OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in Norway

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Foreword

Agriculture and forestry represent a small part of gross value added in Norway, but their presence across the country makes them critical drivers of land use and the natural environment.

The *Food and Agriculture Review of Norway* is part of a series of country studies that use the OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework to analyse how the overall policy environment can foster productivity growth that is supportive of environmental sustainability and resilience. The challenge of reconciling these objectives is common to all countries, but shaped differently in each.

Norway is delivering unevenly across its four agricultural policy objectives: the country enjoys a high level of food security and meets its aim of maintaining agricultural production across the country; however, environmental performance and the efficient creation of value added along the food chain are compromised by support policies that are linked to production levels. Support to producers relative to gross farm receipts is the highest among OECD countries, with 59% of farmers' revenues coming from government support. Only 3% of total support to agriculture is dedicated to research and innovation, and although the country has strong public research institutions and well-designed tax deductions the private sector lacks the right policy incentives to innovate.

This *Review* proposes a new policy approach, centred around innovations that would enable Norway to improve the productivity, sustainability and resilience of its agro-food sector. Specific recommendations include increasing the responsiveness of the sector to markets, giving farmers greater flexibility when making production decisions, placing greater emphasis on agri-environmental outcomes, and attributing a greater role for the private sector in the area of research and innovation.

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This review has taken place in the challenging context of the COVID-19 crisis that has affected all our day-to-day lives. Only one mission to Norway was possible in late 2019. The agenda was full, involving experts and stakeholders, as well as an inspiring discussion with Geir Halvor Vedum and Karoline Finstad Vol when we visited their farms. Without the effort and flexibility shown by all contributors, this review would not have been possible.

The *Review* forms the basis for engagement and policy dialogue with the Norwegian Government and other stakeholders. The ultimate aim of the analysis and associated exchange of policy experiences is to contribute to the design of more effective policies in Norway and in other countries.

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Acronyms

Acronym or title	English title
AIS	Agricultural Innovation System
AMR	Antimicrobial resistance
BAA	Basic Agricultural Agreement
BERD	Business expenditure on research and development
BIOTEK2021	Large-scale Programme on Biotechnology for Innovation
CAP	European Union's Common Agricultural Policy
CBD	Convention on Biological Diversity
CCS	Carbon capture and storage
CFP	European Union's Common Fisheries Policy
CH_4	Methane
CO_2	Carbon dioxide
COVID-19	Coronavirus
CRI	Centre for Research-based Innovation
Crop Trust	Global Crop Diversity Trust
DSB	Norwegian Directorate for Social Security and Preparedness
eCorda	Common Research Datawarehouse of the European Commission
EEA	European Economic Area
EFTA	European Free Trade Association
ENERGIX	Large-scale Programme for Energy Research
ESVAC	European Surveillance of Veterinary Antimicrobial Consumption
ETS	Emission Trading System
EU	European Union
FACCE	Food security, agriculture and climate change (JPI)
FDI	Foreign Direct Investment
FFL	Foundation for Research Levy on Agricultural Products
FHF	Norwegian Seafood Research Fund
FP7	EU's Seventh Framework Programme for Research
FTA	Free Trade Agreement
GBARD	Government budget allocation on R&D
GCE	Global Centres of Expertise
GCI	Global Competitiveness Index of the World Economic Forum
GDP	Gross domestic product
GEM	Global Entrepreneurship Monitor
GERD	Gross domestic expenditure on research and development
GHG	Greenhouse gas
GSSE	General Services Support Estimate
GVA	Gross value added
ICT	Information and Communication Technology
IN	Innovation Norway
IP	Intellectual property
IPC	International Patent Classification

IPCC	Intergovernmental Panel on Climate Change
ITPGRFA	Nagoya Protocol and the International Treaty on Plant Genetic Resources for Food and Agriculture
JA	Agriculture Agreement funds
JPI	EU Joint Programming Initiatives
KSL	Quality system
HDHL	Healthy diet for a healthy life (JPI)
HE	Higher education
HWP	Harvested wood products
LEIT	Leadership in Enabling and Industrial Technologies
LMD	Ministry of Agriculture and Food
LTP	Long Term Plan for Research and Higher Education
LULUCF	Land Use and Land Use Change and Forestry
MNF tariff	Most-favoured-nation tariff. Normal non-discriminatory tariff charged on imports (excludes preferential tariffs under free trade agreements and other schemes or tariffs charged inside quotas)
N	Nitrogen
N_2O	Nitrous oxide
NAA	Norwegian Agriculture Agency
NACE	Statistical Classification of Economic Activities in the European Community
NAP	Norwegian cross-sectoral National Action Plan
NAP	National Agri-environmental Programme
NCE	Norwegian Centres of Expertise
NCO	Non-commodity output
NDC	Nationally determined contribution
NFI	National Forest Inventory
NFSA	Norwegian Food Safety Authority
NHO	Norwegian Confederation of Norwegian Enterprise
NIBIO	Norwegian Institute of Bioeconomy Research
NIC	Norwegian Innovation Clusters
NIFU	Nordic Institute for Studies in Innovation, Research and Education
NKJ	Nordic Committee for Research in Agriculture and Food
NLR	Norwegian Agricultural Extension Service
NMBU	Norwegian University of Life Sciences
NordGen	Nordic Genetic Resources Centre
NORM	Norwegian monitoring system for antibiotic resistance in microbes in human pathogens
NORM-VET	Norwegian monitoring programme for antimicrobial resistance in bacteria from feed, food and animals
NRF	Norwegian Red
NTNU	Norwegian University of Science and Technology
NVH	Norwegian School of Veterinary Science
OECD	Organisation for Economic Co-operation and Development
P	Phosphorus
PCT	Patent Co-operation Treaty
PEM	Policy Evaluation Model
PISA	OECD Programme for International Student Assessment
PMR	OECD Product Market Regulation Indicators
PRESIS	NIBIO's precision agriculture in practice project
PSE	Producer Support Estimate
%PSE	PSE transfers as a share of grossfarm receipts (including support in the denominator)
PSR	OECD Productivity, Sustainability and Resilience Framework
RCN	Provide Research Council of Norway

R&D&I	Research, development and innovation
REP	Regional Agri-environmental Programmes
Ruralis	Institute for Rural Regional Research
SC	Societal Challenge
SFI	Centres for Research-based Innovation
Siva	Industrial Development Co-operation of Norway
SLF	Swedish Farmers' Foundation for Agricultural Research
SMEs	Small and medium-sized enterprises
SMIL	Specialised measures in agriculture
SNS	Nordic Forest Research
SPS	Sanitary and phytosanitary measures (non-tariff barriers to trade)
SPS	Strong sustainable productivity
SPSS	Semi-strong sustainable productivity
SPW	Weak sustainable productivity
TBT	Technical barriers to trade measures (non-tariff barriers to trade)
TFC	Total Final Consumption
TFI	OECD Trade Facilitation Indicators
TFP	Total Factor Productivity
TPES	Total Primary Energy Supply
TQRs	Tariff-rate quotas
TSE	Total Support Estimate
TTO	Technology Transfer Offices
TVET	Technical and vocational and educational training
UMB	Norwegian University of Life Sciences
UNFCCC	UN Framework Convention on Climate Change
UN-REDD	United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries
UPOV	International Union for the Protection of New Varieties of Plants
VAT	Value added tax
VI	Norwegian Veterinary Institute
WBIP	Wood-based innovation programmes
WEF	World Economic Forum
WFD	EU Water Framework Directive
WTO	World Trade Organization

Executive summary

Norway's geography implies that much of the country's current agricultural activity would not be viable without government support. As a consequence, Norway has the highest level of agricultural support of all OECD countries, with 59% of farmers' revenues coming from government support measures. Most of this support is provided through market price support and payments linked to production, with only 3% of total support to the sector dedicated to research and innovation. In contrast, the fisheries and forestry sectors are not dependent on trade protection and high government support.

The stated objectives of Norway's agricultural policies include ensuring food security and "preparedness"; maintaining agriculture across the whole country; increasing value added; and achieving sustainable agriculture with lower GHG emissions. While overall, Norway has high environmental standards and a commitment to open trade, agriculture is an exception with respect to economy-wide policies such as GHG emissions taxes and trade agreements.

The chosen policies encourage production, with the result that domestically produced food is available and agricultural activity is maintained over the entire country. However, they also make food significantly more expensive for consumers. Moreover, high support levels encourage current production decisions, providing a disincentive to innovation, and raise input prices for downstream industries, impeding the generation of value added. They also lead to increased environment stress while raising total GHG emissions. While productivity growth in Norway has been higher than the OECD average, it has been achieved via labour-saving technologies that elevate the input intensity of production and contribute to environmental pressures.

In sum, Norway achieves its first two objectives, but at the cost of the latter two. Alternative policy approaches can ensure food security and some geographical presence of agriculture, without stimulating additional production and imposing negative effects on sustainability and the generation of value added in the food sector. This study proposes such a new policy approach that would enable Norway to improve the productivity, sustainability and resilience of its agricultural sector, and achieve a balance across its multiple objectives. This approach has four main features: an increased responsiveness to markets to position the sector to better meet the needs of consumers and position it to improve its sustainability and innovation; a new approach to maintaining the regional presence of agriculture that gives more flexibility to farmers; a strengthened focus on agri-environmental outcomes; and an upgrade of the agricultural innovation system with a greater role for the private sector. Specifically:

- Gradually reduce border protection and commodity-specific support in a predictable way to allow markets play their role in allocating production resources and responding to innovation demands. Transition co-operatives away from their market regulation role.
- Clarify the meaning and value of agricultural land use in different regions to better orient policies and innovation incentives, and to measure success.
- Make use of targeted support that is not connected to production to provide income support and complementary incentives to maintain land in agriculture, and improve environmental performance.

- Reduce net GHG emissions from agriculture by restructuring support and treating the sector similarly to other sectors in the economy.
- Direct policies towards sustainability priorities, for example, by increasing the share of payments conditional on adopting specific farming practices for environmental reasons beyond the current share of 15% of total support to producers.
- Promote the development of environmental plans at the farm level and develop a system to monitor the agri-environmental performance of farms.
- Introduce voluntary risk-management programmes to help farmers actively manage their business risk.
- Strengthen cross-sectoral innovation priorities and the strategic roles of the Research Council of Norway and Innovation Norway in the Agricultural innovation system. Assure the independence of agricultural research institutes under the Ministry for Agriculture and Food (LMD) and strengthen cross-sectoral collaboration.
- Building on existing agricultural innovation funds, enhance the incentives to match together public and private resources and to respond to business and social demands.

In order to achieve these objectives, Norway could explore wider stakeholder engagement in policymaking. The annual negotiation between government and farmer representatives should be reviewed to ensure it is well suited to current and emerging policy objectives. A multiyear framework agreement and the participation of a wider range of stakeholders could contribute to strengthened performance with respect to environmental and social objectives

Assessment and recommendations

A stable, high support policy environment

Norway is a highly developed, democratic country with a strong role for the state in strategic areas of the economy and high standards of living and wealth underpinned by the petroleum sector. A favourable business environment and the high quality of its institutions and policies also underpin high levels of economic wellbeing and a strong tradition of inclusiveness.

While only representing a small part of gross value added, agricultural properties are present in more than three-quarters of Norwegian territory. Average farm size remains relatively small, although rented land is playing a larger role, facilitating the consolidation of agricultural land and increasing farm size. As in many other countries, there has been a reduction over time in the amount of labour employed in agriculture. In many farms, agriculture and forestry coexist and farmers own most small forest lots. Land ownership by farmers and their heirs, and its agricultural use, are legally protected by the Concession Act, the Inheritance Act and the Allodial Act.

Agriculture is an exception in an otherwise open Norwegian economy. Norway is a net importer of agro-food products, but an even larger net exporter of fish and a highly active trader of wood products. Norway is integrated into global agro-food value chains, despite its highly regulated primary agricultural markets.

Agricultural support in Norway is the highest among OECD countries, with 59% of farmers' revenues coming from support measures, as captured by the Producer Support Estimate (PSE). Policy reform has been modest. In the early 2000s, some payments were decoupled from commodity production. At the same time, market price support (MPS) was slightly reduced, but it continues to account for 44% of support to producers (PSE) and 40% of total support (TSE). Since then, there have also been small and controlled increases in imports through quotas. Unlike agriculture, the highly competitive fisheries and forestry sectors are not dependent on trade protection and government support, notwithstanding some government funding, particularly for the latter.

The Norwegian Agricultural Innovation System consists of a number of specialised institutes and universities, forming part of an economy-wide innovation system operating within the European Research Area. This system has most notably produced good results in animal breeding. Farmers' organisations and co-operatives participate in innovation in all parts of the food chain. The system is vertically organised, with the Ministry of Agriculture and Food earmarking the R&D priorities for the agro-food sector.

Agricultural policies are the result of a political consensus underpinned by an institutional dialogue that is undertaken across most sectors of the economy. Farmers' organisations take part in policy decision making and are responsible for the implementation of some elements of policy. In addition, farmers' co-operatives are in charge of enforcing market regulations. The implementation of policies is transparent, with public access to farm level information, including farm structure and payments. The annual negotiation

between farmers and government is focused on payments and selected prices and sustaining revenues. While this provides an element of trust and stability and reduces the decision-making costs, it is likely to constitute a barrier to bringing other emerging long-term objectives to the front of policy decisions and so can impede more fundamental reforms.

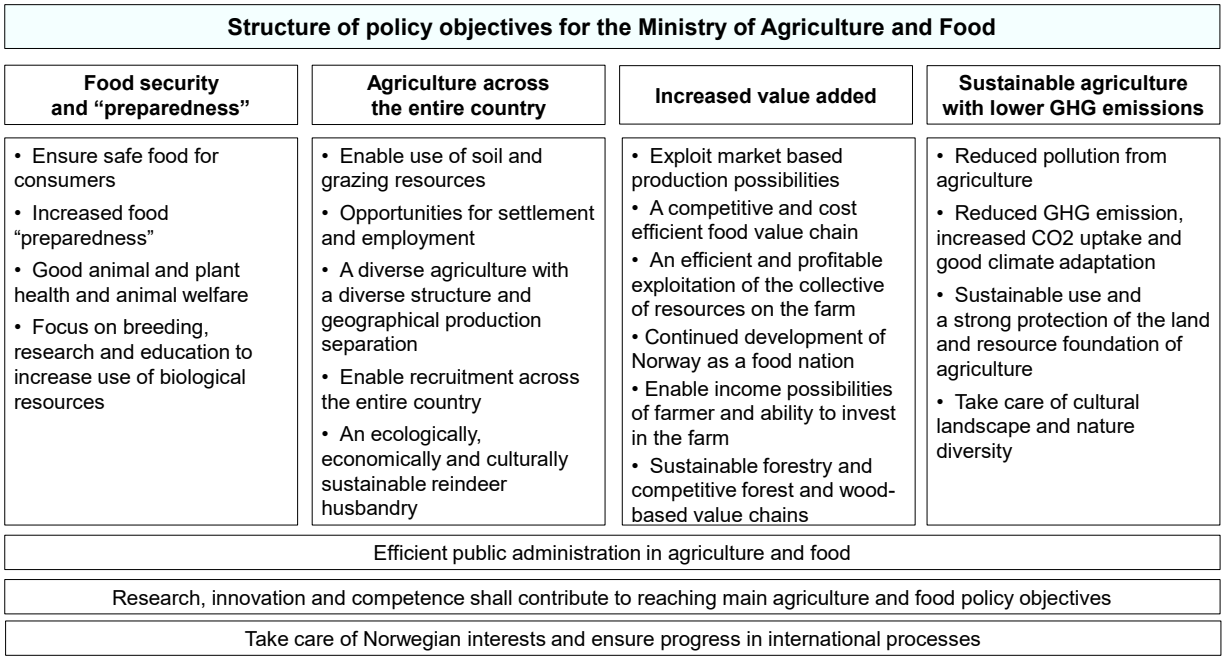
Norway has ambitious environmental objectives, which include a reduction in greenhouse gas (GHG) emissions of at least 50% by 2030 under the Paris Agreement and stringent environmental regulations. However, these ambitions are not reflected in agricultural policies that, for example, do not impose carbon taxes for emissions from soils and livestock, or subject agriculture to other climate policies, despite these being the origin of 8.5% of national emissions. Agricultural support is provided on the premise that it delivers public goods, such as landscape and biodiversity, and rural development, jointly produced with commodities, even though production increases emissions.

Balancing a broad set of objectives remains a challenge

The four policy objectives for agriculture in Norway are (i) food security and preparedness; (ii) maintaining agriculture across the entire country; (iii) increasing value added; and (iv) sustainable agriculture with lower GHG emissions (Ministry for Agriculture and Food, 2016[1]) (Figure 1).

Norway enjoys a high degree of food security, and agricultural production and associated landscapes are present in all regions. However, Norway is not performing well in its sustainability objectives, while productivity growth and the generation of value added in the food industry are hindered by market regulations in the primary sector (Productivity Commission, 2015[2]).

Figure 1. Four policy objectives for agricultural policies in Norway



Source: Agriculture Budget Committee (2019[3]).

There is, nonetheless, a question of whether the first two objectives are being attained in the most efficient and equitable manner. Policy tools have focused on providing support coupled to production, including market price support sustained by trade measures and market regulations. Previous OECD analysis shows that this type of policies is an inefficient and inequitable way of delivering support to farmers, which imposes an unnecessarily burden on consumers in low-income households, and on taxpayers. While food security (gauged in terms of availability) and maintenance of production capacity are assured, this comes at some social cost even in a high-income country like Norway with a relatively low average share of household expenditure dedicated to food. These policies are also sustained by trade barriers and contribute to distortions in international markets, creating negative spill-overs for producers in other countries, including developing countries. Moreover, the same policies, as discussed below, also weaken innovation and performance with respect to value creation and sustainability.

In sum, alternative policy approaches can do better in ensuring food security and the geographical presence of agricultural activity, without imposing the obligation to produce. The new approach would change current production patterns and, possibly, reduce the level of production of some commodities, but will create opportunities for innovation and reduce the negative effects on the objectives related to sustainability and generation of value added in the food sector.

While not all the objectives of Norwegian agricultural policies in Figure 1 are included specifically in the OECD Productivity-Sustainability-Resilience (P-S-R) framework and associated indicators (the goal of maintaining agricultural production throughout the country is specific to Norway), the fundamental goals of Norwegian policies are reflected in P-S-R outcomes. Indeed, productivity, sustainability and resilience are pre-requisites for the efficient and effective achievement of these fundamental goals and objectives. For instance, productivity growth is desirable because a more efficient use of resources responds the desire for enhanced food security and preparedness and to objectives under value added (such as farmer income and investment and competitive value chains). Equally, Norway's sustainability objectives can be assisted by productivity improvements that reduce input use. The OECD P-S-R framework and indicators not only enable analysis to hone in on important means to achieve objectives for the sector, and to track progress, but also to provide insights on the relationship between the attainment of different objectives. That is, some policies aimed at one objective can not only be relatively inefficient in achieving that objective, but can undermine progress on others, while appropriate policy packages can support the efficient attainment of objectives across these areas. This analysis is supported by the OECD's agri-environmental indicators, which can provide useful insights into progress on many of Norway's environmental sustainability objectives.

Productivity growth has not led to improved sustainability

Over the past two decades, the productivity of Norwegian agriculture, as captured by total factor productivity (TFP), has grown at an annual rate of 2.2%, compared with an OECD average of 1.4%. TFP growth was not mainly driven by innovation that reduced the amounts of land and purchased inputs needed to produce a given output, but by the movement of labour out of the sector and associated adoption of capital intensive and labour saving technologies. As a result, the high rate of TFP growth has not contributed to improved environmental performance. This trade-off between productivity and sustainability is particularly concerning because, according to existing agri-environmental indicators, Norway's current levels of nitrogen and phosphorous surpluses, which place pressure on soil, water, and air quality, are amongst the highest in the OECD. In some regions, agricultural production with high density of livestock is also reaching its limits in terms of negative environmental impacts. In terms of changes in environmental pressures over time, sustainable productivity growth has been weak when compared to other OECD countries (Chapter 6).

Current food security comes at an unnecessarily high cost

Food security is an objective shared by all countries. Norway's objectives define this in terms of ensuring a supply of safe food for consumers, good animal and plant health and animal welfare (see first column in Figure 1). However, the rate of domestic self-sufficiency is at best an incomplete indicator of food security (Productivity Commission, 2015[2]); for Norway, food security is ensured through three components: national production, trade and safeguarding production resources (Ministry for Agriculture and Food, 2016[1]). Agricultural border protection that reduces trade, along with coupled farm support measures, focus on increasing domestic production. This serves to maintain agricultural production and landscapes in areas where they would not otherwise be viable, but result in higher food prices and budgetary cost, with both equity and opportunity cost implications.

The resilience of the Norwegian food system with respect to systemic shocks and the core role of international food trade in contributing to food security has been highlighted by the results of the 2017 report on Risk and Vulnerability of Norwegian Food Supply (Directorate for Social Security and Preparedness (DSB), 2017[4]). These high levels of food security are the result of the functioning of the food value chain through trade, and of regulations in areas such as food safety and health. Norway is a net food importer and its food security objectives are to a great extent achieved through trade and value chains that are globally interlinked.

The current patterns of support and barriers to trade may not be necessary to ensure the food security objectives; other approaches may do so at lower cost. Safeguarding land resources does not necessarily require actual incentives to produce, but to keep land and soil in good condition and capable of producing. Payments can be targeted to this purpose. Moreover, other aspects of the food security objective in Figure 1, such as food safety, animal and plant health and animal welfare are achieved through effective regulatory provisions and specialised agencies. Furthermore, Norway can make an important contribution to global food security through its comparative advantage on research and innovation, including breeding. However, Norway's agricultural support measures are highly coupled to production, encourage current production decisions and provide a disincentive for innovation.

The agricultural landscape could be preserved with more cost effective tools

The objective of having agriculture across the entire country is specific to Norway. Agricultural land in Norway is, to a great extent, land that would otherwise be forest. The protection and support for agricultural land use reflects a desire to preserve this open landscape.

Legal protection of agricultural land use and agricultural policies – mainly location specific rates of price support and coupled payments – have been designed to maintain regional production. This policy set – sometimes called "production channelling" policies – has succeeded in preserving agricultural land and cultural landscape, keeping production in unfavourable areas. However, a tighter focus on the economic incentives determining whether or not to allocate land to agricultural production (the extensive margin) rather than on production incentives (the intensive margin) can be more efficient.

