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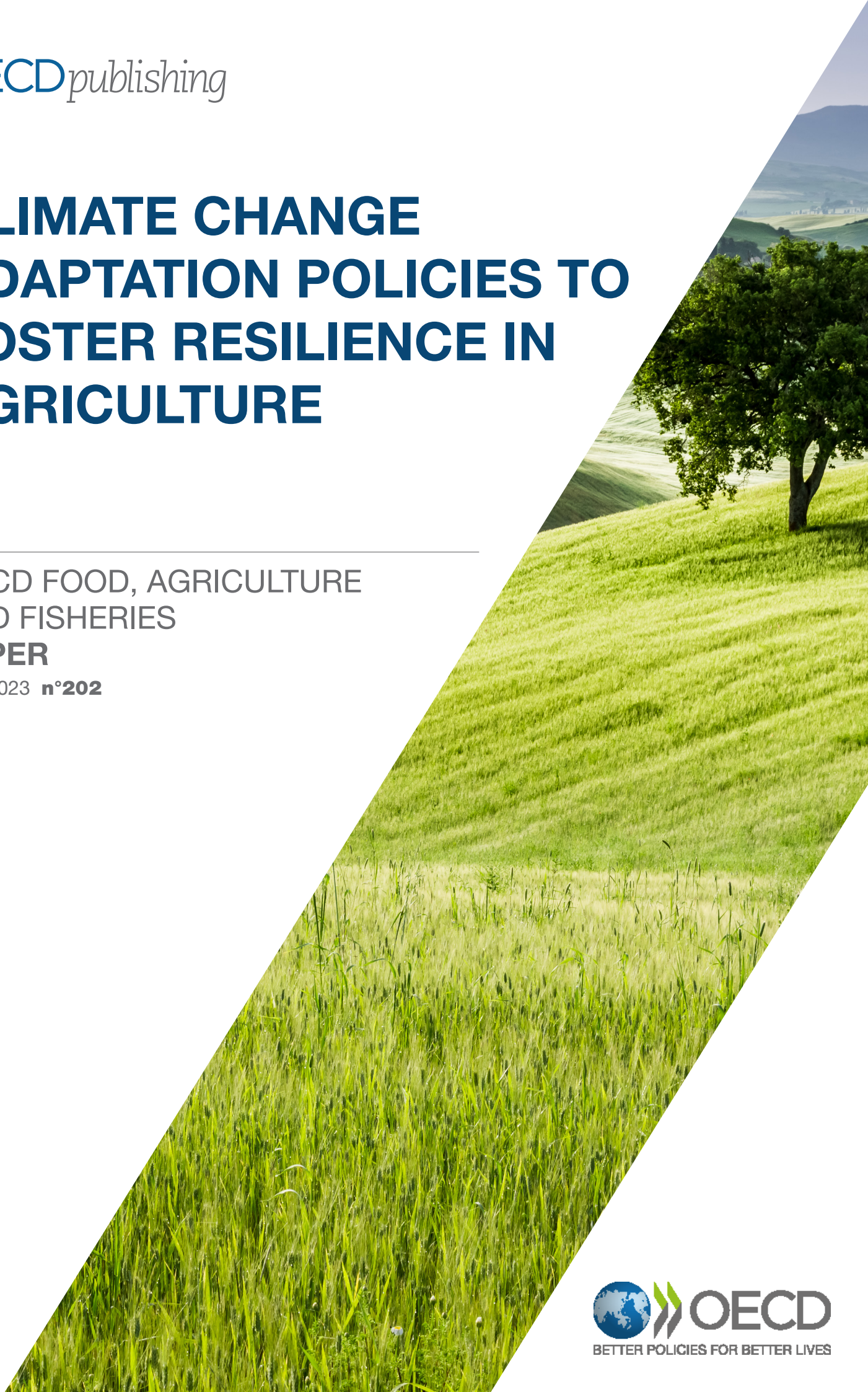
CLIMATE CHANGE ADAPTATION POLICIES TO FOSTER RESILIENCE IN AGRICULTURE



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Climate Change Adaptation Policies to Foster Resilience in Agriculture

Kelly Cobourn

National climate change adaptation programmes can strengthen agriculture's resilience to adverse climatic events by investing in absorptive capacity to mitigate the impact of a shock in the short run, adaptive capacity to effect incremental changes in the medium run, and transformative capacity to create fundamentally new agricultural production systems in the long run. Using UNFCCC reporting documents, this analysis takes stock of agricultural climate change adaptation programmes in OECD countries and evaluates their contribution to developing resilience. Significant investments have been undertaken in the creation of decision support tools, the management of soil and water resources, and cultivar selection and breeding to address key agricultural vulnerabilities, namely drought, flooding and declining crop yields. Adaptation programmes developed to date most heavily emphasise adaptive capacity to address sustained and growing climate risks. Actions that contribute to transformative capacity are beginning to emerge, but lag behind medium-run measures.

Key words: Agricultural production, Climate risk, Content analysis, Transformative capacity

JEL codes: Q18; Q54; Q58

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Key messages

- Governments' climate change adaptation programmes can strengthen agriculture's resilience to adverse climatic events by investing in three key resilience capacities – absorptive capacity to prepare for or recover from a shock in the short run, adaptive capacity to implement incremental changes in the medium run, and transformative capacity to create a fundamentally new agricultural production system in the long run.
- Using UNFCCC reporting documents, this analysis evaluates how OECD countries view the vulnerabilities of their agricultural sectors to climate change; the types of adaptation measures and programmes they have considered or implemented; the degree to which these programmes are targeted to key vulnerabilities; and the contribution of adaptation programmes to developing resilience over the short, medium, and long run. While UNFCCC documents do not capture the full breadth of actions undertaken on agricultural adaptation to date, they can inform a systematic assessment of the evolution of national views and responses to climate change adaptation across OECD members.
- Discussion of adaptation in the UNFCCC reporting documents of OECD members has increased significantly over time and ideas related to resilience have recently begun to gain traction. The extent to which the documents discuss agriculture has remained relatively stable, although the focus has shifted from an early emphasis on identifying vulnerabilities, to now incorporating evidence of specific programmes to support adaptation. That said, the majority of the discussion related to agriculture in these reports focuses on the mitigation of greenhouse gas emissions.
- This stocktake of agricultural climate change adaptation programmes demonstrates that, for the OECD as a whole, significant strength already exists in the creation of decision support tools, the management of soil and water resources, and cultivar selection and breeding. These programmes address the agricultural vulnerabilities identified most frequently by members in the reporting documents, namely concerns related to drought, flooding, and declining crop yields. However, other areas could benefit from greater investment in programmatic development for adaptation, namely livestock production, the development of human capital via extension and outreach, and pest and disease management. There may be opportunities to leverage the considerable catalogue of adaptation programmes that exists among OECD countries to enhance information sharing about adaptation programmes and lessons learned to support efforts to develop resilience.
- Investments in agricultural climate change adaptation programmes to date mostly emphasise measures that contribute to adaptive capacity. This likely reflects a growing recognition that investing in short-run absorptive capacity is not sufficient to address the growing magnitude and range of climate risks. Actions that contribute to long-run transformative capacity are beginning to emerge, but lag behind medium-run measures.
- While not necessarily comprehensive in coverage of country actions, the reporting documents reveal that some foundations to build transformational capacity have been established. Members are cultivating partnerships and collaborative planning, supporting multidisciplinary research, and developing decision support tools for non-incremental changes in agricultural production systems. Future efforts may focus on addressing informational, cost, and institutional obstacles to systemic change.

1. Introduction

Climate change has already adversely affected agricultural production systems in diverse growing regions worldwide by reducing the yields of major commodities and by slowing agricultural productivity growth, particularly in mid- and low-latitudes (Cui, 2020[1]; Porter et al., 2015[2]). Despite international co-operation toward global emissions reductions under the Paris Agreement, these impacts are likely to continue and worsen in the future. In its Sixth Assessment Report, the IPCC (2021[3]) forecasts that climatic events will continue to drive losses in key producing regions, degrade the natural resources supporting agriculture, and render many current growing regions unsuitable for production.

In light of these effects, there is increased recognition that climate change adaptation in agriculture is both urgent and essential (Crumpler et al., 2021[4]). Adaptation has long been a priority in developing countries, where the population is highly dependent upon agriculture and the capacity to adapt is relatively low, both of which increase vulnerability to shocks (Gagnon-Lebrun and Agrawala, 2006[5]). Although developing countries often bear the brunt of climate change impacts, farmers in OECD countries are far from immune. The risk environment is changing rapidly, challenging even the most experienced and innovative farmers and highlighting a need to develop more resilient agricultural production systems (OECD, 2021[6]; Wreford, Moran and Adger, 2010[7]). Developing resilient systems can help to limit damage and position farmers to take advantage of new opportunities as changing growing conditions drive shifts in comparative advantage (Dellink et al., 2017[8]; Zimmermann et al., 2017[9]; Dono et al., 2016[10]; Costinot, Donaldson and Smith, 2016[11]).

Adaptation, defined as "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities," is increasingly viewed as a necessary complement to mitigation (Wreford et al., 2015[12]; IPCC, 2014[13]). Although there is wide agreement on the importance of climate change adaptation, national efforts by developed countries have been slower to emerge than those targeting mitigation, and there is evidence that the pace of their development is not keeping up with the growth in need (Ford, Berrang-Ford and Paterson, 2011[14]; Eisenack et al., 2014[15]). This so-called "adaptation deficit" has been attributed to myriad barriers that complicate adaptation, such as uncertainty over risks and the benefits from adaptation; issues around timescale, such as when short-term interests compete with the long-term vision and financial commitment required for adaptation; and institutional fragmentation, such as when adaptation requires co-ordination across disparate authorities (Eisenack et al., 2014[15]; Klein and Juhola, 2014[16]; Ekstrom and Moser, 2014[17]; Arvai et al., 2006[18]).

1.1. Autonomous vs. planned adaptation

Adaptation can be viewed as a process undertaken by private actors without explicit planning or guidance and in response to changes in the environment or market (Malik, Qin and Smith, 2010[19]). Referred to as "autonomous adaptation," this often involves on-farm innovation in operations management, such as shifting planting dates, altering crop mix, diversifying farming activities, or implementing integrated pest control (IPCC, 2007[20]). Planned adaptation, in contrast, follows from an intentional and deliberative policy decision, typically undertaken by a public entity in anticipation of or in response to a change.

Farmers are often best positioned to determine the adaptive actions necessary to manage climate risk on their farms, provided that they have the resources necessary for investment, access to knowledge, and financial and technical capacity to adapt (Kurnik, 2013[21]; Wreford, Ignaciuk and Gruère, 2017[22]). However, even with assistance to manage risk, there are important limitations to autonomous adaptation, particularly within the context of the mounting severity of the challenges created by climate change. The IPCC states with high confidence that currently available methods of adaptation will be insufficient to offset impacts under high temperature scenarios and in hotter regions (IPCC, 2021[3]).

Farmers undertake decisions within the context of broader social and economic institutions that constrain their choices, and therefore their ability to adapt. Individuals rely on public infrastructure and information provision, and they operate within globalised and regulated markets, which implies that adaptation involves

actors outside the boundaries of the farm (Ortiz-Bobea, 2021[23]).[1] Furthermore, the prevalence of public goods, externalities, and risk management issues implies that privately optimal adaptation decisions are unlikely to correspond to those that are collectively optimal (OECD, 2014[24]).

The sheer magnitude of the climate-driven changes experienced now and predicted in the future are likely to significantly compromise current agricultural production systems. Adapting to such change is likely to require structural change, such as the movement of production to new growing regions, the development of new infrastructure, or the reorganisation of markets and value chains (OECD, 2020[25]). In much the same way that mitigation requires co-ordinated efforts, these types of transformative actions require planning and action at a collective level.

Facilitating, prescribing, or creating incentives for adaptation is therefore essential to responding effectively to climate pressure (Dixit et al., 2012[26]; Oberlack and Eisenack, 2014[27]). Governments can enable adaptation through a variety of mechanisms, such as collecting and disseminating information, providing technical assistance, or helping farms to overcome large adjustment costs when changing operations (OECD, 2014[24]).

In addition, governments may act to help to prevent or overcome barriers to adaptation. Barriers are defined generally by the IPCC as "factors that make it harder to plan and implement adaptation actions or that restrict options" (IPCC, 2014[13]). Barriers arise from diverse sources that are often context specific. One example of a barrier to adaptation arises when institutional fragmentation complicates the co-ordination of approaches to address problems that span sectors, e.g. water management and agriculture (Eisenack et al., 2014[15]). Governments may address such barriers by clearly defining roles and responsibilities for agencies involved or by creating interagency working groups, among other possibilities (Eisenack et al., 2014[15]; Mukheibir et al., 2013[28]; Runhaar et al., 2012[29]). Barriers to adaptation may also arise from the incentives created by existing policies, such as trade barriers or commodity specific coupled payments, in which case governments may remove or revise the impediment to encourage adaptation (Guerrero et al., 2022[30]).

Although planned adaptation has the potential to be beneficial, there also exists the possibility that initiatives may generate adverse effects that reduce the ability of systems to cope with the effects of climate change (Magnan et al., 2016[31]). This is known as maladaptation, which can arise as actions designed to support adaptation increase greenhouse gas emissions, harm the most vulnerable segments of society, reduce the incentives of individuals to adapt, limit future choices, and/or carry high opportunity costs (Barnett and O'Neill, 2010[32]). Frameworks to detect and limit the risk of maladaptation emphasize the importance of intentionally incorporating its consideration into adaptation planning processes (Magnan et al., 2016[31]; Juhola et al., 2016[33]).

1.2. The relationship between adaptation and resilience

Climate change adaptation (henceforth referred to just as adaptation) is undertaken within the context of substantial uncertainty, which makes it difficult to determine the appropriate sequences of specific actions and timing. These details also depend highly upon the local context. As a result, it is generally accepted that policy actions should focus more on developing the *capacity* of a system to adapt than on the specific choice of action (OECD, 2014[24]). To that end, adaptation strategies often focus on increasing resilience.[2]

Definitions of resilience differ widely within the scientific literature as well as across policymaking bodies. OECD (2020[25]) synthesises conceptualisations to define resilience as "the ability to prepare and plan for,

[1] Examples of public infrastructure include gas and energy transmission lines; transportation systems, such as roads, waterways, and ports; communication systems; regional water supply infrastructure, such as canals and dams; and educational facilities and services that support the agricultural sector.

[2] The terms "adaptive capacity" and "resilience" are sometimes used interchangeably to refer to the ability of a system to cope with a change. To avoid confusion, this paper uses the term "adaptive capacity" only to refer to the medium-run component of resilience.

absorb, recover from, and more successfully adapt and transform in response to adverse events." [3] This definition embeds three essential capacities – absorptive, adaptive, and transformative capacity – which differ with respect to the timeframe over which action is taken and correspond to short-, medium- and long-run concepts, respectively (FAO, 2018[34]).[4]

Absorptive capacity is "the ability of a system to prepare for, mitigate or prevent the impacts of negative events using predetermined coping responses in order to preserve and restore essential basic structures and functions" (Mitchell, 2013[35]). This refers to the ability of the system to cope with the impacts of a shock in the short run. Examples of measures to support absorptive capacity include, for example, creating early warning systems that alert farmers to impending pest outbreaks or frost or crop insurance schemes that pay out in the event of a catastrophic loss.[5]

Adaptive capacity is "the ability of a system to adjust, modify or change its characteristics and actions to moderate potential, future damage and to take advantage of opportunities, all in order to continue functioning without major qualitative changes in function or structural identity" (Mitchell, 2013[35]). Developing this capacity consists of efforts to address climate change impacts over the medium run by undertaking incremental, rather than radical, changes in behaviour (Ignaciuk, 2015[36]). Examples include changes in farm operations, such as a shift in planting dates, adjustments in the crop mix, or the adoption of more efficient irrigation technologies.

Transformative capacity refers to the ability "to create a fundamentally new system when ecological, economic or social structures make the existing system untenable" (Mitchell, 2013[35]). When adaptation is insufficient to develop resilience against a shock, more dramatic changes to the system may be necessary. Developing this capacity necessitates long-run structural change, such as developing new production systems or investing in institutional change.

Efforts to support adaptation may involve investments in one or more of these capacities, although typically there exists some trade-off between them. In particular, developing transformative capacity may supplant the need to invest in absorptive or adaptive capacity; conversely, investing in absorptive or adaptive capacity may forestall the need to invest in transformative capacity.

An example of one such trade-off is described in Box 1.1 (Kenny, 2007[37]). Faced with a reduction in winter chilling, producers of kiwifruit in New Zealand's Bay of Plenty region have often responded by applying Hydrogen Cynamide (HC) to artificially induce budbreak in the spring. The availability and use of this short-term action to mitigate damages from a shock is a form of absorptive capacity. Recognising that winter chilling was likely to pose an ongoing challenge, the sector considered, but ultimately rejected, a proposal to move production southward into regions with more favourable temperatures. Instead, the sector invested in developing new cultivars with lower winter chilling requirements, a form of adaptive capacity that allowed production to continue in the Bay of Plenty region. In this case, investments in adaptive capacity allowed the industry to avoid undertaking transformative change.

Transformational change in response to climate remains relatively rare and less well understood than the more incremental changes associated with adaptive capacity. Examples of climate-driven transformation among OECD countries to date include a shift from rice to sugarcane production in Costa Rica in response

[3] The IPCC defines resilience as "the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity for self-organization and the capacity to adapt to stress and change" (2007[20]). This definition seems to focus on absorptive and adaptive capacity, rather than transformative capacity, which would involve a change in the structure of the system. Yet the IPCC also recognises that building climate-resilient pathways requires a combination of incremental and transformational actions (IPCC, 2014[13]).

[4] Preparedness is often included as a fourth key component that consists of actions taken in advance of a shock in order to increase the ability of the system to recover *ex post*. Preparedness thus enhances the other three resilience capacities. In this sense, any of the *ex ante* policy actions taken by governments to build the three resilience capacities can be thought of as an investment in preparedness.

[5] Although insurance programmes can support absorptive capacity and resilience, they can also reduce resilience, for example by crowding out other risk-management strategies or by creating an incentive for maladaptation (OECD, 2020[25]).

to reduced water availability, and the expansion of viticulture in the United Kingdom, made possible by a longer growing season above the minimum temperatures for grape production (Vermeulen et al., 2018[38]). Generally, transformation has arisen in the context of regions or activities that are highly vulnerable to climate change, e.g. in low-lying regions with a high level of poverty, or in cases where impacts are particularly severe, e.g. in climate hot spots or areas experiencing tipping points (Kates, Travis and Wilbanks, 2012[39]). In the vast majority of cases, transformation occurs autonomously and as an *ex post* response, rather than as the result of a planned, or anticipatory, approach.

A variety of obstacles impede transformation in cases where it may be beneficial. Examples known to limit the capacity of systems to transform include uncertainty over the effects of climate change, large initial costs of change, and institutional or behavioural constraints (Kates, Travis and Wilbanks, 2012[39]). Even though transformational change remains less well understood and less well studied than the more incremental changes supported by adaptive capacity, policy attention is increasingly turning toward the necessity of facilitating the transformation of food and agricultural production systems. For example, the United Nations has placed greater emphasis on the need for transformation in the context of food systems and the IPCC recognises the necessity for transformational change of food and agricultural production systems to support sustainable development, albeit with concern about the implications from the standpoint of ethics and equity (Denton et al., 2014[40]; Webb et al., 2021[41]).

Box 1.1. Absorptive, adaptive, and transformative capacities in the case of kiwifruit production in New Zealand's Bay of Plenty

Climate challenges to kiwifruit production

The primary variety of kiwifruit traditionally grown in New Zealand is the Green ('Hayward') fruit. The Bay of Plenty region, located on the North Island, is home to the majority of the country's kiwifruit industry. This region has experienced an ongoing reduction in winter chilling, which delays budbreak and leads to a reduction in flower numbers and yield. One mechanism traditionally used by growers to compensate for a lack of winter chilling is the application of Hydrogen Cynamide (HC) in the spring to stimulate uniform budbreak and early bloom. HC is used not only for kiwi, but also for blueberry, grape, apple, and peach production. The efficacy of HC is expected to decline due to climate change.

Adaptation rather than transformation

Originally, researchers believed that the kiwifruit industry would be required to relocate further southward in the country to ensure adequate winter chilling for the Green variety. However, investments in research and development yielded new cultivars that have allowed production to continue in the Bay of Plenty region. The new varieties of fruit, e.g. the "SunGold" kiwifruit ('Zesy002'), have a lower winter chilling requirement than the Green variety. Alongside the development of new cultivars, growers have implemented a number of changes in operations management specific to the new cultivars, including trunk girdling to increase fruit size and the use of artificial shelters above and below the canopy to manage air movement, temperature, and light.

Source: Kenny (2007[37]).

1.3. Objective and questions

The overarching objective of this paper is to identify whether and how OECD countries are investing in adaptation programmes, and how those investments may contribute to the development of resilience within the agricultural sector. The focus is on planned adaptation undertaken at a collective level, rather than on autonomous adaptation. Governments have an important role to play in adaptation: they have the capacity to alter the institutional constraints that shape the ability of farmers to undertake autonomous adaptation; they can address issues related to market failures and equity; and they can invest in long-term transformative capacity beyond what is possible at the scale of the private individual or group. Developing

transformative capacity, in particular, is essential to building resilience to the dramatic climate-driven changes the sector is already experiencing and which will continue to increase in intensity in the coming years. This work complements and builds on existing work related to resilience by digging deeper into the particular policies, investments and incentives that countries are considering or using to facilitate climate change adaptation given the critical challenge this poses for the agriculture and food sector going forward.

To accomplish the overarching objective, this study undertakes an empirical analysis of international reporting documents submitted by current OECD countries to the United Nations Framework Convention on Climate Change (UNFCCC). These include national communications submitted by all Parties to the Convention, as well as documents submitted by Parties to the Paris Agreement, namely nationally determined contributions (NDCs) and adaptation communications. The scope for reporting on adaptation in these documents is discussed in Section 2.

