments oversee urban development plans, and can incorporate climate risk assessments to help limit construction in vulnerable areas such as flood-prone zones, and inform local building codes (see Box 6 ; Table 2).

Box 6. Climate action among all levels of government: Basel's green roof strategy

Basel, Switzerland's successful green roof strategy showcases the multiple levers available to subnational governments to drive adaptation. In 2002 (and reinforced in 2010), an amendment to the city's Building and Construction Law stipulated that all new and renovated flat roofs must be greened. The strategy aims at increasing the surface of green roofs to address flooding risks and urban heat island effects while providing additional benefits in terms of energy saving and biodiversity. Both financial and regulatory schemes were used to actively promote green roofs. The installations were also promoted though resources collected via the Energy Saving Fund, established by a 1990 local law requiring that 5% of all customers' energy bills to be put into a fund. Basel now boasts the world's largest green roof area per capita.

Source: (OECD, 2023[56]).

Table 2. Local standards or regulations targeting climate adaptation

Selected municipalities

Locality	Implemented regulation	Description	Targeted hazard
Basel, Switzerland	Building regulation	Regulation and tax incentives to promote the installation of flora on roofs which fosters cost-saving and richer biodiversity.	Extreme temperatures & precipitation
Cape Town, South Africa	Water usage regulation	The "Water By-law" regulation restricts water usage and promotes water conservation by residents, property owners, builders, and other stakeholders. It prescribes measures such as water-efficient plumbing fixtures, rainwater harvesting systems, and water-use restrictions during drought conditions.	Drought
Denver, Colorado, United States	Building regulation	The Green Roof Ordinance (2017) requires new buildings over 25,000 square feet to incorporate climate-proof design features such as green roofs.	Extreme temperatures & precipitation
Hoboken, New Jersey, United States	Land use regulation	The "Resist, Delay, Store, Discharge" (RDS) programme includes regulations that require new developments to incorporate measures, such as rain gardens and permeable pavement, to capture and store stormwater runoff.	Flooding
San Francisco, California, United States	Building regulation	The Better Roofs Ordinance requires all new buildings and roof replacements to have solar panels or a green roof, to increase energy efficiency, reduce the urban heat island effect, and improve stormwater management.	Extreme temperatures & precipitation
Tokyo, Japan	Building regulation	Metropolitan-wide regulations require new developments to incorporate green spaces, such as rooftop gardens and vertical vegetation, to combat the urban heat island effect and improve	Extreme temperatures & precipitation

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		resilience to extreme precipitation and flooding.	

Source: (OECD, 2023[33]).

Strong co-ordination mechanisms are needed to align national and local action. Differing priorities between local and national governments, a lack of co-ordination structures, and limited financial resources and capacities of local governments pose significant barriers to aligning national and local adaptation efforts. Priorities can be aligned through better co-ordination processes, ensuring that national adaptation strategies and plans involve local stakeholders, and strengthening local technical capabilities by providing training, resources, and expertise to help subnational authorities effectively identify, assess, and address climate risks. Dedicated co-ordination units, such as Ireland's Climate Action Regional Offices, can provide subnational authorities with financial and technical support for the design and implementation of local adaptation plans aligned with countries' NAS/NAP (OECD, 2023[56]).

Evidence suggests that **strategies for cities should be developed at the metropolitan (functional urban area) level**. Metropolitan areas can leverage functional relationships and proximity with rural areas to better address climate impacts. Integrated urban development strategies, as opposed to sectoral strategies, can help to generate co-benefits and address and manage complex trade-offs (OECD, 2023[56]).

Limited financial resources are a particular challenge, as the most vulnerable communities and regions often also face the greatest financial constraints. Socio-economic factors such as population size, sociocultural characteristics, or economic structure heavily influence the financial resources available to local authorities. As a result, regions with weaker economic performance struggle to finance their resilience needs, compounding disparities in adaptation efforts (OECD, 2023[9]), (OECD, 2023[33]).

Subnational governments will need to mobilise a diverse set of funding instruments to finance action. Across the OECD, most subnational government revenue comes from taxes (shared and own source), grants and subsidies from national government and, to a lesser extent, from user charges and fees. National governments should ensure that local governments have the flexibility to adjust local taxes, set localised tariffs and establish regulatory frameworks that balance the need for increased financing vs. maintaining creditworthiness. Recourse to innovative climate finance tools and mechanisms (e.g. green bonds or value capture schemes that help recover the cost of climate-resilient infrastructure in a spatially targeted way), can also play an important role. Notably, targeted fiscal support to fill funding gaps from central governments remains key to addressing regional and local disparities (OECD, 2024[26]).