Policies can be targeted to the extensive margin of agricultural land to keep it in use as part of the landscape without requiring any specific production. This would maintain the capacity to use land, soil and grazing resources. It would also create incentives for activities that are economically and environmentally sustainable, while preserving the landscape and leaving farmers the freedom of choice and scope for entrepreneurship to foster innovation. If decoupled from production, these measures increase farm income because they create more revenue with lower input costs, and this additional income implies higher economic incentives to preserve land usable for agriculture and the landscape.

Current support policies reduce the competitiveness in food value chains

Increasing value added requires exploiting market opportunities in food value chains, enhancing competition and competitiveness for an efficient management of the food system, and reducing the high costs of primary agricultural inputs. Supported prices and regulated markets reduce the incentives to create value added, while transferring income to farmers less efficiently than decoupled forms of support. Agriculture TFP growth in Norway has been driven by reductions in the contribution of labour, which also suggests that high levels of coupled support have nonetheless not been able to overcome structural factors pulling labour out of the sector.

High primary agriculture prices also reduce incentives to innovate or make more efficient use of inputs, thwarting the competitiveness and capacity of value creation downstream. While the degree of concentration at retail level is similar to neighbouring EU countries, market concentration at the wholesale level in the dairy and meat sectors is high. There is also evidence of higher prices and lower diversity of food products in Norway than in neighbouring EU countries –and, while product diversity has improved, food price differences with neighbouring countries have increased. Agricultural policies and regulations could be better targeted to create incentives for innovation in the whole value chain – which could also bring benefits in terms of other objectives, by promoting a path of productivity growth that also promotes improved environmental outcomes.

Current policies make meeting environmental goals more challenging

The sustainability objective for agricultural policies in Norway has a strong focus on lowering GHG emissions (Figure 1), although agriculture is exempted from key policies seeking to achieve these ambitions, notably carbon taxes (except those on fossil fuels) and other emission mitigation schemes. Notwithstanding regional differences, the performance of Norway on emissions and pollution from nutrients is weak compared to other countries, including other Nordic countries and high livestock density countries like the Netherlands. Meeting international commitments related to GHGs, ammonia emissions and water protection is challenging. Displacing production to unfavourable areas may dilute pollution, but difficulties stem from the separation between livestock production and arable crops, which leads to reduced nutrient efficiency and higher ammonia emissions. Gains could be obtained from redesigning “production channelling” policies, decoupling them from specific production, and therefore reducing the incentives to produce, and targeting different regions with differentiated payment rates, while keeping open farmers’ options for different mixes of crop and livestock production.

Norwegian agricultural policies are underpinned by the premise that rural development and several public goods are positive externalities produced together with agricultural commodities, such as landscape, biodiversity and ecosystem services, and that implementation costs of alternative policies are quite large. The OECD work on “multifunctionality” has demonstrated that this view is valid only if the public good externalities cannot be separated from the production (they are “joint and non-separable outputs”) (OECD, 2003[5]; Hodge, 2008[6]).

At the extensive margin of production, if land is not used for agriculture in some Norwegian regions, there is a risk of abandonment, with resulting loss of habitat and cultural heritage. In such cases, continuation of extensive farming practices is an advantageous option both for production capacities and biodiversity preservation and landscape maintenance. However, at the intensive margin of production, as resources are over-used, production may lead to negative environmental outputs such as nutrient run-offs. In this case, agricultural policies coupled to production enter into conflict with environmental considerations. Moreover, even at the extensive margin in the use of land, there might be a conflict between agricultural policy objectives and some environmental objectives, for example with policies seeking to increase production raising GHG emissions. Environmental objectives most often require targeted measures, whereas coupled support contributes to exacerbate emissions intensity and other negative environmental outcomes. For instance, recent legislation restricting the cultivation of peatlands – one of the largest

sources of GHG emissions from agriculture in Norway – goes in the right direction and gains could be obtained from an ambitious application of this type of targeted measure.

Norway delivers high standards of animal health and welfare

While antimicrobial resistance (AMR) is not explicitly mentioned in the list of objectives in Figure 1, it is strongly linked to the objective of animal welfare (while also affecting human health and the environment). Moreover, the Norwegian Government has AMR as a top priority both on the national and international agenda. Norway has a strong performance on animal health, and has undertaken long-standing efforts to promote increased awareness about AMR. The prevalence of contagious animal diseases is low in Norway and use of antibiotics in animals is amongst the lowest in Europe. Norway has had a regularly updated cross-sectoral action plan against AMR since 2000 and a livestock industry action plan since 2017. OECD work shows that optimising the use of antibiotics on animal farms from the standpoint of animal health, and avoiding their use for purposes of growth promotion, has little or no adverse impact on the economic or technical performance of the farms (Ryan, 2019[7]).

The Agriculture Innovation System faces challenges in both ensuring effectiveness and addressing cross-sectoral issues

Despite good results in terms of scientific publications, the agricultural innovation system should increase the participation of the private sector. That said, tax incentives for innovation at the firm level (SkatteFUNN programme) are generous and user friendly, and reach SMEs and peripheral regions. Innovation policies in Norway are organised in line with sectoral responsibilities by the different ministries, including the Ministry for Agriculture and Food (LMD). This sectoral approach reduces the capacity of the innovation system to respond to long-term societal challenges such as climate change, with strong cross-sectoral priorities. Low cost effectiveness of public innovation policies are a concern for both the agriculture and the economy-wide innovation systems.

In sum, policy objectives need to be re-balanced while improving cost-efficiency

Norwegian agricultural policies navigate complex trade-offs between different objectives. There is evidence that Norway is meeting its objectives for food security and production across the country, but with policies that undermine delivery on the two other objectives of value creation and sustainability. Furthermore, the delivery of the first two objectives can be pursued effectively without market distorting measures in a more cost-efficient way.

How can Norway improve policy performance?

Norway can reform its policy package in order to achieve a better balance of outcomes across its agricultural policy objectives. The priority is to improve the delivery on environmental outcomes and the economic competitiveness of the sector, while enhancing the cost-efficiency of keeping agricultural land use and landscape across the country and maintaining high standards on food security, food safety and health. Undertaking such an ambitious policy re-orientation will require an evaluation of how to make the current agricultural policy-making process more focused on emerging long-term challenges. The new policy approach should be guided by four main long-term drivers: an increased responsiveness to markets; a new decoupled “production channelling” scheme; a strengthened focus on agri-environmental outcomes; and an upgrade of the agricultural innovation system. Finally, new risk management policies should enhance farmers’ resilience.

1. Allow a better balance among objectives through reform of the political economy process of negotiations between the farmers and the government

The consensus institutional framework of annual negotiations and agricultural agreements between farmers' associations and the government in Norway provides stability and a platform for regular evaluation and gradual adjustment. However, negotiations focus almost exclusively on annual farm incomes, thereby paying insufficient attention to other societal concerns and long-term objectives of government policy. Current emerging societal concerns such as climate change and nutrition face difficulties in finding their way into policy considerations.

- Undertake an assessment, including opportunities for public submissions, of whether the current format of annual negotiations between government and farmer representatives is well-suited to promoting reform and addressing emerging policy objectives.
- Explore alternative or supplementary mechanisms. For example, building on the experience of the recent voluntary agreement with farmers on climate change, negotiation of some aspects of policy, such as agri-environmental sustainability, could be part of multiyear framework agreements with a longer-term perspective and open to input from other stakeholders. Some aspects of the negotiation could also be opened to other fora, with the participation of other stakeholders such as consumers, the downstream industry and environmental players.
- Maintain the current approach of providing transparency over farm level payments and activities, and make further use of farm level information for policy design and monitoring of outcomes.

2. Promote food security, landscape and sustainability more cost effectively through reforms to support and increase responsiveness to market signals within a well-defined time horizon

The objectives of food security, agricultural landscape and environmental sustainability could be achieved more efficiently through targeted measures that relied more on innovation and competition. To this end, market price support, border protection and market controls should be gradually reduced. Providing a clear and agreed time horizon and direction for this gradual reform process will ensure transparency and policy predictability, and facilitate investment.

- Keep land in agricultural use by providing appropriate amounts of decoupled support to farmers that is more efficient in transferring income and creates incentives to keep land in agricultural use. These payments would be integrated in a new generation of payments.
- Improve consumers' access to a variety of affordable food by reducing border protection of most protected commodities such as meat, milk and cereals. Gradually reduce tariffs and make them converge to a predetermined level after a transition period, and expand imports through TRQs, converging to a given level of market access.
- In order to make primary agriculture more competitive and thus support more competitive value chains, gradually reduce market-restricting regulations. Liberate co-operatives from their market regulator role and transform target prices into indicative prices not binding for co-operatives, then gradually reduce them. Continue to allow co-operatives to organise farmers to better compete in the market with other players. As the processing industry will gain in competitiveness, subsidies to buy domestic agricultural products (processed food RAK products and price equalisation schemes) should be gradually phased out.
- Undertake an assessment of the application of competition policy with the aim of better defining the limits of the primary agriculture exception. Investigate the possibility to extend the application of competition policy upstream in the food system to the wholesale sector as part of this system.

- Strengthen the consumer information system building on existing initiatives like “Enjoy Norway”, investing in the brand of Norway’s food as quality food with specific attributes and farming practices such as animal husbandry with high animal welfare standards and low use of antibiotics. This system allows consumers to reveal their preferences and willingness to pay for these practices and public goods.

3. Increase the efficiency of landscape objectives by creating a new generation of decoupled “production channelling” policies

Efficiently achieving landscape objectives requires modernising policies designed to maintain land in agricultural use in all regions of Norway. If support is decoupled from production decisions, farmers will better leverage the location of their farm and its specific economic comparative advantage and environmental situation. A well-defined transition period will ensure smooth adjustment.

- Create a new scheme that includes a decoupled payment based on historical area and requiring that land be kept in agricultural use. Shift a portion of current coupled support based on animals, output and land, and the partial compensation for price reductions into the new scheme. The payment will create additional economic incentives to keep land in agriculture beyond the legal incentives from land use regulations, while ensuring farmers have incentives to innovate and improve the use of the land.
- The main objective of the new payment would be to provide cultural landscape and land ready to produce agricultural products, and to provide ongoing income support to farmers. The payment should be targeted to the extensive margin, applying differentiated payment rates for different land, adjusting to the reality of land characteristics in each region or location in order to cover the costs of keeping land in agriculture and avoid the move into forestry or abandonment. Payment rates are already differentiated by region in the current policies, but they are mostly coupled to specific production choices. The new payment should be decoupled from specific production decisions.
- Undertake a study to better define agricultural use in different areas and invest in strengthening the information behind the map of regions and areas that – because of their differentiated landscape value - may deserve different rates of payments. Develop measures of landscape quality or environmental risk based on scores that identify the most valuable or risky agricultural lands. Payments could then be tied to the score received by the land in a grading process.
- Update the implementation of land regulation polices to add more flexibility in land definitions and change of use while keeping the objective of total landscape areas. Many farms in Norway have also small forestry plots as part of their holdings and business model. Encouraging consolidation of plots can bring efficiency and gains for farmers. Provide flexibility in land regulations or in their implementation to encourage innovative new land uses that add value for both agriculture and forestry.
- Ensure that the new scheme and the land use legislation are applied in a way that does not interfere unduly with consolidation and rationalisation of agricultural production and the use of forest land.

4. Invest in a sustainable sector through risk management polices with a resilience approach

In 2018, Norway experienced the driest and warmest summer for the last seventy years and several ad hoc measures and increases in existing payment rates were implemented to help farmers. Extreme weather conditions are likely to increase with climate change and drought support measures should focus on encouraging preparedness and resilience through the extension services and voluntary risk management programmes, rather than on the provision of ex-post financial aid.

- Enhance the role of farmers in managing business risk by introducing voluntary risk-management programmes such as mutual funds, or a programme that allows farmers to place savings in a special account with incentives from the government such as tax exemptions. These savings could be withdrawn after an extreme event such as a drought, or for investing on on-farm resilience measures.

5. Strengthen achievement of sustainability objectives through a new agri-environmental strategy for agricultural policies in Norway

All agricultural policies should embrace a strengthened focus on agri-environmental outcomes, including the new "production channelling" scheme and other programmes. Norway could develop a strategy to fully internalise the environmental pressures from agriculture, in particular those from nitrogen and phosphorus surpluses and emissions. The additional public goods to be delivered by farmers that may not be delivered by the new scheme need also to be well defined in this strategy.

- Building on the current agreement with farmers' organisations, develop an ambitious strategy to significantly reduce GHG emissions from agriculture. Economic incentives should be provided by restructuring support under the new scheme and by ending the exemption of agriculture from the main emissions reduction policies such as cap-and-trade system or GHG emission taxes.
- Develop and adopt a definition of reference levels and environmental targets for agri-environmental policies. The reference level would be the minimum level of environmental quality that farmers are required to provide at their own expense, and environmental targets represent a higher desired level of environmental quality. To establish a solid and efficient framework of agri-environmental policies, Norway should clarify the reference environmental quality, as well as environmental targets which are well adapted to local ecological conditions.
- Develop an information system for monitoring and evaluating agri-environmental policies and outcomes, using all the information already available at farm level from farmers' files and from the Norwegian Institute of Bioeconomy Research (NIBIO) and other sources. Use digital technologies to connect different sources of information and link them to decision making.
- Apply the polluter-pays-principle more systematically with regulations that hold farmers accountable for all harmful environmental effects from crop and livestock pollution. The development of environmental plans at the farm level could make farming more environmentally accountable. These plans would need to be enforceable, with strengthened monitoring capacities using digital technologies. They need to respond to current and new regulations, including on a more balanced application of nitrogen fertiliser.
- Increase the share of payments conditional on adopting specific farming practices for environmental reasons beyond the current share of 15% of total support to producers. Such conditionality can be effective if adapted to the diversity of local farming practices and conditions, and included in the farm level environmental plans. Create incentives for improving farm practices and technology adoption for better manure management through strengthened general environmental regulation and increasing cross compliance with location specific conditionality. Examples – some of them already underway – could include promoting low emissions application techniques (such as injection or band spreading), reductions in ammonia emissions and nitrogen, and restriction on cultivation of peatlands. There is also scope for strengthening the efforts of advisory and extension services in specific areas; for instance, to increase the utilisation of livestock manure through improved nutrient management planning.
- Explore the possibility of developing agri-environmental programmes based on outcomes rather than practices. Notwithstanding the implementation difficulties, Norway should advocate performance-based agri-environmental policies that reflect the diversity of its agri-environment. Payments would remunerate farmers for the provision of environmental outputs that Norwegian

society wants. Provision could go beyond what is expected of farmers as reference levels, and payments could be made available based on more ambitious outcomes, after a transparent assessment in terms of costs and benefits, and within the overall budgetary constraints.

6. Add value and promote sustainability by upgrading the agricultural innovation system through greater private sector engagement and a cross sectoral focus

The Norwegian agricultural innovation system has well-developed institutions. Despite the small size of the sector, the R&D system in Norway produces a larger share of agri-food patents and publications than in other countries. However, agricultural innovation needs more dynamic engagement by the private sector, focusing research and adoption at firm and farm level on emerging areas of social interest. The current priority of development of the bio economy provides a good basis in which Norway can find potential areas of comparative advantage. Increasing innovation by the private sector in agri-food requires stronger incentives and signals from markets to identify opportunities to innovate. The reduction of price support and the introduction of decoupled payments will also strengthen the link between innovation and market returns.

- Building on recent developments, strengthen cross-sectoral innovation prioritisation and further strengthen the strategic role of the Research Council of Norway and Innovation Norway in the agricultural innovation system. Policies should invest in consolidating multidisciplinary and multi-sectoral research and innovation networks with increasing leadership from a more competitive industry. The Long-Term Plan for Research and Higher Education process should be more actively used for broader cross-thematic priority setting.
- Strengthen the independence and cross-sectoral collaboration of agricultural research institutes under LMD (NIBIO, VI and Ruralis). Keep high incentives for research excellence, maintain basic funding for the long term strategic plans and ensure their independence. These institutes should be encouraged to actively embrace research multidisciplinary co-operation with other actors in other sectors.
- Assess the performance of the FFL levy fund and JA innovation funds which are interesting initiatives to engage farmers and the private sector, and propose improvements in their governance. The assessment should explore the opportunity to broaden the focus of both funds towards long-term transformative innovation challenges and new opportunities for the industry. The current interlinks between the two funds could be enhanced, channelling the financial resources of both through a single merged fund for agricultural research. Alternative modalities for funding such as linking the amount of government funding to that from the industry could also be explored to a greater extent. A larger single fund combining and linking public and private resources is likely to enhance the strategic long-term approach and incentives to private innovation.
- Enhance current priorities for the bioeconomy and the interlinkages with other sectors and climate change to contribute to a circular economy. Link innovation with the new policy focus on agri-environmental performance. Encourage more co-ordination between forestry, agriculture and aquaculture on innovation in new products and processes like bioenergy.
- Build on the comparative advantage in specific scientific areas, in particular in animal breeding where there is research capacity, knowledge and well-positioned private enterprises. Identifying such areas could allow the agri-food sector and support policies to shift focus to producing and even exporting knowledge rather than focusing on producing specific commodities.
- Invest in digital technologies to develop an information system for the monitoring of the agri-environmental performance of farms and for the redesign of policies towards environmental sustainability priorities. Norway has considerable geo-localised data and information from different sources. The government should commit to the use of this information system in the implementation, design and evaluation of its agri-environmental programmes. The new information

system will respond to the emerging climate and environmental challenges and contribute to innovation in this area.

- Keep and strengthen international cooperation for agri-food research and innovation. This includes collaboration and partnerships for funding, project design and implementation, publications and adoption of innovation.
- Norway should pursue policies to improve the competitiveness of wood-based products relative to traditional concrete and steel. This could include changes to building codes to decarbonise construction, mandates for use in public buildings, and tax credits.

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1 Context and general policy environment driving the performance of the agro-food and forestry sector

Norway is a highly developed economy with high standards of governance and wellbeing. This chapter provides an overview of the diversity of economy-wide incentives to which the agro-food and forestry sector responds, and which interact with sectoral policies. Two key element are the wider structural aspects of the Norwegian economy and the structure of agro-food demand and trade. The sector dynamics are also crucially driven by natural resource constraints, and by the processes of structural adjustment and innovation. The following general policy areas have been identified as particularly relevant in determining the sector's policy environment and its potential for innovation: trade and investment, finance, entrepreneurship, taxation, labour and skills, infrastructure and ICT, and food safety and animal health. Many of the elements in this contextual and general policy overview are analysed in greater depth in other chapters.

Key messages

- Norway is a highly developed democracy with a strong role of the state in strategic areas of the economy. It is among the top performing countries on key indicators of economic, human and social capital.
- The crop and animal production sector plays a relatively minor and shrinking role in the economy, at only 0.6% of Gross Value Added (GVA) and 1.4% of employment, while forestry is responsible for just 0.2% of GVA. In contrast, the share of fisheries and aquaculture is growing. Most of agriculture production value (62%) comes from livestock products.
- As a member of the European Free Trade Association and the European Economic Area, Norway has low barriers to trade and investment in most sectors (including fish and forest products), except primary agriculture. Norway is a net importer of most agro-food products except for fish, but its cumulated trade balance, including fish, shows a net exporting position. Norway's main trading partner is by far the European Union.
- Only 3% of Norway's total land area is cultivated land, although extensive grazing covers above 40% of total land area and agricultural properties are present on around 77% of the territory. Policy, landscape and climate determine the distribution of production, which is highly differentiated among regions, with crops concentrated in the Eastern lowlands and livestock more spread across the rest of the country. Renting has facilitated the consolidation of agricultural land in recent years, but average farm area remains small and most farm-households have significant off-farm income.
- Climate change is expected to have, on average, positive effects on agriculture in Norway, but extreme events are likely to become more frequent, and forestry is likely to experience less favourable conditions due to pathogens and fire.
- Labour costs are high, but the Norwegian labour market is able to adapt through wage negotiations and the inflow of economic immigrants, which is particularly important in agriculture.
- Norway attaches great importance to food safety and animal health with strict standards in regulations. It has a long-standing history of high awareness of antimicrobial resistance (ARM) and a low use of antibiotics in animals.

Norway is a highly developed, democratic country with a strong role of the state in strategic areas of the economy. The sound management of natural resources, oil and gas, and favourable business dynamism combined with high quality institutions and economic and social policies promoting inclusiveness and equality ("Nordic model") ensures Norway a place among the wealthiest and most happy nations of the world, ranking 10th in terms of GDP per capita (PPP) and 5th in the happiness ranking (World Bank, 2020[1]; Helliwell et al., 2020[2]).

According to the OECD (2020[3]) "How's Life" report, Norway performs well on most of the dimensions of "current well-being", such as income and wealth, housing, work and job quality, health, subjective well-being, and work-life balance; not only on average but also in terms of equality across the population. In terms of resources and assets that underpin "future well-being", Norway is among the top performing countries on at least some indicators of economic, human and social capital. However, its performance is relatively low in terms of natural capital indicators, such as stocks of natural resources, land cover and species biodiversity, as well as ecosystems and their services.