These documents do not present a comprehensive catalogue of all measures undertaken to date by OECD countries. The UNFCCC documents must balance material related to mitigation and adaptation and they must cover all sectors, not only agriculture. As a result, the coverage of agricultural adaptation is likely to be more superficial than what might be found in a national or sector-level adaptation plan. Reviewing national-level documents is a challenging task because they are in various stages of development and they vary in terms of content, publication date and language of publication.[6] Analysis of national documents for all OECD members is a worthy future goal, but is outside of the scope of this study.[7]

Nevertheless, these documents serve as a mechanism to showcase the actions and activities that the countries themselves perceive to be of greatest significance on an international stage. As such, they can provide some insights into the importance of agricultural adaptation to member countries. Focusing on this set of documents also presents several practical advantages. The set of documents are comprehensive in their coverage of OECD members and they are submitted on approximately the same timeline, ensuring that they represent a reasonable cross section. In addition, the formatting of the documents, particularly the national communications, is standardised, which facilitates a cross-country analysis.

In analysing the UNFCCC documents, this study seeks to address four questions:

- To what extent do the UNFCCC documents articulate concerns related to climate change adaptation and agriculture? (Section 3)
- What types of agricultural adaptation measures are of interest to OECD countries and what specific programmes have been established to date? (Section 4)
- To what extent are the adaptation programmes reported by members responsive to the climate change vulnerabilities identified in the UNFCCC documents? (Section 5)
- Do the agricultural adaptation programmes proposed by members potentially contribute to strengthening resilience along all three dimensions of absorptive, adaptive, and transformative capacity? (Section 6)

This study provides a complement to OECD (2020[25]) by exploring government responses in the form of adaptation planning to respond to climate-driven trends and risks. This study focuses specifically on government measures and to one particular source of risk – that which arises from climate – although in many cases policies that address climate risk also address other risks. This study marks a first effort to comprehensively take stock of programmes to support climate change adaptation in agriculture across OECD countries. Furthermore, it complements Gagnon-Lebrun and Agrawala (2006[5]) and Mullan et al.

[6] The European Union maintains the ClimateADAPT website (https://climate-adapt.eea.europa.eu/), including a thematic map illustrating the status of development of national and sectoral adaptation strategies and plans and a link to the most recent documents registered by each country. A UNFCCC website provides links to national adaptation plans for Non-Annex I members (https://www4.unfccc.int/sites/NAPC/Pages/national-adaptation-plans.aspx).

[7] Mullan et al. (2013[42]) reviewed the status of national adaptation plan (NAP) development across OECD countries. The first national adaptation strategy within the OECD was published by Finland in 2005. As of 2013, their review revealed that 26 OECD countries had already developed, or were in the process of developing, strategic frameworks for national adaptation. Among those, 17 countries had developed, or had begun developing, detailed NAPs for implementation.

(2013[42]) by presenting a complete time series analysis of UNFCCC documents to generate new insight into how the treatment of adaptation, resilience, and agriculture has evolved over the past three decades.

1.4. Analytical approach

The approach taken to answer these questions is grounded in content analysis, established within the social sciences as a method for analysing text. At its core, content analysis views words and the context in which they are used as data. Content analysis is defined as "a research method for the subjective interpretation of the content of data through the systematic classification process of coding and identifying themes or patterns" (Hsieh and Shannon, 2005[43]).

In practice, approaches to content analysis may be qualitative and/or quantitative. A quantitative approach to textual analysis often involves examining the frequency of coding instances using statistics.[8] A qualitative approach to content analysis, in contrast, examines the characteristics of the words used to communicate, taken within the context of the text from which the words are extracted (McTavish and Pirro, 1990[44]). A qualitative content analysis can be approached in many ways, but generally follows seven steps: i) formulating the research questions to be answered; ii) selecting the sample to be analysed; iii) defining the categories to be applied; iv) outlining the coding process; v) implementing the coding process; vi) determining trustworthiness (or internal consistency; i.e. demonstrating that the textual evidence is consistent with the interpretation);[9] and vii) analysing the results of the coding process.

This analysis uses a mixed-methods approach, i.e. a combination of quantitative and qualitative methods. The analysis begins with quantification of the frequency of word use in Section 3, which serves as an indicator of the extent of interest in, or importance assigned to, particular words without considering their contextual meaning (Potter and Levine-Donnerstein, 1999[45]). For example, the number of instances in which words relevant to agriculture appear in the UNFCCC documents may indicate the degree of concern over the consequences of climate change for the sector (Gagnon-Lebrun and Agrawala, 2006[5]). The analysis then uses a qualitative approach in Sections 4-6 to examine the context within which keywords of interest are used. This second stage involves examining the text near a keyword to determine, for example, if words related to agriculture are used the context of discussing mitigation, vulnerabilities, or adaptation.

1.5. Caveats

A number of limitations of this analysis are worth noting. First and foremost is that this analysis is not a comprehensive catalogue of adaptation activities developed by OECD members to date. Instead, it seeks to provide an overview of the breadth of programmes undertaken within the OECD membership that are contained in the UNFCCC documents. OECD members may have developed other documents that contain additional information not covered by this report, such as national adaptation strategies and/or national adaptation plans (NAS/NAP) or sectoral adaptation plans specific to agriculture or natural resource management. In addition, other reporting requirements, such as those under the United Nations Convention to Combat Desertification (UNCCD), potentially contain more information on agricultural adaptation programmes than the UNFCCC documents. Future OECD work could integrate data from these sources to complement the analysis presented herein.

Moreover, the material in the UNFCCC documents is self-declared. Governments do not necessarily share common definitions of adaptation nor of the measures that qualify as efforts to support adaptation. The programmes included in these documents thus may represent a biased sample.[10] As such, this analysis is

[8] This is sometimes referred to as "the quantitative analysis of qualitative data" and its use is cautioned within the social science literature (Morgan, 1993[81]). For this reason, quantitative interpretations are typically combined with qualitative analysis in a mixed-methods approach, rather than used in isolation.

[9] In this study, reliability of the coding frame is assessed via a comparison of coding results across time: the coding frames were used to analyse the set of UNFCCC documents on two occasions, first during the period April-June 2022, then during the period July-September 2022. Differences in coding between the two analyses were identified and reconciled to arrive at the final results presented in this paper.

[10] It is possible also that reporting is affected by the national commitments made toward mitigation under the Paris Agreement, even though there is no direct linkage made between mitigation and adaptation in the reporting guidelines.

limited in its ability to support inference about the state of adaptation programming in member countries. That said, this study offers a first attempt to outline the scope of actions undertaken throughout the OECD toward adaptation and to generate insights into whether and in what ways members are supporting resilience in agriculture. In addition, the programmes described herein can serve as useful models that can be adapted to differing contexts and used to support countries within the OECD and beyond as they undertake efforts to facilitate adaptation.

This study also does not attempt to measure progress in developing adaptation programmes for agriculture. Measuring progress on adaptation is a difficult challenge in general and requires a depth of investigation beyond what is possible for an OECD-wide analysis (OECD, 2021[46]; Rambali and Kirsch, 2022[47]). Instead, this study offers a first attempt to catalogue and examine systematically the nature of the programmes presented in international reporting documents.

It is also not possible using the documents reviewed here to evaluate the outcomes of programmes and activities undertaken by members, nor is it possible to evaluate whether actions have resulted in increased resilience. Many of the programmes and activities are planned for future implementation, ongoing, or only recently completed and data on their outcomes is limited. Even when programmatic outcomes are known, quantifying the relationship between programmatic outcomes and resilience is challenging (Jones, 2018[48]; Dilling et al., 2019[49]). This analysis therefore examines the potential for the programmes described to contribute to strengthening the capacities necessary for resilience.[11] Even with this limitation, it is possible to gain insight into where programmatic strengths are concentrated and where there may be opportunities for expansion.

Additionally, this analysis focuses specifically on activities that are explicitly linked to agriculture within the language of the documents reviewed. Limiting attention to textual references that explicitly link to agriculture means that if a programme supports agriculture, but the relationship is not articulated within the documents reviewed, it will not be captured in the analysis. Expanding the analysis to national-level programmatic documentation is outside the scope of this study.[12]

Finally, this analysis incorporates reporting documents submitted to the UNFCCC prior to 1 February 2023. This date fell one month after the submission deadline for the 8th national communication under the Convention's reporting requirements. For those OECD members that did not submit an updated report prior to 1 February 2023, the next most recent national communication, in most cases the 7th, was analysed. Given that the 7th national communication was generally submitted in 2017 or 2018, the analysis contained herein may omit for some members recent progress on adaptation, such as actions undertaken with the most recent cycle of the Common Agricultural Policy (CAP) for EU Members.

This paper finds little correlation between the extent of discussion of agriculture in the context of mitigation and the extent of discussion in the context of adaptation within the reporting documents examined. However, this work has not considered whether the existence of agricultural mitigation targets or their stringency is correlated with whether or how adaptation activities are reported.

[11] This is similar to the definition of progress in policy design in Gruère and Shigemitsu (2021[82]), which is useful, but not sufficient, to assess progress. The other two dimensions required to gauge progress are implementation capacity and policy results, neither of which can be assessed using the UNFCCC documents reviewed in this analysis.

[12] In addition, activities related to international support of agriculture in developing countries are excluded from this analysis in order to sharpen the focus on the programmes that serve agriculture domestically.

2. Adaptation documentation by OECD countries

This document examines adaptation and resilience by analysing the text of international reporting documents submitted to the UNFCCC. There are two main mechanisms by which OECD members codify their plans, activities and accomplishments relevant to adaptation: through periodic national communications required of Parties to the Convention (197 Parties) and through reporting under the Paris Agreement (191 Parties) in the form of nationally determined contributions (NDCs) and adaptation communications.

2.1. International reporting via national communications to the UNFCCC

The UNFCCC, which entered into effect in 1994, sets the objective of stabilising greenhouse gas concentrations "at a level that would prevent dangerous anthropogenic (human induced) interference with the climate system… within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened, and to enable economic development to proceed in a sustainable manner" (UNFCCC, 1992[50]).

The Convention defines three main groups of Parties: Annex I Parties that were members of the OECD as of 1992 as well as economies in transition (EIT); Annex II Parties that consist of OECD members as of 1992 but exclude the EIT and Türkiye;[13] and Non-Annex I parties. Table A.I lists the UNFCCC classifications for all current OECD and G20 members. This distinction is important because reporting requirements differ between groups, as do expectations with respect to climate financing.

Each Party to the Convention is required to submit national communications in accordance with guidelines developed and adopted by the Conference of the Parties (COP). Annex I Parties are required to submit a national communication every four years, with the most recent being the 8th national communication due on 31 December 2022. Non-Annex I Parties are required to submit their first national communication within three years of entering the Convention and every four years thereafter.

For Annex I Parties, the COP adopted guidelines for a standardised national communication format that includes a chapter devoted to assessing climate change vulnerabilities and reporting adaptation measures. For Non-Annex I Parties, the reporting guidelines are more flexible, but the national communications are expected to include sections on programmes that facilitate adaptation to climate change, barriers to implementation of adaptation measures, and information on how support programmes through the Convention help to meet the Party's adaptation needs.

2.2. International reporting under the Paris Agreement

A core component of the Paris Agreement is the preparation by each Party of a nationally determined contribution (NDC), which embodies "efforts by each country to reduce national emissions and adapt to the impacts of climate change" (UNFCCC, 2022[51]). Each Party is required to communicate an updated NDC every five years starting in 2020, where each NDC represents a progression compared to the previous version and captures the Party's "highest possible ambition." As of October 2021, all 191 Parties to the Agreement had submitted one or more NDCs to the UNFCCC.

In addition to the NDCs, Parties are encouraged to provide information on climate change impacts and adaptation progress as part of an adaptation communication. Although not a formal requirement, article 7 of the Paris Agreement establishes the expectation that each Party submit and update a communication on adaptation in order to: "(a) increase the visibility and profile of adaptation and its balance with mitigation; (b) strengthen adaptation action and support for developing countries; (c) provide input to the global stocktake; (d) enhance learning and understanding of adaptation needs and actions" (UNFCCC, 2022[52]).

While NDCs are mandatory under the Paris Agreement, reporting on adaptation within them is not. In contrast, adaptation communications are not mandatory, but their content by design focuses exclusively on adaptation. There is considerable flexibility in the form of the adaptation communication. Slightly more than half of those submitted thus far are unique documents. The remainder take the form of the most recent

[13] Türkiye was excluded from Annex II starting in 2001.

NDC, national adaptation plan (NAP), or national communication to the UNFCCC. Adaptation communications are relatively new, with first submission dates generally in 2020-2022.[14]

2.3. Prior studies of adaptation in the UNFCCC documents

Leveraging the relatively standardised format of national communications, Gagnon-Lebrun and Agrawala (2006[5]) undertook a content analysis to examine the treatment of adaptation across countries and over time. To examine trends over time, they analysed the 2nd and 3rd national communications. Their analysis focused on general adaptation within developed countries, not agricultural adaptation specifically. Using the quantity of space within a national communication allocated to the discussion of adaptation as an indicator of the emphasis placed on adaptation planning, they found that the national communications devoted relatively little attention to adaptation relative to the attention given to mitigation. Within the text devoted to adaptation, they found that climate change impacts and vulnerabilities dominated the discussion. Text on adaptation tended to identify generic options, with little evidence provided on specific programmes or their implementation. They supplemented their analysis of the national communications with a review of national-level adaptation documents and presented evidence of an increase in the development of national and regional adaptation strategies and frameworks.

Mullan et al. (2013[42]) updated the analysis of Gagnon-Lebrun and Agrawala (2006[5]) to the 5th round of national communications. Their analysis identified a significant increase in adaptation planning among OECD countries. In particular, they found that all countries discussed climate change impacts and future scenarios in their national communications and that the number of countries discussing adaptation in general terms increased from 15 to 31 from 2006-2012. Over the same time frame, the number of countries discussing specific adaptation policies or programmes rose from 5 to 27.

Pauw et al. (2019[53]) reviewed the NDCs submitted by all Parties to the Paris Agreement. They found that in their NDCs, Annex I Parties were more likely to focus on presenting mitigation targets, while Non-Annex I Parties tended to more heavily emphasise adaptation actions in order to justify requests for financing. These differences in country commitments and reporting stem from the Paris Agreement's language allowing for "common but differentiated responsibilities and respective capabilities" among Annex I and Non-Annex I Parties.

According to a synthesis report by the UNFCCC Secretariat (2021[54]), although NDCs may present information on both mitigation and adaptation (as well as mitigation-adaptation co-benefits), the majority tend to focus on mitigation. While all of the Parties to the Paris Agreement defined mitigation targets in their NDCs, fewer provided information on adaptation actions and even fewer defined mitigation-adaptation co-benefits. The report found that the coverage of adaptation in NDCs increased over time and exhibited greater focus on the development and implementation of national adaptation plans (NAPs). Top adaptation priorities identified by Parties that are relevant to agriculture included food production and security and freshwater resources and ecosystems. Of the adaptation measures discussed, Parties tended to emphasise research and identifying climate change vulnerabilities.

A review by Crumpler et al. (2021[4]) found a trend toward greater coverage of adaptation in the NDCs specifically within the context of agriculture, forestry and fisheries. They found that the NDCs exhibited "a steady improvement in both the coverage and quality of mitigation and adaptation in the agricultural, forestry and fisheries sectors," and that they tended "to be aligned with longer-term low-emissions and climate-resilient goals and pathways." They found that 95% of NDCs included adaptation priorities or actions relevant to agriculture, including cropping (70%), livestock systems (55%) and the agri-food value chain (51%). Specific adaptation actions referenced include switching to drought-resistant cultivars, a return to indigenous livestock breeds, dry post-harvest processing, and cross-cutting approaches such as climate-smart agriculture.

Despite an increase in the attention to adaptation within agriculture, Crumpler et al. (2021[4]) also found that only 40% of NDCs referenced long-term adaptation goals. When long-term goals were discussed, they

[14] The exception is New Zealand, which submitted its first adaptation communication in 2017 and a second version in 2022, both in the form of a national communication.

found that they most often included changes to existing agricultural production systems, such as diversifying income sources or restoring nitrogen in soils.

2.4. Documents reviewed in this analysis

All OECD countries are Parties to the Convention. As listed in Table A.1, there are 39 OECD countries at present (38 countries plus the EU, which submits some reporting documents as a collective). Of these, 33 are classified as Annex I, 24 as Annex II, and 6 as Non-Annex I (Chile, Colombia, Costa Rica, Israel, Korea, and Mexico).

For the quantitative portion of this report (Section 3), all national communications submitted to the UNFCCC prior to 1 February 2023 are analysed, including archived documents. The national communications by version are listed in Table A.2. This analysis thus represents an extension to Mullan et al. (2013[42]) of up to three reporting rounds (the 6th-8th) covering approximately 12 years. There is some variation in submission dates, particularly among Non-Annex I Parties relative to Annex I Parties due to differences in the timing with which they signed the Convention: version 1 was generally submitted in 1995, with version 2 occurring slightly sooner than 4 years, generally in 1997, and continuing every 4 years thereafter. The quantitative analysis examines the entirety of the national communication document, including chapters focused on mitigation as well as text focused on vulnerabilities and adaptation.

The qualitative portion of this report (Sections 4-6) focuses only on the most recent version of the national communication submitted by each OECD member country as of 1 February 2023. The 8th national communication was submitted and made publicly available via the UNFCCC registry for 23 OECD members by this deadline. For other Annex I OECD members, the most recent document available was the 7th national communication, which was generally published in 2017 or 2018 and thus may not include the most recent changes in adaptation actions. The most recent communication for Non-Annex I OECD members was the 3rd (Colombia, Israel), 4th (Chile, Costa Rica, Korea), or 6th (Mexico). The qualitative analysis focuses only on the chapter(s) devoted to climate change vulnerabilities and adaptation measures.

All current OECD members are subject to the Paris Agreement's reporting requirements and all have submitted at least one NDC as of 1 February 2023. The NDCs analysed herein are listed in Table A.3. The first versions of NDCs were generally submitted in 2016; nearly all OECD members have published a second version. The European Union submits a single NDC on behalf of all EU members. The quantitative portion of the analysis includes all NDC versions, whereas the qualitative portion focuses on the most recent submissions as of 1 February 2023.

To date, 19 OECD members (48.7%) have submitted an adaptation communication.[15] In some cases, the adaptation communication is identical to other UNFCCC documentation. Specifically, Colombia and Costa Rica's NDC serves as the adaptation communication and New Zealand's adaptation communications are identical to their national communications. These materials are excluded from the review of adaptation communications to avoid double-counting. Table A.3 lists the adaptation communications reviewed.

In total, the quantitative portion of this analysis reviews 261 national communications, 44 NDCs, and 16 unique adaptation communications for a total of 321 documents. The qualitative analysis focuses on the most recent document versions, comprising 39 national communications, 17 NDCs, and 16 adaptation communications. Appendices, corrigenda, and updates, which generally do not contain new material relevant to the analysis, are excluded.

[15] All percentages of OECD membership are calculated relative to a total of 39, including the European Union as a collective, the individual European Union countries that are also current OECD countries, and the OECD countries that are not part of the European Union.

3. Treatment of adaptation, resilience, and agriculture in the UNFCCC documents

The objective of this section is to address the first question: "To what extent do the UNFCCC documents articulate concerns related to climate change adaptation and agriculture?" As a starting point, the section presents a quantitative analysis of the frequency with which words related to adaptation and resilience are used within the UNFCCC documents, as well as the evolution of their use over time. It then explores the frequency of the use of words related to agriculture, as well as the context within which agriculture is referenced (mitigation, vulnerabilities, or adaptation). Finally, the section revisits and updates the conclusions of the studies discussed in Section 2.3 to assess how the treatment of agricultural adaptation by OECD members has evolved.

3.1. Frequency of word use: Adaptation and resilience

This analysis first evaluates the extent to which the UNFCCC documents address adaptation and resilience in a general sense. Text referencing adaptation is identified based on a keyword search for any word containing the stem "adapt-," e.g. adapt, adaptation, and adaptive, and their Spanish and French equivalents. Similarly, text related to resilience is identified based on a keyword search for the stem "resil-," e.g. resilient, resilience, and resiliency, and Spanish and French equivalents. Figure 3.1 reports the frequency of keyword use as a percentage of the total number of words published in all versions of the Paris Agreement documents; Figure 3.2 presents the same information for the national communications.