3 Summary and conclusion

With average global temperatures nearly 1.5°C above pre-industrial levels in 2023 and extreme weather events becoming more frequent and intense, governments must act urgently to support climate change adaptation. Adaptation entails adjusting human and natural systems to mitigate harm and capitalise on opportunities; this requires comprehensive strategies, localised solutions, and enhanced monitoring and evaluation to ensure long-term resilience.

Effective policy making for adaptation involves a four-step, iterative process: 1) assessing climate risks, 2) developing national adaptation strategies and plans, 3) implementation, and 4) evaluating results. Assessing climate risks is an essential step aimed at identifying adaptation gaps and prioritising actions, and should combine data on hazards, exposure, and vulnerabilities. Evidence highlights that data and methodological limitations are still key barriers to this first critical step of adaptation policy making.

Recent data shows that countries are increasingly developing National Adaptation Strategies and Plans, but implementation often lags. Strategies and plans should include specific, measurable, and time-bound objectives based on the outcome of risk assessments, be developed through a whole-of-government and whole-of-society approach and prioritise flexible adaptation actions. Furthermore, a multipronged approach is often needed to drive effective adaptation. Governments need to implement policy packages that leverage multiple instruments including regulations, subsidies, taxes, and the provision of infrastructure. Skills upgrading for public officials and adequate funding are critical to ensure effective planning and implementation.

Measurement and evaluation should be carried out more consistently. Large and complex data requirements, together with methodological limitations, are among the key challenges. Anchoring adaptation measurement and evaluation in national laws could help to ensure that these are timely and effectively performed, and that their outcomes are used to inform policy decisions.

While climate change is already affecting several human and natural systems, food systems are among the most impacted. Recognising this vulnerability, countries committed to integrating food systems into NAP, NDCs, and long-term strategies at COP28. Policies that encourage flexibility and support structural adjustments and innovation are necessary levers that governments should pull to drive adaptation in this sector.

Finally, climate risks vary significantly between regions, necessitating a "place--based" perspective for effective adaptation. Subnational authorities, who are responsible for infrastructure and regulatory functions key to climate resilience, play a crucial role in climate adaptation. Strong co-ordination between national and local governments, supported by technical and financial resources, is essential for addressing local adaptation needs and disparities.

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Notes

[1] Estimates of the global temperature rise in 2023 differ. Copernicus, the Earth observation component of the European Union Space Programme, estimates that 2023 was 1.48°C warmer than pre-industrial (1850-1900) levels; the World Meteorological Organization calculated that the 2023 annual average global temperature was 1.45 ± 0.12 °C above pre-industrial levels; and NASA found that the Earth was about 1.36°C warmer in 2023 than the preindustrial average (Copernicus, 2024[58]); (WMO, 2024[57]); (NASA, 2024[59]).

[2] Although the temperature increase in 2023 is dangerously close to the 1.5°C threshold, this does not definitively imply failure to meet the Paris Agreement target. The Paris Agreement's temperature goal is based on long-term global trends over decades, as short-term fluctuations can be influenced by natural events such as El Niño/La Niña weather patterns and volcanic eruptions (WMO, 2024[57]).

[3] Including both direct (environmental impacts, deaths, agriculture losses etc.) and indirect (housing market impact, loss of ecosystem services, psychological impacts from lost amenities etc.) losses.

[4] Slow onset events are climate change impacts resulting from gradual environmental transformation occurring over long periods of time. These include sea-level rise, increasing temperatures, ocean acidification, glacial retreat, salinisation, desertification, and biodiversity loss (OECD, 2023[1]).

[5] Small Island Developing States are particularly affected by sea-level rise, which may lead to significant population displacement. For example, in Comoros, sea-level rise of 20 centimetres is estimated to result in 10% of the country's population being displaced by 2050 (OECD, 2023[61]). Some governments are seeking to avoid forced displacement by looking into the possibility of pro-actively relocating affected communities. However, planned relocation may lead to maladaptive outcomes (e.g. unemployment, heritage loss) (Bower et al., 2023[60]).

[6] A separate paper focusing specifically on finance for adaptation will also be published in the Net Zero+ policy paper series.

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NET ZERO+
Building Climate
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Climate change adaptation: Policies for a resilient future

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With average global temperatures nearly 1.5°C above pre-industrial levels in 2023 and extreme weather events becoming more frequent and intense, governments need to urgently act to accelerate climate change adaptation. This paper highlights the need for a four-step, iterative process for effective climate adaptation policy making, including (i) climate risk assessment, (ii) policy planning and design, (iii) implementation, and (iv) measurement and evaluation. Effective adaptation requires measurable objectives, whole-of-government co-ordination, stakeholder engagement, sufficient funding, and sound mechanisms to monitor progress and evaluate effectiveness of policies. Data and methodological limitations are key challenges for sound measurement and evaluation. Specific attention is paid in this paper to the role of multi-level governance and policies for building resilience in food systems due to their vulnerability to climate change.

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