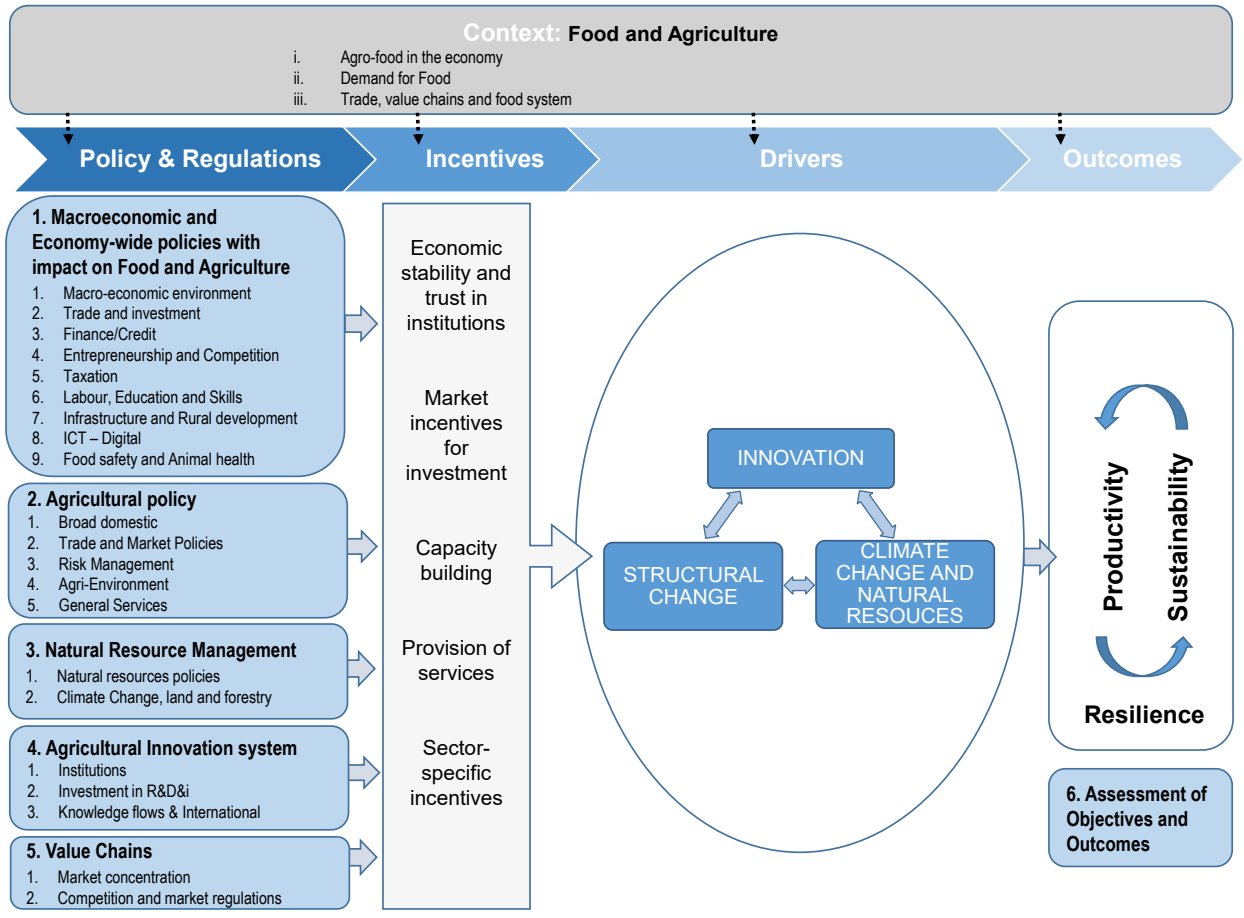
Agriculture and forestry constitute a relatively small part of the Norwegian economy in terms of both employment and value creation. Due to the northern climate and difficult topography, only a small share of land is suitable for farming. Most produced value comes from livestock products, such as milk and meat, and most agricultural products are destined for the domestic market.

The number of agricultural holdings has declined over the last half century and the farmland in use has been consolidated, mainly through renting. Income from agricultural production accounts on average for only 30% of farmers' revenues, the remaining coming from non-farming activities, including forestry. The production of grain, which requires the best growing conditions, is located in lowlands close to the main urban centres. Roughage-based livestock production is more profitable but relatively labour intensive, and located in areas with less favourable natural conditions and with less opportunity for off-farm employment (Knutsen, 2020[4]). Small farms dominate, but easy access to capital, tight labour supply, and innovation have led to some recent structural change.

The panoply of general policies that impacts the agro-food and forestry sector is wide. Based on the OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework (OECD, 2020[5]), some general policy areas have been identified as particularly relevant in determining the policy environment in which innovation takes place as a driver of the sector performance in Norway (Figure 1.1)[1]: trade and investment, finance, entrepreneurship, taxation, labour and skills, infrastructure and ICT, and food safety and animal health. These policies, together with sectoral and specific policies on agriculture, natural resources, innovation system and value chains, create the incentives under which the main drivers on innovation, structural adjustment, and climate change interact. As a result of this interaction, the sector produces outcomes that can be used to assess its performance (Chapter 6).

The OECD Agro-food Productivity-Sustainability-Resilience (PSR) Policy Framework (OECD, 2020[5]) is the benchmark used for this review, implementing an evidence-based approach built on indicators. This publication refers to Norway's agro-food and forestry sectors, except fish, unless otherwise stated. Following the framework, this chapter develops three important blocks of information in Figure 1.1, setting out the context of the agro-food and forestry sectors, the linkages between the main drivers of change, and the economy-wide policies that have an impact on the sector performance. The discussion focusses on: the agro-food and forestry sectoral context in terms of its share in the economy, food demand and trade (Section 1.1); some aspects of the three drivers identified in the PSR framework (Section 1.2): natural resources, structural adjustment and innovation; and the general policies defining environment in which agro-food and forestry sector operates (Section 1.3). This chapter provides the main elements of the context, drivers and economy-wide policies, but many aspects of this overview are analysed more in-depth in other chapters of the review.

Figure 1.1. Innovation as part of the OECD agro-food productivity-sustainability-resilience policy framework



Note: The six light blue boxes refer to the six chapters of this review. Chapter 1, besides economy-wide policies, also discusses the context of the agro-food and forestry sectors and three drivers of change.
Source: Adapted from Figure 1 in OECD (2020[5]).

1.1. Agro-food and forestry into context: Value added, employment, consumption, production and trade

The agriculture and forestry sector is a small and shrinking part of the Norwegian economy

Norway has one of the highest standards of living in the world, with GDP per capita of around USD 65 000 annually. This is partly due to the petroleum sector (covering both oil and natural gas), which experienced strong growth in the 1970s and 1980s, and between 2005 and 2013. Real GDP growth has recovered from the fall in global oil-prices in 2014 and remained robust until the COVID crisis in 2020. Norway has low unemployment rates and low inflation.

The broad agriculture, forestry and fishing sector represented 2.2% of total gross value added (GVA) in 2017, of which the greatest contribution is from fisheries and aquaculture (1.49% of total GVA). Forestry and logging is responsible for just 0.19% of GVA and this share is well below Canada (0.37%), Sweden (0.83%) and Finland (2.13%). Crop and animal production play a relatively minor role in the economy, at only 0.55% of GVA, compared with 0.77% in Sweden, 1.55% in France and 1.27% in the EU28.

The participation of the broad agricultural sector in the Norwegian workforce amounts to 2.1%, while the crop and animal production sector is responsible for 1.42%, equivalent to 37 000 people in 2016, similar to Iceland (1.41%), and between Sweden (1.10%) and France (2.29%). The ratio between the shares of GVA and employment (referred to hereafter as "implicit GVA per unit of labour"), is below the average of the whole economy, as is the case for most OECD countries. The contribution of the forestry sector to total employment in Norway is 0.16%, with an implicit GVA per unit of labour being above the average of the whole economy, even if not as high as for fisheries and aquaculture (Table 1.1).

Table 1.1. Crop and animal production play a minor role in the Norwegian economy

Shares of the sector in the economy (%), 2018[1]

	Agriculture land area[2]	Gross value added[3]					Employment[4]					Agro-food exports[5]	Agro-food imports[5]
		Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Fishing and aquaculture	Total: Manufacture of food and beverages	Total: Agriculture, forestry and fishing	Crop and animal production and hunting	Forestry and logging	Fishing and aquaculture	Total: Manufacture of food and beverages		
Norway	2.7	2.2	0.55	0.19	1.49	1.56	2.1	1.42	0.16	0.51	1.69	1.0	9.0
Canada	6.4	2.0	1.52	0.37	0.11	1.73	1.9	..	..	..	..	11.0	7.9
Denmark	65.8	1.2	0.91	0.11	0.16	1.77	2.2	1.94	0.17	0.08	2.03	16.5	12.3
Finland	7.5	2.8	0.65	2.13	0.06	1.32	..	2.82	0.82	..	1.51	2.4	7.5
France	52.4	1.7	1.55	0.15	0.04	2.14	2.5	2.29	0.11	0.06	2.47	12.6	9.0
Iceland	18.7	4.2	0.96	0.01	3.21	4.13	..	1.41	..	2.57	..	6.2	8.4
Japan	12.2	1.2	..	..	..	2.46	3.2	..	..	..	..	0.7	8.0
Korea	17.2	2.0	..	..	..	..	5.0	..	..	..	..	1.1	5.2
Sweden	7.4	1.6	0.77	0.83	0.03	1.11	1.7	1.10	0.60	0.03	0.89	3.6	7.6
Switzerland	38.3	0.7	0.62	0.05	0.01	1.95	..	2.81	0.14	..	1.63	3.2	4.5
United States	44.3	0.9	0.86	0.07	0.02	1.31	1.6	..	..	..	..	10.2	5.5
EU28[6]	42.9	1.5	1.27	0.18	0.05	2.12	4.0	3.70	0.23	0.07	2.19	6.8	5.6
OECD[7]	34.3	1.5	..	..	..	..	4.5	..	..	..	..	8.4	7.6

Notes: ..: not available.
1. or latest available year.
2. Share of total land area.
3. Share of total gross value added. For Norway, it refers to the country total.
4. Share of employed persons, aged 15 years and over, in total NACE activities.
5. Share of total exports (or imports). Agro-food definition does not include fish and fish products. Agro-food codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360.
6. For EU28, imports and exports include only extra-EU trade.
7. For OECD, imports and exports include both intra- and extra-OECD trade. OECD does not include Colombia.
Source: Authors' calculations based on OECD (2020[6]), System of National Accounts and Annual Labour Force Statistics (databases), http://stats.oecd.org/; UN (2020[7]), UN Comtrade database, https://comtrade.un.org/; Eurostat (2020[8]), [nama10_a10], [lfsa_egan2], http://ec.europa.eu/eurostat/data; FAO (2019[9]), FAOSTAT, Land use (database), http://www.fao.org/faostat/en/ .

The share of the crop and animal production sector in total GVA shrank between the 1970s and 2000s from 3.5% to less than 1% as the rest of the economy grew at a faster pace. Since 2000, crop and animal production have kept pace with the larger economy, growing by one-third in real terms. The decline in the agriculture share in total employment is one of the steepest among OECD and European countries, implying a structural adjustment dominated by high labour productivity growth (Chapter 6). Over the last two decades, the share of forestry in value added has remained stable, while it has more than doubled in fishing and aquaculture as salmon production has grown very rapidly.

The majority of Norwegian agricultural production is from livestock products

Animal production contributed to 62% of the total value of Norwegian agricultural production in 2019. Milk with a share of 25%, shrinking from 31% in 2000, and beef (13%) are the main commodities. Forage plants and cereals, mainly used for animal feed, make up the majority of crop production and about a quarter of total output. The share of fresh vegetables grew from 3% in 2000 to 7% in 2019, following increasing domestic demand (Section 1.1.2). The contribution of oilseeds and protein crops remains low (below 0.2%). Most production is consumed domestically (agro-food exports account for only 1% of all exports). Imports fill remaining production gaps and Norway is a net importer of the agro-food products (agro-food imports represent 9% of total imports, Table 1.1).

The forestry sector is an important part of the rural economy

The forest and forest product sectors employed nearly 21 500 people in 2017 in Norway (Table 1.2). The sales value of the forest-based industries was NOK 43.5 billion (USD 5.3 billion) in 2017, while the export value of round wood and forest industry products was NOK 12.9 billion (USD 1.6 billion). The major actors in the Norwegian forest-based industries are sawmills, pulp and paper producers, and a single advanced bio-refinery.

Table 1.2. The forest sector is a major driver of economic activity in rural areas

Key statistics of the Norwegian forestry sector, 2017

	Unit	Value
Sales of timber for industrial purposes	Million m^3	10.5
Gross value of timber for industrial purposes	Million	3 714
Employment		
Forestry and related services	People	5 682
Timber and wood products industry	People	13 008
Paper and stationery industry	People	2 732
Total forestry and wood-based industry	*People*	*21 422*
Turnover		
Timber and wood products industry	Million	32 274
Paper and stationery industry	Million	10 846
Total wood-based industry (without furniture)	*Million*	*43 120*
Production value		
Timber and wood products industry	Million	29 312
Paper and stationery industry	Million	14 590
Total wood-based industry (without furniture)	*Million*	*43 920*

Notes: Production value means turnover adjusted for changes in inventory of finished goods, work in progress and goods and services purchased for resale. Purchases of goods and services for resale have been deducted, while capitalised own investment work has been added.
Source: Statistics Norway (2020[10]), provided data.

Food and beverages processing is a large contributor to Norway's relatively small manufacturing sector

The manufacturing of food and beverages is the largest and one of the fastest growing Norwegian mainland manufacturing industries in the last decade. It generated NOK 46 billion (USD 5.6 billion) of value added and employed approximately 45 000 people in 2017. Contributions of this sector to the total GVA and employment, 1.56% and 1.69% respectively, are however relatively low (Table 1.1).

Around 2 500 enterprises operated in the food and beverages sector in Norway in 2017, which is 25% more than ten years earlier. Food and beverage companies with more than 250 employees constitute only

1% of all firms, but produce 46% of the sector's turnover. The average turnover per food and beverage enterprise in Norway, EUR 10 million (USD 11 million), is more than twice as high as in the European Union (Table 1.3).

Table 1.3. A small fraction of food and beverages enterprises produces almost half of the total sector's turnover in Norway

Structure of the food and beverages industry

		Number of persons employed					
		Total	0-9	10-19	20-49	50-249	>= 250
Norway, 2017	Enterprises, %	100	69.9	12.2	11.7	5.2	1.1
	Turnover, %	100	2.8	4.5	12.5	33.8	46.4
	Turnover per enterprise, EUR million	10.2	0.4	3.8	10.9	66.7	434.3
Norway, 2008	Enterprises, %	100	67.0	14.5	11.1	6.0	1.4
	Turnover, %	100	6.3	6.2	14.3	29.1	55.1
	Turnover per enterprise, EUR million	8.4	0.8	3.6	10.9	40.8	341.2
EU28, 2017	Enterprises, %	100	79.8	9.7	5.9	3.8	0.9
	Turnover, %	100	0.7	4.3	8.5	24.6	57.3
	Turnover per enterprise, EUR million	4.1	0.0	1.8	6.0	26.9	263.4

Source: Eurostat (2020[8]), Structural Business Statistics (database) [sbs_sc_sca_r2], http://ec.europa.eu/eurostat/data/database.

1.1.2. Norwegians' food demand and diet are slowly moving towards healthier food choices

Given its orientation towards the domestic market, domestic demand for food shapes the potential for Norwegian agriculture. This can be affected by demographic trends, price trends of domestic and competing imported commodities, trade policies and agreements, the appearance of new products on the market as well as evolving food trends and consumer expectations (see Section 1.3 on the general policy environment, and Chapters 2 and 5). However, the potential for agricultural production is limited by Norway's natural conditions (Section 1.2.1).

The Norwegian diet has changed over the last two decades. Following EU and OECD trends, the daily caloric intake has increased by roughly 3%, reaching an average of 3 488 kcal per person per day in 2018, a comparable level to the OECD and EU (3 471 kcal each) (OECD, 2020[11]). Cereals constitute the base of the Norwegian diet and provided 29% of the daily energy intake in 2018 (Figure 1.2). Its consumption grew up to the mid-2000s, but has slightly decreased in recent years.

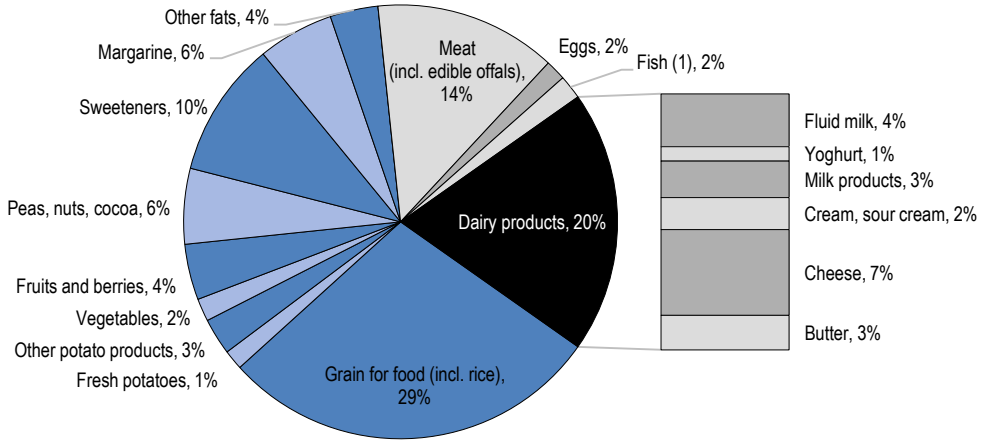
Dairy products are the second most important food group for Norwegians. Its percentage in daily energy intake has remained relatively stable over time, at around 20%, thanks to an increasing demand for cheese compensating for the negative trend in liquid milk consumption per capita (Knutsen, 2020[4]). There has also been a shift towards milk products with lower fat content (Norwegian Directorate of Health, 2019[12]), strongly encouraged by the Dietary Guidelines of the Norwegian Directorate of Health (Norwegian Ministries, 2017[13]).

Meat production and consumption has gradually increased over the last two decades, only to note a minor decline in 2018. This growth was mostly driven by an increase in poultry meat, of which the annual consumption per capita reached a level comparable to beef in 2018 (around 19 kg), but still below pork (around 26 kg) (Knutsen, 2020[4]). The share of meat in daily caloric intake is comparable both to EU and OECD levels (OECD, 2020[11]). Conversely, despite the recommendations of the Norwegian Directorate of Health, less than 40% of the population eats the advised amount of fish (Norwegian Ministries, 2017[13]).

This has not improved over the last two decades, however it still exceeds EU and OECD levels (OECD, 2020[11]).

Figure 1.2. Cereals and dairy products constitute the base of the Norwegian diet

Composition of food consumption, 2018



Notes: Food consumption in terms of energy content, at the wholesale level (estimates).
1. Based on uncertain data.
Source: Statistics Norway (2020[10]), provided data.

The consumption of sugar decreased from 43 kg to 24 kg per capita per year between 2000 and 2018, although one in five adults continues to consume more sugar than recommended (Norwegian Directorate of Health, 2019[12]; Norwegian Ministries, 2017[13]). The consumption of vegetables increased from 59 kg to 76 kg per capita per year, and that of fruits and berries from 69 kg to 89 kg in the period 2000-17 (Statistics Norway, 2019[14]).

The Norwegian government encourages efforts towards a healthy and varied diet for the entire population. The Minister of Health and Care Services has reached out to the major actors in the food industry and plans to work with them to reduce added sugar, saturated fat and salt content in food, as well as promoting an increased consumption of fruits, berries, vegetables, whole grain food, and fish (Norwegian Ministries, 2017[13]).

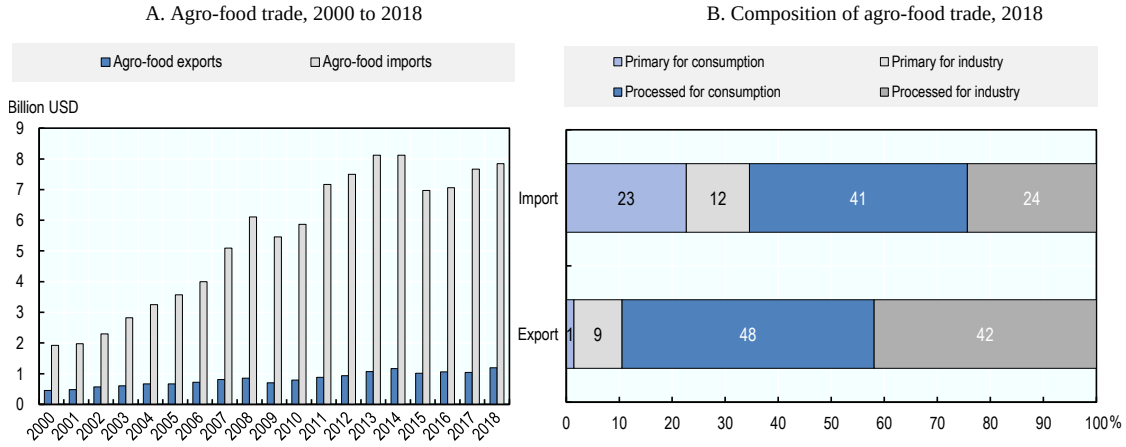
1.1.3. Trade: Norway is an agriculture and food net importer, except for fish

Agricultural commodities are produced mainly for the domestic market

Norway is an open economy for all products with the exception of agriculture (Section 1.3.2); trade represents 35% of GDP and there was a positive merchandise trade balance of NOK 285 billion (USD 35 billion) in 2018 (World Trade Organization, 2020[15]). Fuel and mining products represent 62.4% of its exports. However, with respect to agro-food products (excluding fish), Norway is a net importer. Since 2000, imports of agriculture and food products have been increasing more rapidly than exports (with average annual growth of 8% and 5%, respectively), amounting to NOK 63.5 billion (USD 7.8 billion) and NOK 9.8 billion (USD 1.2 billion) in 2018 (Figure 1.3, Panel A). Agro-food products represent 1.0% of total Norwegian exports (10.7% if fish products are included) and 9.0% of imports (Table 1.1 and Table 1.4). Both Norwegian imports and exports of agro-food products are dominated by processed goods, accounting for 65% and 89% of total imports and exports respectively. Norwegian households' final consumption absorbs 64% of agriculture and food imports, of which two-thirds are processed goods. Forty-nine per cent

of Norwegian agro-food exports are intended for direct consumption and almost all are processed (Figure 1.3, Panel B.).

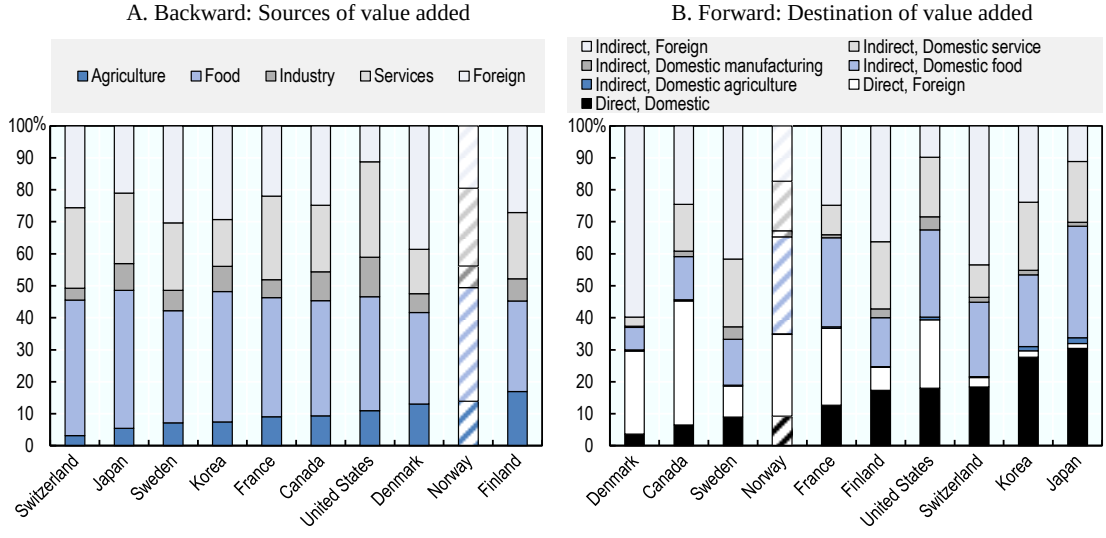
Figure 1.3. Norway is increasingly a net-importer of agro-food products (excluding fish) and its trade is dominated by processed goods



Notes: The definition of agro-food trade does not include fish and fish products. Agro-food codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360. Numbers may not add up to 100 due to rounding.
Source: UN (2020[7]), UN Comtrade (database), http://comtrade.un.org/ (accessed January 2020).