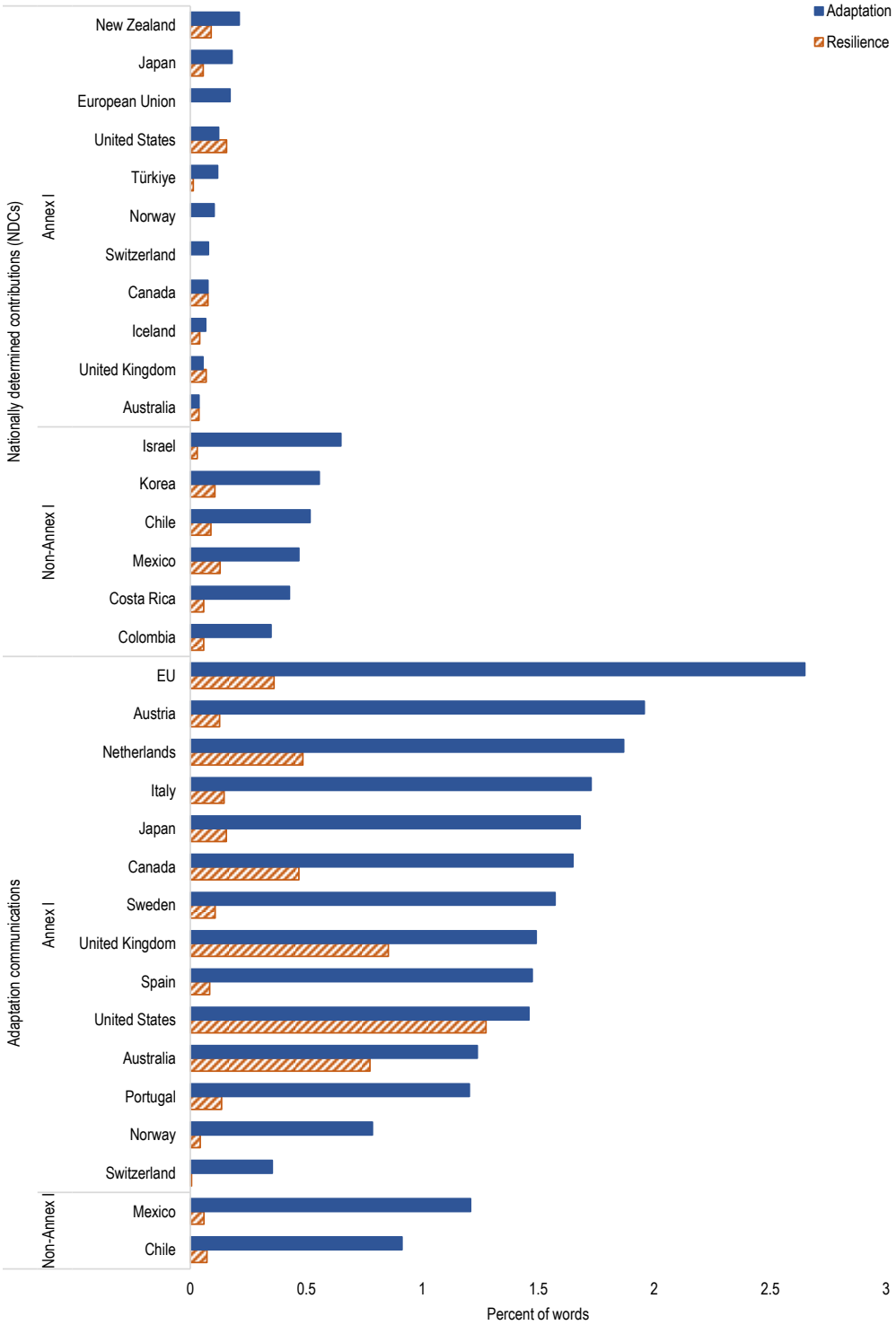
Expressing the results as a percentage of the total adjusts for differences in the lengths of documents across type (NDCs are generally shorter than adaptation communications or national communications) and across UNFCCC Parties (the NDCs of Non-Annex I Parties tend to be longer than those of Annex I Parties). These results are based on the frequency with which a word appears, without considering the context within which the word is used. As a result, some spurious references to adaptation and resilience, such as the template text of the NDCs, headers, footers, and references, are included. Nonetheless, the frequency of word use supports insight into broad trends across members and documents.

From Figures 3.1 and 3.2, each UNFCCC document type contains some reference to adaptation within at least one version, although the frequency of references varies significantly by document type. Across all versions, the average frequency of references to adaptation is lowest in the national communications, with a mean of 0.16%. The mean number of references to adaptation among the NDCs is slightly higher at 0.25% and the mean frequency of use is greatest among the adaptation communications at 1.45%.

The term resilience is used far less often than adaptation in the UNFCCC documents, although the patterns across document type and Parties is similar. The mean percent of text within the national communications is lowest at 0.02%. The NDCs are slightly higher with a mean of 0.06% and the adaptation communications reference resilience most often with a mean of 0.32%. Resilience is not mentioned at all in 44% of the national communications reviewed and in 38% of the NDCs reviewed.

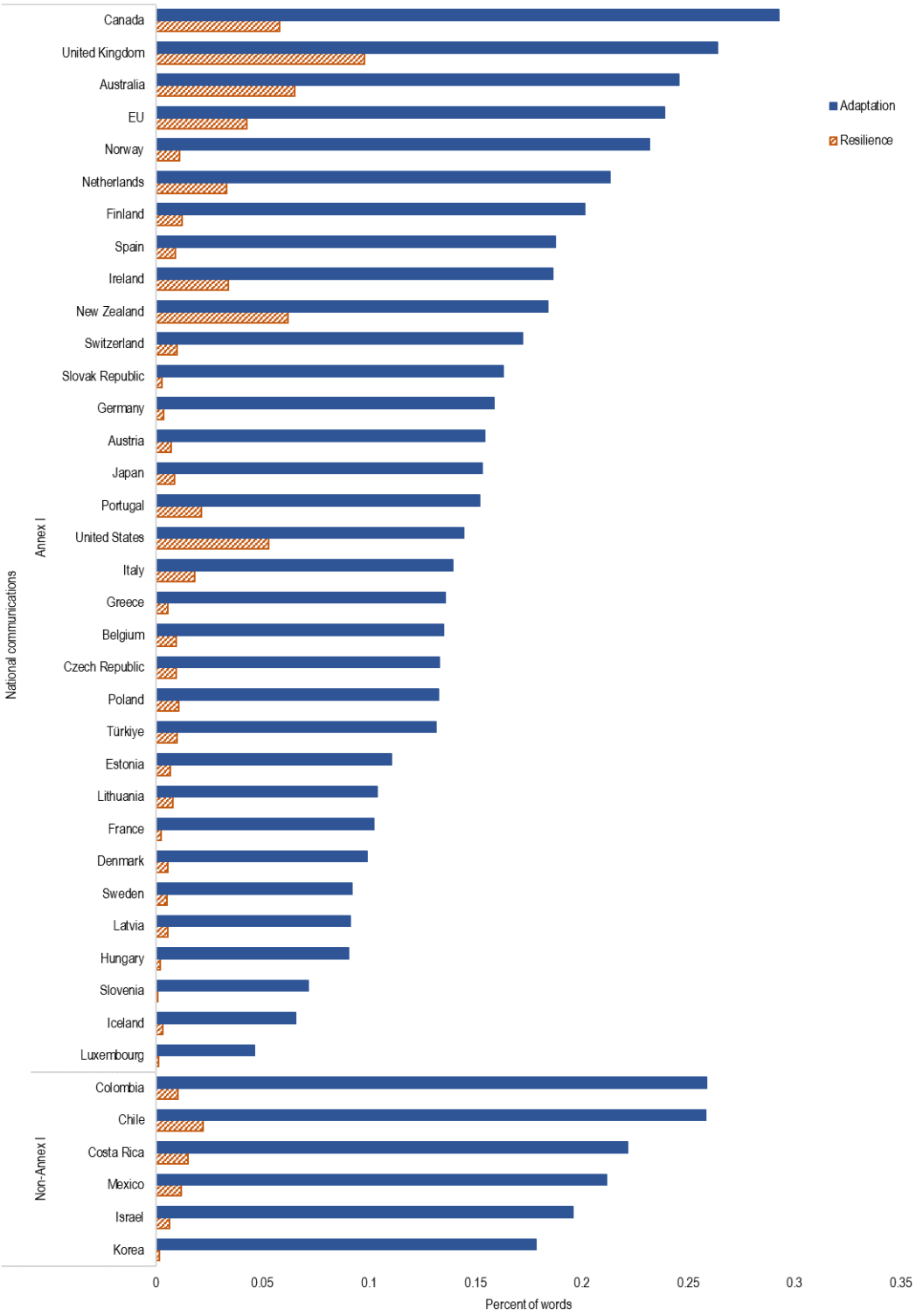
The figures illustrate heterogeneity across member countries in terms of the frequency with which they reference adaptation and resilience in their documents: references to adaptation range from 0.05% (Luxembourg) to 0.29% (Canada) for the national communications and from 0.04% (Australia) to 0.65% (Israel) for the NDCs.

Figure 3.1. Frequency of references to adaptation and resilience, Paris Agreement documents



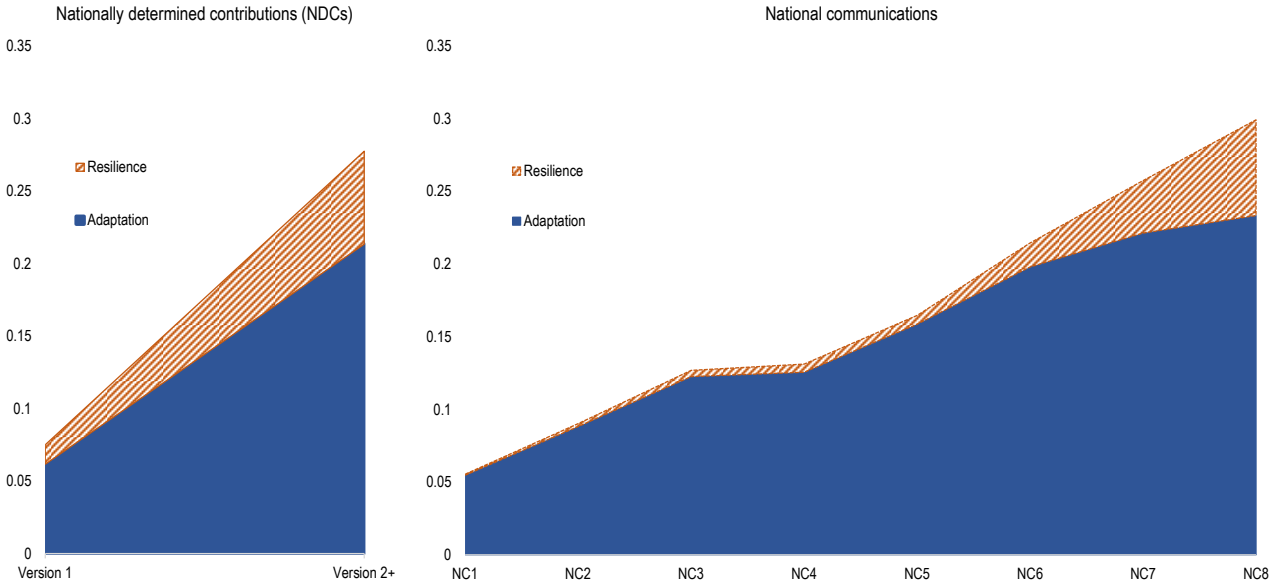
Note: Frequencies are reported for occurrences of keywords across all historical versions of the documents submitted.

Figure 3.2. Frequency of references to adaptation and resilience, national communications to the UNFCCC



Note: Frequencies are reported for occurrences of keywords across all historical versions of the documents submitted.

Figure 3.3. Change in frequency of adaptation and resilience across document versions



A particularly striking difference between Annex I and Non-Annex I member submissions is evident among the NDCs: the documents submitted by Non-Annex I members more heavily emphasize adaptation than the equivalent documents submitted by Annex I members. For adaptation, the frequency of reference is 0.49% for Non-Annex I members compared with 0.11% for Annex I countries. This heterogeneity between Annex I and Non-Annex I members does not persist across the national communications or the adaptation communications, although fewer Non-Annex I members have submitted one to date.

The keyword frequencies are challenging to interpret without additional context. To aid in their interpretation, Figure 3.3 illustrates the trend across document versions in the frequency of references to adaptation and resilience.[16] Across the NDCs and the national communications, the number of references to adaptation increased over time for the OECD in aggregate. Among the NDCs, adaptation and resilience have received increased attention since the first version: references to adaptation more than doubled, increasing by 246% between the two periods. References to resilience increased by 381%, although the frequency of references remains low, at a level roughly equivalent to early use of the word adaptation. The frequency of adaptation more than quadrupled from 0.05% in the 1st national communication to 0.23% in the 8th. Similarly, the frequency of resilience increased, with a particularly large change between the 6th and 8th national communications.

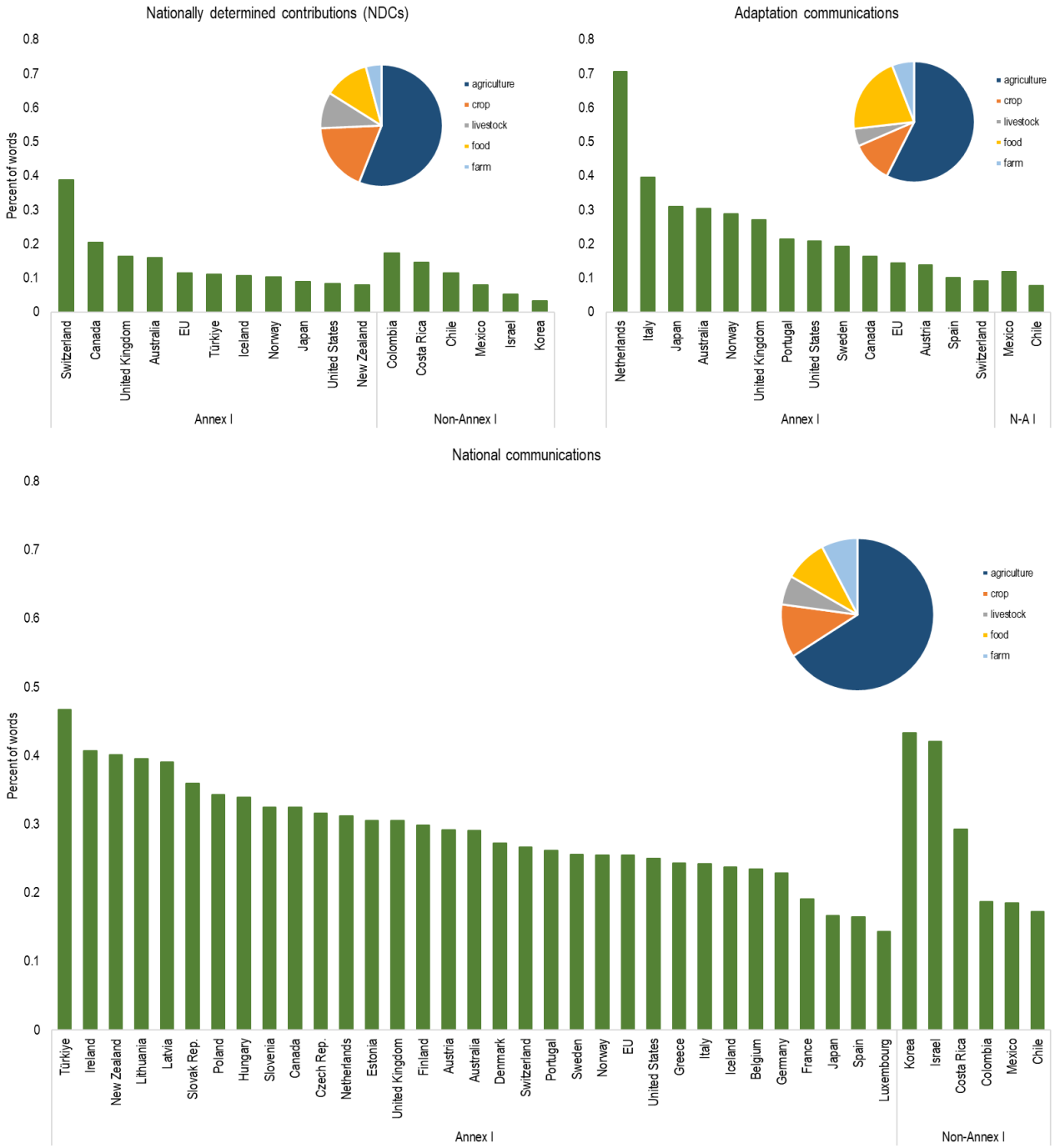
The same trends hold for OECD members taken individually: references to adaptation increased for all NDCs between version 1 and subsequent versions; and references to adaptation for the national communications increased for 38 member countries (97.4%) between the 1st and last national communication. References to resilience increased for all members in both the NDCs and the national communications.

3.2. References to agriculture: Frequency and context

The frequency of references to agriculture across countries and reporting documents is similarly evaluated based on a keyword search although the dictionary of terms is expanded beyond “agriculture” and related variants to include “food”, “farm”, “crop”, “livestock”, related variants for each, and their Spanish and French equivalents. Figure 3.4 presents the frequency of agricultural word use as a percentage of all words by document type, as well as a proportional breakdown of keyword appearance within each document type.

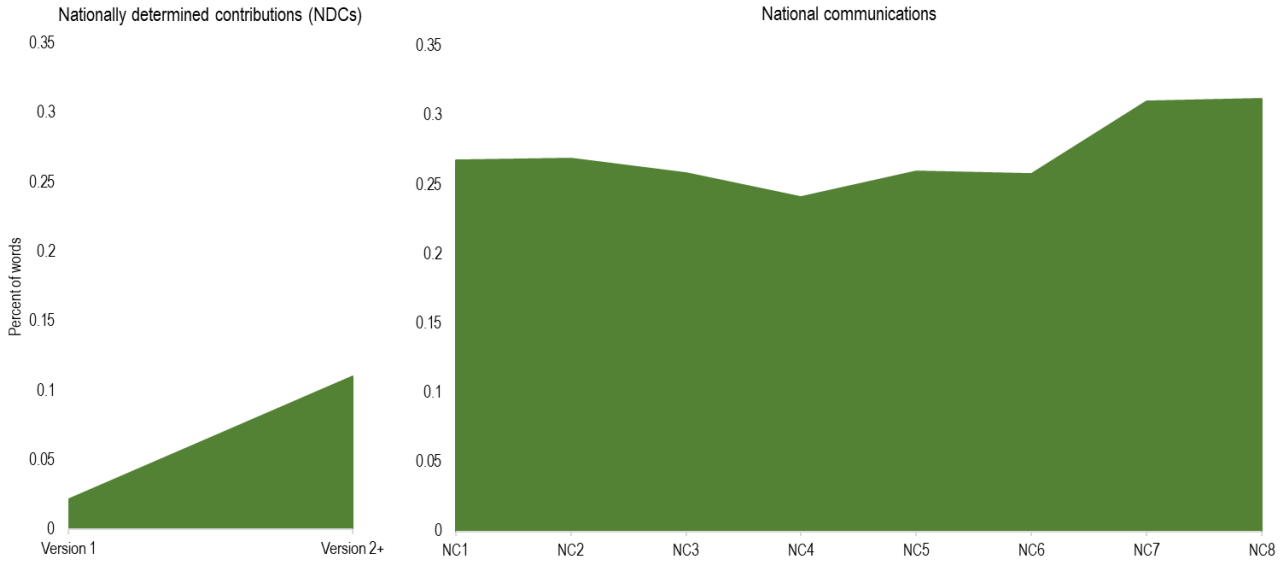
[16] Trends across versions are only relevant for the NDCs and national communications as only a single version of the adaptation communication has been submitted to date by OECD countries.

Figure 3.4. Frequency of reference to agricultural keywords, by document type



Note: Bar charts illustrate the total percentage of agricultural keywords cited within the document type. Pie charts illustrate percentage of agricultural references by keyword for all documents analysed. Keywords are inclusive of all words that share the same stem and corresponding keywords in Spanish and French: agriculture (agricultural, agriculturally, agricultura, agriculturas, agropecuario, agropecuarios, agricole, agricoles); crop (cropped, cropping, crops, cultivo, cultivos, culture); livestock (livestocks, ganadería, ganaderías, bétail, élevage); food (foods); farm (farms, farmed, farming, finca, fincas, granja, granjas, ferme).

Figure 3.5. Change in frequency of agricultural keywords across document versions



Agriculture appears least often in the NDCs, with a mean frequency of 0.13% across member countries. Agriculture is referenced twice as often in the adaptation communications with a mean of 0.23% and slightly more often in the national communications with a mean of 0.29%. The degree of heterogeneity in word use across members is similar to that of adaptation, although unlike adaptation, there is little difference in the frequency of word use between Annex I and Non-Annex I Parties. In all document types, close variants of "agriculture" are used most often, but references to "food" appear most often in the adaptation communications, typically in the context of food systems, rather than agricultural production systems.

Figure 3.5 illustrates the change across versions in the use of words related to agriculture. Although the level of usage is relatively low in the NDCs, there is a pronounced increase in references, of nearly 400% between version 1 and later versions. In contrast, the frequency of references within the national communications remained relatively stable across versions but increased slightly in the 7th and 8th rounds.

The frequency with which keywords appear in the documents gives an indication of the extent to which agriculture is discussed, but those keywords may be used in different contexts: for example, the increase in agricultural references across the NDC versions may be due to increased attention to mitigation within the sector. To examine this possibility, each reference to an agricultural keyword is extracted along with its surrounding paragraph in order to capture the context within which the word is used. Each reference is then searched for a dictionary of contextual keywords indicating whether the discussion pertains to mitigation, vulnerabilities, and/or adaptation.[17]

The frequency of references by context and document type is given in Table 3.1. The first row reflects the number of instances within which agricultural keywords are used in context, i.e. excluding references without context such as headers. Of the contextual references that appear in the NDCs, 66.5% are within the context of mitigation. Remaining references are primarily used in the context of adaptation alone (15.2%) or mitigation and adaptation in combination (8.9%), typically in a discussion of co-benefits.

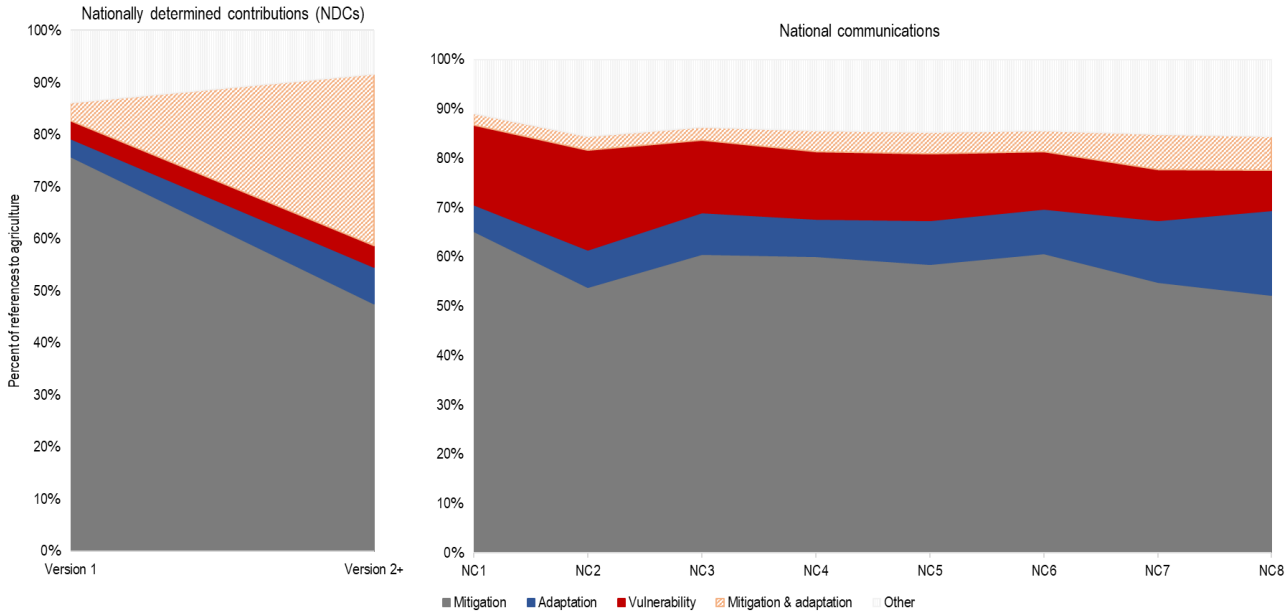
The breakdown by context is similar for the national communications: 59.2% of agricultural references are in the context of mitigation and 10.6% are in the context of adaptation alone. The discussion of vulnerabilities features slightly more prominently in these documents, accounting for 10.4% of all references, although an additional 5.7% discuss vulnerabilities and adaptation together. Mitigation and adaptation co-benefits (5.5%) are less often discussed in this document type.