Figure 1.4. The Norwegian agricultural sector is integrated into longer value chains

Linkages of the agricultural sector with the value chain, 2014



Source: Adapted from Greenville, Kawasaki and Jouanjean (2019[16]).

The Norwegian agricultural sector is integrated into longer and global value chains. Twenty-four per cent of the value of agricultural production comes from the service sector (compared with 21% in Sweden), and 20% are inputs that originate from abroad (compared with 30% in Sweden, see Figure 1.4). The final destination of agricultural value added is mostly other sectors that transform it in combination with other sources of value. Direct domestic consumption concerns only 9% of the value, compared to 30% in Japan,

and most of the value added that goes into exports is directly consumed rather than transformed abroad, implying there is a large food processing industry in Norway.

Large trade surplus of fish and fish products exceeds net imports of all other food products combined

Norway is a net importer of agro-food products. However, including fish and fish products, the cumulated trade balance of agriculture and food products is positive. In 2018, fish was the only food group with a trade surplus, with exports reaching NOK 95.2 billion (USD 11.7 billion) compared to NOK 3.3 billion (USD 0.4 billion) of imports, and a positive balance that almost doubles the negative balance of the rest of agro-food products. Fish, and in particular Atlantic salmon, is by far the most exported Norwegian agro-food product (90% of all agro-food exports).

Norway's imports of animal or vegetable fats and oils, residues from food industries (including animal feed preparations), beverages and fruits each account for around 10% of the total agricultural and food import value. Exports of fruits and vegetables are almost zero, contributing to Norway's negative trade balance with NOK 10.6 billion (USD 1.3 billion) of imports. Norway is a net importer of dairy, cereals and meat, with these product groups representing only 3% of the value of agro-food trade (including fish; Table 1.4).

The European Union is Norway's main trading partner. In 2018, it was the source of 66% of Norwegian agro-food imports, and the export destination for 65% of Norwegian agro-food products. Within the European Union, the closest neighbouring countries – Sweden and Denmark – are key partners, together accounting for one-third of Norwegian agro-food exports. The main agro-food exports to these countries are: products resulting from the extraction of soya-bean oil to Sweden; and raw mink fur-skins and crude soya-bean oil to Denmark. However, Norway's imports from the European Union are more evenly distributed across member countries, with Sweden (e.g. tobacco products and its substitutes), Denmark (e.g. animal feed, refined sugar), the Netherlands (e.g. live plants, animal feed), Germany (e.g. bakers wares, wheat), France (e.g. wine, wheat gluten), Spain (e.g. mandarins and oranges, wine), Italy (e.g. wine, apples) and the United Kingdom (e.g. animal feed, wheat gluten) being the origin of between 4% and 9% each. Outside the European Union, Brazil (7%, with food preparations and soya beans being the main agro-food imports) and the Russian Federation (4%, with crude canola, rape, colza or mustard oil) are the main origins of Norwegian agriculture and food imports, while the United States is the first destination for exports (10%, with cheese products and residues from starch manufacture) (Figure 1.5).

Table 1.4. Norway's positive trade balance for fish outweighs its negative trade balance for all other agro-food products

Agro-food imports and exports, 2018

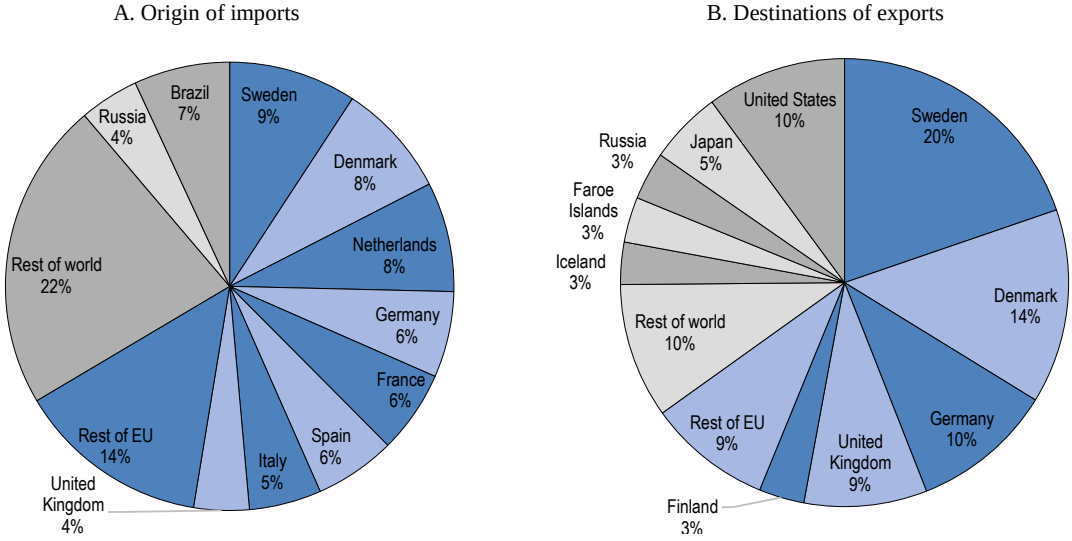
		Export	Share in agro-food[1] exports	Import	Share in agro-food[1] imports	Balance	Total trade (X+M)
	Commodities groups	million USD	%	million USD	%	million USD	million USD
03	Fish	11 674.1	89.3	438.4	5.0	11 235.7	12 112.5
23	Residues and wastes from food industry	400.0	3.1	919.0	10.4	- 519.0	1 319.0
15	Animal or vegetable fats and oils	225.4	1.7	936.2	10.6	- 710.8	1 161.6
22	Beverages, spirits and vinegars	122.7	0.9	864.2	9.8	- 741.5	986.9
21	Miscellaneous edible preparations	199.9	1.5	743.8	8.4	- 543.9	943.7
08	Fruit	6.6	0.1	801.3	9.1	- 794.7	807.9
19	Preparations of cereals, flour, starch or milk	50.3	0.4	586.9	6.7	- 536.6	637.2
07	Vegetables	2.1	0.0	450.3	5.1	- 448.1	452.4

24	Tobacco and manufactured tobacco substitutes	1.5	0.0	414.9	4.7	- 413.5	416.4
11	Products of milling industry	9.0	0.1	337.3	3.8	- 328.3	346.3
12	Oil seeds	7.8	0.1	307.7	3.5	- 299.9	315.5
20	Preparations of vegetables and fruits	14.5	0.1	282.5	3.2	- 268.0	297.0
18	Cocoa and cocoa preparations	48.2	0.4	217.5	2.5	- 169.3	265.8
06	Live trees and plants	4.1	0.0	260.4	3.0	- 256.3	264.5
16	Preparations of meat and fish	59.8	0.5	203.0	2.3	- 143.2	262.7
04	Dairy products, eggs, honey	89.5	0.7	157.5	1.8	- 68.0	247.0
09	Coffee and tea	3.8	0.0	212.6	2.4	- 208.8	216.4
10	Cereals	1.0	0.0	200.0	2.3	- 199.0	201.0
17	Sugars and sugar confectionery	6.0	0.0	175.7	2.0	- 169.6	181.7
02	Meat	28.7	0.2	132.2	1.5	- 103.6	160.9
05	Other animal products	47.6	0.4	71.2	0.8	- 23.6	118.8
01	Live animals	9.1	0.1	24.7	0.3	- 15.6	33.9
13	Lac, gums, resins	0.1	0.0	17.2	0.2	- 17.2	17.3
14	Vegetable plaiting materials, other vegetable products	0.0	0.0	3.3	0.0	- 3.3	3.3
	Agro-food (including fish and fish products)[1]	13 075.6	100.0	8 823.3	100.0	4 252.3	21 898.8
	Agro-food (excluding fish and fish products)[2]	1 192.6	9.1	7 840.8	88.9	-6 648.1	9 033.4
	All commodities total	122 636.3		87 440.1		35 196.3	210 076.4

Notes: Commodities are ranked based on their total trade values (sum of exports and imports).
1. Agro-food trade (including fish and fish products) codes in H0: 01 to 24, 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360.
2. Agro-food trade (excluding fish and fish products) codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360.
Source: Authors' calculations based on UN (2020[7]), UN Comtrade (database), http://comtrade.un.org/ [accessed January 2020].

Figure 1.5. European Union is Norway's main trade partner for agro-food commodities

Norway's main trade partners for agricultural and food products (excluding fish), 2018



Notes: The definition of agro-food trade does not include fish and fish products. Agro-food codes in H0: 01, 02, 04 to 24 (excluding 1504, 1603, 1604 and 1605), 3301, 3501 to 3505, 4101 to 4103, 4301, 5001 to 5003, 5101 to 5103, 5201 to 5203, 5301, 5302, 290543/44, 380910, 382360. Numbers may not add up to 100 due to rounding.
Source: UN (2020[7]), UN Comtrade (database), http://comtrade.un.org/ (accessed January 2020).

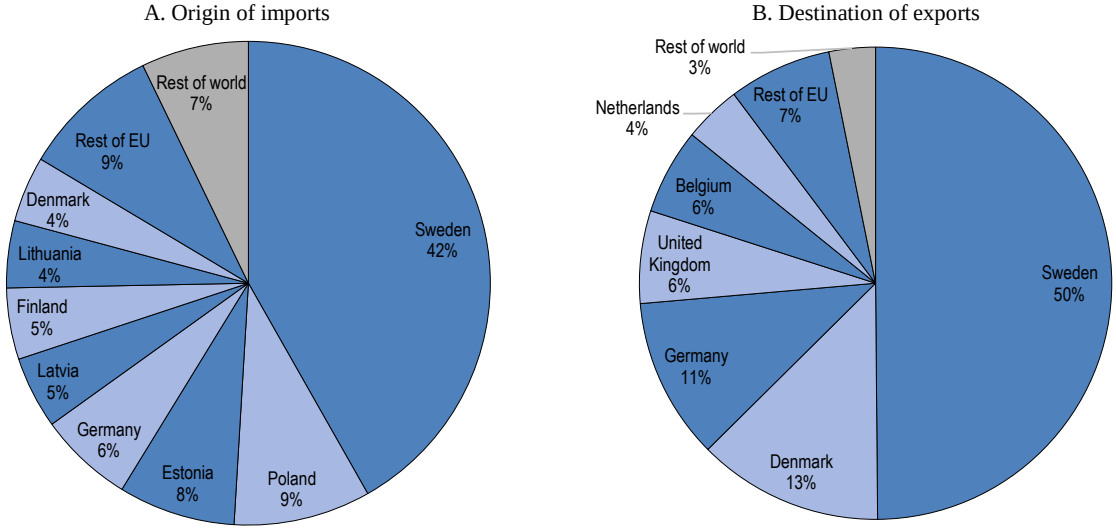
There are low trade barriers for both imports and exports of forest products

There is free trade of both timber and other raw materials from the forests, as well as products and services form the forest industries. Norway is a net exporter of wood pulp and other fibrous cellulosic material that are then processed abroad. It imports paper, wood and wood articles, and furniture. After the collapse of the Norwegian pulp and paper industry, domestic demand decreased and more wood is now exported.

Trade in forest products is highly developed with large shares of all products being exported. Norway's trade in forest and wood primary and secondary products is mostly bilateral with Sweden, which is able to absorb the excess Norwegian round wood production (Figure 1.6). The value chain is integrated across borders, with most exports of round wood products subject to additional processing in the destination country. Pulp and paper make up 60% of exports (Norwegian Ministry of Agriculture and Food, 2020[17]).

Figure 1.6. Sweden is the most important trading partner, but forest products are exported across Europe

Norway's main trade partners for wood and wood products, 2018



Notes: Sweden imports mainly raw logs for processing into pulp and paper and sawn products. Numbers may not add up to 100 due to rounding.
Source: OECD (2020[6]), International Trade by Commodity Statistics (ITCS), Harmonised System 2017 (database), http://stats.oecd.org/ (accessed April 2020).

1.2. Drivers of the agro-food and forestry sector's performance

The performance of the agro-food and forestry sector is driven by the dynamic interaction between three sets of constraints and dynamic forces. Following the OECD Productivity-Sustainability-Resilience Policy Framework (OECD, 2020[5]) this section discusses three drivers: natural resources and climate change (also analysed in Chapters 3 and 6); structural adjustment (also discussed in Chapters 3, 5 and 6); and innovation (also discussed in Chapter 4). This section provides a general introduction into the main structural and contextual aspects, while the specific chapters focus on a more in-depth analysis.

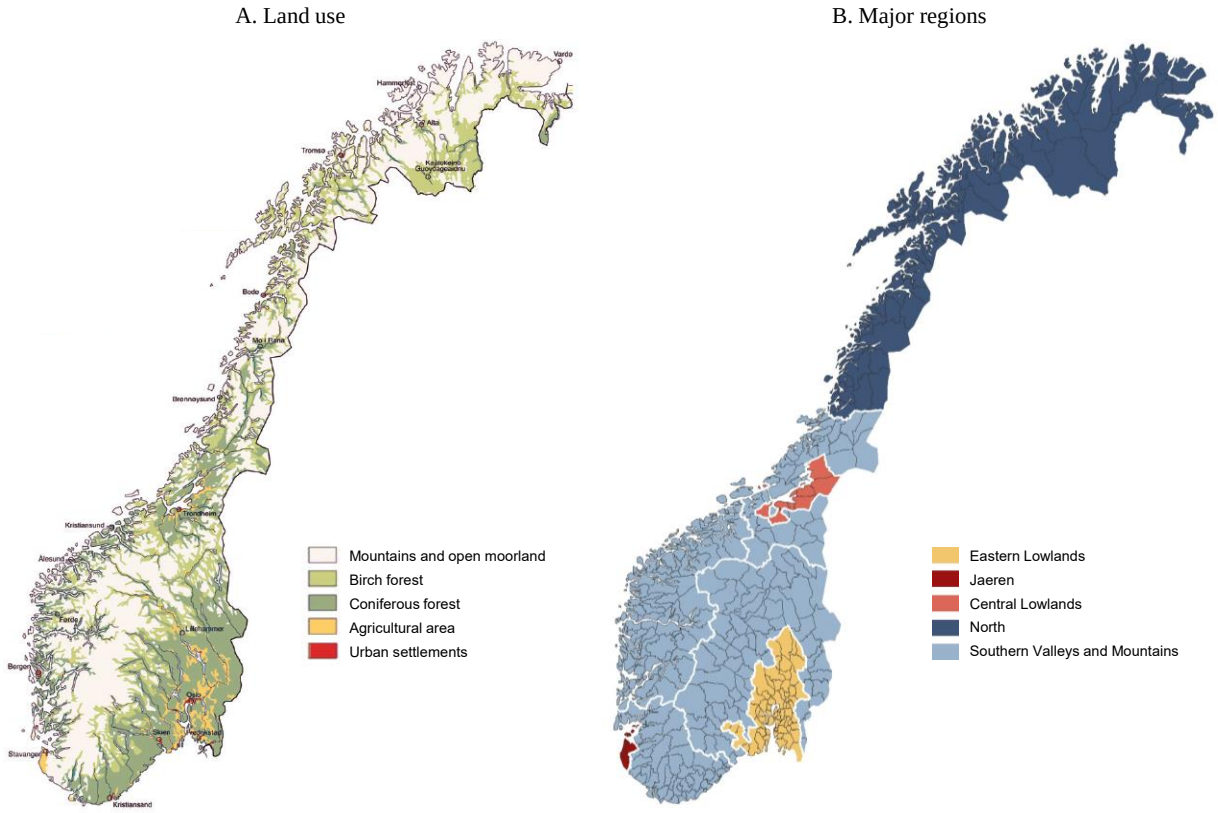
1.2.1. Natural resources and climate change

Climate and geography severely limit the types of crops that can be grown and their yields

Norway is a North European country located on the northern and western parts of the Scandinavian peninsula. It is one of the world's northernmost countries, with the mainland reaching beyond the Arctic Circle. Its long and narrow territory is surrounded by waters: the Barents Sea to the north, the North Atlantic Ocean to the west, the North Sea to the southwest, and the Skagerrak strait to the south. To the east, Norway shares land borders with Sweden, Finland, and the Russian Federation.

A mountain range divides the country into an oceanic western and a continental eastern part (Figure 1.7, Panel A). The climate varies from temperate along the south coast to subarctic in the mountains and in the north. Most of the production is located in the eastern and central lowlands, although the warm Gulf Stream makes agriculture also possible further north. Dairying is localised along the coast for a considerable distance to the north.

Figure 1.7. Maps of land use and major regions in Norway



Notes: Panel B presents five major regions defined based on common agricultural characteristics.
Source: Panel A: Adapted from Statistics Norway (2018[18]); Panel B: Provided by NIBIO (2020[19]).

Due to the climate, certain varieties of plants cannot be grown in Norway, e.g. sugar crops. What is more, Norwegian grain yields per hectare are among the lowest in Europe (Knutsen, 2020[4]). Norwegian yields for barley (3 861 kg/ha) and wheat (4 010 kg/ha) are respectively 17% and 25% lower than the European Union average in 2016-18. Over a longer time span such as the last half-century, there has been a positive

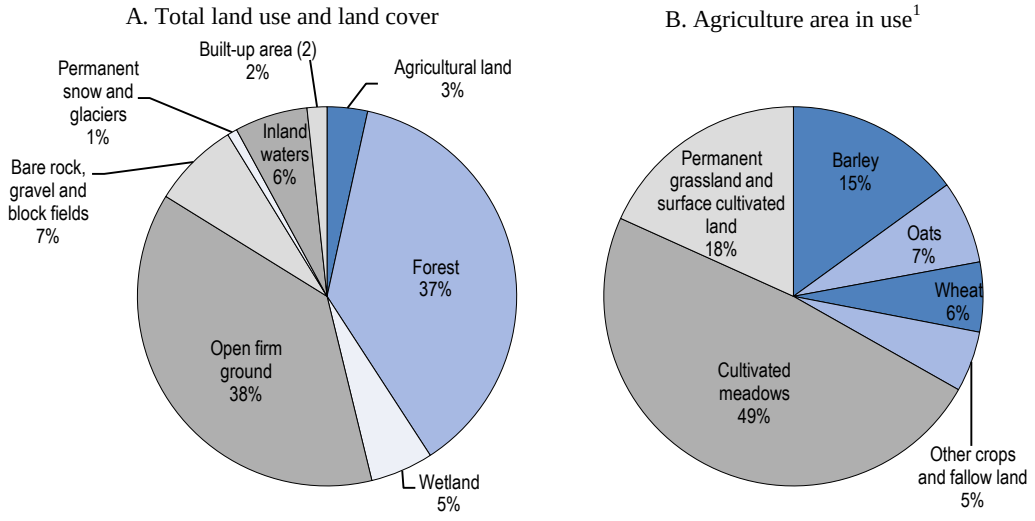
trend in yields for grains (FAO, 2020[20]). There are, however, significant annual variations affecting farms growing cereals in monoculture in particular.

The geography of Norway has an important influence on land use and agricultural activities

The total area of Norway is 324 000 km^2 and is largely dominated by mountains, which stretch along the entire country from the northeast to the southwest. Forest is the natural vegetation of the lowest elevation levels, occupying 37% of the country area. Above the tree line, dwarf trees turn into tundra formed among others by grasslands. The highest levels of mountains consist of bare rocks, as well as permanent snow and glaciers (respectively 7% and 1% of the total area). Mountain valleys are rich in wetlands, including peatlands, and ribbon lakes. The area suitable for farming is scarce, with agricultural land accounting for only 3% of the country's surface, 88% of which is in use (Figure 1.7, Panel A and Figure 1.8, Panel A). This share is one of the smallest in the world and well below the OECD average of 34% (Table 1.1).

Figure 1.8. Agricultural land is scarce in Norway and only a small share is suitable for cereal growing

Land use by area classification, 2018



Notes: Numbers may not add up to 100 due to rounding.
1. Agricultural area in use accounted for 88% of the agricultural land in 2018.
2. Built-up area includes unclassified undeveloped areas that account for less than 0.01% of the total.
Source: Statistics Norway (2020[21]), Land use and land cover and Holdings, agricultural area and livestock (databases) [tables: 09594 and 11506], https://www.ssb.no/en/statbank/ (accessed February 2020).

Over the last 60 years, total agricultural area in use has been stable, oscillating between 0.90 million hectares (its lowest level in 1976) and 1.05 million hectares (its highest level in 2001) and amounted to 0.99 million hectares in 2018 (Statistics Norway, 2020[10]). The decline over the last two decades can be mainly attributed to the expansion of transport infrastructure and the housing sector, as well as to the abandonment of land that is too difficult to cultivate (Statistics Norway, 2018[18]).

The Norwegian landform and climate conditions combined with national support policies determine allocation of agricultural activities across the country. The agricultural areas with the best growing conditions are dedicated to grain cultivation, while those with less favourable ones are used for animal husbandry. In 2018, roughly one-third of the agricultural area in use was used to grow crops (327 000 ha,

including 500 ha of fallow land) and this share has declined by 5 percentage points over the last 20 years (Statistics Norway, 2020[21]). The remaining agricultural area in use was attributed to pastures, meadows and other permanent grasslands typically used for grazing-pastures or harvesting of grass (Figure 1.8, Panel B).

Forest and other wooded land cover approximately 43% of Norway's land area. About 58% of this is considered productive forest, capable of producing 1 m^3 or more of wood per acre each year. The most important commercial wood species are Norway spruce (47%), Scots pine (33%) and birch (18%) (Norwegian Ministry of Agriculture and Food, 2020[17]).

Agricultural activities vary significantly among regions responding to natural conditions

Based on their common geographic characteristics, five major regions can be distinguished in Norway (Figure 1.7, Panel B and Table 1.5). The first, Eastern Lowlands, is located around Oslo in the southeast of the country and benefits from favourable soil and weather conditions allowing for cereal, potatoes and field vegetable production. It contributes to 68% of the agricultural area used for growing cereals in the country and roughly one-third of the national production value of poultry and pork.

Table 1.5. Agricultural activities vary significantly among regions in Norway

Agricultural production in major regions, 2017

	Norway	Eastern Lowlands	Jaeren	Central Lowlands	Southern Valleys and Mountains	North
Number of animals (thousand)						
Dairy cows	220	11%	12%	8%	59%	10%
Suckler cows	93	27%	6%	9%	51%	7%
Area in use (thousand hectare)						
Fodder	652.5	12%	7%	6%	61%	13%
Cereals	284.8	68%	1%	13%	19%	0.1%
Yields						
Milk delivery (litre per dairy cow)	6 588	1.02	1.07	0.93	1.01	0.90
Beef production (kg per cow)	260	1.01	0.99	1.11	0.98	1.03
Cereals production (kg per ha)	4 587	1.04	0.98	0.89	0.94	0.65
Production, volume						
Milk (million litre)	1 449	11%	13%	7%	59%	9%
Beef (thousand tonne)	81	16%	10%	9%	55%	10%
Cereals (thousand tonne)	1 306	70%	1%	11%	17%	0.1%
Production, value (million KR)						
Milk	7 321	11%	13%	7%	59%	9%
Beef	4 045	16%	10%	9%	55%	10%
Sheep	1 159	9%	7%	3%	69%	11%
Pork	2 920	35%	19%	12%	31%	4%
Poultry	1 847	33%	23%	19%	25%	0.0%
Cereals	3 382	71%	1%	11%	17%	0.1%
Other crops	4 958	50%	25%	5%	18%	2%
Total	25 632	31%	14%	9%	40%	5%

Notes: For regions, numbers refer to shares in country total and ratios of region yields to national yields.
Source: Authors' calculation based on data provided by NIBO (2020[22]).

Jæren is the second and smallest region in terms of agricultural area. It is located at the southwestern edge of the Scandinavian peninsula and enjoys favourable natural conditions. Agricultural activity focuses mainly on intensive livestock production. It covers 7% of the country's fodder area and concentrates 10% of Norwegian cows, mainly dairy, and achieves the highest milk deliveries per dairy cow (7 065 litres). The

area dedicated to cereals is limited, but the yields are the highest in the country (4.5 t/ha). In this region, greenhouse vegetables are also grown.

The Central Lowlands are located around Trondheim and have favourable climatic conditions for growing grain. Contrary to the Eastern Lowlands and Jæren, which specialise in crops and livestock respectively, farming in this region involves both crops and animal husbandry. Production, however, remains relatively modest compared to the other two regions.

A fourth zone, Southern Valleys and Mountains, combines valleys in eastern and central Norway with western and southern Norway, excluding Jæren. This region specialises in extensive livestock production. It concentrates around 60% of the fodder area and Norwegian cows and contributes to a similar share of milk and beef production. Sheep farming accounts for nearly 70% of the national production.

Finally, the North region spreads beyond the Arctic Circle and its natural conditions are very harsh for agriculture. The agricultural production generated in this region is the lowest among the five regions (5% of the country's total). Most of agricultural production value created in the North comes from the dairy and beef sectors. The area used for cereal growing amounts to only 200 ha and produces 0.1% of Norwegian cereal production.

Climate change might bring new opportunities but also some risks

According to the Norwegian White Paper on Climate Adaptation (Norwegian Ministry of Climate and Environment, 2013[23]), the government wants to take a precautionary approach with respect to climate change adaptation in agricultural production, and focuses the risk assessment on the most extreme climate change projection. A report for the Norwegian Environment Agency (I. Hanssen-Bauer, E.J. Førland, I. Haddeland, H. Hisdal, S. Mayer, A. Nesje, J.E.Ø. Nilsen and A.B. Sandø, 2017[24]) estimates significant impacts of the IPCC scenario RCP8.5 by the end of the century. The median value of the annual temperature and precipitation will increase by about 4.5ºC (interval: 3.3ºC to 6.4ºC) and 18% (interval: 7% to 23%) respectively. Extreme events will be more intense and frequent, in particular heavy rainfall but also droughts. Floods induced by rainfall will increase in magnitude and occur more frequently, while reduced snowfall means that snowmelt floods will decrease in magnitude and frequency. In lowland areas, the winter snow cover will often be negligible or non-existent, while snow volumes may increase in some areas in the high mountains. The number of glaciers will be reduced and mean sea level will increase by 15-55 cm depending on the location along the Norwegian coast.

The effect on yields per hectare varies for different locations and crops, but a positive yield response to temperature increases is expected in most parts of Norway, with the exception of Eastern Norway (Sengar, Sengar and Eds., 2014[25]; Torvanger, Twena and Romstad, 2014[26]). Climate change effects are likely to be stronger moving from the south to the north of the country. Increasing exposure to diseases and the introduction of new animal diseases may also be expected. Examples of diseases that may spread north include bluetongue, several tick-borne diseases (e.g. Borreliosis, Babesiosis and Erlichiosis), West Nile fever, Leishmaniasis, and African horse sickness. Likewise, climate change will provide more favourable conditions for weeds, pests, and crop diseases (e.g. barley yellow dwarf virus, rust fungi and powdery mildew) (Åby et al., 2014[27]). Migration of some animal species further north, facilitated by climate change, might also be a challenge for farmers, with the most recent example being wild boars.

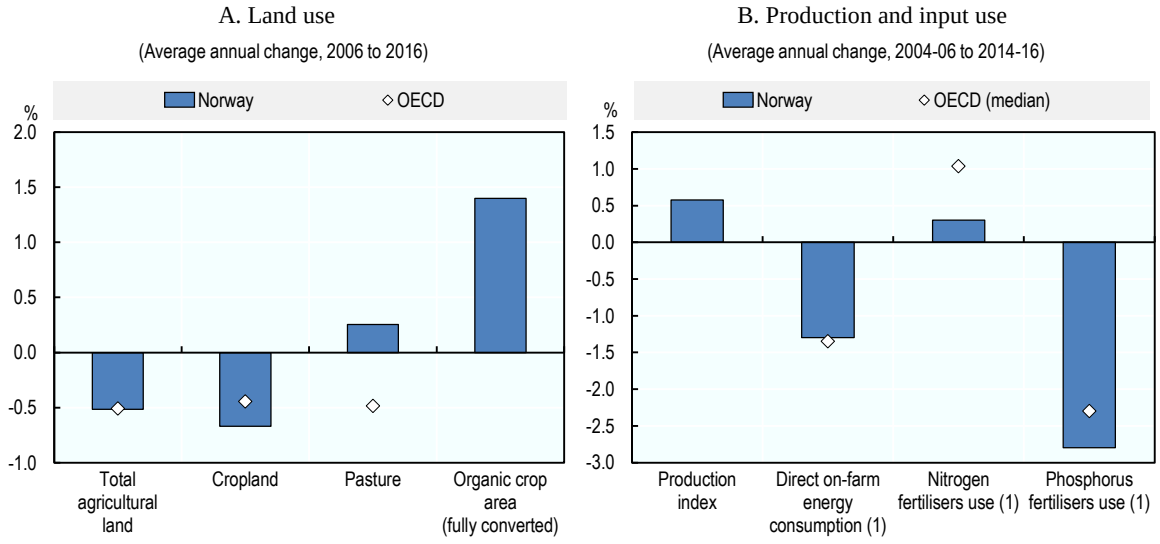
This implies that even in the most extreme scenario, future climatic changes are expected to be on average positive for agriculture in Norway. Still, the consequences depend on the interaction between different weather and biological elements, as well as political, economic and social conditions (Kvalvik et al., 2011[28]). In northern Norway in particular, these changes will imply increasing temperatures and precipitation as well as increased frequency of certain types of extreme weather events. Despite challenges such as unstable winters, increased autumn precipitation and possibly more weeds and diseases, a prolongation of the current short growth season (April–September) together with higher growth temperatures can give new opportunities for agriculture in the north. The impacts are expected to differ

both within and between municipalities and will require tailored adaptive strategies that may not pose major difficulty to implement (Uleberg et al., 2014[29]). Forestry is likely to experience less favourable conditions due to climate change, particularly related to pests, pathogens and fire.

There are signs of improvements in some agri-environmental indicators of inputs use, but there is still a long way to go

Increases in Norwegian agricultural production observed over the last decade are combined with decreases in the use of some inputs: the area of farming land, direct on-farm energy consumption and phosphorus fertiliser use (Figure 1.9). Chapter 6 analyses how this has translated into limited progress in terms of nutrients balances, as well as into still missing reductions in greenhouse gas (GHG) and ammonia emissions, and improvements in biodiversity.

Figure 1.9. Norwegian agricultural production is growing despite some decline in input use



Note: 1. per agricultural land area.
Source: Authors' calculations based on OECD (2019[33]), OECD Agri-Environmental Indicators (database), http://data.oecd.org/; and Eurostat (2020[34]), Organic crop area (fully converted area) (database), https://ec.europa.eu/eurostat/databrowser/product/page/TAG00098 (accessed May 2020).

The agricultural land used for farming was reduced on average by 0.5% per year between 2006 and 2016.[2] Unlike the OECD average, the decrease affected only crop land (-0.7% per annum), while the area of permanent pasture was marginally expanded (0.3% per annum, Figure 1.9, Panel A). Agricultural area under organic certification expanded quickly from 1995 until 2012, reaching a maximum of 50 000 hectares. Since then it slowly declined to 4.7% of the total farm land in use in 2018, below the average for the European Union (EU27, 8%) (Eurostat, 2020[30]).

Internal fresh water resources available in Norway amount to 382 billion m^3, being in terms of volume per capita one of the highest among OECD countries, next to Iceland and Canada. Precipitation in Norway (1 412 mm) is high, 50% above the OECD average. The share of irrigation in agricultural water abstraction is relatively low: only 11% of the cultivated area is equipped for irrigation, of which 21% is actually irrigated, mainly in vegetable growing areas. Agriculture was responsible for 28% of total water withdrawal in 2003-07 (FAO, 2020[31]; Statistics Norway, 2020[21]).

The Norwegian agricultural sector consumed 1.5% of the country's total final energy consumption in 2017. The consumption per hectare of agricultural land was reduced on average by 1.3% a year between 2004-06 and 2014-16, a comparable change to the OECD median (Figure 1.9, Panel B). Agricultural energy mix consists mostly of electricity (52%) and oil products (43%), in particular diesel used for agricultural machinery (IEA, 2020[32]). Approximately one-quarter of the electricity is consumed by greenhouses, mostly for growing lighting and boilers (Statistics Norway, 2020[21]).

Norwegian agricultural farming supplies nutrients essential to plant growth through manure application and fertiliser use. Thirty-four per cent of all nitrogen (N) and 58% of all phosphorus (P), measured by nutrient content, come from manure (Snellingen Bye et al., 2019[35]). Agriculture phosphorous fertiliser use fell by 2.7% between 2004-06 and 2014-16, slightly beyond the OECD median of 2.3%, while the use of nitrogen fertiliser remained almost constant (Figure 1.9, Panel B). The sales of fertilisers increased very rapidly in the 1960s and 1970s. Since then, sales of nitrogen have remained stable, while phosphorous and potassium sales fell significantly between 1980 and 2009 but have since remained stable (Norwegian Food Safety Authority, 2020[36]).

Use of pesticides in Norway, estimated as the amount of active substance applied on arable crops in agriculture, varies from year to year in response to weather and pest conditions and changes in plants treatment. Between 2001 and 2014, it fluctuated between 354 tonnes (its highest level in 2003) and 282 tonnes (its lowest level in 2008), with the shares of herbicides and fungicides being roughly two-thirds and one-fourth of the total respectively (Statistics Norway, 2020[21]). Sales of pesticides decreased significantly from 1967 to 1997, due mainly to the switch from high-dose to low-dose preparations for weeds in grain cultivation, but have stabilised in the 2000s (Chapter 3).

1.2.2. Structural adjustment in Norwegian agriculture

Renting has facilitated the consolidation of agricultural land, although average farm area remains relatively small

Historically, the agricultural sector in Norway has been characterised by a large number of small farms. This picture has largely evolved over the last 60 years. In 1959, there were approximately 210 000 agricultural properties,[3] defined based on the ownership, and their farm land was operated by 198 000 farm holdings with 5.2 hectares of agricultural area in use on average. Since then, the total number of farm holdings has declined to roughly 40 000 in 2018, while the number of agricultural properties has remained relatively stable (Figure 1.10, Panel A), indicating a growing number of agriculture property owners who are not actively farming their land but renting it out to others.

Farms have consolidated, especially in the early 2000s. There have been legal changes that have facilitated a shift from owner occupation to renting (Chapter 3), and the share of agricultural area in use that is leased increased from 15% in 1969 to 45% in 2017 (Figure 1.10, Panel C). The proportion of wholly owned farm holdings was reduced from 87% in 1959 to 35% in 2010 and 30% in 2017. At the same time, the shares of partially rented farms increased from 6% to almost 60% in 2010 (Forbord, Bjørkhaug and Burton, 2014[37]).

Even if only 3% of all land is suitable for agricultural use, agricultural properties are spread over close to 77% of the Norwegian territory (approximately 25 million ha in 2015), (Statistics Norway, 2020[21]). Agricultural land and productive forest occupy just about one-third of these agricultural properties, while two-thirds are covered by non-productive areas such as mountains, swamps and water (Figure 1.10, Panel B). However, an abundance of unimproved pasture in mountains and hillsides offers Norway a relatively unique opportunity for extensive ruminant livestock.

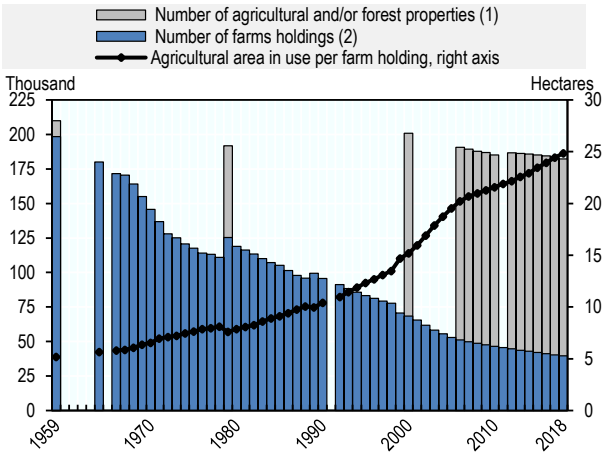
Most of the 182 300 agricultural properties in Norway in 2018 combined agricultural and forest activities: 89% of all agricultural properties contain at least 0.5 ha of agricultural area and 71% of them at least 2.5 ha

of productive forest area (Statistics Norway, 2020[21]). Seven per cent of the Norwegian population, i.e. 369 500 people, lived on agricultural properties. However, this is 148 000 less than in 2000 (Statistics Norway, 2020[21]; Norwegian Ministry of Agriculture and Food, 2020[17]).

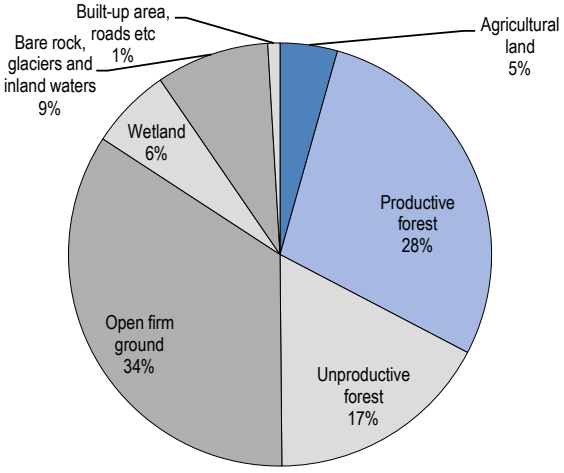
Figure 1.10. Agricultural farm holdings in Norway have been consolidated mainly through renting

Characteristics of agricultural properties[1] and farm holdings

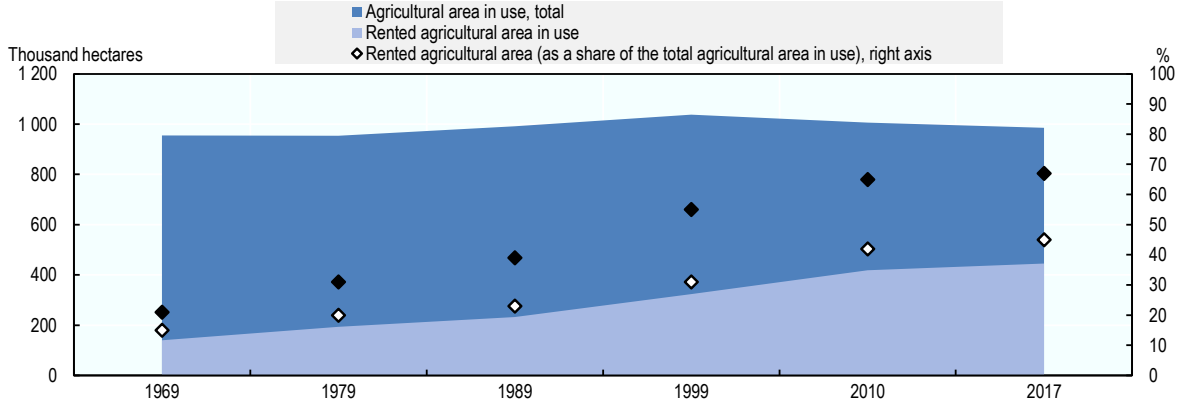
A. Evolution of the number of agricultural properties[1] and the number of farm holdings and area



B. Land cover of agricultural properties,[1] 2015



C. Rented agricultural land in use



Notes: Panel B: Numbers may not add up to 100 due to rounding.
1. Registered agricultural and/or forest proprieties include only properties with at least 0.5 ha of agricultural area and/or at least 2.5 ha of productive forest area.
2. For years 1979-1998, only holdings with at least 0.5 hectares of agricultural area in use are included.
Source: Data provided by Statistics Norway (2020[10]); Statistics Norway (2020[21]), Agricultural properties and Holdings, agricultural area and livestock (databases) [table: 10206 and 12658], https://www.ssb.no/en/statbank/ (accessed February 2020); Forbord, Bjørkhaug and Burton (2014[37]).

Consolidation has led to larger farms and concentration of livestock on fewer holdings without decreasing production volume

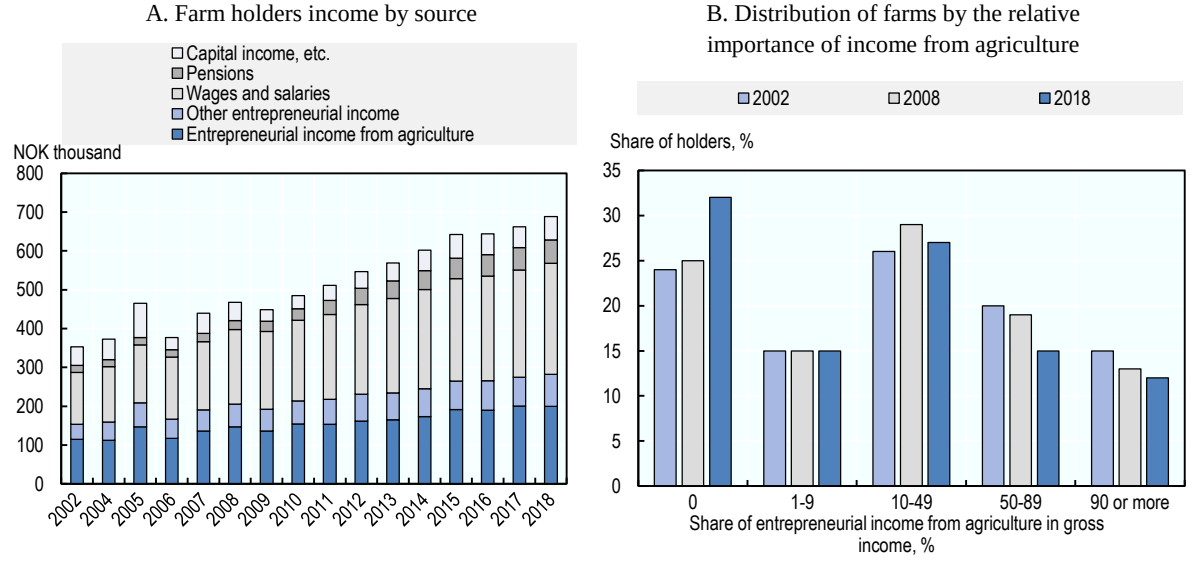
Over the last two decades, the structure of farm holdings has changed both in terms of size and specialisation. The average utilised agriculture area per farm holding has increased from 15.2 ha in 2000 to 24.9 ha in 2018 (Statistics Norway, 2020[21]), lower than in other Nordic countries – Finland 44.9 ha,

Sweden 47.9 ha and Denmark 76.6 ha – or France with 60.9 ha in 2016 (Eurostat, 2020[38]; Statistics Norway, 2020[21]). The most common size for a Norwegian farm is between 10 ha and 20 ha, which is the case for 26% of all farm holdings. Consolidation has led to higher participation of larger farms of 50 ha and more, with the number of such farms increasing from less than 2 000 in 2000 to almost 5 000 in 2018, representing 12% of all farm holdings, and to a higher average number of animals per farm, with figures for beef cows, hens and pigs more than doubling since 2000 (Statistics Norway, 2020[21]). This long-term structural change has been accompanied by reductions in agricultural employment and a rapid productivity growth over the last two decades (Chapter 6).

Most Norwegian farms complement income from agriculture production with other revenue streams, often from off-farm activities

In Norway, there is a large diversity of agricultural holdings in terms of size and specialisation, from hobby-like small producers to holdings with a turnover of more than NOK 1 million, leading to a considerable variation in entrepreneurial income from agriculture. In 2018, only 29% of farmers' annual gross income came from agricultural entrepreneurial activities. The rest consisted mostly of wages and salaries (42% of total), and to a lesser extent of incomes from other entrepreneurial activities, including forestry (12%) and from pensions, capital income, etc. (17%; Figure 1.11, Panel A). In the same year, income from farming accounted for more than 90% of the revenue for only 12% of agricultural holdings, while it contributed to less than half of gross income for nearly three-quarters of holdings. Furthermore, the share of farm holdings without any positive income from agricultural activities increased over time, from 24% in 2002 to 32% in 2018 (Figure 1.11, Panel B).

Figure 1.11. Only a small share of Norwegian farmers' income comes from agricultural entrepreneurial activities



Note: Figures include personal farm holders only (37 443).
Source: Statistics Norway (2020[21]), Farmers' income and debt (databases) [tables: 05038 and 05043], https://www.ssb.no/en/statbank/ (accessed April 2020).

The share of farm households deriving 50% or more of their income from agriculture is highest for the largest farms (60% of holdings with 50 ha or more of the agricultural area in use), for holdings specialised in mixed cattle and dairying cattle (respectively 75% and 72% of farms of these specialisations), and for those in more remote areas, such as the northern part of the country with reduced access to off-farm

employment (nearly 40% in Nordland, Troms and Finnmark). Conversely, relatively small holdings, with between 0.5 ha and 10 ha of agricultural area in use, and holdings specialised in cereals and oil seeds, and sheep, seldom reach 50% of income from agriculture, with respectively 7%, 6% and 12% (Statistics Norway, 2020[21]).