[17] Contextual keywords used for mitigation include mitigation, emission, carbon, greenhouse, gas, enteric, fermentation, and "food waste" along with words that share the same stems and Spanish and French equivalents. Keywords for adaptation include adaptation, resilience, words that share the same stems and Spanish and French equivalents. Keywords for vulnerability include vulnerability, impact, pressure, words that share the same stems and Spanish and French equivalents.

Table 3.1. Frequency of agricultural references by context and document type

	Nationally-determined contributions	Adaptation communications	National communications
Total contextual references to agriculture	191	776	39 630
Percent references to agriculture in the context of:			
Mitigation	**66.5**	3.2	**59.2**
Vulnerability	6.3	18.6	10.4
Adaptation	15.2	**49.7**	10.6
Mitigation and adaptation	8.9	7.7	5.5
Vulnerability and adaptation	2.6	16.0	5.7
Other	0.5	4.8	8.6

Figure 3.6. Changes in context within which agriculture is discussed across versions



Discussion of agricultural adaptation features most prominently within the adaptation communications. Nearly half of references focus solely on adaptation (49.7%), followed by 18.6% on vulnerabilities and 16.0% on vulnerabilities and adaptation.

Figure 3.6 illustrates the changing context in which agriculture is discussed in the NDCs and national communications. Between version 1 and later versions of the NDCs, there was a decline in the percentage of references to mitigation from 75.9% to 47.6%. References to agricultural adaptation and vulnerabilities remained relatively constant between versions but increasing attention has been placed on describing mitigation-adaptation co-benefits, with an increase from 3.4% in version 1 to 32.9% in later versions.

The change across versions in the national communications likewise indicates a decrease in references to agricultural mitigation, although the magnitude of the decline is less pronounced than that for the NDCs: references to agricultural mitigation decreased from 65.2% on average in the 1st national communication to 52.2% in the 8th. Across versions, discussion of vulnerabilities initially increased from the 1st to the 2nd version, then decreased thereafter. Greater space has been given over time to discussion of adaptation (3.4% in the 1st versus 17.2% in the 8th) and to mitigation and adaptation together (2.3% in the 1st versus 6.7% in the 8th).

3.3. Comparison with prior studies of UNFCCC documents

The results of the quantitative content analysis presented in this section are consistent with the original analyses of Gagnon-Lebrun and Agrawala (2006[5]) and Mullan et al. (2013[42]) for national communications up to the 5th round. Adaptation tended to receive less attention than mitigation in early versions, although coverage of adaptation increased up to the 5th version. This analysis demonstrates that this trend has continued with a 47.1% increase in the frequency of references to adaptation between the 5th and 8th versions. Discussion of adaptation is now universal in the national communications and ideas surrounding resilience are beginning to appear with greater frequency.

Consistent with Pauw et al. (2019[53]) and the UNFCCC Secretariat (2021[54]), the NDCs of Annex I Parties tend to focus less heavily on adaptation than do those of Non-Annex I Parties, largely because the latter tend to focus on justifying a need for adaptation financing. This analysis finds that Annex I countries reference adaptation at a frequency of roughly one-fourth that of Non-Annex I countries. Nonetheless, discussion of adaptation is becoming more prevalent in the documents of Annex I members. Between version 1 and later versions, the frequency of references to adaptation increased nearly six-fold on average.

This analysis demonstrates that some of the trends documented in earlier studies with respect to adaptation generally also hold for agricultural adaptation more specifically. Following Crumpler et al. (2021[4]), later versions of the NDCs demonstrate increased attention to agriculture. This analysis finds a four-fold increase in the average per cent coverage of agriculture between version 1 and later versions. This analysis adds the insight that discussion in later versions focuses less heavily on agricultural mitigation alone, and more heavily on the joint role of agriculture in supporting mitigation and adaptation. In line with the results of Gagnon-Lebrun and Agrawala (2006[5]), this analysis also demonstrates that early versions of the national communications tended to focus more on identifying agricultural vulnerabilities, while later versions have shifted the emphasis towards adaptation. At the same time, the coverage of agriculture within the national communications has been relatively stable across versions.

The quantitative content analysis in this section provides insight into broad trends in the treatment of adaptation, resilience, and agriculture in the UNFCCC reporting documents. However, a deeper analysis is required to address questions related to whether the documents describe specific adaptation activities, whether those activities respond to the climate vulnerabilities identified within the documents, and whether those activities contribute to the development of resilience over the short, medium, and long run. Sections 4-6 undertake an in-depth qualitative assessment of a portion of the UNFCCC document pool as a complement to the quantitative results of Section 3.

4. Agricultural adaptation programmes

This section undertakes a qualitative content analysis in order to answer the second question: “What types of agricultural adaptation measures are of interest to OECD countries and what specific programmes have been established to date?”

The analysis presented in Sections 4-6 does not rely on a keyword search because countries use a wide range of vocabulary to discuss adaptation programmes. Rather, text related to adaptation is manually inspected and coded based on its content. The analysis starts from the contextual references to agriculture in Table 3.1, although the analysis is limited to the most recent rounds of documents submitted to the UNFCCC. In most cases, this is the 2nd version of the NDC, the 1st version of the adaptation communication, and the 8th version of the national communication.

The classification scheme for adaptation programmes and activities developed for this analysis combines an inductive and a deductive approach to qualitative content analysis (Bingham and Witkowsky, 2022[55]). A preliminary list of the types of agricultural adaptation activities examined in prior research was first developed (deductive), then refined based on the range of activities discussed in the documents reviewed (inductive). The latter step ensures that the coding scheme is inclusive of all types of activities reported by member countries.

Activities are coded into ten categories, which represent the top level of coding. These categories are intended to be relatively broad and, as such, capture a range of adaptation actions, including:

- Planning and support, including adaptation planning, online decision support, land-use planning, and early warning systems.
- Programmes targeting water resources, including infrastructure development, water management, and irrigation and drainage technologies.
- Crop production, including production methods, breeding or selection of climate-tolerant crops, pest management, and soil and nutrient management.
- Research or research funding.
- Agri-environmental measures, including organic production, payments for conservation practices, land rehabilitation, and preservation of agro-biodiversity.
- Livestock production, including breed selection, husbandry, and pasture management.
- Building partnerships, including collaborative planning.
- Extension and outreach, including training, education, and the dissemination of information.
- Cross-cutting approaches, including agro-ecology and climate-smart agriculture.
- Insurance mechanisms.

A second level of coding captures more specific activities within these overarching categories. As an example, crop production is inclusive of practices to strengthen soil health as well as programmes to develop new varieties of crops. In the second level of coding, references to each are coded into sub-categories.

4.1. Types of adaptation activities

Figure 4.1 presents an overview of the number of references made by member countries within each broad category, with the results divided into references that present a general discussion versus those which present specific actions or programmes. The top three types of agricultural adaptation activities cited by OECD countries are those related to planning and support (178 references), water resources (141 references) and crop production (101 references). The majority of references to planning and support tools point to specific programmes or activities, whereas the majority of references to water resources and crop production are general. This is in large part because planning and support tools include the development of documents (adaptation plans, strategies, and other planning documents) rather than on-the-ground adaptation activities.

The least frequently cited activities identified in Figure 4.1 are extension and outreach, cross-cutting measures, and insurance. Although less often referenced, the references tend to be to specific programmes or activities. In contrast, the majority of references to adaptation of livestock production systems are general in nature.

Figure 4.1. Agricultural adaptation references by category

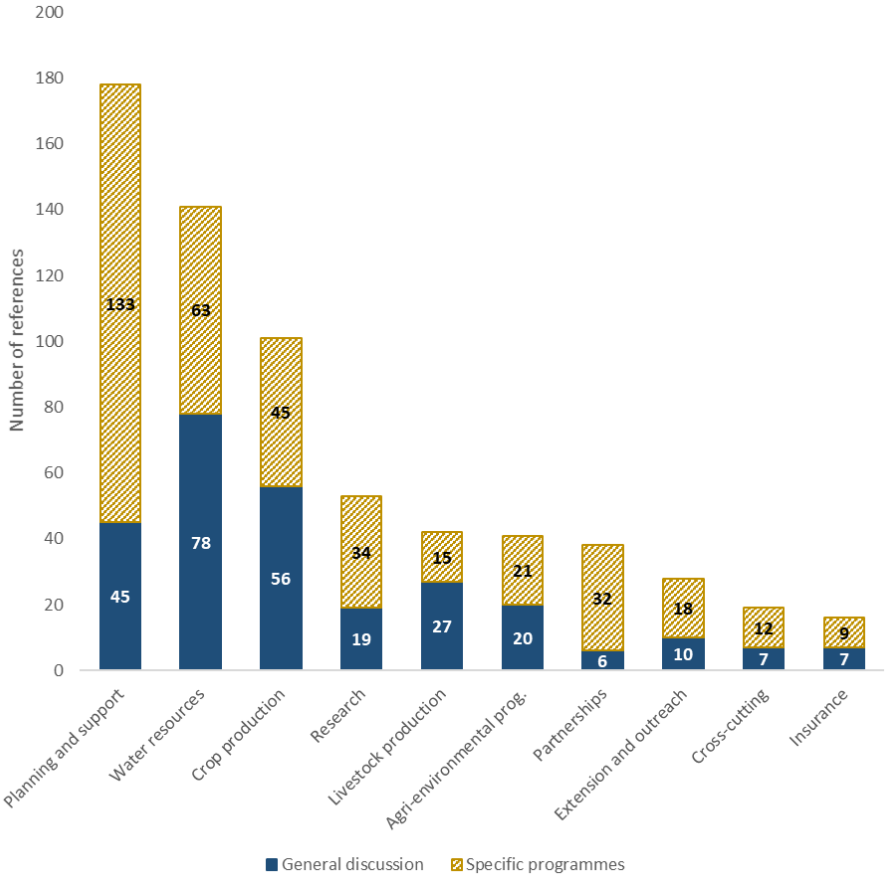


Table 4.1 presents the activities referenced by each member country, the sources of the references, and whether they are specific or general in nature. Shading indicates that an activity within a category was discussed at least once in general terms. The presence of a symbol indicates that there was at least one specific programmatic reference within the UNFCCC documentation, where the type of symbol indicates the source: ● for the most recent NDC, ○ for the most recent adaptation communication, ▲ for the most recent national communication, and * for supplementary documentation provided by the country. The vast majority of the information on specific adaptation activities can be found in the national communications and the adaptation communications (where applicable), though the NDCs are an important source of information on Non-Annex I Parties. Detailed data on number of references by source and specificity for each country and activity category is included in Tables A.4-A.13.

Countries are organised in Table 4.1 (and Tables A.4-A.13) in descending order of the percentage of text across all documents that is devoted to agricultural adaptation. Shading and symbols are most heavily concentrated in the upper left-hand corner of the table, indicating that those countries with more text on agriculture tend to cover a wider range of activity categories, and generally, although not always, in greater specificity.[18]

[18] Exceptions clearly exist. For example, the Slovak Republic ranks relatively highly in terms of percentage of text on agricultural adaptation (1.38%), though that discussion is predominantly general in nature. Finland, in contrast, devotes less text to discussion of agricultural adaptation (0.69%) but identifies specific actions in six of the 10 categories.

Table 4.1. References made to agricultural adaptation activities, by country and source

	% text on ag. adaptation	Planning and support	Water	Crops	Research	Agri-environment	Livestock	Partnerships	Extension and outreach	Cross-cutting	Insurance
Hungary	3.39	▲	▲	▲							▲
Australia	2.52	○▲	○▲	○▲	○▲	▲	▲	▲	▲		
Türkiye	2.50	▲	▲	▲	▲	▲	▲	▲	▲		▲
Greece	2.32	▲	▲	▲	▲	▲	▲	▲	▲	▲	▲
Netherlands	2.05	○▲	○▲	▲		▲	▲	▲			▲
Japan	1.76	○▲	○		○			○▲		▲	
Portugal	1.69	○▲	○▲	○	▲	○▲		▲		○	▲
Colombia	1.64	●▲	●	●	▲			▲			
Korea	1.63		●								
Slovak Rep.	1.38										
Switzerland	1.23	▲	○▲	▲	▲	▲	▲				▲
Norway	1.07	○▲	○	○▲	○▲	▲	▲	▲	○▲	○▲	
Mexico	1.01	○●	○	○			○	○			○
Czech Rep.	0.90										
Canada	0.85	▲*	▲*	▲*	▲*	*	*	▲*	▲*		▲*
United States	0.85	○▲	○		▲			○▲	▲	▲	
United Kingdom	0.83	○▲	▲	○▲	○▲	▲	▲		▲		
Chile	0.82	○●▲	●▲	●▲		▲	●				▲
Germany	0.80	▲	▲	▲							
Sweden	0.76	○▲		○							
Spain	0.74	▲	▲								
Finland	0.69	▲	▲		▲		▲	▲			▲
Belgium	0.68			▲	▲				▲		
Costa Rica	0.67	●▲		▲							
Israel	0.58				▲						
Poland	0.58	▲		▲		▲				▲	
Latvia	0.53	▲									
Estonia	0.50	▲		▲	▲	▲					
Luxembourg	0.41	▲	▲								
Austria	0.39	○	○	○		○▲					
Lithuania	0.38	▲									
France	0.37	▲		▲							
EU	0.35	○▲	○		○			○			
Slovenia	0.28	▲	▲								
Ireland	0.16	▲									
Italy	0.11										
New Zealand	0.03	*	*	*	*	*	*		*		
Denmark	0.00										
Iceland	0.00										

Note: Shading indicates that reference is made in the UNFCCC documents in a category; symbols indicate that specific references can be found in the NDC (●), adaptation communication (○), or most recent national communication (▲). * indicates that references to programming in the area can be found in supplementary data added by request (Canada: United Nations Convention to Combat Desertification; New Zealand: National Adaptation Plan).

Programmatic efforts beyond the UNFCCC documentation are not captured in this table, which is not intended to be comprehensive. Nonetheless, looking across the OECD as a whole, the UNFCCC documents provide evidence that programmatic depth is concentrated in planning and support, water resources, crop production and research, whereas specific programming in the areas of livestock production, extension and outreach and cross-cutting approaches is relatively sparse. The specific programmes presented by some of the member countries in these areas may form an important resource for others to draw upon in designing new programmes in these areas. The remainder of this section explores the types of activities within each category and presents examples of specific programmes described by member countries by area.

4.2. Adaptation programmes by category

This section characterises in greater detail the programmes cited by member countries in support of agricultural adaptation in the UNFCCC documents.[19] Table 4.2 provides a breakdown of references from Figure 4.1 into sub-categories; Table 4.3 presents examples by category of specific programmes cited in the UNFCCC documents.

4.2.1. Planning and support

Among OECD countries, 84.6% refer to planning and support tools in 178 references, the majority of which are for adaptation planning and decision support tools. References to adaptation planning predominantly include the development adaptation strategies or plans relevant to agriculture and efforts toward risk assessment and preparedness. For example, Australia's National Soil Strategy is a AUD 214.9 million effort that sets out a 20-year plan for "prioritising soil health, empowering soil innovation and stewards, and strengthening soil knowledge and capability" (8th national communication). Chile's sectoral adaptation plan for forestry and agriculture defines 21 adaptation measures for water management; research, information and training; management of crops and forests; and risk management and insurance (Ministerio del Medio Ambiente, 2013[56]). Japan's "Assessment Report on Climate Change Impacts in Japan," published in 2020, evaluates the significance, urgency, and confidence of climate change impacts across 71 categories spanning seven sectors, including agriculture, forestry and fisheries.

The majority of references to decision support are to online tools developed to support farmers in proactively planning farm operations. For example, the Tasmanian Government's Enterprise Suitability Mapping project was developed and recently updated to allow farmers to evaluate the suitability of sites for the production of vegetables, cereals, perennial horticulture, pasture, and forestry (Department of Natural Resources and Environment Tasmania, 2023[57]). Norway's online climate adaptation resource, *klimatilpasning*, provides descriptions of expected climate change impacts and vulnerabilities along with resources to support adaptation (Miljø-direktoratet, 2023[58]).

Japan's Climate Change Adaptation Information Platform (A-PLAT) is another example of an informational platform to support adaptation (National Institute for Environmental Studies, 2023[59]). Developed and launched in 2016 by the Climate Change Adaptation Center of the National Institute for Environmental Studies of Japan, the site contains interviews with people who have adopted adaptation measures, a database of adaptation practices, and links to local climate change adaptation plans and centres, among other materials. Examples of topics covered in the database of adaptation actions for agriculture include improving produce quality and yield with Information and Communication Technology (ICT), developing heat-tolerant crop varieties (e.g. rice, lettuce, and citrus), and production practices to protect crops from temperature extremes (e.g. fruit and tea).

[19] To the extent possible, links are provided to the specific programmes cited as examples herein. External references were used in this section to elaborate on the details of the programmes cited, but this material was not used in the content analysis itself.

4.2.2. Water resources

Water resource programmes are cited by 76.9% of member countries in 141 references. Activities cited are predominantly those related to management and planning, followed by irrigation, drainage, and infrastructure development. Programmatic references encompass actions taken off the farm, such as the development of data or monitoring resources for drought and/or flooding, as well as efforts to promote on-farm actions, such as the adoption of water conserving irrigation technology.

Table 4.2. Agricultural adaptation references by sub-category

Category and sub-category	Number of references	% specific
Planning and support, all references	178	74.7
Adaptation planning	115	78.3
Development of strategies and plans	*84*	*77.4*
Risk assessment and preparedness	*34*	*85.3*
Decision support tools	40	72.5
Land-use policies	23	56.5
Early warning systems	20	50.0
Water resources, all references	141	44.7
Management and planning	100	42.0
Irrigation and drainage	41	41.5
Infrastructure development	20	40.0
Water quality	5	60.0
Crop production, all references	101	44.6
Soil and nutrient management	54	38.9
Cultivar selection and breeding	32	46.9
Production methods (calendar, rotations, technology)	22	45.5
Pest, disease and invasive species management	19	21.1
Cold weather and freeze protection	3	100.0
Research, all references	53	64.2
Agri-environmental measures, all references	41	51.2
Preservation of agrobiodiversity or genetic resources	16	43.8
Policies or payment programmes	14	57.1
Land conservation, retirement or rehabilitation	9	55.6
Organic production	6	50.0
Livestock production, all references	42	35.7
Planning and financial support	22	31.8
Heat stress and stockwater	14	14.3
Pasture and feed management	12	58.3
Breeding and breed selection	9	33.3
Disease management	7	28.6
Developing partnerships, all references	38	84.2
Extension and outreach, all references	28	64.3
Outreach	21	71.4
Education and training	6	50.0
Publications (fact sheets, brochures, case studies)	2	100.0
Cross-cutting approaches, all references	19	63.2
Insurance mechanisms, all references	16	56.3

Note: Totals across sub-categories do not sum to category totals because references may be cross-coded to multiple activities. Category totals correspond to those presented in Figure 4.1.

Examples of water management and planning activities include Spain's Plan PIMA Adapta AGUA, which includes actions to assess the impact of climate change on water resources, e.g. improved groundwater monitoring, and to support adaptation to extreme events, e.g. development of pilot programmes for adapting to flood risk in the agriculture and livestock sectors (Ministerio Para la Transición Ecológica y el Reto Demográfico, 2023[60]). Slovenia and Türkiye have invested in enhanced drought monitoring, through the development of a new water balance model (mGROWA-SI) and the development of the Agricultural Monitoring and Information (TARBIL) System Project, respectively.

A number of members have invested in activities related to irrigation and drainage. Several, including Colombia, Portugal, Türkiye, and the United Kingdom have developed programmes to improve irrigation efficiency. For example, the United Kingdom's Farming Transformation Fund includes a water management theme that "is intended to support farmers by providing grant scheme funding for investments such as the construction of water storage reservoirs or abstraction or irrigation pumps" (8th national communication). Switzerland promotes increased irrigation efficiency by including it as a criterion when assessing or determining public financial contributions to irrigation infrastructure projects. A number of countries cite activities to adapt to an excess of water, such as the development of flood maps and plans by Luxembourg and financial support to install drainage systems in Norway.

In the category of infrastructure development, Canada's province of Alberta allows industrial greenhouse gas emitters to (optionally) pay into the Technology Innovation and Emissions Reduction (TIER) fund (Government of Alberta, 2023[61]). Revenues from the fund have been used to support projects through the Alberta Community Resilience Program, which seeks to protect infrastructure, including that for irrigation, from flooding and drought (Government of Alberta, 2023[62]).

4.2.3. Crop production

Activities related to crop production are described by 71.8% of member countries in 101 programmatic references. The majority of the references in this category are to soil and nutrient management; cultivar selection and breeding; production methods; and pest, disease, and invasive species management. References in this category tend to be general: across all sub-categories less than half of the references are to specific activities. This is particularly pronounced for pest management references, for which the majority (nearly 80%) of references are general in nature.