The debt of farm holdings in 2018 corresponded on average to NOK 2.1 million (USD 0.3 million) per farmer, ranging from NOK 1.2 million (USD 0.1 million) for farmers specialised in sheep to just over NOK 5.0 million (USD 0.6 million) on average for those with mixed livestock and specialised in pigs or poultry. About 20% of farm holders had less than NOK 0.1 million (USD 0.01 million) in debt, while 16% had more than NOK 4 million (USD 0.5 million) in debt (Statistics Norway, 2020[21]).

1.2.3. Agriculture innovation at farm level

A third main driver of the achievements in terms of productivity-sustainability-resilience outcomes is the performance of the agricultural innovation system. Norway has a sophisticated agricultural innovation system highly supported by the public sector. Its strengths and weaknesses, and related policy issues are analysed in Chapter 4. This section focuses on some indicators of farm level innovation following recent work by the OECD Network for Farm Level Analysis (Sauer and Moreddu, 2020[39]) that used a sample of farms to group crop, dairy and cattle farms in technology classes to analyse their productivity and technical change.

Differences in productivity among farms are not larger than in other countries, but technology catch-up is slow and apparently not driven by innovation

The technology classes[4] are grouped accounting for similarities across farms with respect to characteristics such as farm structure, location, sustainability of production practices, innovation and technology adoption. The analysis for Norway finds three classes of crop farms, three classes of dairy farms and two classes of cattle and studies the relationship between performance and selected indicators (Sauer and Moreddu, 2020[39]) and (Table 1.6).

Classes 1 (C1) are the most productive farms, with very large differences with respect to the least productive classes, which are 53 percentage points less productive for dairy farms, 39 percentage points for crop farms, and 12 percentage points for cattle farms. These differences in farm performance are bigger than in France, but smaller than in Sweden where the least productive class of crop farms has a productivity level that is 76 percentage points lower than the best performing. Low productivity classes of Norwegian crop and dairy farms are slower in introducing technical changes, which implies an increasing size in the productivity gap among farms. This is not the case for cattle farms and in many other countries. For instance, the less productive dairy farms in Denmark, France and Sweden experience higher levels of technical change contributing to the decrease in the productivity gap.

Sauer and Moreddu (2020[39]) also analyse farm level indices of innovation and technology built on information and proxies available at farm level.[5] An innovation index considers investment in new technologies and engagement in new activities such as agritourism or biofuel production, while a technology index is based on indicators of capital, labour and material intensity per hectare, per cow or per worker, depending on the farm type. The evidence from the countries covered in this study shows that innovative farms tend to be more productive. However, in Norway, this relationship is weak for crop farming and almost flat for other farm types; according to these statistical indicators, there do not seem to be strong links between productivity and technical change performance on the one hand, and innovation and technological indices on the other (Figure 1.12).

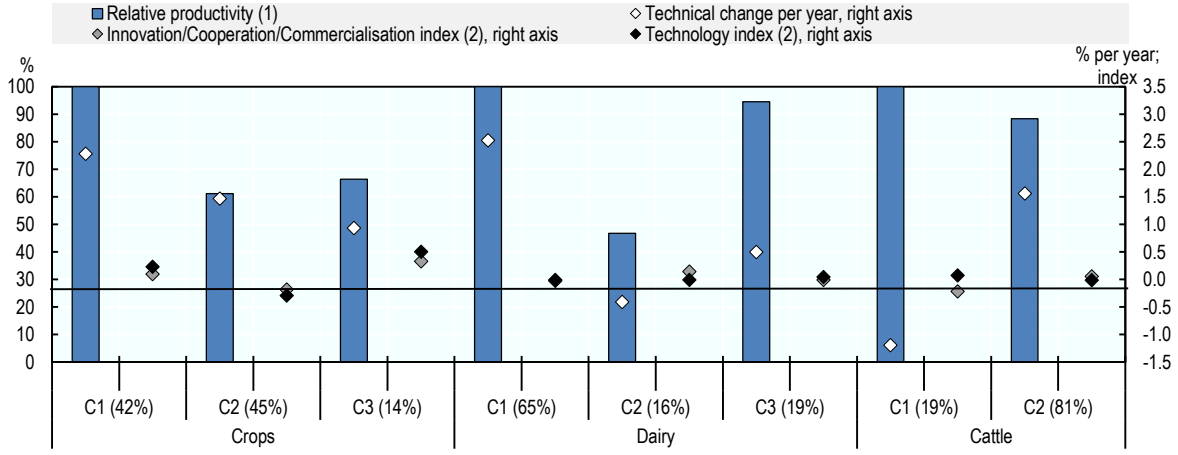
Table 1.6. Main characteristics of farm classes in Norway according to the OECD farm level analysis

	Class 1 (Most productive)	Class 2 (Least productive)	Class 3 (Medium productive)
Crops	Most productive farms, which account for 42% of all farms, are the least sustainable. They are smaller, less diversified operations, with more intensive practices and higher capital intensity per labour. They are managed by older farmers, more likely to be women. They generate below average off-farm income and receive below average subsidies.	Most sustainable farms are the least productive and account for 45% of all farms. They are larger operations, more likely to rely on hired labour. Managers farm more sustainably and are more likely to adopt organic practices. They invest relatively less than other farms and have low capital intensity. But they have higher assets, receive more subsidies and have higher off-farm income.	14% of farms have productivity levels slightly above the weakest category and below average sustainability. They have less land and lower assets, but they are the most capital intensive and more likely to use contract farming. Managers are more likely to be younger than average and women. They receive below average subsidies.
Dairy	Close to two-thirds of farms are in the most productive, least sustainable category. Of about average herd size, but with less land, they are more specialised operations, more likely to be partnerships. They are less capital intensive than average and have intermediary scores in terms of investment in new technologies. They are more likely to adopt organic practices and receive higher agri-environmental payments, but use more fuel per hectare. They rely more on off-farm income than average.	Least productive farms with an above average sustainability account for 16% of all farms. They have a much smaller herd size than average and are managed by younger farmers, with higher reliance on family labour. They have the highest stocking density and receive lower agri-environmental payments. They have lower capital intensity than average, operate with a lower than average asset endowment and are less likely located in a favourable area.	Most sustainable farms, accounting for close to 20% of all farms, achieve productivity levels close to the highest in Class 1. They are much smaller than average and more diverse. They are more likely to be in mountainous areas and to use more extensive production practices. They receive lower levels of subsidies and have lower debt ratios than average.
Cattle	The most productive farms are also the most sustainable and account for about 20% of all farms. They are larger operations with a higher share of hired labour. They are more diversified and capital intensive than average, and more likely to be managed by younger men. They have larger assets and receive more subsidies than average. They are also more likely to have income from forestry.	Over 80% of all farms achieve productivity levels that are close to the highest (12% lower), but with worse sustainability performance. They are smaller operations (ha) with smaller herd size. They are less diversified operations and more likely to be managed by older farmers or women. Their capital intensity is lower than average and they employ the highest rate of labour per capital animal.	

Notes: Dataset used to estimate the model was provided by Norwegian Institute of Bioeconomy Research (NIBIO). Farm level panel data refer to the 2005-16 period and cover 285 crop farms, 948 dairy farms and 293 livestock farms, jointly 8 817 observations, with farms staying on average between 5.6 and 5.8 years in the panel. See Sauer and Moreddu (2020[39]) for methodological details.
Source: Adapted from Sauer and Moreddu (2020[39]).

Figure 1.12. The least productive crop and dairy farm classes in Norway display relatively slow technical change

Relative productivity and technical change in Norwegian crops, dairy and cattle farms by farm type and technology class



Notes: Number in the bracket indicates share of farms in that class.
1. Productivity level in the class as a percentage of productivity level in the most productive class.
2. At class means, scaled values.
Source: Sauer and Moreddu (2020[39]), based on farm samples 2005-16, surveys from NIBIO.

Farms could be more productive if they were larger and more diversified, although this does not guarantee better environmental performance

A recent study (Alem et al., 2019[40]) confirms that there is a scope to improve farm efficiency beyond the current observed structural change. Using farm level data for the period 1991-2014 and a flexible technology approach, OECD estimates farming costs in different types of farms (crops, dairy and mixed) across regions. This study finds that all three types of farms experience significant economies of scale; that is, there are opportunities to enhance farm productivity by increasing the size of farms in Norway, which are currently constrained by several land regulations (Chapter 3). It also finds the possibility for economies of scope; that is, there are opportunities to reduce total production costs by up to 28% by moving towards more diversified mixed farms, e.g. producing both crops and dairy outputs. However, dairy quotas and payments linked to specific productions are likely to be constraining factors (Chapter 2). There is also evidence that dairy farms have improved technology, shifting their production frontier in all Norwegian regions, while keeping a similar average level of technology efficiency across all regions (Alem et al., 2019[41]). This study found that farm size and the experience of farm managers have a positive impact on technical efficiency across all regions, while government support did not help in this respect.

Sauer and Moreddu (2020[39]) define a sustainability index based on low intensity of chemicals, fuel use and stock density, and the use of sustainable practices. They find a systematic trade-off between productivity and these indices of local sustainability across covered countries and farm types. In the case of Norway, crop and dairy farm classes exhibit a negative correlation between productivity and sustainability, implying that most productive farm classes are less sustainable. However, cattle farms present a relatively strong positive relationship between productivity and sustainability; that is, most productive cattle farms are more sustainable.

1.3. General policy environment

The social and macroeconomic environment is a key determinant of the performance of the agro-food and forestry sector. Together with the broad macroeconomic background, many government policies that are not specific to the sector also have a direct or an indirect impact, i.e. by either promoting or impeding the potential for innovation, including policies in the areas of trade and investment, finance, entrepreneurship, taxation, labour and skills, infrastructure and ICT, and food safety and animal health.

1.3.1. Macro-economic environment and governance

Stable and sound macroeconomic policies accompanied by good governance systems and high-quality institutions play an important role in creating a favourable environment for investment. High economic growth and low and stable inflation combined with government being accountable, transparent and predictable can lead to higher investor confidence and encourage public and private investment in the economy leading to potential benefits for investors and the host country. Farms and agri-food businesses profit from such favourable conditions to undertake research and development, introduce new products, and to adopt new production methods or introduce organisational changes (OECD, 2020[5]).

Favourable macroeconomic conditions and solid institutions generate the stability required for the good functioning of markets and investment decisions

Norway is a highly developed democratic country with a stable economy. Up to 2020 and the COVID crisis, economic growth remained robust driving declines in unemployment and keeping it at one of the lowest levels among the OECD countries, while inflation oscillated around the target of 2%. Monetary and fiscal policy stances were appropriately adapted to economic conditions and the government budget aimed for a neutral stance (OECD, 2019[42]).

On the World Economic Forum's (WEF) aggregate Global Competitiveness Index (GCI), Norway is consistently ranked 11th amongst close to 140 countries and has been a leader on the macroeconomic environment pillar. In the 2017/18 edition, Norway scored very high in most areas (Figure 1.13, Panel A), demonstrating that the country has strong institutions, high-performing education and health systems, and a well-developed financial market (ranking among the top 10 in the world). Given its high levels of information and communication technology (ICT) use and dynamic business sector, Norway is in good position to benefit from the new opportunities related to the digital transformation (Section 1.3.8).

The Norwegian economy profits from the high quality of its public institutions (scoring highly in the WEF GCI 2017/18; Figure 1.13, Panel B). It scored above the OECD average in all sub-categories of the WEF public institutions index. Norway enjoys the reputation of a country secure for businesses, reflecting a very low level of organised crimes and a high reliability of police services. It is highly valued for its ethics, with few illegal diversions of public funds and a juridical system that is independent from influences of government, individuals or companies. Property rights, including financial assets and intellectual property rights, are well protected. Government efficiency, in particular the burden of government regulations, was the weakest component of the quality of public institutions index, but Norway nevertheless remained above the OECD average.

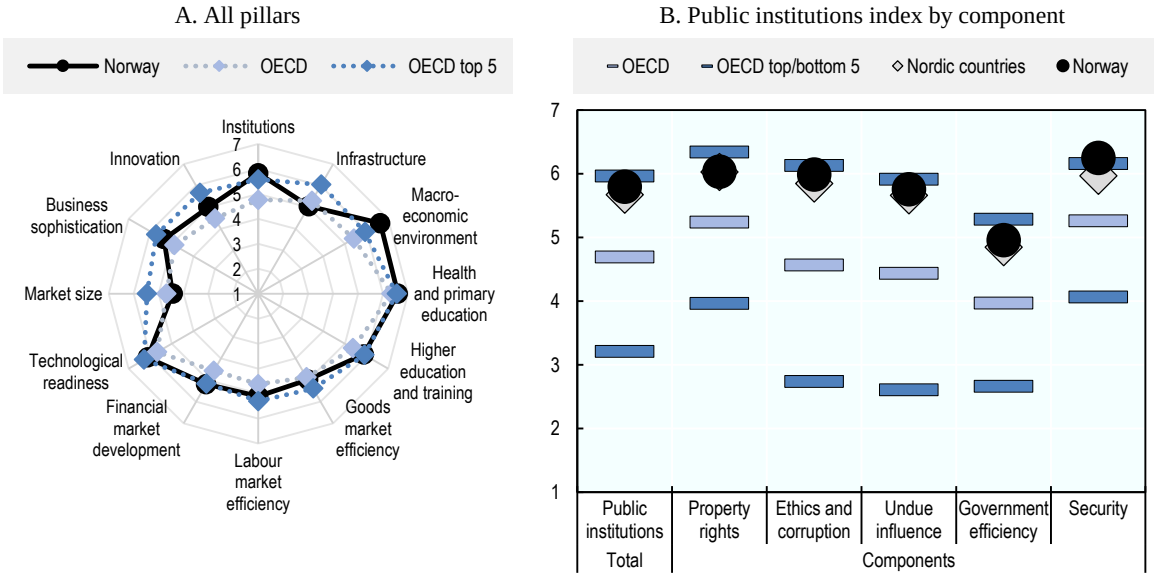
The recent outbreak of COVID-19 and the associated shutdown have had an impact on the economy. According to OECD projections, the mainland GDP is expected to fall by between 7% and 8.7% in 2020 ("single-hit" and "double-hit" scenarios). The registered unemployment rate soared after the introduction of confinement measures as did applications for benefits by temporarily laid off employees. Although the lifting of restrictions began on 20 April, both GDP growth and unemployment rates are not likely to return to the pre-crisis levels by the end of 2021. Norway's monetary and fiscal policy response to the crisis has been prompt and the country's economy model, based on a large public sector and a comprehensive

welfare system, contributed to a substantial stabilisation. However, a rapid deterioration of the fiscal balance in 2020 will imply a substantial drawdown from the wealth fund. A partial recovery in 2021 is expected to be driven by a rebound in tax revenues and the termination of temporary support measures. At the same time, weak demand will continue to depress the consumer price inflation (OECD, 2020[43]).

According to the *OECD Economic Survey* (2019[42]), the Norwegian economy is facing several risks. The global slowdown in trade and investment combined with weakening business and consumer confidence in the euro area is a risk to Norwegian trade capacity. At the domestic level, the increasing household debt to disposable income ratio signals a potential cutback in consumption, and the ageing population will result in declining labour participation as well as in rising health care and pension costs. The high rates of absence due to sickness among workers and the large spectrum of disability benefits have not been fully addressed. Efforts are needed to better integrate immigrants in a labour market with limited demand for low-skilled workers. The recent sharp fall in global oil prices and demand has caused an additional economic shock, confirming the need to move further towards a green, more diversified economy (OECD, 2020[43]) (Chapter 3).

Figure 1.13. Norway enjoys favourable macro-economic conditions accompanied by solid public institutions

Global Competitiveness Index, 2017-18



Notes: Scale from lowest (1) to highest (7) performance. Indices for OECD and Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) are the simple average of member-country indices. OECD top/bottom 5 refers to the average of the scores for the top/bottom 5 performers on the aggregate Global Competitiveness Index (Panel A) and aggregate Public institutions index (Panel B) among OECD countries.

Source: WEF (2017[44]), The Global Competitiveness Report 2017-2018: Full data Edition, http://reports.weforum.org/global-competitiveness-index-2017-2018/.

1.3.2. Trade and investment policy

Trade and investment openness is beneficial to innovation as it enlarges markets for innovators, strengthens competition, facilitates access to new ideas, technologies and processes, as well as promotes international collaboration. The entire food supply chain (Chapter 5), from input suppliers to food service and retail firms, can profit from being integrated into global systems as knowledge transfer accompanied

by exposure to international competition can contribute to the development of market mechanisms that favour productivity growth and environmentally sustainable production (OECD, 2020[5]).

Although in general Norway has low restrictions to trade and investment, trade in primary agriculture remains highly restricted

Norway is highly dependent on trade to maintain its high standard of living (Section 1.1.3). As a small country, it relies on trade agreements to secure access of Norwegian businesses to international markets and to facilitate trade with its partners. Over the last decade, Norway's openness to trade, defined as the value of merchandise trade (exports plus imports) relative to the gross domestic product (GDP), has remained relatively stable (48% in 2018) and is between the OECD and Nordic countries' averages (43% and 56% respectively). It was, however, below the averages for the EU27 (70%) and countries with comparable GDP per capita (87%[6]).

Norway, together with Iceland, Liechtenstein and Switzerland, negotiates free trade agreements through the European Free Trade Association (EFTA). Since 1994, it has been a member of the European Economic Area (EEA) which has led to important liberalisation measures and to the country's integration into Europe. The EU Common Agricultural Policy (CAP) and Common Fisheries Policy (CFP) are not part of the EEA Agreement and therefore the free movement of goods within this framework does not apply to all products (Chapter 2).

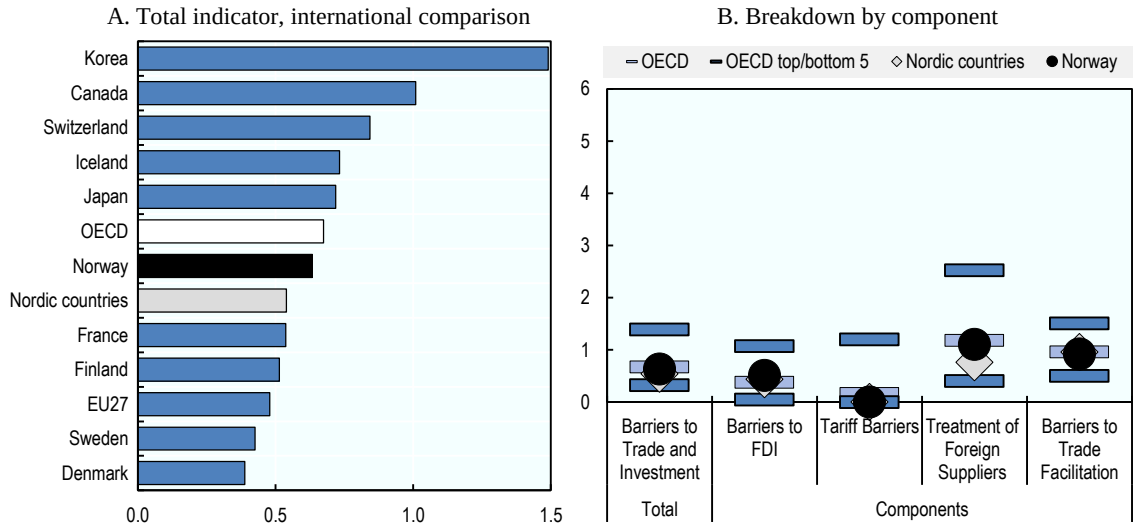
The barriers to trade and investment in Norway are comparable to other OECD countries (Figure 1.14). According to the 2018 edition of the "OECD Product Market Regulation (PMR) Indicators", regulatory restrictions to trade and investment in Norway were minor (aggregated score of 0.63 on the scale from 0 to 6). They were slightly less restrictive than in the OECD (average of 0.67), but more than in Nordic countries (0.54) or the EU27 (0.48). Norway's scores for all indicators – tariffs, differential treatment of foreign suppliers, barriers to foreign direct investment (FDI) and to trade facilitation – were closely aligned with the OECD averages. However, compared to other Nordic countries, Norway has scope for improvement in terms of equal treatment of foreign suppliers compared to domestic ones.

According to the OECD Trade Facilitation Indicators evaluating different types of border procedures, Norway scores high, above the OECD average, for most indicators (OECD, 2018[45]). The highest scores concern governance and impartiality related to customs structures and functions, accountability and ethics policy (2.0, being the maximal score), information availability (1.95) and co-operation of border agency with neighbouring and third countries (1.91). Compared to 2015, Norway made significant progress in terms of reducing formalities; however, it has slightly higher barriers related to providing advance rulings on customs matters, which is below the averages for the OECD and Nordic countries (OECD, 2017[46]).

Norway, in general, does not impose severe restrictions on Foreign Direct Investment (FDI) that could impede the creation of stable and long-lasting links with other economies. The OECD FDI Restrictiveness Index – which evaluates rules related to foreign equity, screening or approval mechanisms, and key foreign personnel and operational decisions – indicates that the restrictiveness of the Norwegian economy as a whole is relatively low (0.085 on the 0 to 1 scale), although above the OECD total level (0.065). For the economy as a whole, in 2018 the inflow of FDI (0.05% of GDP) was one of the lowest of OECD countries, while the outflows were much higher (2.6% of GDP). However, the agriculture, food and forestry sector attracts only a small share of the total FDI (OECD, 2020[47]).

Figure 1.14. Restrictions to trade and investment in Norway are low and regulations are mostly competition-friendly

Economy-wide Product Market Regulation Indicators: Barriers to Trade and Investment indicator, 2018



Notes: Scale from most (0) to least (6) competition-friendly regulations. Indices for the EU27, OECD and Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) are the simple average of member-country indices. OECD top/bottom 5 refers to the average of the scores for the top/bottom 5 performers among OECD countries on a given component.
Source: OECD (2018[48]), Product Market Regulation Database, https://www.oecd.org/economy/reform/indicators-of-product-market-regulation/.

1.3.3. Finance policy

Efficient financial markets that are accessible for all sectors of the economy and across the country are an enabler of balanced economic development. The agro-food sector can profit from policies that facilitate the functioning of financial markets through easier access to credit, which allows productivity and sustainability investment to be improved, in addition to boosting the innovation capacity of firms with high growth potential (OECD, 2020[5]).

Norway's robust financial markets contribute to a balanced economic development and advocate for investment opportunities

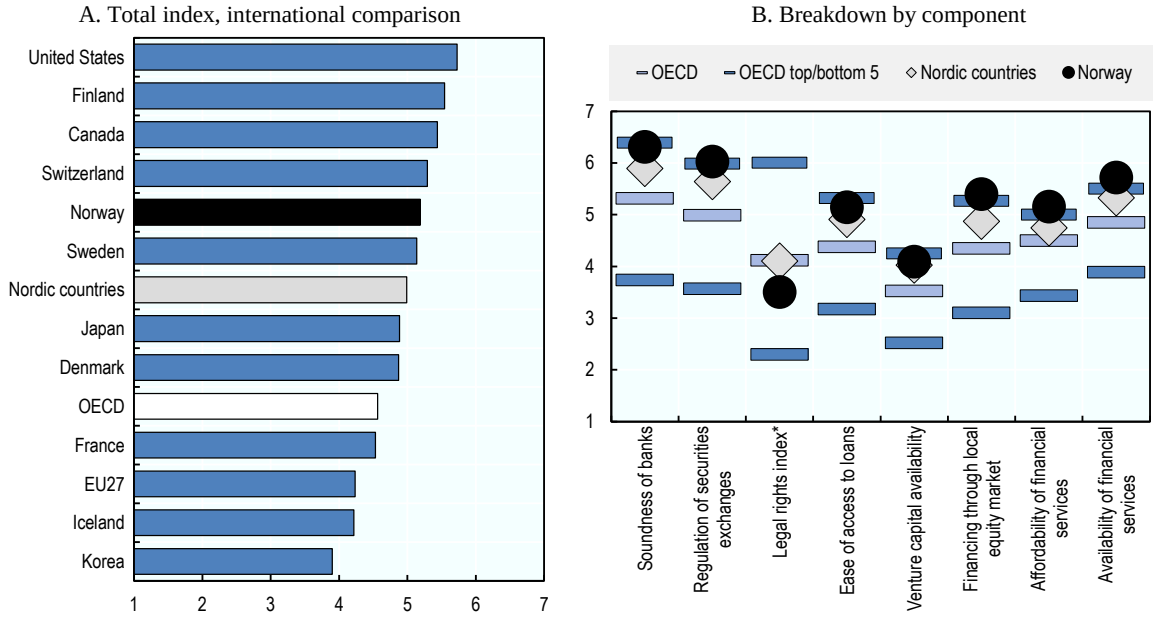
According to the *OECD Economic Surveys* (2019[42]), Norway's financial system is in good shape overall and should be able to resist tensions and shocks should these occur. This is confirmed by the results of the WEF Global Competitiveness Index (Figure 1.15). Norway's score on the financial market development index (5.2) remains above the OECD (4.6) and Nordic countries (5.0) averages; however, it has decreased by 0.4 points over the last decade. The analysis of the index components indicates the efficiency and the trustworthiness of the financial sector. Only the legal rights index, measuring the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders and thus facilitate lending, has been ranked below the OECD average (3.5 vs. 4.1) in recent years.

In general, Norwegian farmers have no problem accessing credit (Chapter 2). Loans granted to the agriculture and forestry sectors in 2019 amounted to NOK 744 billion (USD 85 billion) and NOK 58 billion (USD 7 billion), corresponding to 3.6% and 0.3% of the total loans value to all sectors. These loans were mostly financed by banks (83% and 70%, respectively). Finance companies were responsible for 6% of

the loans value for agriculture and 23% for forestry, while state lending institutions (7% and 4%) and mortgage companies (2% and 5%) played a much smaller role (Statistics Norway, 2020[21]).

Figure 1.15. Norwegian financial market is efficient and trustworthy

Global Competitiveness Index: Financial market development index, 2017-18



Notes: Scale from lowest (1) to highest (7) performance. Indices for EU27, OECD and Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) are the simple average of member-country indices. OECD top/bottom 5 refers to the average of the scores for the top/bottom 5 performers on the aggregate Financial Market Development Index among OECD countries.
* The Legal rights index (1-to-12) was converted to 1-to-7 scale.
Source: WEF (2017[44]), The Global Competitiveness Report 2017-2018: Full data Edition, http://reports.weforum.org/global-competitiveness-index-2017-2018/.

1.3.4. Environment for entrepreneurship and product regulations

The overall regulatory environment sets the framework within which firms operate and make investment decisions. Competitive conditions in domestic markets, created largely due to low entry and exit barriers, can promote structural adjustment and encourage innovation and productivity growth all along the agro-food value chain. Regulations may also directly enable or impede knowledge and technology transfer, including sustainability-enhancing ones (OECD, 2020[5]).

Norway's regulatory environment promotes entrepreneurship, although the agricultural sector is less exposed to competition

Acknowledging the need for structural adjustments resulting from an ageing society and climate and environmental challenges, in 2016 the Norwegian Government launched a plan that sought to boost entrepreneurship. It focused on three areas: enabling better access to capital at an early stage; increasing access to relevant skills and competences; and making Norway more attractive to national and foreign entrepreneurs and investors (Norwegian Ministry of Trade, 2016[49]).

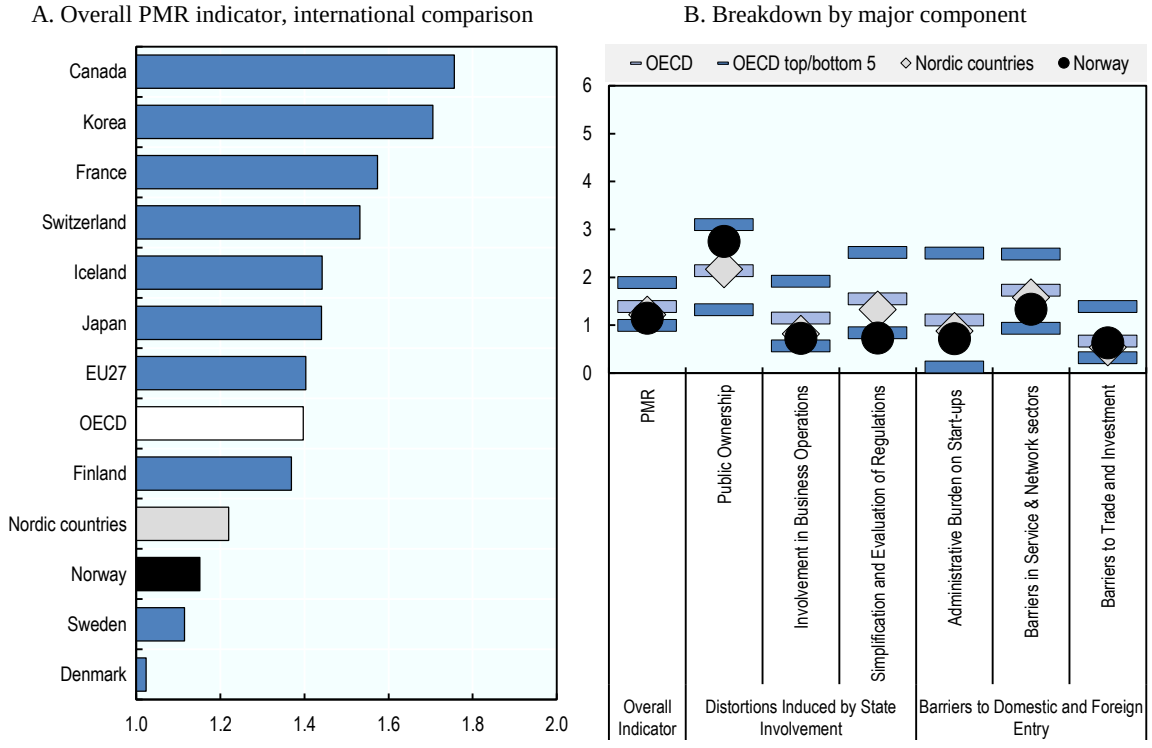
According to the Global Entrepreneurship Monitor (GEM) (2020[50]), Norway enjoys a favourable environment for entrepreneurship that improved between 2015 and 2019. On most of the entrepreneurial

framework conditions identified by the GEM,[7] Norway's scores exceeded averages for Europe and the North American region and for high income economies. Although on average Norwegians believe more than do their European and North American peers that successful entrepreneurs enjoy a high status (93% vs. 67%) and that it is a good career choice (67% vs. 60%), they have fewer nascent entrepreneurs and new business owners (8% vs. 10%). Entrepreneurial attitudes in Norway show a strong belief in the opportunities available and a low fear of failure, but there is a lower belief in their capabilities to start a business.

With regard to the business environment for entrepreneurship, Norway ranked 9th out of 190 countries in the World Bank's Doing Business 2020 project[8] with an overall score that was above the OECD aggregate. While Norway led in "Enforcing Contracts" and "Resolving Insolvency", confirming its secure environment to conduct business, there is scope for further improvement in the strengthening of its credit reporting systems and the effectiveness of its collateral and bankruptcy laws in facilitating lending that would allow for effective access to finance (World Bank, 2020[51]).

Figure 1.16. Regulatory barriers to competition in Norway are among the lowest in the OECD

Economy-wide Product Market Regulation Indicators: Overall indicator, 2018



Notes: Scale from most (0) to least (6) competition-friendly regulations. Indices for the EU27, OECD and Nordic countries (Denmark, Finland, Iceland, Norway, and Sweden) are the simple average of member-country indices. OECD top/bottom 5 refers to the average of the scores for the top/bottom 5 performers among OECD countries on a given component.
Source: OECD (2018[48]), Product Market Regulation Database, https://www.oecd.org/economy/reform/indicators-of-product-market-regulation/.

Generally, regulatory barriers to competition in Norway are among the lowest in the OECD (Figure 1.16, Panel A).The administrative burden imposed on new firms is low, regulations in the services sectors are competition-friendly, and barriers that could limit the access to domestic markets of foreign firms and foreign investors are few. Regulatory procedures are simple and there are rules in place to ensure

transparency in the interaction between interest groups and policy makers. However, the presence of state-owned enterprises is stronger than in most other OECD countries. There is also scope for a better alignment of regulations in network sectors with the international best practices (Figure 1.16, Panel B) (OECD, 2017[52]).

Competition laws in Norway aim to achieve well-functioning markets for the benefit of consumers and businesses in various national markets. As a consequence of the agreement with the European Economic Area (EEA), the Norwegian Competition Act generally mirrors EU rules related to unlawful co-operation, abuse of a dominant position, and control of mergers and acquisitions. The agriculture and fisheries sectors are exempted from competition law through a specific regulation (Chapter 5). This exemption allows farmers' co-operatives to reduce produced quantities or to fix market prices without breaching the Competition Act. The only requirement is that such actions are in accordance with other laws and regulations and/or agreement between the government and farmers' organisations (Norwegian Ministry of Agriculture and Food, 2020[17]).

1.3.5. Tax policy

Tax policy affects innovation, productivity sustainability and resilience in many ways: it affects the decision of firms and households to save or invest in physical and human capital, and thus the adoption of innovation; it raises government revenues, which can then finance public services; it can provide direct incentives to investments in private R&D. Tax policy influences the conduct, structure and behaviour of farmers, input suppliers and food companies, in particular in response to taxes on income, property and land and capital transfer, and to differential tax rates on specific activities (polluting or environmental friendly), resources, or input use, which may affect sustainability (OECD, 2020[5]).

Norway's tax burden is amongst the highest in the OECD, but innovation is incentivised and farmers benefit from several exceptions

The tax system in Norway is composed of direct taxes, which includes personal income tax, corporate income tax and taxation of assets, and indirect taxes such as value added tax, excise duties, custom duties, and fees and sectoral taxes. In 2019, income tax for individuals was charged at a flat rate of 22% on "ordinary income", but for "personal income" a progressive tax was applied. Income earned on shares and self-employment was taxed, but special concessions were applied to farmers (see Chapter 2 and OECD (2020[53]) for all tax incentives applied to farming). In order to create incentives for employment in remote areas, employer rates for social security contributions differed depending on location, with zero rates in the northern region compared with 14.1% in the Oslo area. This benefitted agricultural employment in many rural areas.

Norway's tax burden is among the highest in OECD countries; in 2015, it was around 45% of GDP (excluding petroleum-related revenues). The OECD has recommended lowering the tax burden and shifting the tax mix from direct to indirect sources as this would encourage business enterprise and productivity growth (OECD, 2017[54]). However, R&D tax incentives are among the most effective in increasing employment, turnover, and value added for newly established firms (see Chapter 4 and OECD (2019[55])).

1.3.6. Labour, education and skills policies

Labour market, education and skills policies influence employment composition and labour mobility. They can facilitate (or impede) labour adaptation to new circumstances and ensure (or hamper) a better match of labour supply with the demand. In agriculture, labour policy can also promote structural adjustment, including farm consolidation. All along the food chain, education and skills policies can facilitate the

acceptance of innovation, promote their development and adoption, including productivity, resilience and sustainability enhancing practices and technologies (OECD, 2020[5]).

Norway's population is ageing, although less rapidly than in other countries. Elderly dependence is especially high in rural areas

Norway's population is currently close to 5.3 million and, according to the projections of the Statistics Norway, will exceed 6 million by 2040. Norwegians live longer (life expectancy at birth increased from 78.8 in 2000 to 82.5 in 2016, exceeding the OECD average of 80.1) (OECD, 2019[42]) and spend more years in good health than before (Statistics Norway, 2019[14]).

The country's population is getting older, with the share of seniors growing rapidly since 2007. In 2018, people aged 65 and over accounted for 17.1% of the Norwegian population, 2 percentage points more than a decade earlier, which is comparable to the OECD average of 17.2%. The share of the working age population (15-64 years old) is expected to decline at a slower pace than in many other European countries, mainly due to the relatively higher fertility rate (1.6 compared to 1.5 in the European Union) and the high net immigration of young people (OECD, 2020[56]; Statistics Norway, 2019[14]). Aging is expected to be an important issue in Norwegian rural areas, where the elderly dependency ratio (population aged 65 and above per 100 population aged 15-64) largely exceeds the national average (30.6 vs 25.9 in 2018) (OECD, 2020[57]). This is likely to create challenges to welfare in rural areas (Ministry of Local Government and Modernisation, 2019[58]).

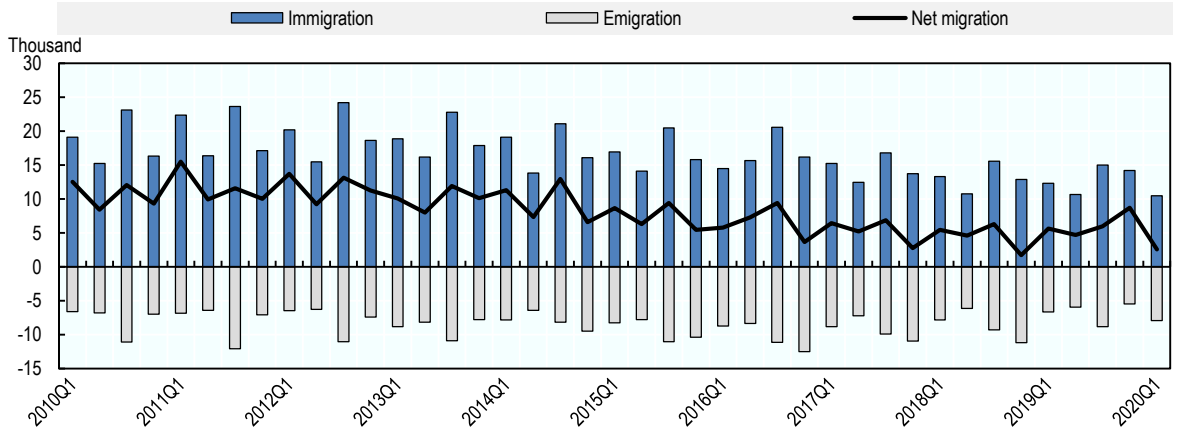
Labour costs are high, but the Norwegian labour market adapts through wage negotiations and the inflow of economic immigrants

Norway has a well-functioning labour market. Its employment rate is one of the highest among OECD countries (74.8% of the Norwegian working age population in 2018 compared to 68.3% in the OECD), wages are comparatively high, while labour market insecurity and job strain are low. Norway's socioeconomic model ensures there is a low level of income inequality, mainly by compressing wage distribution through co-ordinated wage bargaining and the imposition of taxes and transfers (Sila and Hemmings, 2020[59]).

The labour market is also relatively resilient. The co-ordinated wage negotiation system ensures that real wages are responsive to macro-economic conditions and helps to limit the impact of a potential economic shock. Most of the Norwegian economy participates in a two-tier bargaining system. At the country level, a target wage increase is negotiated for the manufacturing sector, which is highly exposed to international competition. The result provides a framework for wage increases in other sectors of the economy, including agriculture income (Sila and Hemmings, 2020[59]) (see also information on the "Basic Agricultural Agreements" in Chapter 2). However, this leads to high labour costs (NOK 479.5 or USD 59 per hour in 2018, compared to the EU27 average of USD 32) (Eurostat, 2020[38]).

Labour migration is another shock absorber as it responds dynamically to economic cycles (Figure 1.17). Since 2004, the Norwegian labour market has been open to migration inflows from the European Economic Area (EEA). Initially, most of the immigration was primarily work-related. However, in recent years, family reunification and refuge have become more frequent reasons for migration, with the highest inflow of refugees, mostly from outside the EEA, occurring during 2015-16 (Statistics Norway, 2019[14]). The growing proportion of foreign-born residents (15.4% in 2018 compared to 6.6% in 2000) (OECD, 2020[56]) is changing the demographic composition of society and requires policies that focus on the complex issue of integrating immigrants into the labour market (Sila and Hemmings, 2020[59]).

Figure 1.17. Migration in Norway responds dynamically to economic cycles



Source: Statistics Norway (2020[21]), Population (databases) [table: 11327], https://www.ssb.no/en/statbank/ (accessed July 2020).

Agriculture and forestry are examples of sectors relying on labour immigrants. According to the estimates by the Institute for Rural Regional Research (Ruralis) (Norwegian Ministry of Agriculture and Food, 2020[17]), well over 20 000 immigrants worked on Norwegian farms in 2011, which corresponds roughly to 13% of the total agricultural labour effort. After a temporary slowdown in the use of foreign-born labour around 2009-10, it has accelerated. The duration of the involvement of labour immigrants in agriculture has also been steadily increasing. As Norway is part of the common European labour market through the EEA Agreement and the EFTA Convention, immigrants with EU/EEA/EFTA citizenship do not need special work permits. Such permits are necessary for seasonal workers from outside this area (Norwegian Ministry of Agriculture and Food, 2020[17]).

Despite high expenditures on education, the results are not outstanding

Norway gives high national priority to education. The country's overall expenditure on education, from elementary to tertiary, is one of the highest among OECD countries. In particular, spending on higher education is high (USD 21 993 or NOK 184 746 per student), and growing rapidly (20% increase between 2010 and 2016, compared to 5% for the OECD). Up to 6.5% of GDP is spent on higher education (OECD, 2019[60]).

In this context, Norwegian educational attainment levels appear to be relatively weak. Norway's PISA (OECD Programme for International Student Assessment) scores have remained stable across cycles at a level close to or slightly above the OECD average. Nevertheless, OECD analysis indicates there are persistent performance gaps between immigrant and non-immigrant students, as well as between boys and girls that will need to be addressed by policy makers (OECD, 2020[61]). Moreover, although the tertiary education in Norway is above the OECD average (44% of the population aged 25-64, compared to the OECD average of 39%) (OECD, 2019[60]), the completion rate of upper secondary education in some age groups have been deteriorating slightly (OECD, 2020[61]). There are also interregional differences in this respect, with some municipalities in eastern and northern parts of Norway having over 35% of the population aged 25-64 with only a basic education (compared to the national average of 20%) (Ministry of Local Government and Modernisation, 2019[58]).

With respect to agro-food or forestry specific education, there are three universities that offer bachelor and master level programmes: Norwegian University of Life Sciences (Campus Ås); Inland Norway University of Applied Science (Campus Blæstad: agriculture and Campus Evenstad: forestry); and Nord University (Campus Steinkjer). The number of university students in fields related to agro-food and forestry is

relatively low and has been declining over the last decades (Chapter 4). In 2019, of a total of 293 000 students in Norway, approximately 2 000 pursued agro-food and forestry studies, and only one in four studied "core" agriculture or forestry. To address this issue, the Norwegian Institute for Bioeconomy Research (NIBIO) recently launched a research project for a better alignment of university courses with the skills and competences required in the sector (Norwegian Ministry of Agriculture and Food, 2020[17]).

1.3.7. Infrastructure and rural development policies

Investments in physical and knowledge infrastructure, including Information and Communication Technology (ICT), (Section 1.3.8), are essential to overall growth and development as they facilitate the delivery of and access to important services. In the agro-food sector, they play a critical role in linking farmers and related businesses to markets. They also boost agriculture productivity and encourage investment in innovative techniques and products. Broader rural development policies increase opportunities of off-farm income and employment, mitigate the income risks of farm households, facilitate on-farm investment, and enable a wider range of choices for farm production. Good quality rural services, from banking to education and health, are essential to ensure the connectivity and attractiveness of these areas for customers, suppliers, and collaborators. Moreover, favourable rural policy can attract innovative upstream and downstream industries, with possible spill-over effects locally (OECD, 2020[5]).

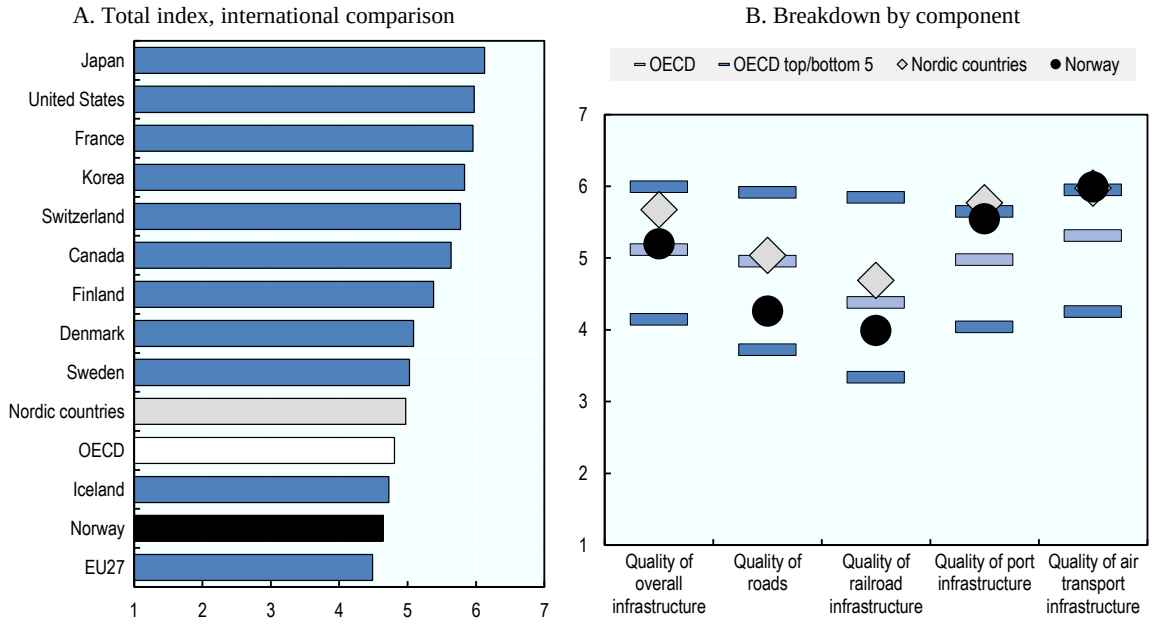
High investment in infrastructure is delivering comparatively low results

The 2018 White Paper on Rural and Regional Policy sets the framework for Norwegian regional policies (OECD, 2019[62]). The government promotes policies aimed at preserving rural and remote communities and underlines the necessity of minimising differences between regions in Norway and levelling living conditions and access to basic services across the country. Support to rural and remote areas encompasses a wide range of policies, including subsidies for transport and ICT infrastructure, health and cultural facilities, and economic activities, notably support to agriculture (Chapter 2) (OECD, 2017[63]). As a result, the population living in predominantly rural remote regions is stable and its share in the national population (23%) is fourth highest among OECD countries, after Iceland (28%), Greece (28%) and Ireland (24%) (OECD, 2020[57]). However, this apparent stability hides relatively low birth rates and interregional domestic migration to urban centres, balanced by immigration (Ministry of Local Government and Modernisation, 2019[58]).