A number of programmes cited in the most recent national communication submissions focus specifically on soil health, including the National Programme for Agricultural Soils of the Netherlands; a programme of direct payments for minimal soil disturbance in Switzerland; and the United Kingdom's Sustainable Farming Incentive, which rewards actions to improve soil structure under the Arable and Horticultural Soils and Improved Grassland Soils standards. Other activities targeting soils include research and outreach on soil erosion and mudflows in agricultural areas within Belgium and efforts targeting desertification by Greece and Mexico, among others.

Discussion of cultivars largely revolves around efforts to support selection among existing varieties as well as the development of varieties suited to new and expected climatic conditions. For example, Switzerland developed a plant breeding strategy that defines an approach to further the development of breeding programmes and undertook the sixth funding phase of the National Action Plan for the Conservation of Crop Diversity (NAP-PGREL) in 2019-2022. Other examples of cultivar selection and breeding are cited by Australia, Netherlands, Norway, Switzerland, and the United Kingdom.

While references to pest and disease management tend to be general in nature, activities cited in this sub-category include enhanced monitoring, forecasting and warning systems to limit the economic damages from outbreaks (Chile, Finland, and Norway) and inspection to reduce the risk of pest introduction (Poland).

References to programmes that target changes in crop production methods include efforts to encourage the adoption of precision technologies (Colombia, Türkiye), promote the diversification of crop rotations (Finland), and ensure the continued production of perennial crops, such as fruit (Japan). Although references to specific changes in production methods are relatively rare, the online decision support tools discussed in Section 4.2.2 often contain information to assist farmers in adapting production practices to changing climatic conditions. One such example, drawn from Japan's A-PLAT, is the use of snow trenching to prevent stray potato weed growth (Box 4.1).

Box 4.1. Controlling potato weeds and greenhouse gas emissions with snow breaks

An essential element in potato production in the Hokkaido region of Japan is the freezing of soil in the winter, which kills residual, unharvested potatoes. In recent years, the amount of snow cover in the region has increased in early winter, providing an insulating layer that prevents the soil from freezing to the required depth of 20 cm. As a result, unharvested potatoes can survive the winter, becoming "stray potatoes" the following spring. Stray potatoes reduce the efficacy of fertiliser applications, inhibit crop growth, serve as a host for pests, and contaminate other potato varieties in the ensuing season.

To reduce the depth of snow cover and permit adequate freezing, the National Agriculture and Food Research Organization (NARO) demonstrated the efficacy of snow breaks, which remove snow from alternating strips of land. Compared with manual removal of stray potato plants, the use of snow breaks is cost-effective. Moreover, by controlling the insulating capacity of snow, farmers can ensure that freezing of the soil is not too deep (less than 30 cm), which limits greenhouse gas emissions from the soil in early spring, thereby also contributing to climate change mitigation objectives.

Source: A-PLAT (2020[63]). Original figure from National Agriculture and Food Research Organization (NARO) press release.

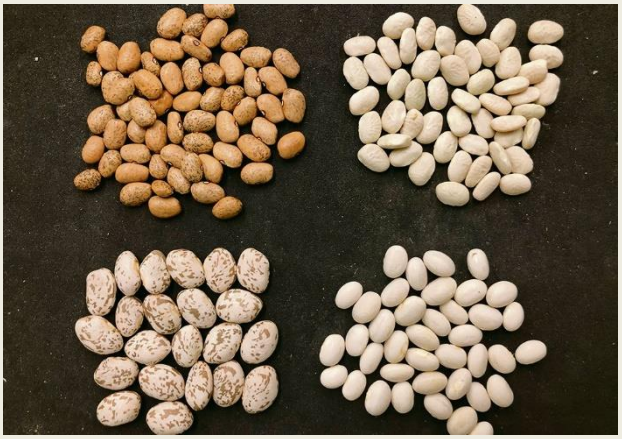
4.2.4. Research

Among member countries, 51.3% refer to research or research funding activities to support agricultural adaptation in 34 specific references. In some cases, government agencies undertake research directly. An important area for research, and one which overlaps with the category of crop production, is the development of new cultivars. For example, Canada's Crop Development Centre (CDC) was established in 1971 as a research organization at the University of Saskatchewan "to improve economic returns for farmers and the agriculture industry of western Canada by improving existing crops, creating new uses for traditional crops, and developing new crops" (University of Saskatchewan, 2023[64]). To date, the Centre has released over 500 commercial varieties of 40 different crops, including the development of four varieties of Canadian Western Red Spring wheat that offer increased resistance to wheat midges and early maturation dates. Recent work includes research to improve the heat tolerance of the common bean by leveraging characteristics of its close genetic relative, the tepary bean (Box 4.2).

In addition to undertaking research directly, governments have established funding programmes to support research. For example, New Zealand's Sustainable Land Management and Climate Change (SLMACC) research programme includes an Adaptation Program that provides NZD 2.26 million to fund basic and applied research that focuses on social impacts, policy research, and the science around adaptation to climate change (Ministry for Primary Industries, 2023[68]). The programme supports research on diverse topics, examples of which include adaptation of the kiwifruit industry (Box 1.1), the application of high-resolution climate data to adaptation in vineyards, and the effects of climate change on grazing livestock.

The United Kingdom supports a number of research funding programmes, including the UK Research and Innovation (UKRI) Transforming Food Production (TFP) Initiative, which has been funded at GBP 90 million over four years to "support the rapid development and deployment of advanced precision agricultural solutions" (8th national communication). The programme invests in future food production systems, e.g. with a project that explores advances in vertical farming, and in science and technology, e.g. with a project on the use of robots to pick and pack fruit and treat crops against diseases and one on the use of ground-penetrating radar to improve potato yield forecasting and management (UK Research and Innovation, 2023[69]).

Box 4.2. Genetic diversity to support bean breeding for hot, dry growing conditions



The tepary bean (*Phaseolus acutifolis* A. Gray), native to the Sonoran Desert, has gained attention in recent years in plant breeding research due to its adaptation to high temperatures and arid growing conditions. Although the tepary bean itself is grown on a limited basis, it shares a close genetic relationship with the common bean (*Phaseolus vulgaris* L.), a staple legume consumed worldwide. Current growing regions for the common bean are expected to become unsuitable for continued production by 2050 due to high temperatures, which reduce bean yield and nutritional quality. The close genetic relationship between tepary and common beans means that the tepary bean offers potential as a genetic resource to improve the climate resilience of the common bean. Recent breeding efforts have succeeded in using the tepary bean to improve the drought tolerance of the common bean (Moghaddam et al., 2021[65]).

Researchers at the Crop Development Centre in Canada sequenced the genome of the tepary bean in an effort to study how it adapts to changing temperatures and how its genetic attributes can be combined with those of the common bean. Although the tepary bean offers advantages in terms of its performance in hot, dry conditions, it has a lower resistance to disease than the common bean. Ultimately, the team seeks to combine the advantages of the two species and to develop tepary bean varieties that perform well in dry regions like Saskatchewan.

Note: Two varieties of tepary bean (upper right and left) compared to two varieties of common bean (pinto beans, lower left, and navy beans, lower right).
Source: Crop Development Centre (2021[66]); image from Pratt (2021[67]).

4.2.5. Agri-environmental measures

Agri-environmental programmes are cited by 48.7% of member countries in 21 specific references. The majority of programmatic references concern efforts to preserve agrobiodiversity or genetic resources and agri-environmental policy or payment programmes. Programmes cited in this category include Austria's agri-environmental programme ÖPUL and Chile's Soil Programme: SIRSD-S.

Austria's fifth ÖPUL, in place since 2015, offers incentives to compensate farmers for additional environmental services provided in an effort to counteract trends toward the abandonment of agricultural land and the intensification of production (Republic of Austria, 2016[70]). Examples of incentives include compensation for reduced yield as a consequence of actions to improve soil health and genetic diversity, such as the decision to renounce the use of chemical-synthetic fungicides and growth regulators in cereal crops or to shift to rare and regionally valuable agricultural varieties and species of plants.

Chile's SIRSD-S, administered by ODEPA (Oficina de Estudios y Políticas Agrarias) under the Ministry of Agriculture, is a 12-year soil recovery programme that started in 2010 (Odepa, 2023[71]). Farmers who qualify can submit management plans that address practices to enhance the phosphorus fertility of soils, correct acidity or salinity, establish vegetative cover on bare or degraded lands, incorporate crop rotations to reduce erosion, or remove impediments to production, such as stumps or stones. Recent chemical analysis of soils in three regions of southern Chile attribute improved soil fertility to the programme (Sanchez, 2020[72]).

4.2.6. Livestock production

Although activities related to livestock production are referenced by 48.7% of member countries, there are relatively few references to specific programmes or activities. As examples of specific programmes,

Tasmania and Victoria in Australia cite initiatives supporting adaptation relevant to livestock production. Through Tasmania's Agricultural Development Fund of AUD 3 million, a Tasmanian company received support in 2022 to develop a feed supplement from seaweed to enhance the productivity of cattle and sheep as well as to reduce methane emissions (Department of Natural Resources and Environment Tasmania, 2023[73]). In Victoria, The Ellinbank SmartFarm provides a testing ground for technologies and production methods relevant to dairy, including projects on optimising homegrown feed and increasing milk production with nutrition and pasture management (Agriculture Victoria, 2023[74]).

Other activities relevant to livestock include Norway's Climate Smart Agriculture project, which includes work on adapting seed production for pasture production with increased rainfall, and Switzerland's animal breeding strategy, which defines objectives for the sector under climate change. In 2021, Finland's Ministry of Agriculture and Forestry established a working group on reindeer husbandry, which undertook the development of a model for reindeer pasture management plans to ensure the sustainable use of pasturelands.

4.2.7. Developing partnerships

Among member countries, 35.9% refer to activities to develop partnerships, either domestically or with other OECD countries. Efforts to develop partnerships are both vertical, i.e. partnering between different levels of government or across government agencies and stakeholders, and horizontal, i.e. partnering across federal agencies. Partnerships between OECD members are often cited within the European Union documents.[20]

Colombia's Environmental Management and Climate Change Group develops partnerships between government agencies and industry by co-ordinating with production guilds representing rice producers (Fedearroz), cereal producers (Fenalce), livestock producers (Fedegan), palm growers (Cenipalma), banana producers (Asbama), and sugar cane producers (Cenicaña). Other examples of partnerships between government agencies and stakeholders include Climate Northern Ireland, which is governed by a steering group representing government, business, communities, and academia, and Japan's Regional Adaptation Consortium Project, which builds collaboration between local governments, research institutions, and stakeholders.

Efforts to develop partnerships bridge across government agencies at the national level and between national, regional, and local authorities. One such example is Finland's National Monitoring Group, which was initially established in 2008-09 to conduct a mid-term review of Finland's first National Adaptation Strategy, adopted in 2005. The group includes civil servants from diverse government ministries (e.g. Agriculture and Forestry, Transport and Communications, and Finance, Education, and Environment), research organisations (e.g. the Academy of Finland, the Finnish Meteorological Institute, and the Finnish Environmental Institute), and representation from the Association of Finnish Local and Regional Authorities. The goal of the group is to "promote cooperation and adaptation between the government authorities and sectors of business and society, identify needs for research and give proposals to further develop research on adaptation, promote the practical use of research information, and steer projects in support of adaptation" (Ministry of Agriculture and Forestry of Finland, 2023[75]).

4.2.8. Extension and outreach

Extension and outreach activities are cited by 38.5% of member countries. The majority of citations are related to outreach activities. Examples include the "publication of good practices and guidance to avoid soil erosion, mudflows and floods in agricultural and rural areas by the dedicated research and technical unit 'GISER'" in Belgium's Walloon Region (8th national communication) and the development of "workshops to transmit traditional teachings and collaboration with regional environmental organizations to share resources, expertise, and knowledge" for the Mistawasis Nêhiyawak, a First Nation of Saskatchewan, Canada (8th national communication).

[20] References to partnership development among members of the European Union are retained in the analysis, while other international partnerships, which typically take the form of adaptation financing in developing countries, are excluded.

Australia's Indigenous Ranger Program (IRP) supports "knowledge sharing, combining traditional knowledge with conservation training to protect and manage land, sea and culture" (National Indigenous Australians Agency, 2023[76]). It involves a two-way transfer of knowledge to leverage complementarities between traditional knowledge and western science in an effort to improve environmental outcomes. For example, the Murray-Darling Basin IRP involves five groups of rangers working to improve waterway health and to combat "pest animals and weeds posing a significant threat to Australian primary production, the environment and Australia's biodiversity."

4.2.9. Cross-cutting approaches

Cross-cutting approaches, such as agroecology, agroforestry, and climate-smart agriculture are referenced by 33.3% of OECD countries. References include a programme to support climate-smart agriculture by providing climate advisory services at the farm level in Norway and the establishment of agroforestry model systems in the Zielawa River Valley of Poland. Although not featured heavily within the documentation reviewed, climate-smart agriculture is of broad interest from the standpoint of agricultural climate change mitigation and has received increasing attention for its capacity to simultaneously support adaptation.

In the United States, the USDA Climate Hubs are an example of a cross-cutting programme spanning planning and support tools, research, extension, and partnerships. The Climate Hubs, with ten regional locations, undertake activities along three thematic lines, including research and science information synthesis; tool development, technology exchange, and implementation assistance; and stakeholder education, outreach, and engagement. They are "a unique cross-agency collaboration" involving contributions from diverse USDA agencies, including the Agricultural Research Service, the Forest Service, the Natural Resources Conservation Service, and other USDA agencies, in order to "enable climate-informed decision making, reduce agricultural risk, and build resilience to climate change" (U.S. Department of Agriculture, 2023[77]).

4.2.10. Insurance mechanisms

In the documents reviewed, 35.9% of OECD countries refer to insurance provision in the context of agricultural climate change adaptation. Finland ended their government compensation for crop damage but introduced a tax exemption through 2027 for insurance products related to crop damage, plant pests, and animal health. Greece's Hellenic Agricultural Insurance Organization (ELGA) compensates farmers for plant and livestock losses due to extreme weather and has recently announced an expansion to include climate-change considerations. The Netherlands' Broad Weather Insurance likewise protects against damage due to weather extremes. There is a general recognition across the documents that private insurance products, while available in some cases, remain insufficient, particularly to manage large-scale risks. As a result, many governments continue to provide insurance or are exploring mechanisms to co-finance crop insurance premiums.

Table 4.3. Summary of selected examples of programmes reported in UNFCCC documents

The table is not a comprehensive list of programmes reported in the UNFCCC documents.

	Country	Programme, activity, or mechanism	Description
Planning and support	Australia	Enterprise Suitability Maps, Tasmania	Online mapping tool to assist farmers and investors in analysing potential crop or enterprise options for a property; defines crop rules to show where poppies, wheat, potatoes, wine grapes and barley can be grown under different climate scenarios
	Canada	Agriculture and Agri-Food Canada	Department provides data, information, tools, and models for use by agricultural sector, e.g. by analysing changing land suitability and forecasting crop production
	Japan	Climate Change Adaptation Information Platform (A-PLAT)	Online compilation of adaptation case studies across sectors, including agriculture and water resources
	Latvia	Latvian National Hydrometeorological and Climate Service (LEGMC)	System designed to monitor adaptation to climate change nationally, including data and indicators to measure the vulnerability of different economic sectors, such as agriculture and forestry
	Luxembourg	National Adaptation Strategy on Climate Change	Defines objectives and measures relevant to agriculture, including measures related to soil health, protection of animals against heat and diseases, adaptation of plant production, and the management of risk through multi-risk insurance and rural development policy
	Norway	Klimatilpasning	Web-based information portal to support stakeholders by providing tools, case studies, and other materials on adaptation
Water resources	Canada	Alberta TIER program	Technology Innovation and Emissions Reduction (TIER) regulation system creates a mechanism for large industrial emitters to pay into the fund; revenues are used for mitigation and adaptation activities
	Chile	Plan de Inversión en Iniciativas Hídricas 2020-2050	Water investment plan spanning the medium to long-term, with the objective of integrated management at the scale of the basin and covering human consumption, environmental flows, and water for agriculture, mining, and industry
	Spain	Plan PIMA Adapta AGUA	A plan that encompasses projects to reduce risk and encourage adaptation, including actions such as improved groundwater monitoring and the development of pilot programmes for adapting to flood risk in the agriculture and livestock sectors
	United Kingdom	Farming Transformation Fund	Water management theme supports farmers by providing grant funds to invest in actions to increase water supply resilience, such as the construction of water storage reservoirs or irrigation pumps
Crop production	Colombia	Adopción masiva de tecnología (AMTEC 2.0)	Implements a model of technology transfer to augment yields and reduce costs of rice production
	Costa Rica	Estrategia sectorial para el cambio climático y la gestión de riesgos de desastres en el sector agropecuario (SEPSA)	Plan defining an adaptation component focused on securing and protecting genetic stock as basis for maintaining and improving strategic crops
	Mexico	Programa de Fomento a la Agricultura	Programme developed by the Secretaría de Agricultura y Desarrollo Rural (SADER) for the productive improvement of soil and water resources
	Netherlands	CROP-XR	Virtual institute, funded at EUR 42 million in 2022 by the National Grow Fund, to develop agricultural crops that are more resistant to climate change and less dependent on plant protection products
Research	Belgium	"GISER" unit, Walloon Region	Research centre developing guidance to avoid soil erosion, mudflows, and floods in agricultural and rural areas
	Estonia	RITA ForBee	Project conducted under EULS Institute of Agriculture and Environment to explore "Possibilities to reduce the death of pollinators, including honeybees"
	Israel	Israel Plant Gene Bank	National center for the preservation of genetic reserves of the region's flora; promotes research on conservation of genetic diversity
	New Zealand	Sustainable Land Management and Climate Change (SLMACC) Adaptation Program	Supports climate change adaptation research relevant to agriculture and forestry; over 50 projects supported to date to evaluate agricultural impacts out to the year 2100
	United Kingdom	Transforming Food Production (TFP) Initiative	Project funded at GBP 90 million over four years to support rapid development of precision agricultural technologies

	Country	Programme, activity, or mechanism	Description
Agri-environmental measures	Austria	ÖPUL	Agri-environmental programme containing measures that contribute to adaptation, such as organic farming and management practices to promote biodiversity
	Chile	ODEPA	Programa de Sistemas de Incentivos para la Sustentabilidad Agroambiental de los Suelos Agropecuarios; adaptation initiative undertaken by the Ministry of Agriculture
	Greece	Desertification-specific projects	Funds allocated to support early retirement of aged farmers, organic farming, and broadening public awareness of desertification
	Türkiye	National Biological Diversity Strategy and Action Plan	Covers six thematic areas including agricultural biological diversity
Livestock production	Australia	Ellinbank SmartFarm	Partnership between Agriculture Victoria Research, industry, agribusiness, education, and communities; studies and tests technologies for use in the dairy industry
	Finland	Working group on reindeer husbandry	Promotes the development of reindeer husbandry and to develop a model for pasture management plans specific to reindeer herding cooperatives
	Türkiye	IPARD I programme	Supports activities related to dairy farming, red meat, and poultry production in 42 provinces, as well as marketing of meat products
	Switzerland	Swiss animal breeding strategy	Defines objectives of animal breeding measures, namely animal health, environmental impact, and resource efficiency
Building partnerships	Finland	National Monitoring Group	Group of more than 20 key stakeholders across sectors responsible for the implementation, monitoring, and communication of the National Adaptation Plan
	Japan	Regional Adaptation Consortium Project	Joint project of the Ministries of Environment; Agriculture, Forestry and Fisheries; and Land, Infrastructure, Transport and Tourism to build collaboration system between local governments, universities, research institutions, and others
	Portugal	Portuguese Climate Law	Engages participatory approaches and partnership projects between public and private actors to support research and development
Extension	Australia	Indigenous Ranger Program (IRP)	Supports two-way knowledge sharing to integrate traditional knowledge and science to protect land, sea, and cultural resources
	Canada	Mistawasis Nêhiyawak adaptation planning exercise	Project integrating First Nation community members, leadership, and Elders to develop partnerships and workshops on traditional teachings
	Türkiye	Developing Agricultural Publication Project (TAR-GEL)	Applied from 2007-2013 to meet the needs of farmers in terms of knowledge, skills, and technical methods; included publication and education activities relevant to soil protection
Cross-cutting	Norway	Climate Smart Agriculture	Programme funded by Solberg Government that provides climate advisory services at the farm level
	Poland	Zielawa River Valley agroforestry project	Develops and implements new model of alley cropping of herbs with endangered and protected species and introduces wild plants in cultivation
	United States	Climate Hubs	A unique cross-agency collaboration consisting of ten centers to support farmers, ranchers, forest and land managers, and rural communities
Insurance	Finland	Tax exemption	Exemption through 2027 for insurance products that cover damage to crops, plant pests, and animal health
	Greece	Hellenic Agricultural Insurance Organization (ELGA)	Country's primary insurance carrier that compensates for plant and livestock losses due to extreme weather (e.g. floods, hail, and frost)
	Netherlands	Broad Weather Insurance	Provides insurance against for agricultural entrepreneurs against damage from extreme weather

Note: Programme descriptions are based on UNFCCC documents, with supplementary online resources used when available.

5. Identifying and addressing vulnerabilities in agriculture

This section evaluates the third question posed in Section 1: “To what extent are the adaptation programmes reported by members responsive to the climate change vulnerabilities identified in the UNFCCC documents?” The objective in addressing this question is to identify gaps or mismatches between expected vulnerabilities and investments in programme development to date, as well as to highlight opportunities to develop or expand programmes to address key challenges facing the sector.

The analysis departs from contextual references to agriculture (found in the first row of Table 3.1), but considers only the most recent documents submitted to the UNFCCC by each member country. Each text excerpt discussing agricultural vulnerabilities is reviewed and coded by vulnerability type. The vulnerabilities identified are then grouped thematically to identify inductively a list of the types of climate change impacts of greatest concern to member countries, according to the UNFCCC documents reviewed.

After identifying the key vulnerabilities articulated within the documents, each of the specific adaptation programmes identified in the analysis of Section 4 are manually reviewed to determine to which vulnerability, or vulnerabilities, they respond. In some cases, the text explicitly states whether a programme responds to particular vulnerabilities, but in many cases the link between vulnerability and programme development is implicit. The classification developed herein is based solely on the material presented within the UNFCCC documents. To the extent that the full breadth of the programmes is not articulated, this analysis may understate the degree of responsiveness by member countries to perceived vulnerabilities.

5.1. Types of vulnerabilities identified

Within the UNFCCC documents, the key types of impacts on agriculture identified by members fall into six categories, which represent the top level of coding, i.e. they are intended to be relatively broad and, as such, capture a range of impacts:

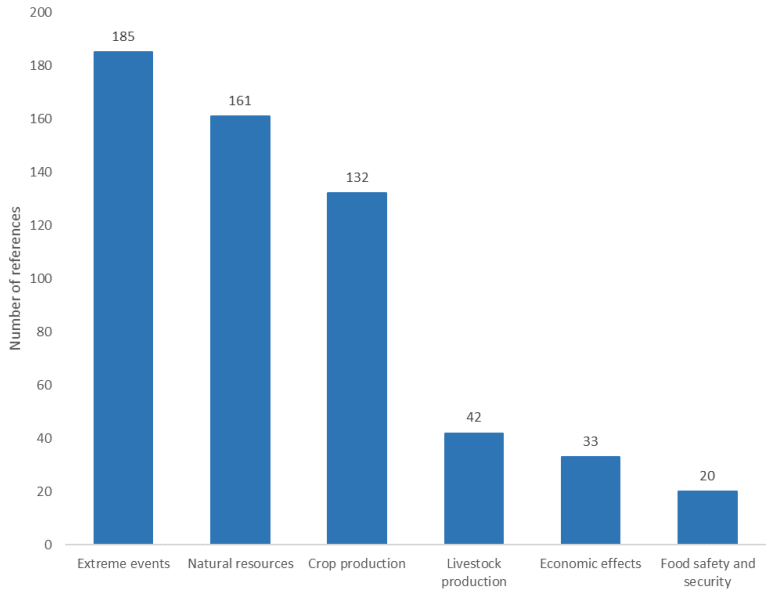
- Crop production, e.g. the effects of climate change on crop yields, production and quality, changes to growing locations, changes in the timing of crop development during a growing season, and changes in specialty crop production (e.g. wine, fruit, horticulture).
- Food safety and security.
- Natural resources, e.g. the effects of climate change on the resources that support agricultural production, including water quantity and quality, pollinator populations, arable land availability (desertification and water logging), and soil fertility.
- Livestock, e.g. production, the prevalence of disease, heat stress, effects on the yield or quality of pasture or forage.
- Extreme events, e.g. drought, flooding, fire, frost, pests, diseases, invasive species, and other extreme weather phenomena (heat waves, hail or wind).
- Economic effects, e.g. unemployment, changes in relative prices and costs of production, changes in exports/imports, and changes in farmer income or welfare.

Changes in water resources can appear in one of two categories depending on whether the concern articulated relates to changes in mean levels or changes in the frequency of extreme events. Changes in the mean availability of water are included in the natural resources category; whereas statements about large deviations from the mean in the form of drought or flooding are included in the extreme events category.

As illustrated in Figure 5.1, the top vulnerabilities of concern identified in the UNFCCC documents are the impacts of extreme events (185 references), the availability and health of natural resources (161 references), and crop production (132 references). More than 80% of OECD countries express concerns about vulnerabilities in these top three categories. Fewer references are made to other types of vulnerabilities, namely livestock production (42 references), economic effects (33 references), and food

safety and security (20 references). Even though the number of references to livestock is low, the references are relatively widely distributed across country documents: 53.8% of members expressed some concern about vulnerabilities to livestock within the UNFCCC documents.

Figure 5.1. References to agricultural vulnerabilities by category



A second level of coding, presented in Table 5.1, captures more specific vulnerabilities within each of these broad categories. Examining the references by sub-category reveals widespread concern related to water resources, both in terms of average availability in quantity and in extreme shortage or overabundance. Following concerns related to water quantity, 69.2% of members articulate concerns about changes in crop yields or production levels and 66.7% articulate concerns about agricultural vulnerabilities resulting from other extreme weather events, such as heatwaves, storms, and wind.

Table 5.1. Agricultural vulnerability references by sub-category

Category and sub-category	Number of references	Pct. members with ≥1 reference
Extreme events, all references	185	84.6
Drought or flooding	77	79.5
Extreme weather (heat, storms, wind)	56	66.7
Pest, invasive species, or disease outbreaks	32	46.2
Fire and frost	20	35.9
Natural resources, all references	161	87.2
Water quantity (mean availability)	90	79.5
Environmental externalities	36	51.3
Soil health	25	43.6
Quantity of arable land	10	20.5
Crop production, all references	132	79.5
Crop yields or production	57	69.2
Crop phenology	26	51.3
Growing location	25	48.7
Specialty crop production (viticulture, fruit)	14	28.2
Crop quality	10	17.9

Category and sub-category	Number of references	Pct. members with ≥1 reference
Livestock production, all references	42	53.8
Pasture yield and quality	13	25.6
Heat stress	12	28.2
Disease outbreaks	11	23.1
Economic effects, all references	33	41.0
Employment	9	20.5
Income or welfare	9	20.5
Prices and costs of production	8	17.9
Trade	7	7.7
Food safety and security, all references	20	30.8
Food safety	4	10.3
Food security	16	30.8

Note: Totals across sub-categories do not sum to category totals because references may be cross-coded to multiple vulnerabilities. Category totals correspond to those presented in Figure 5.1.

5.2. Vulnerabilities by category

This section characterises in greater detail the climate change vulnerabilities discussed in the UNFCCC documents. Although there is significant heterogeneity among the OECD countries in terms of the projected effects of climate change on agriculture, broad themes emerge from the documents related to the effects on crop production and water resources.

5.2.1. Extreme events

Among extreme events, concerns about the effects of drought and/or flooding on agriculture are most often cited in 77 references by 79.5% of member countries. While some documents emphasize either drought or flooding, most countries expect both to be problematic for agriculture due to temporal and/or regional differences in precipitation. Examples of references include:

- "The impacts of climate change are already being felt by the agricultural sector with events such as drought becoming more frequent and extreme." (Australia, 1st adaptation communication).
- "Increased winter precipitation and rising water levels in some areas will lead to flooding or to groundwater levels which are so high that security of cultivation will be difficult to maintain. This may be particularly relevant along a number of fjords and watercourses, but there may also be problems for other drained areas with poor drops to watercourses in the event of greater precipitation intensity." (Denmark, 7th national communication).
- "Early summer droughts may become more frequent and interfere with crop growth and yield formation, while increasing rains outside the growing season may put soils and their functionality at risk." (Finland, 8th national communication).

Other extreme events identified by members include heat waves, storms, wind, fire and frost. Among member countries, 46.2% discuss the likelihood of increased pest, invasive species or disease outbreaks. The references to pests and disease generally anticipate that outbreaks are likely to worsen to the detriment of crop and livestock production.

5.2.2. Natural resources

Even in areas anticipating more favourable growing conditions in some regions or for some crops, climate change is expected to lead to degradation of the critical natural resources that support production. The leading concern articulated in the UNFCCC documents is increased water scarcity (referenced by 79.5% of members), followed by the increased production of environmental externalities and degradation in soil health.

Predicted changes in water availability differ broadly across member countries and are subject to a higher degree of uncertainty than changes in temperature.[21] Nevertheless, several themes emerge from the review of documents. Most members, e.g. Australia, Chile, Costa Rica, Japan, and Mexico, anticipate a reduction in total precipitation in current producing regions, as well as changes in the timing of water availability relative to the periods in which crop water needs are greatest. As a result, members predict an increase in the demand for water in irrigation and greater competition between sectors for limited water supplies. For other members, e.g. Denmark, Estonia, Netherlands, and Norway, increased precipitation is expected to generate problems as elevated groundwater levels lead to water logging.

Examples of references to water availability include:

- "With regards to rainfall, trends show a decrease between 2031 and 2050, leading to a drier climate compared to the historical average, which affects mostly the regions between Atacama and Los Lagos, the most productive from an agricultural point of view and with the highest population density in the country." (Chile, 2nd NDC).
- "For water, land and agricultural infrastructure, a lack of agricultural water is predicted for some areas due to a decrease in snowmelt runoff during the wet-ploughing (shirokaki) season for paddy rice cultivation…" (Japan, 1st adaptation communication).
- "All these pressures will reduce the capacity to regenerate reservoirs, thus increasing competition among the different water uses (civil, industrial and agricultural), especially in summer and in southern regions." (Italy, 8th national communication).

Among the member countries, 51.3% refer to the potential for climate change to exacerbate the production of environmental externalities. Chief among these are degradation in water quality due to nutrient and sediment runoff, increased risk of seawater intrusion into freshwater aquifers, and changes in the populations and behaviours of pollinators.

A number of members describe the degradation of soil resources as a critical vulnerability, with concerns expressed primarily about increased erosion and declining fertility. Members also express concern about the loss of arable land due to worsening desertification in the south (e.g. Greece, Italy, Türkiye) and waterlogging in the north (e.g. Denmark, Estonia).

5.2.3. Crop production

In discussing the effects of climate change on crops, members most often cite changes in yields or levels of production as an anticipated effect of climate change. In the majority of cases, the references are descriptive of broad trends. Examples include:

- "Agricultural cultivation may be affected in the following ways: reduced productivity from heat stress; plants must close their stomata to avoid losing too much water, and therefore cannot undergo gas exchange for photosynthesis." (Israel, 3rd national communication).
- "In agriculture, the quality and yields of many crops have seen declines nationwide in Japan… with decreases in the ratio of first-class rice produced, poor growth of vegetables, and physiological disorders of fruit trees…" (Japan, 8th national communication).
- "Changes in the climate will generally improve the average climatic conditions for farming in the Netherlands, especially in comparison to southern European countries. Higher temperatures mean longer growing seasons and higher potential crop yields." (Netherlands, 8th national communication).
- "Changing temperature and rainfall patterns may increase winter yields of some crops but reduce the yield of others reliant on winter chill. An overall decline in crop yield and quality is expected with rising temperatures." (New Zealand, 8th national communication).

[21] A complementary source of information on agriculture and water policies, including reported trends and policies related to water availability, drought, and flooding can be found in the country profiles at https://www.oecd.org/agriculture/topics/water-and-agriculture.

Anticipated effects on crops are predominantly negative, although members located in northern latitudes express the potential for positive effects as well. For example, the Netherlands anticipates increased productivity for sugar beets due to higher temperatures and carbon dioxide concentrations. Similarly, Denmark, Sweden, and Switzerland anticipate growing conditions to improve for certain crops due to an increase in temperatures and the length of the growing season. In countries with warmer climates, such as Greece, Israel, Italy, Mexico, Portugal, and Türkiye, increased temperatures are expected to increase heat stress and shorten the growing season, reducing yields. Even so, a decrease in frost is expected to be advantageous for the production of certain crops in these regions.

Although the majority of references to changing yields and production refer to broad trends, some discuss the anticipated effects on specific commodities; relatively few quantitative estimates of anticipated changes are included in the UNFCCC reports. Examples of statements about specific crops include:

- "Maize productivity is expected to decline by 2050-2059." (Mexico, 6th national communication).
- "In the future, yields for grain maize and wheat will decrease substantially; the losses in Southern Europe will reach 50%." (European Union, 8th national communication).
- "…it was predicted that there would be a 7.6% decrease in wheat and barley yields, a 10.1% decrease in corn yield, a 3.8% decrease in cotton yield, and a 6.5% decrease in sunflower yield across the country." (Türkiye, 7th national communication).
- "In maize, faster accumulation of growing degree-days would allow the crop to be harvested earlier than under current conditions (10 to 20 days by 2060, depending on emission scenario and location)… Under rainfed cultivation, maize grain yields are projected to increase until about 2060 but do decline thereafter if climate protection measures are not implemented…" (Switzerland, 8th national communication).

Among members, 48.7% identify challenges and/or opportunities related to growing location and 51.3% discuss changes in the timing of crop development. A reduction in winter chilling or an increase in the number of days with temperatures exceeding crop growth thresholds are projected to reduce yields and production. Some members anticipate benefits as current agricultural production systems shift northward and warmer conditions allow for the introduction of novel or higher quality crops. Changes in temperature are also expected to drive a change in the timing of crop growth and production activities, such as earlier sowing dates in the spring and later harvesting dates in the fall. The extension of the growing season into the spring and fall months may be beneficial, but also carries new risks, such as complications in harvesting operations due to wet conditions:

- "Earlier spring has enabled the earlier sowing of cultures while later autumn allows for later harvesting. Later harvesting may however be complicated due to excessive water content of the soil in some areas." (Estonia, 8th national communication).

Concerns relevant to specialty crop production, predominantly viticulture, are expressed by 28.2% of members. Wine production and the quality of grapes is expected to decline in many current producing regions, but opportunities exist for production to expand northward and into higher-elevation producing regions. Similar changes are described for citrus (Greece, Italy, Japan, and Portugal), apples (Japan), and olives (Greece, Italy).

5.2.4. Livestock vulnerabilities

In the set of UNFCCC documents reviewed, concerns related to livestock are less heavily emphasised than those related to crop production. The documents primarily reference vulnerabilities related to heat stress, increased disease prevalence, and changes in pasture yield or quality. The majority of references indicate that the effects of climate change on current livestock production systems will be negative, although in a few cases, members anticipate increased productivity and quality of grasslands and fodder:

- "Farms are likely to face increased pressure under severe climate scenarios, largely due to the effects of higher temperatures such as animal heat stress resulting in declining livestock productivity and potentially increased stock losses." (Australia, 8th national communication).
- "The health and food sources of livestock are also vulnerable to extreme heat." (Israel, 3rd national communication).

- "Warmer temperatures and extreme weather events will have negative impacts on livestock productivity and welfare. Pasture growth rates may be affected more in terms of seasonality than yield." (New Zealand, 8th national communication).

5.2.5. Economic vulnerabilities

Some documents discuss potential economic vulnerabilities, such as changes in employment, farmer income, and shifts in relative prices. In a few cases, members anticipate beneficial changes, such as an increase in employment opportunities for specialized labour or higher prices for domestic commodities. Most often, however, members project losses in these areas, particularly over the long run:

- "A report on transboundary risks points to, among other things, an expected gradual weakening of global productivity, which may cause increased volatility and higher prices on several commodities in the Norwegian market. Such risk is particularly evident within agriculture, a sector that is highly exposed to climate impacts, and Norway is currently importing the majority of its consumption." (Norway, 8th national communication).
- "Climate change is also expected to lead to large-scale shifts in the availability and prices of many agricultural products across the world, with corresponding impacts on US agricultural producers and the US economy. These changes threaten future gains in commodity crop production and put rural livelihoods at risk." (United States, 8th national communication).

5.2.6. Food safety and security vulnerabilities

Fewer references, by 30.8% of member countries, cite vulnerabilities related to food safety or security. References to food security tend to be broad statements about the general consequences of climate change or statements about the link between resource degradation and food production:

- "Impacts on soil properties as a consequence of climate change will have implications for agriculture, significant economic repercussions, and will reduce food production capacity, which will compromise the food security of future generations." (Mexico, 6th national communication).[22]
- "Food security and increased production on Norwegian resources depends on protection of soil resources. Norway has very little farmland compared to other countries. Only 3% of the land is cultivated soil, one-third of which can be used for the production of food grains." (Norway, 8th national communication).

Statements related to food safety generally arise in the context of water contamination and the spread of pests and diseases:

- "The wider spread of plant diseases and mycotoxins presents a hazard related to food safety, which, according to the RCP8.5 scenario, may increase in the period of 2050-2100." (Estonia, 8th national communication).

5.3. Correspondence between vulnerabilities and adaptation programmes

This section explores the correspondence between the discussion of adaptation programmes and the discussion of climate change vulnerabilities in the UNFCCC documents reviewed. The objective is to determine in which areas there is evidence of greatest programmatic investment and in which there exist opportunities to expand activities to address vulnerabilities of concern to the OECD membership.

It is reasonable to expect that documents that allocate greater space to discussion of agricultural climate change adaptation will also present more evidence on adaptation programmes or activities. Given that many papers in this area of research use keyword counts as an indicator of progress, it is useful to examine

[22] Author's translation; original text: "*Los impactos en las propriedades del suelo a consecuencia del cambio climático tendrán implicaciones para la agricultura, repercusiones económicas considerable, y la disminución de la capacidad de producción de alimento, lo caul compromete la seguridad alimentaria de las generaciones futuras* (Harley et al., 2006[83])."

whether a correlation exists between the use of contextual keywords and self-reported programmatic development.

The correlation between the percent of text discussing agricultural adaptation (the top row in Table 5.2) and the total number of programmatic references (the penultimate column) is strong and positive, at 0.76. The correlation with specific programme references (last column) is slightly lower, at 0.63. Thus, documents that more heavily discuss agricultural adaptation also discuss adaptation activities more, and typically provide a greater number of concrete examples of adaptation programmes.[23]

Table 5.2. Correlation coefficients between programmatic development, agricultural adaptation, and agricultural vulnerabilities

		Programmatic references by category											
		Planning and support	Water resources	Crop production	Research	Agri-environment	Livestock production	Building partnerships	Extension and outreach	Cross-cutting	Insurance	Total references	Specific references
% text on ag. adaptation		0.55	0.66	0.47	0.38	0.43	0.44	0.51	0.37	0.31	0.45	0.76	0.63
Vulnerabilities	Extreme events	0.31	0.39	0.19	0.11	0.39	0.16	0.32	0.07	0.23	0.24	0.52	0.33
	Natural resources	0.30	0.43	0.35	0.23	0.58	0.37	0.27	0.17	0.19	0.26	0.46	0.41
	Crops	0.39	0.38	0.18	0.05	0.40	0.42	0.43	0.11	0.15	0.55	0.54	0.39
	Livestock	0.14	0.22	-0.12	-0.05	0.31	0.01	0.26	-0.08	0.11	0.08	0.35	0.12
	Economic	0.40	0.48	0.24	0.17	0.38	0.23	0.31	0.29	0.24	0.13	0.39	0.41
	Food	0.34	0.37	0.35	0.13	0.17	0.17	0.18	0.13	-0.09	0.51	0.23	0.33

Note: Medium blue shading indicates a correlation coefficient greater than 0.50; light blue shading indicates a correlation coefficient of 0.25-0.50; no shading indicates a correlation coefficient less than 0.25.

To the extent that there is a need to further develop adaptation programmes to address critical climate change vulnerabilities in some regions, this analysis demonstrates that there exists a body of programmatic experience across the OECD as a whole that can be leveraged to support that need. The programmes captured within this analysis could serve as a starting point for others to draw on and adapt to their own needs, or as a source of lessons learned to assist future efforts. If instead the issue is that programmes exist but are not reported in the UNFCCC documents, then the question becomes one of how other countries may learn about and benefit from unreported work in member countries. This suggests a need to facilitate information sharing across the membership to cultivate greater awareness of the breadth of approaches used to support adaptation to critical vulnerabilities in the diverse contexts spanned by member countries.

Examining the correlation coefficients between the percent of text discussing agricultural adaptation and the number of programme references by category (the top row of Table 5.2) indicates that those documents that devote more space to agricultural adaptation are also those that have greater evidence of programmatic development in the areas of water resources, planning and support tools, and building partnerships. In contrast, there is a weaker correlation between a discussion of agricultural adaptation and crosscutting measures, extension and outreach, or research.

Table 5.2 also presents correlation coefficients between the categories of vulnerabilities from Section 4 and programmatic references. In general, the correlation coefficients indicate a weak correlation between vulnerabilities and programmatic references, with two notable exceptions. First, countries that articulate concern about natural resource degradation tend to be those that also include more references to agri-environmental policies or programmes. Second, countries that articulate concerns about changes in crop

[23] This is consistent with the pattern illustrated in Table 4.1.

production and food security tend to also include more references to insurance programmes to guard against climate-related losses.

Table 5.3 examines the responsiveness of adaptation programmes to vulnerabilities across all OECD countries. Each cell is the percentage of programme references within the activity category that address a particular type of climate change vulnerability. For example, looking at the column for planning and support tools, 36.4% of references discuss the use of these tools to address natural resource vulnerabilities. However, planning and support tools typically tend to support a variety of objectives in one, addressing vulnerabilities related to extreme events (22.7%) and crop production (27.3%) as well. Programmes focused on crop production emphasize crop vulnerabilities as well as the degradation of natural resources that support production. Programmes focused on water resources tend predominantly to address changes in the mean availability of water, with a secondary focus on extreme drought and flooding. Nearly all programmatic development speaks to the top three vulnerabilities of concern.

The results in Table 5.3 suggest that the areas of greatest programmatic development for the OECD as a whole correspond with the vulnerabilities most frequently cited by members. However, Table 5.2 indicates that there is lower correlation between programmatic references and articulated vulnerabilities in the documents of individual members. This difference in correlation for the OECD as an aggregate and for individual members could result from two factors: either programmes have not yet been fully developed to address the vulnerabilities foreseen within each member country, or programmes exist but they are not reflected in the UNFCCC reporting documents.

Table 5.3. Responsiveness of adaptation programmes to vulnerabilities

		Per cent programmatic references by category										
		Planning and support	Water resources	Crop production	Research	Agri-environment	Livestock production	Building partnerships	Extension and outreach	Cross-cutting	Insurance	Total programmes referenced
Vulnerabilities	Extreme events	22.7	24.7	17.8	18.5	12.0	14.3	9.1	11.1	0.0	17.9	185
	Natural resources	36.4	41.6	28.8	25.9	40.0	14.3	36.4	27.8	37.5	14.3	161
	Crops	27.3	16.9	28.8	37.0	24.0	23.8	36.4	27.8	37.5	21.4	132
	Livestock	7.6	5.2	9.6	11.1	8.0	28.6	9.1	16.7	25.0	14.3	42
	Economic	4.5	9.1	6.8	0.0	8.0	14.3	0.0	5.6	0.0	28.6	33
	Food	1.5	2.6	8.2	7.4	8.0	4.8	9.1	11.1	0.0	3.6	20

Note: Cells represent the percentage of total references within each programmatic category that target each type of vulnerability. Dark blue shading indicates a percentage greater than 30%; medium blue indicates a percentage of 20-30%; light blue indicates 10-20%; no shading indicates 0-10%.

6. Agricultural programmes and their potential to support resilience

This section reviews the adaptation programmes and activities identified in UNFCCC documents to answer the question: “Do the agricultural adaptation programmes proposed by members potentially contribute to strengthening resilience along all three dimensions of absorptive, adaptive, and transformative capacity?”

Each of the agricultural climate change adaptation programmes or activities cited in the UNFCCC documents is reviewed to determine whether it has the potential to contribute to building the three capacities that support resilience, namely absorptive, adaptive, and/or transformative capacity. This analysis does not assess whether a programme or activity has actually produced an increase in resilience. The text of the UNFCCC documents does not typically report outcomes from programmes or activities. Moreover, measuring resilience, or the relationship between programmatic outcomes and resilience, is

itself a challenging problem that is outside of the scope of this analysis (Jones, 2018[48]; Dilling et al., 2019[49]).

This section builds on OECD (2020[25]), which describes examples of the types of actions taken by governments that may contribute to the development of each resilience capacity. The three resilience capacities are defined and distinguished as follows.

- Measures to build absorptive capacity are those that operate in the short run to reduce the initial impact of a shock or to expedite recovery afterwards. These measures do not alter the structure of current agricultural production systems. The impact of a shock can be mitigated by providing information on seasonal risks so that farmers can prepare for an anticipated event; developing contingency plans; or investing in risk mitigation by developing infrastructure, institutional capacity, and monitoring systems. Actions to expedite recovery typically take the form of financial assistance, including the provision of insurance programmes.
- Developing adaptive capacity requires efforts that extend past short-run shock mitigation and recover to effect incremental changes in the structure of agricultural production systems. Examples of mechanisms to improve adaptive capacity include measures that address information gaps to facilitate improved farm management, for example by assisting farmers to choose new crop varieties or adopt new irrigation technology. These can also include efforts to develop human capital or to increase investments that permit stakeholders to adopt new strategies.
- Building transformative capacity requires actions that target long run, non-incremental changes in production systems. Transformative capacity can be developed through the provision of information and the development of human, social or natural capital, but the focus must go beyond marginal changes in the production environment to fundamental and long-lasting shifts in production systems. Examples include the adoption of new methods of production (e.g. agroforestry or climate smart agriculture), development of new governance or institutions, multidisciplinary research programmes, and investments in large-scale infrastructure projects that change the agricultural landscape.

The boundaries between categories are not strict. In many cases, one activity may contribute to multiple capacities and the distinction becomes one of the time frames over which it operates or the degree of change in current production systems. For example, the provision of informational resources may contribute to all three capacities. Information may be used to develop an early warning system with the intent to mitigate damages from an impending shock (absorptive capacity). Those same informational resources could also support farmers in choosing between established crop varieties on their existing land base (adaptive capacity), or to define new geographic areas for production or new crops that could be introduced under changing climatic conditions (transformative capacity). In cases where a programme may contribute to multiple capacities and there is no clear information that defines the timeframe of the measure or the extent of changes in production systems, the programmatic reference is coded to all potentially applicable categories.

Table 6.1 identifies the number of programmatic references that support each resilience capacity and the manner in which they do so (e.g. by providing information, supporting research and development, or executing changes in government structure). Figure 6.1 describes the resilience capacities supported by each type of programme identified in Section 4; Figure 6.2 describes the resilience capacities supported by programmes that address each type of vulnerability identified in Section 5.

6.1. Building absorptive capacity

From Table 6.1, 32.9% of programmes cited by members have the potential to support the development of absorptive capacity. The most often-used mechanism to support adaptive capacity is the provision of information to facilitate short-run changes in response to anticipated climate shocks. These most often take the form of seasonal forecasts, monitoring, or early warning systems. Examples include:

- The Queensland Government's LongPaddock website, which "provides climate information, seasonal forecasts and decision support tools to help producers improve their climate risk management." (Australia, 8th national communication).

- Chile's Phytosanitary Alert System to alert farmers to the best timing to implement monitoring and control of *Lobesia botranal.*[24] (4th national communication).
- Japan's government provides weather information and Wet-Bulb Globe Temperatures (WBGT), and other resources to address heat-related emergencies for agriculture, including a "Heat Stroke Alert" designed to take preventive action against heat-related illness. (Japan, 8th national communication).

Table 6.1. Resilience capacity building through adaptation programmes

	Pct. of references	Pct. member countries with ≥1 reference
Absorptive capacity	32.9	51.3
Information provision (data for risk management, seasonal forecasts, monitoring, early warning systems)	13.0	33.3
Planning (emergency preparedness, risk management, contingency planning)	8.7	17.9
Risk reduction (infrastructure development, short-term operations management)	8.1	25.6
Recovery (insurance instruments, support/relief programmes, disaster response)	6.8	28.2
Adaptive capacity	48.4	66.7
Information provision (identification of adaptation options, decision support tools)	23.6	48.7
Ecosystem service provision (maintain or improve soil fertility, water availability, agrobiodiversity)	11.2	20.5
Research and development (crop breeding, changes in operations management, efficacy of adaptation measures)	11.8	30.8
Infrastructure and technology (infrastructure development, technology transfer)	9.9	28.2
Human capital development (education and training)	3.1	10.3
Transformative capacity	18.6	43.6
Collaborative planning and scenario development (horizontal or vertical)	5.6	17.9
Research (interdisciplinary efforts, long-term programmes)	5.0	20.5
Agricultural production systems (climate smart agriculture, circular agriculture, agroforestry)	3.7	12.8
Governance (changes in governance structure)	2.5	10.3
Infrastructure (large-scale projects, landscape reconfiguration)	2.5	5.1

Ex ante measures for emergency preparedness and risk reduction account for 8.7% and 8.1% of programmatic references in the UNFCCC documents. The former include the development of emergency plans and risk assessments for emerging pests and diseases and for drought. For example, Switzerland's parliamentary procedural request, "Water and agriculture. Future challenges," involves developing "a water strategy which, among other things, sets out how water will be distributed in times of scarcity and how to deal with conflicting interests regarding conservation and use" (1st adaptation communication). Risk-reduction activities include the development of infrastructure to reduce the risk of shocks, such as enhancing dams to reduce flooding risk on agricultural land. Other actions include support for deploying existing technologies, such as the application of ice to protect grape vines from freeze damage.

A smaller number of references, 6.8% of the total, describe efforts to support recovery from a shock. These references predominantly refer to crop insurance, delivered either through existing or newly developed programmes. Examples include the development in Hungary of an agricultural insurance system via a process launched by "the entry into force of Act CLXVIII of 2011 on Handling Weather-Related and Other Natural Risks Affecting Agricultural Production" (7th national communication). Greece's Hellenic Agricultural Insurance Organisation (ELGA) compensates farmers for losses from extreme weather and is in the process of updating insurance to account for climate change (8th national communication). Türkiye's Agricultural Insurance Pool (TARSIM) was formed following the enactment of the Agricultural Insurance

[24] *Lobesia botrana*, a moth from the Tortricidae family that is native to southern Italy, is commonly known as the European grapevine moth or European grape worm. The invasive species was first reported in Chile in 2008.

Law (2005) and now provides district-based drought yield insurance and support for the risk of frost in fruits grown in open fields (7th national communication).

There are also examples of funding for programmes targeting faster recovery following a shock. The United States Department of Agriculture is undertaking "new investments to support drought recovery" through the Commodity Credit Corporation, and the Department of the Interior "has reprogrammed significant funding to support drought response actions in heavily impacted states" (1st adaptation communication). The Drought Communities Program Extension of Australia likewise focuses on drought relief activities (1st adaptation communication).

From Figure 6.1, it is clear that programmes that develop planning and support tools contribute most significantly to absorptive capacity. There is significant overlap in this category with adaptive capacity, in large part because the majority of references focus on the provision of information, which can support both short-run responses to climate shocks as well as medium-run adjustments in operations management. Programmes that play a lesser role in developing absorptive capacity are those that are focused on longer-term goals, such as changes in agricultural production systems (cross-cutting and agri-environmental measures), the development of knowledge capital (research), and the development of human capital (extension). From Figure 6.2, it is programmes that address extreme events that are most heavily focused on developing the capacity to respond to shocks in the short run.

Actions that ensure farmers have access to services, credits, and markets to minimise risk and programmes to support *ex post* disaster response and recovery can also support absorptive capacity (OECD, 2020[25]). In the documents reviewed, there was no discussion of these types of activities in the context of agriculture.

Figure 6.1. Resilience capacity building by programmatic area

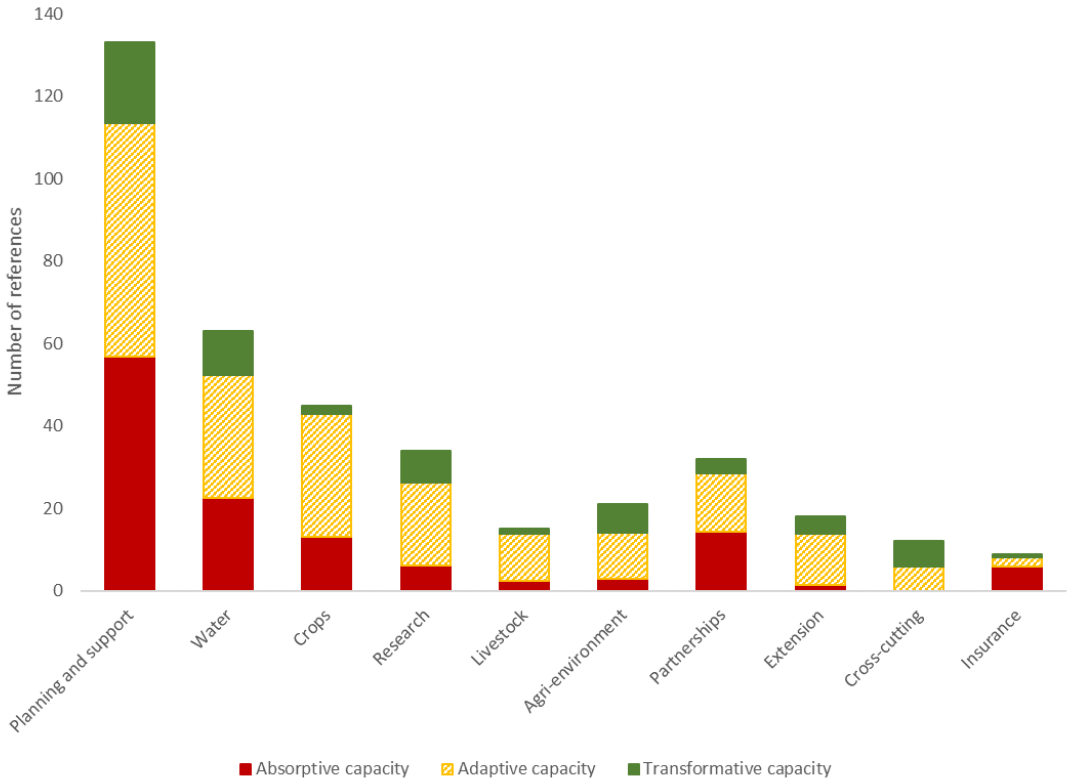
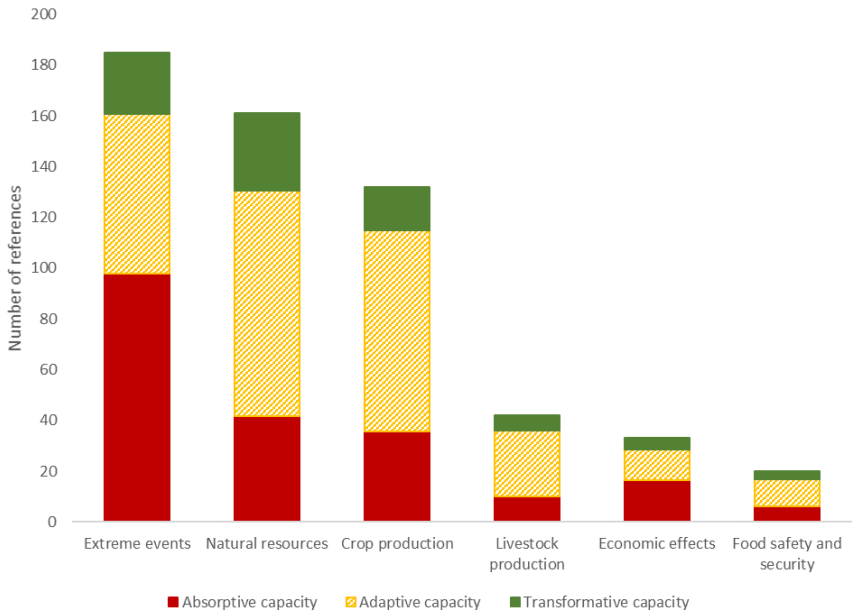


Figure 6.2. Resilience capacity building by vulnerability targeted



6.2. Building adaptive capacity

From Table 6.1, 48.4% of programmes cited by members have the potential to support the development of adaptive capacity. The greatest emphasis among these references is placed on the provision of information, often in the form of decision support tools or materials that identify options for adaptation. Examples include the development of web-based tools with climate and adaptation information by Ireland, Japan, and Norway, among others (Box 6.1); and Slovenia's LIFE ViVaCCAdapt project, which supports irrigation and planting of windbreaks (7th national communication).

Investments in research also play an important role in supporting adaptive capacity. Programmes created by member countries focus on crop breeding through the Crop Development Centre at the University of Saskatchewan (Box 4.2) and the Israel Plant Gene Bank (3rd national communication). Research efforts also seek to identify the impacts of climate change on the agricultural sector and the efficacy of adaptation measures, as in New Zealand's SLMACC (8th national communication). There are a number of programmes that build research networks, including Colombia's work to conduct research in collaboration with production guilds for rice, cereal grains, livestock, palm, bananas, and sugarcane (3rd national communication) and the United Kingdom's support for long-term Genetic Improvement Networks (GINs), which bring together internationally recognised researchers in crop genetics (8th national communication).

Investments in capital – human, natural, and social – contribute to adaptive capacity by helping farmers to develop the flexibility to respond to new challenges and risks in production. A number of programmes invest in maintaining or enhancing the provision of ecosystem services, such as soil fertility, water quality, and agrobiodiversity. Examples include Chile's ODEPA programme to sustain soil health (4th national communication); Mexico's efforts to combat desertification (1st adaptation communication); and Switzerland's efforts to improve soil health via direct payments and proof of ecological performance requirements (8th national communication).

There are comparatively fewer references to programmes that develop human capital by investing in extension. Nevertheless, there are examples of programmes in this area, including the community adaptation planning exercise undertaken with the Mistawasis Nêhiyawak First Nation in Canada (8th national communication); education programmes on the impact of climate change on water resources in Greece (8th national communication); outreach and education programmes provided by Mexico's SADER (1st adaptation communication); and Türkiye's Developing Agricultural Publication Project (7th national communication).

Although efforts to ensure that existing policies do not distort incentives to undertake adaptation are critical to developing adaptive capacity, there is no discussion of such measures within the documents reviewed.

Box 6.1. Examples of web-based resources to support adaptation

Climate Ireland

Climate Ireland's site (www.climateireland.ie) "provides information, advice and support" for adaptation to climate change. The site includes a link to Ireland's Climate Status Tool, with information on climate variables "across atmospheric, terrestrial and oceanic domains." The site includes a variety of tools and resources relevant to adaptation in general, as well as a page that presents opportunities, impacts, adaptation, and resources for agriculture.

Japan's Climate Change Adaptation Information Platform (A-PLAT)

A-PLAT (https://adaptation-platform.nies.go.jp/en/) is designed to provide easily understood materials to promote adaptation. The National Institute for Environmental Studies (NIES) was designated by the Climate Change Adaptation Act of 2018 as the entity responsible for compiling information and advice on adaptation for dissemination through the platform. The site includes an adaptation database with examples of measures undertaken by national and local governments as well as the private sector. Examples relevant to agriculture include an optimal rice planting date map, the introduction of citrus varieties that are resistant to high temperatures, and technological measures to protect plants and livestock from heat stress.

Norway's klimatilpasning portal

Created by the Norwegian Environment Agency, the *klimatilpasning* portal (www.klimatilpasning.no) hosts climate adaptation resources by sector, including those for agriculture and reindeer husbandry. For example, information is provided about measures to adapt to a higher risk of floods and landslides on agricultural land, such as those that reduce flood peaks (e.g. sedimentation basins or weirs) and those that facilitate drainage. The site provides a description of potential measures as well as links to additional resources.

6.3. Building transformative capacity

From Table 6.1, 18.6% of programmes cited by members have the potential to support the development of transformative capacity. References predominantly focus on collaborative planning processes and research activities. Other references are to programmes that support changes in agricultural production systems (e.g. climate-smart or circular agriculture), governance structure, and large-scale infrastructure.

Examples of collaborative planning include efforts to build partnerships by bridging between government agencies and stakeholders, as well as efforts to develop connections across government agencies. For example, Japan's Regional Adaptation Consortium Project "built a collaboration system between local governments, universities, research institutions, and other local relevant people" (1st adaptation communication). The Climate Hubs in the United States are "a unique collaboration across the USDA's agencies," which serve as "a focal point for delivering accessible, usable research and tools for both climate adaptation and mitigation in the agriculture and forestry sectors and rural economies, towards building resilience" (8th national communication).

Potentially transformative research efforts often likewise involve an element of collaboration beyond country and disciplinary boundaries. Examples include collaboration across Europe via Joint Programming Initiatives (JPIs) that involve "work on agricultural model intercomparison and improvement for studying climate risks to agriculture and adaptation responses" (Belgium, 8th national communication) and the establishment of the Drought Management Centre for Southeastern Europe (DMCSEE), with the mission "to coordinate and facilitate the development, assessment and application of drought risk management tools and policies in Southeastern Europe" (DMCSEE, 2023[78]).

Transformation in agricultural production systems is supported by tools like the Enterprise Suitability Maps developed by the Tasmanian Government, which identify new areas that are likely to become suitable for the production of specific crops (e.g. wheat, potatoes and wine grapes) under climate change (Australia, 8th national communication). The maps provide a mechanism to reduce uncertainty related to investments to establish new areas for production. Other references to agricultural production system changes include the Netherland's plan to transition to circular agriculture (1st adaptation communication), Norway's financing of a new project on Climate Smart Agriculture (1st adaptation communication), and Portugal's creation of a National Competence Centre for Climate Change in the Agroforestry Sector (1st adaptation communication).

Developing financial resources to support transformation is another mechanism that governments can use to develop transformational capacity, given that large costs and significant uncertainty often push farmers to favour medium-run adaptive actions over costly and risky long-term change. There is no explicit discussion within the documents reviewed of plans to develop such programmes.

7. Discussion and conclusions

The objective of this analysis is to identify whether and how OECD countries are investing in agricultural climate change adaptation programmes and to what extent these programmes potentially support the development of resilience within the agricultural sector. A mixed-methods content analysis of UNFCCC reporting documents submitted by OECD countries is used to answer four questions concerning the evolution of attention to adaptation and agriculture in the documents over the past three decades; the areas of programmatic development to date; the correspondence between programmatic development and self-reported agricultural climate change vulnerabilities; and the potential for the programmes developed to support the development of the three critical components of resilience, namely absorptive, adaptive, and transformative capacity.

Attention devoted to adaptation has clearly increased over time in the UNFCCC documents and discussion of resilience is beginning to feature more prominently. However, the intensity of treatment differs by document type and across OECD countries. The NDCs of Non-Annex I countries are an important resource for understanding their adaptation efforts to date, whereas national communications and adaptation communications are a better source of information on the activities of Annex I countries. This difference between Annex I and Non-Annex I countries is consistent with that found by Pauw et al. (2019[53]) and arises from the core premise of the Paris Agreement regarding common but differentiated responsibilities for the two groups.

With respect to information specifically on agriculture, similar heterogeneity exists among documents and member states. Even within a document type, the treatment of agriculture and adaptation varies substantially from one member state to another. Some place a relatively heavy emphasis on agricultural vulnerabilities, whereas others focus on adaptation, although there has been a shift over time from mainly discussing vulnerabilities to also discussing adaptation. Over time, the amount of text devoted to agriculture has remained relatively stable, although the composition has shifted: mitigation of greenhouse gas emissions remains the most frequent context within which agriculture is discussed, but discussion of adaptation and mitigation-adaptation co-benefits have become increasingly important in later reporting rounds.

The catalogue of agricultural adaptation programmes culled from these documents illustrates that significant strength exists among the OECD countries in the development of planning and support tools, programmes to support water resource management, and efforts to facilitate adaptation in crop production. Clear investments have been made to date in adaptation planning, decision support, soil and nutrient management, cultivar selection and breeding, and water resource management.

Broadly, these programmatic strengths correspond to the climate change vulnerabilities that are most often cited by member countries as important concerns, namely drought, flooding, and declining crop yields. Other concerns that are often cited revolve around the increased production of environmental externalities (e.g. nutrient runoff, declining pollinator populations), shifts in production to new growing regions and increased damage from pest or disease outbreaks. While some programmes have been developed to

address these issues, there is considerably less depth in programmatic development across the OECD than for water and crop yield concerns.

The analysis also suggests that there are broad areas in which there are likely opportunities to invest more heavily in programmatic development. In particular, the implications of climate change for livestock production is one area in which over half of the membership defines a vulnerability. At the same time, the majority of the discussion of activities related to livestock production is general. Programmatic development in extension and outreach and in cross-cutting measures is similarly skewed toward general discussion, rather than specific actions.

Taken as a whole, the programmes discussed in the UNFCCC documents contribute most heavily to adaptive capacity building. A focus on adaptive capacity over absorptive capacity likely reflects a growing recognition that investment in short-run absorptive capacity, while an important element of resilience, is not sufficient to address the increasingly severe effects of climate change on agriculture. At the same time, the overall number of programmes that support transformative capacity in the long run, at least as reported in the UNFCCC documents, remains relatively low.

This result is not surprising given that examples of successful transformation to date, particularly transformation that is deliberately planned, are rare. However, the available evidence increasingly suggests that developing the capacity to support such change will likely be necessary. There is evidence in the UNFCCC documents that the foundations for such change are nascent – member states are actively engaged in cultivating partnerships and collaborative planning, in multidisciplinary research to gain insights into complex problems and in refining and applying decision support tools to include non-incremental changes in production systems.

In terms of the barriers to transformation, there is widespread recognition that better information is necessary to resolve uncertainty regarding the risks associated with climate change and the potential benefits from adaptation. However, there is little attention within the documents reviewed to addressing other factors that inhibit transformational capacity. Institutional barriers, such as current regulations and rights-based systems, as well as uncertainty surrounding them, are known obstacles to transformation (Kates, Travis and Wilbanks, 2012[39]; Jakku et al., 2016[79]; Vermeulen et al., 2018[38]; Rickards and Howden, 2012[80]). Moreover, transformation requires a large initial investment with payoffs that may only be realised in the long term. Incorporating deliberate efforts to address these obstacles presents a critical area for growth for member states moving forward.

Taken in aggregate, the OECD membership possesses significant strength in terms of programming to respond to a diversity of anticipated vulnerabilities in agriculture. This points to opportunities to share information about programmes and lessons learned to date between members. Developing social capital is known to be effective in advancing transformational change at the level of the farm (OECD, 2020[25]). Developing mechanisms to share information and learning about adaptation programmes across the OECD countries and beyond can serve to advance planned adaptation to proactively address the shifting and complex risks driven by climate change.

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Annex A. Supplementary tables

Table A.1. UNFCCC classification, OECD and G20 countries

	Current OECD country	G20 member	UNFCCC classification		
			Annex I	Annex II	Non-Annex I
Argentina		✓			✓
Australia	✓	✓	✓	✓	
Brazil		✓			✓
Canada	✓	✓	✓	✓	
Chile	✓				✓
China		✓			✓
Colombia	✓				✓
Costa Rica	✓				✓
European Union	✓	✓	✓	✓	
Austria	✓		✓	✓	
Belgium	✓		✓	✓	
Czech Republic	✓		✓		
Denmark	✓		✓	✓	
Estonia	✓		✓		
Finland	✓		✓	✓	
France	✓	✓	✓	✓	
Germany	✓	✓	✓	✓	
Greece	✓		✓	✓	
Hungary	✓		✓		
Ireland	✓		✓	✓	
Italy	✓	✓	✓	✓	
Latvia	✓		✓		
Lithuania	✓		✓		
Luxembourg	✓		✓	✓	
Netherlands	✓		✓	✓	
Poland	✓		✓		
Portugal	✓		✓	✓	
Slovak Republic	✓		✓		
Slovenia	✓		✓		
Spain	✓		✓	✓	
Sweden	✓		✓	✓	
Iceland	✓		✓	✓	
India		✓			✓
Indonesia		✓			✓
Israel	✓				✓
Japan	✓	✓	✓	✓	
Korea	✓	✓			✓
Mexico	✓	✓			✓
New Zealand	✓		✓	✓	
Norway	✓		✓	✓	
Russia		✓	✓		
Saudi Arabia		✓			✓
South Africa		✓			✓
Switzerland	✓		✓	✓	
Türkiye	✓	✓	✓		
United Kingdom	✓	✓	✓	✓	
United States	✓	✓	✓	✓	
Total	39	20	34	24	13

Table A.2. National communications submitted to the UNFCCC prior to 1 February 2023

Member country	NC1	NC2	NC3	NC4	NC5	NC6	NC7	NC8
Australia	9/1994	11/1997	8/2002	12/2005	2/2010	8/2013	6/2018	12/2022
Canada	1994	11/1997	2/2002	3/2007	2/2010	9/2014	12/2017	12/2022
Chile	2/2000	10/2011SP	11/2016SP	5/2021SP				
Colombia	12/2001SP	12/2010SP	9/2017SP					
Costa Rica	11/2000SP	10/2009SP	12/2014SP	12/2021SP				
European Union	HC*	6/1998	12/2001	2/2006	12/2009	1/2014	12/2017	12/2022
Austria	8/1994	1998	11/2001	10/2006	2/2010	2/2014	2/2018	12/2022
Belgium	1/1997FR	8/1997FR	4/2002	12/2005	3/2010	4/2014	12/2017	12/2022
Czech Republic	HC*	1997	12/2001	2/2006	11/2009	4/2014	12/2017	1/2023
Denmark	ND	ND	6/2003	12/2005	1/2010	1/2014	1/2018	
Estonia	1995	2/1998	11/2001	12/2005	2/2010	2/2014	3/2018	12/2022
Finland	1/1995	ND	11/2001	2/2006	12/2009	12/2013	12/2017	12/2022
France	ND	11/1997	11/2001	7/2006FR	2/2010	7/2015	2/2018	1/2023
Germany	ND	4/1997	ND	10/2006	2/2010	10/2014	12/2017	
Greece	2/1995	6/1997	2/2003	3/2006	1/2010	12/2013	12/2017	12/2022
Hungary	1994	1997	7/2002	3/2006	12/2009	1/2014	1/2018	
Ireland	6/1995	ND	12/2003	4/2007	3/2010	3/2014	3/2018	
Italy	1/1995	11/1998	1/2003	6/2008	3/2010	4/2014	1/2018	12/2022
Latvia	1995	HC*	11/2001	5/2006	3/2010	12/2013	12/2017	12/2022
Lithuania	ND	1/2003	12/2005M,*	12/2005M,*	2/2010	1/2014	12/2017	1/2023
Luxembourg	3/1995	2/2010M	2/2010M,*	2/2010M,*	2/2010M,*	2/2014	2/2018	
Netherlands	8/1994*	4/1997	11/2001	12/2005	12/2009	12/2013	2/2018	12/2022
Poland	10/1994	1998	11/2001	12/2006	3/2010	2/2014	12/2017	12/2022
Portugal	1994	1997	6/2003	7/2006	6/2010	3/2014	12/2017	12/2022
Slovak Republic	5/1995	ND	10/2001	12/2005*	2/2010	1/2014	12/2017	
Slovenia	8/2002	10/2004M	10/2004M,*	6/2006	4/2010	5/2014	3/2018	
Spain	HC*	10/1997SP	4/2002SP	3/2006SP	12/2009SP	12/2013SP	12/2017SP	12/2022SP
Sweden	9/1994	ND	11/2001	12/2005	2/2010	4/2014	12/2017	
Iceland	1994	1997	4/2003	4/2006	3/2010	3/2014	3/2018	
Israel	11/2000	11/2010	8/2018					
Japan	1994	1997	5/2002	2/2006	12/2009	9/2014	12/2017	12/2022
Korea	2/1998	12/2003	3/2012	11/2019				
Mexico	12/1997	7/2001SP	11/2006	4/2010SP	12/2012SP	4/2019SP		
New Zealand	9/1994	6/1997	11/2001	5/2006	12/2009	12/2013	12/2017	12/2022
Norway	9/1994	4/1997	5/2002	2/2006	6/2010	7/2014	1/2018	12/2022
Switzerland	1994	1997	11/2001	12/2005	12/2009	2/2014	12/2017	9/2022
Türkiye	2/2007				12/2013	4/2016	8/2019	
United Kingdom	HC*	2/1997	10/2001	5/2006	6/2009	1/2014	12/2017	12/2022
United States	HC*	7/1997	5/2022	7/2007	5/2010	1/2014	10/2021	12/2022
No. analysed	33	37	35	34	32	34	33	23

Note: Where no submission date is recorded, date of publication is extracted from the document; ND indicates that neither a submission nor a publication date are available; HC indicates that the document is available only as a hard copy; SP indicates document is in Spanish; FR indicates document is in French (all other documents are in English); M indicates that multiple communications are included in one document, in which case the document is analysed only once; * indicates that a document is excluded from the analysis, in some cases to avoid redundancies and in others because it is not readable by the content analysis software.
Source: UNFCCC national communication registry.

Table A.3. Documents submitted under the Paris Agreement prior to 1 February 2023

	Nationally determined contributions (NDCs)				Adaptation communication	
Member country	Version 1	Version 2	Version 3	Version 4	Version 1	Version 2
Australia	11/2016	12/2020	10/2021	6/2022	10/2021	
Canada	10/2016	5/2017	7/2021		7/2021	
Chile	2/2017SP	4/2020			12/2022SP	
Colombia	7/2018SP	12/2020SP			12/2020SP,*	
Costa Rica	10/2016	12/2020SP	12/2020SP		12/2020SP,*	
European Union	10/2016	12/2020			10/2021	
Austria					10/2021	
Italy					11/2021	
Netherlands					9/2021	
Portugal					11/2021	
Spain					10/2021SP	
Sweden					11/2022	
Iceland	9/2016	2/2021				
Israel	11/2016	7/2021				
Japan	11/2016	3/2020	10/2021	10/2021	10/2021	
Korea	11/2016	12/2020	12/2021			
Mexico	9/2016	12/2020SP	11/2022SP		2/2022	
New Zealand	10/2016	11/2021			12/2017**	12/2022**
Norway	6/2016	2/2020	11/2022		5/2021	
Switzerland	10/2017	12/2020	12/2021		12/2020	
Türkiye	10/2021					
United Kingdom	11/2016	12/2020	9/2022		12/2020	
United States	9/2016	4/2021			11/2021	
No. analysed	17	16	9	2	16	0

Note: SP indicates the document is in Spanish (all others are in English); * indicates the adaptation communication is identical to the nationally determined contribution; ** indicates the adaptation communication is identical to the national communication; * and ** documents are excluded from the adaptation communication analysis to prevent double counting.
Source: UNFCCC nationally determined contribution and adaptation communication registries.

Table A.4. References made to planning and support activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	3			1
Australia	2.52	14	0	1	11
Türkiye	2.50	7	0		8
Greece	2.32	11			10
Netherlands	2.05	11		2	6
Japan	1.76	13	0	3	4
Portugal	1.69	12		2	6
Colombia	1.64	9	4		3
Korea	1.63	3	0		0
Slovak Republic	1.38	0			0
Switzerland	1.23	7	0	0	2
Norway	1.07	7	0	3	2
Mexico	1.01	4	1	2	0
Czech Republic	0.90	2			0
Canada	0.85	10	0	0	9
United States	0.85	8	0	1	3
United Kingdom	0.83	8	0	1	7
Chile	0.82	3	1	1	1
Germany	0.80	1			1
Sweden	0.76	4		3	1
Spain	0.74	6		0	5
Finland	0.69	6			5
Belgium	0.68	0			0
Costa Rica	0.67	5	2		1
Israel	0.58	0	0		0
Poland	0.58	1			1
Latvia	0.53	3			2
Estonia	0.50	4			2
Luxembourg	0.41	3			2
Austria	0.39	1		1	0
Lithuania	0.38	2			2
France	0.37	4			3
EU	0.35	3	0	1	1
Slovenia	0.28	2			1
Ireland	0.16	4			4
Italy	0.11	0		0	0
New Zealand	0.03	2	0		0
Denmark	0.00	0			0
Iceland	0.00	0	0		0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.5. References made to water resources activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	15	0	0	1
Australia	2.52	14	0	2	6
Türkiye	2.50	11	0	0	11
Greece	2.32	8	0	0	7
Netherlands	2.05	10	0	2	3
Japan	1.76	6	0	1	0
Portugal	1.69	18	0	3	2
Colombia	1.64	3	1	0	0
Korea	1.63	1	1	0	0
Slovak Republic	1.38	3	0	0	0
Switzerland	1.23	16	0	1	2
Norway	1.07	1	0	1	0
Mexico	1.01	2	0	1	0
Czech Republic	0.90	4	0	0	0
Canada	0.85	3	0	0	3
United States	0.85	5	0	1	0
United Kingdom	0.83	2	0	0	2
Chile	0.82	3	1	0	1
Germany	0.80	1	0	0	1
Sweden	0.76	0	0	0	0
Spain	0.74	2	0	0	1
Finland	0.69	4	0	0	3
Belgium	0.68	1	0	0	0
Costa Rica	0.67	0	0	0	0
Israel	0.58	2	0	0	0
Poland	0.58	0	0	0	0
Latvia	0.53	1	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	3	0	0	2
Austria	0.39	3	0	1	0
Lithuania	0.38	0	0	0	0
France	0.37	1	0	0	0
EU	0.35	2	0	1	0
Slovenia	0.28	1	0	0	1
Ireland	0.16	0	0	0	0
Italy	0.11	2	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.6. References made to crop production activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	8	0	0	1
Australia	2.52	11	0	2	6
Türkiye	2.50	5	0	0	5
Greece	2.32	4	0	0	3
Netherlands	2.05	3	0	0	1
Japan	1.76	1	0	0	0
Portugal	1.69	12	0	1	0
Colombia	1.64	1	1	0	0
Korea	1.63	0	0	0	0
Slovak Republic	1.38	1	0	0	0
Switzerland	1.23	13	0	0	3
Norway	1.07	3	0	1	1
Mexico	1.01	3	0	2	0
Czech Republic	0.90	7	0	0	0
Canada	0.85	1	0	0	1
United States	0.85	0	0	0	0
United Kingdom	0.83	9	0	1	6
Chile	0.82	5	1	0	1
Germany	0.80	1	0	0	1
Sweden	0.76	1	0	1	0
Spain	0.74	0	0	0	0
Finland	0.69	2	0	0	0
Belgium	0.68	1	0	0	1
Costa Rica	0.67	1	0	0	1
Israel	0.58	0	0	0	0
Poland	0.58	1	0	0	1
Latvia	0.53	1	0	0	0
Estonia	0.50	2	0	0	1
Luxembourg	0.41	1	0	0	0
Austria	0.39	2	0	1	0
Lithuania	0.38	0	0	0	0
France	0.37	1	0	0	1
EU	0.35	1	0	0	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.7. References made to research activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	0	0	0	0
Australia	2.52	11	0	1	6
Türkiye	2.50	2	0	0	2
Greece	2.32	4	0	0	3
Netherlands	2.05	2	0	0	0
Japan	1.76	3	0	1	0
Portugal	1.69	1	0	0	1
Colombia	1.64	1	0	0	1
Korea	1.63	0	0	0	0
Slovak Republic	1.38	0	0	0	0
Switzerland	1.23	2	0	0	1
Norway	1.07	3	0	1	2
Mexico	1.01	0	0	0	0
Czech Republic	0.90	2	0	0	0
Canada	0.85	2	0	0	1
United States	0.85	3	0	0	3
United Kingdom	0.83	6	0	2	3
Chile	0.82	0	0	0	0
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	0	0	0	0
Finland	0.69	2	0	0	1
Belgium	0.68	2	0	0	2
Costa Rica	0.67	1	0	0	0
Israel	0.58	2	0	0	1
Poland	0.58	0	0	0	0
Latvia	0.53	2	0	0	0
Estonia	0.50	2	0	0	1
Luxembourg	0.41	0	0	0	0
Austria	0.39	0	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	1	0	1	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.8. References made to agri-environmental measures

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	1	0	0	0
Australia	2.52	1	0	0	1
Türkiye	2.50	3	0	0	3
Greece	2.32	4	0	0	3
Netherlands	2.05	3	0	0	2
Japan	1.76	2	0	0	0
Portugal	1.69	2	0	1	1
Colombia	1.64	0	0	0	0
Korea	1.63	0	0	0	0
Slovak Republic	1.38	1	0	0	0
Switzerland	1.23	6	0	0	2
Norway	1.07	1	0	0	1
Mexico	1.01	1	0	0	0
Czech Republic	0.90	4	0	0	0
Canada	0.85	0	0	0	0
United States	0.85	0	0	0	0
United Kingdom	0.83	1	0	0	1
Chile	0.82	2	0	0	1
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	0	0	0	0
Finland	0.69	1	0	0	0
Belgium	0.68	0	0	0	0
Costa Rica	0.67	0	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	1	0	0	1
Latvia	0.53	2	0	0	0
Estonia	0.50	2	0	0	2
Luxembourg	0.41	0	0	0	0
Austria	0.39	2	0	1	1
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	0	0	0	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.9. References made to livestock production activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	4	0	0	0
Australia	2.52	3	0	0	3
Türkiye	2.50	2	0	0	1
Greece	2.32	2	0	0	2
Netherlands	2.05	3	0	0	1
Japan	1.76	0	0	0	0
Portugal	1.69	2	0	0	0
Colombia	1.64	4	0	0	0
Korea	1.63	3	0	0	0
Slovak Republic	1.38	1	0	0	0
Switzerland	1.23	3	0	0	1
Norway	1.07	5	0	0	2
Mexico	1.01	5	0	1	0
Czech Republic	0.90	0	0	0	0
Canada	0.85	0	0	0	0
United States	0.85	0	0	0	0
United Kingdom	0.83	1	0	0	1
Chile	0.82	2	1	0	0
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	3	0	0	0
Finland	0.69	3	0	0	2
Belgium	0.68	0	0	0	0
Costa Rica	0.67	3	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	0	0	0	0
Latvia	0.53	0	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	1	0	0	0
Austria	0.39	1	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	0	0	0	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.10. References made to developing partnerships

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	0	0	0	0
Australia	2.52	8	0	0	5
Türkiye	2.50	1	0	0	1
Greece	2.32	6	0	0	5
Netherlands	2.05	4	0	0	2
Japan	1.76	8	0	2	4
Portugal	1.69	3	0	0	2
Colombia	1.64	1	0	0	1
Korea	1.63	0	0	0	0
Slovak Republic	1.38	0	0	0	0
Switzerland	1.23	0	0	0	0
Norway	1.07	1	0	0	1
Mexico	1.01	2	0	1	0
Czech Republic	0.90	0	0	0	0
Canada	0.85	1	0	0	1
United States	0.85	4	0	1	3
United Kingdom	0.83	0	0	0	0
Chile	0.82	0	0	0	0
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	0	0	0	0
Finland	0.69	2	0	0	2
Belgium	0.68	0	0	0	0
Costa Rica	0.67	1	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	0	0	0	0
Latvia	0.53	0	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	0	0	0	0
Austria	0.39	0	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	2	0	1	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.11. References made to extension and outreach activities

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	0	0	0	0
Australia	2.52	3	0	0	3
Türkiye	2.50	1	0	0	1
Greece	2.32	5	0	0	5
Netherlands	2.05	1	0	0	0
Japan	1.76	2	0	0	0
Portugal	1.69	1	0	0	0
Colombia	1.64	0	0	0	0
Korea	1.63	0	0	0	0
Slovak Republic	1.38	0	0	0	0
Switzerland	1.23	1	0	0	0
Norway	1.07	2	0	1	1
Mexico	1.01	0	0	0	0
Czech Republic	0.90	0	0	0	0
Canada	0.85	2	0	0	2
United States	0.85	3	0	0	3
United Kingdom	0.83	1	0	0	1
Chile	0.82	0	0	0	0
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	0	0	0	0
Finland	0.69	1	0	0	0
Belgium	0.68	1	0	0	1
Costa Rica	0.67	1	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	0	0	0	0
Latvia	0.53	0	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	0	0	0	0
Austria	0.39	0	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	0	0	0	0
Slovenia	0.28	1	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.12. References made to cross-cutting approaches

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	1	0	0	0
Australia	2.52	2	0	0	2
Türkiye	2.50	0	0	0	0
Greece	2.32	2	0	0	2
Netherlands	2.05	0	0	0	0
Japan	1.76	1	0	0	1
Portugal	1.69	1	0	1	0
Colombia	1.64	0	0	0	0
Korea	1.63	0	0	0	0
Slovak Republic	1.38	1	0	0	0
Switzerland	1.23	0	0	0	0
Norway	1.07	2	0	1	1
Mexico	1.01	0	0	0	0
Czech Republic	0.90	1	0	0	0
Canada	0.85	0	0	0	0
United States	0.85	3	0	0	3
United Kingdom	0.83	0	0	0	0
Chile	0.82	0	0	0	0
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	1	0	0	0
Finland	0.69	1	0	0	0
Belgium	0.68	0	0	0	0
Costa Rica	0.67	0	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	1	0	0	1
Latvia	0.53	0	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	0	0	0	0
Austria	0.39	0	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	1	0	0	0
Slovenia	0.28	0	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

Table A.13. References made to insurance mechanisms

References used to develop Table 4.1

	% text on ag. adaptation	Total number of references	Number of specific references by source		
			Nationally determined contribution	Adaptation communication	National communication
Hungary	3.39	2	0	0	1
Australia	2.52	0	0	0	0
Türkiye	2.50	1	0	0	1
Greece	2.32	3	0	0	2
Netherlands	2.05	1	0	0	0
Japan	1.76	0	0	0	0
Portugal	1.69	1	0	0	0
Colombia	1.64	0	0	0	0
Korea	1.63	0	0	0	0
Slovak Republic	1.38	0	0	0	0
Switzerland	1.23	1	0	0	1
Norway	1.07	0	0	0	0
Mexico	1.01	1	0	1	0
Czech Republic	0.90	0	0	0	0
Canada	0.85	1	0	0	1
United States	0.85	1	0	0	0
United Kingdom	0.83	0	0	0	0
Chile	0.82	1	0	0	1
Germany	0.80	0	0	0	0
Sweden	0.76	0	0	0	0
Spain	0.74	0	0	0	0
Finland	0.69	1	0	0	1
Belgium	0.68	0	0	0	0
Costa Rica	0.67	0	0	0	0
Israel	0.58	0	0	0	0
Poland	0.58	0	0	0	0
Latvia	0.53	1	0	0	0
Estonia	0.50	0	0	0	0
Luxembourg	0.41	1	0	0	0
Austria	0.39	0	0	0	0
Lithuania	0.38	0	0	0	0
France	0.37	0	0	0	0
EU	0.35	0	0	0	0
Slovenia	0.28	1	0	0	0
Ireland	0.16	0	0	0	0
Italy	0.11	0	0	0	0
New Zealand	0.03	0	0	0	0
Denmark	0.00	0	0	0	0
Iceland	0.00	0	0	0	0

Note: Data do not reflect references to programming found in supplementary data added by request to Table 4.1 for Canada and New Zealand.

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Comments are welcome and can be sent to tad.contact@oecd.org.