In view of Norway's low population density (17 persons per km^2), high concentration in the main urban centres or intermediate areas (74% of the Norwegian population) (OECD, 2020[57]), and the large geographical distances, the provision of infrastructure and services throughout the country presents specific challenges. Every four years, the Norwegian Government publishes "National expectations to regional and municipal planning". The most recent edition covers the period 2019-23; the government emphasises the need for the regional transport network to contribute to resource efficiency, industrial development, settlement, and social sustainability in various parts of the country. The current National Transport Plan for 2018-2029 aims at better mobility for people and goods throughout the country, decreased transport costs, improved safety conditions, and reduced emissions. To meet these broad goals, the government increased the related budget considerably, from NOK 42 billion (USD 7 billion) in 2013 to NOK 73 billion (USD 8 billion) in 2019 (Norwegian Ministry of Agriculture and Food[17]). However, given the large number of planned projects to improve the low quality of roads and railroad infrastructure (as evaluated by the WEF Global Competitiveness Index, Figure 1.18), OECD (2019[64]) advises strengthening the project selection process based on robust cost-benefit analysis.

Figure 1.18. Quality of roads and railroads infrastructure in Norway remains below the OECD average

Global Competitiveness Index: Transport infrastructure index, 2017-18



Notes: Scale from lowest (1) to highest (7) performance. Indices for EU27, OECD and Nordic countries (Denmark, Finland, Iceland, Norway and Sweden) are the simple average of member-country indices. OECD top/bottom 5 refers to the average of the scores for the top/bottom 5 performers on the aggregate Transport infrastructure index among OECD countries.
Source: WEF (2017[44]), The Global Competitiveness Report 2017-2018: Full data Edition, http://reports.weforum.org/global-competitiveness-index-2017-2018/.

In 1990, an "Action zone" was established in Finnmark and Nord-Troms to increase access to skilled labour. The instruments applied included: reduction in personal taxes, exemption from employer's social contributions, depreciation of study loans, and exemption from electricity tax on consumption (Ministry of Local Government and Modernisation, 2019[58]; Norwegian Ministry of Local Government and Modernisation, 2019[65]). The mountainous areas of southern Norway impose other challenges with respect to development and are covered by the special rural policy programmes aimed at developing expertise and networks, entrepreneurship and innovation in business and industry (Norwegian Ministry of Local Government and Regional Development, 2013[66]).

Subsidies provided to farmers are adjusted by regions to partially compensate for the hardship resulting from natural conditions (Chapter 2). Nevertheless, the importance of the agricultural sector varies considerably across regions. In absolute terms, Rogaland County in southwestern Norway, and in particular Jæren, is the main farming region with respect to gross product and employment. However, agriculture's role in the regional economy is highest in Nord-Trøndelag County, which is located mostly in the Central Lowlands (Knutsen, 2020[4]).

1.3.8. ICT and new technologies policies and regulations

Basic Information and Communication Technologies (ICT) infrastructure and an appropriate regulatory framework strongly impact the adoption of innovation and the use of data (OECD, 2020[5]). In the agro-food sector, the development of a physical ICT infrastructure not only facilitates the flow of knowledge and access to information, but also provides an opportunity to improve productivity and sustainability at the

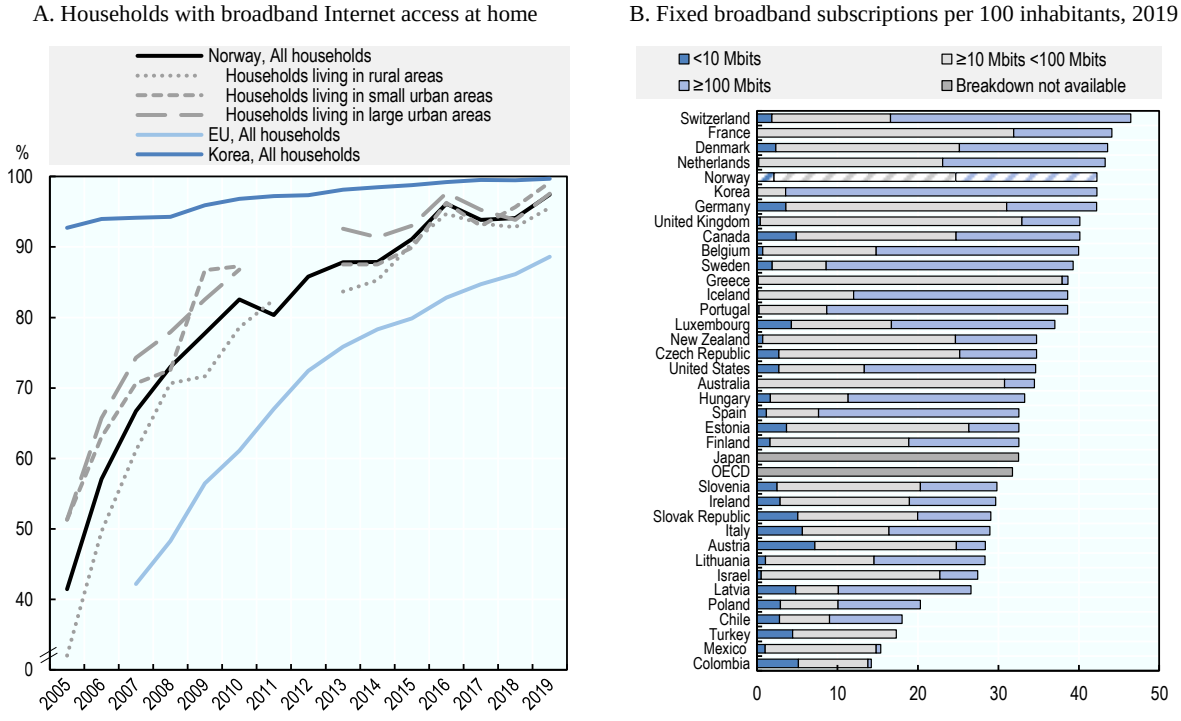
farm level by applying new digital tools and data (OECD, 2019[67]). Good quality agricultural data (e.g. farm- or field-level data) are a prerequisite for evidence-based policies and for the development of new, tailored services for agricultural producers (OECD, 2020[5]).

Norway is well-positioned on digitalisation and technology adoption

In the Digital Agenda for Norway (Norwegian Ministry of Local Government and Regional Development, 2015[68]), the government acknowledged the importance of digitalisation and its underlying infrastructure which will contribute to achieving its ambitious objectives to modernise and simplify the public sector, and facilitate daily activities of business, industry, and private citizens.

Norway is well-positioned in terms of coverage and use of fixed and mobile broadband. Almost all Norwegian households have access to broadband Internet. The share of households with such access nearly doubled between 2005 and 2009 (from 40.2% to 77.8%), and continued to grow, albeit at a slower pace, to reach 97% of all Norwegian households in 2019. This is only 2.3 percentage points below the most advanced country, Korea (Figure 1.19, Panel A). Furthermore, the gap between urban and rural areas has been gradually closing: almost 20 percentage points in 2005, 15 in 2009, and only 4 in 2019.

Figure 1.19. Broadband use is widely spread in Norway with the rural-urban gap closing



Notes: Panel B: Data for Canada, Switzerland and the United States are preliminary; for New Zealand, speed tiers refer to 2018.
The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.
Source: Panel A: OECD (2020[6]), Information and Communication Technology database (ICT Access and Usage by Households and Individuals table), http://stats.oecd.org/ (accessed July 2020); Panel B: OECD (2019[69]), OECD Broadband Portal, https://www.oecd.org/sti/broadband/oecdbroadbandportal.htm.

The market penetration of fixed broadband is one of the highest among OECD countries (42 subscriptions per 100 inhabitants, only four less than the leader – Switzerland, Figure 1.19, Panel B). However, in 2019,

only 42% of subscriptions were contracted for a speed exceeding 100 Mbits, which gives room for improvement compared to Korea (92%). Moreover, the offer of higher speed connections is not uniformly available across the country. In the coming years, coverage is expected to grow steadily as fibre networks expand due to private sector investment supported by government financial aid (Norwegian Ministry of Agriculture and Food, 2020[17]).

Norway is open to the adaptation of new technologies and in this regard it ranks very high (8 out of 137 countries) on the WEF Global Competitiveness Index, with a score above the Nordic countries and OECD averages. The availability of the latest technologies and their adaptation at the firm level are one of Norway's strengths.

The agriculture and forestry sector also seeks to take advantage of digital technologies to improve policy design and implementation (Chapter 4). For instance, in 2020, NIBIO undertook a precision agriculture in practice project (PRESIS) aimed at developing an entire system that will provide Norwegian farmers with information services and counselling on the intersection of new technology and agronomy. There are also some initiatives to look into using digital maps to define subsidies, particularly for steep, small, and poorly shaped fields (Norwegian Ministry of Agriculture and Food[17]).

1.3.9. Food safety and animal health and welfare

Regulations on products and processes aiming to protect human, animal and plant health can also impact natural resource use and boost innovation in response to societal demands. They can build consumer and societal trust in the safety and sustainability of new products or processes. However, unnecessary or disproportionate regulations can stifle innovation and technological developments (OECD, 2020[5]).

Norway attaches great importance to food safety and animal health

The Norwegian Food Safety Authority (NFSA) is a national government body in the food policy area. Its aim is to ensure that food and drinking water are safe for consumers and to contribute to a high level of plant, fish and animal health. The NFSA also contributes to the ethical keeping of animals and encourages environmentally-friendly production. NFSA drafts legislation and provides guidance on existing legislation, performs risk-based inspections, monitors food safety and health, and plans for emergencies.

The NFSA advises the Ministry of Agriculture and Food, the Ministry of Fisheries and Coastal Affairs and the Ministry of Health and Care Services (the Three "Food Ministries"). The Ministry of Agriculture and Food is responsible for the institutional management of the Norwegian Food Safety Authority, in close co-operation with the two others Ministries. The "Food Law" is the overarching law regulating food policy in Norway and it is under the responsibility of the Ministry of Health and Care Services, in co-operation with the two other "Food Ministries" (Norwegian Ministry of Agriculture and Food, 2020[17]). As a member of the EEA, Norway is bound by the adopted EU legislation in the food policy area, including animal health (with the implementation process of EU legislation in this area ongoing until 2021). Norway, as a WTO member, also follows the relevant WTO obligations in this policy area.

The Norwegian Veterinary Institute (VI) (Chapter 4) is a biomedical research institute and the national leading centre of expertise in biosecurity in fish and land animals. Its goal is to become Norway's centre of preparedness for One Health. It focuses on contingency planning and competence development to prevent threats to the health of fish, animals and human beings. Core activities include diagnostics, research, innovation, monitoring, risk assessment, consulting and communication, being a national and international reference laboratory involved in a wide range of international collaboration.

Animal health is good in Norway, which has a long-standing history of high awareness of antimicrobial resistance (AMR) (Box 1.1). The prevalence of contagious animal diseases is low in Norway for several reasons. These include: climate and geography, with the Scandinavian peninsula being at "the corner of Europe"; demography, with scattered and small-scale production; limited movement of animals both inland

and cross border, with trade mainly being with ova and semen; close co-operation between the authorities, veterinarians, and a responsible and competent livestock industry. Norway has surveillance programmes in place to maintain the situation.

The 2010 Animal Welfare Act was a milestone legislation for animal welfare. The Act outlined the general rules for the protection of all animal species and was based on the European Convention for the Protection of Animals kept for Farming Purposes. The rules reflect the so-called “Five Freedoms”.

Box 1.1. Anti-Microbial Resistance is a priority for the government in Norway

Antimicrobial resistance (AMR) is a top priority on Norway’s national and international agenda. The use of antibiotics in animals in the country is among the lowest in Europe according to the Report on the European Surveillance of Veterinary Antimicrobial Consumption (ESVAC) (European Medicines Agency, 2019[70]). AMR is one of the world’s greatest challenges to human health today, and because AMR knows no boundaries, whether geographical or sectoral, as reflected in the Global Action Plan by WHO/OIE/FAO, it can only be contained through co-ordinated global action. The goal is to promote the prudent and responsible use of antibiotics to minimise the threat of AMR and, more importantly, to ensure availability of effective and life-saving drugs in the future for both animals and humans. Sustainable food systems based on good agricultural and animal husbandry practices, hygiene measures, and biosecurity are fundamental.

The AMR priorities for Norway include: 1) strengthening global capacity to monitor the use of antibiotics and growing resistance; and 2) help strengthen national capacities to develop, implement, and enforce regulations. Norway emphasises the use of preventive measures as well as reduced and the correct use of antibiotics. This includes ending all use of antibiotics as growth promoters and routine prophylaxis in animal food production. Article 17 of The Medicines Act states that veterinarians are allowed to dispense medicines only in acute situations and are limited to non-profit sales.

The Norwegian monitoring system of antibiotic resistance in microbes (NORM) is a surveillance programme for antimicrobial resistance in human pathogens. The NORM-VET is a monitoring programme for antimicrobial resistance in bacteria from feed, food and animals. Both present data on the occurrence of antimicrobial resistance and the usage of antimicrobial agents in humans and animals. The NORM and NORM-VET programmes were established as part of the Norwegian Government’s Action Plan against Antimicrobial Resistance issued in 2000. NORM is co-ordinated by the Department of Microbiology and Infection Control, University Hospital of North Norway in Tromso, while NORM-VET is managed by the Norwegian Veterinary Institute in Oslo. A joint NORM/NORM-VET report is issued annually. Following the Commission Implementing Decision 2013/652/EU, the official Norwegian monitoring programme NORM/NORM-VET was confirmed as legally binding.

The first Norwegian cross-sectoral National Action Plan (NAP) against antibiotics resistance was adopted in 2000, and is regularly revised. The Norwegian National Strategy Against Antibiotic Resistance 2015-2020 presents the most recent government long-term goals. An overarching goal is to be a driver in international and normative work to improve access, responsible use, and development of new antibiotics, vaccines and better diagnostic tools. Sector-specific goals include: mapping the reservoirs of antibiotic resistant bacteria; preventing LA-MRSA in the Norwegian pig population and reducing ESBL in the Norwegian poultry-production to a minimum; and the use of antibiotics in terrestrial animals used for food production is to be reduced by at least 10% compared with 2013 (Norwegian Ministries, 2015[71]). All these goals are expected to be achieved by 2020, and it is planned that the same strategy will continue in following years.

The Norwegian livestock industry, including poultry, has engaged in a joint action plan on antimicrobial resistance. This includes strengthening preventive veterinary medicine and organised disease control,

and eradication via different animal health services. The livestock industries have collaborated in developing this action plan to prevent the spread and development of antimicrobial resistance in microorganisms. The measures will be adapted to fit different animal species and will be incorporated into and described in greater detail in action plans on health and welfare for individual animal species. Recent socioeconomic analyses of surveillance and control of LA-MRSA transmission in the Norwegian pig population have shown that the most comprehensive action strategies – including prevention and control – is the most cost-effective approach (Norwegian Food Safty Agency, 2016[72]; 2014[73]).

Source: Norwegian Ministry of Agriculture and Food.

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Notes

[1] For a precise definition of some of the concepts in Figure 1.1, and their corresponding indicators, see the OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework (OECD, 2020[5]). As defined by the Oslo Manual (OECD/Eurostat, 2018[77]), innovation is interpreted as a broad concept, beyond research and development (R&D) and encompassing both the creation and adoption of innovation, which can be "new to the firm, new to the market or new to the world". For productivity, the most comprehensive indicator of productivity – the Total Factor Productivity – is used by default, while sustainability refers to the preservation of natural capita, i.e. environmental sustainability.

[2] In the period 2005-13, a new digital map basis was introduced as a control basis when applying for a production subsidies. During this period, the registered area showed a decrease of 4.7%. Figures from the Norwegian Agriculture Agency show that the introduction of the new digital mapping system meant a reduction in the area of approximately 3.3%. It is not possible to say whether the decline is due to more accurate measurements or whether previous declines have not been captured before a new map was introduced. Area decrease outside the new map system was thus approximately 1.4% in the same period (NIBIO, 2020[76]).

[3] Registered agricultural and/or forest proprieties include only properties with at least 0.5 ha of agricultural area and/or at least 2.5 ha of productive forest area.

[4] "Technology classes (…) are defined statistically using a production function based latent-class estimation procedure linked to a principal component analysis. A number of multi-dimensional indices define the farms' characteristics, on the basis of which the estimation procedure groups them into up to four distinct classes. The production technologies and productivity patterns are modelled and evaluated for the different kinds of farms using a flexible functional form, and measures of farm performance are derived." (Sauer and Moreddu, 2020[39]).

[5] Multidimensional indices are calculated using the principal components analysis (PCA) method (Sauer and Moreddu, 2020[39]).

[6] Authors' calculations based on data from the World Integrated Trade Solution (WITS, 2020[74]).

[7] The Global Entrepreneurship Monitor (GEM) analyses the following entrepreneurial framework conditions: entrepreneurial finance, support and relevance of governmental policies, taxes and bureaucracy, government entrepreneurship programmes, entrepreneurial education at school stage and post school stage, R&D transfers, commercial and legal infrastructure, internal market dynamics, internal market burdens or entry regulations, physical infrastructure, and cultural and social norms. See more information at https://www.gemconsortium.org.

[8] The World Bank's Doing Business indicators compare business regulation environments across economies and over time. Based on standardised case scenarios, Doing Business measures aspects of business regulation affecting domestic small and medium-size firms located in the largest business city of each economy (World Bank (2020[75]). See more information at http://www.doingbusiness.org.

2 The agricultural policy environment in Norway

Norway provides the highest levels of support to agricultural producers among OECD countries. Reforms have been limited and the main agricultural sectors remain highly insulated from world markets. Market price support is provided though high border protection and regulated primary domestic markets, while a large share of budgetary support remains coupled to current production. These coupled support measures are not only potentially the most trade distorting, but are generally found to have a negative impact on productivity and technical efficiency, and to produce negative environmental outcomes. A key goal is to sustain agricultural activity in rural areas across the country. However, the share of support that is targeted to environmental objectives is low. It is possible to reform the support policy package with more targeted and decoupled measures that improve environmental outcomes, while maintaining production capacity across the country.

Key messages

- Agricultural policies in Norway pursue four main objectives: food security; agriculture throughout the country; increased value creation; and sustainable agriculture with lower emissions. These are implemented through four pillars: the annual agricultural agreements between farmers and the government; strong border protection; farmers' responsibility for marketing balance through producer co-operatives; and a property policy to secure family-owned farms.
- Norwegian farmers receive on average 59% of their revenue from agricultural support measures (PSE). This is the highest level across all OECD countries and more than three times higher than the OECD average. Market price support (MPS) –sustained by tariffs and market regulations – and coupled payments remain the main components of support. This type of support is not only potentially the most trade distorting, but generally found to have a negative impact on productivity and technical efficiency, and to produce negative environmental outcomes.
- Sustaining agricultural activity in rural and remote areas is a stated policy objective. Agricultural policies attempt to reserve the scarce most favourable lands for arable crops, while ruminant livestock is channelled to regions with less favourable conditions. To achieve this regional pattern, agriculture is highly supported, with support prices and payments differing across regions. However, climate change ranks high in the current agricultural policy debate and it will be increasingly difficult to reduce greenhouse gas (GHG) emissions from agriculture without significant policy reform.
- Norway needs to gradually reduce border protection and commodity-specific support in a predictable way to allow markets to play their role in allocating production resources. The current high levels of support are likely to become increasingly untenable over time.
- Norway should address the conflicts between its agricultural and environmental policy goals. It is possible to achieve the objective of preserving production capacity and agricultural landscape across the country, while reducing the negative environmental impacts. The core objectives of production-channelling policies could be achieved more efficiently through decoupled support with payment rates that are adapted to each location, and subject to requirements for maintaining production capacity.
- Direct payments to farmers should be made conditional on proper implementation of an environmental plan. The polluter-pays-principle should be applied more systematically to hold farmers accountable for all harmful environmental effects; for example, taxes on fertilisers and penalties can be imposed where these contribute to water pollution. Efforts should be increased to provide targeted advice to farmers on sustainable technologies and practices.
- Consideration should be given to enhancing the role of farmers in managing their business risk by introducing voluntary risk-management programmes.

2.1. Agricultural policy framework and objectives

The strategic objectives of agricultural and food policies, as set out in the 2016-17 White Paper *Change and Development – A Future-oriented Agricultural Production,* are: food security; agriculture across the country; increased value creation; and sustainable agriculture with lower emissions of greenhouse gases (GHG) (Det Kongelige Landbruks - Og Matdepartementet, 2016[1]).

Consumers are to be provided with nutritious, high quality products, and the production process should be mindful of aspects related to the environment, public health, and animal welfare. Norway's agricultural policy aims to safeguard agricultural resources, develop know-how, and contribute to the creation of employment and value added in farming and farm-based products across the country.

The political platform released by the coalition government, formed in January 2019, broadly follows the strategic orientations of the 2016-17 White Paper. The government aims*, inter alia*, to enhance the efficiency and competitiveness of the sector, while maintaining the overall system of market regulation. Agricultural policy will continue to build on four pillars: the system of annual agricultural negotiations and agreements; a strong border protection; farmers' responsibility for marketing balance through producer co-operatives; and a property policy to secure family-owned farms.

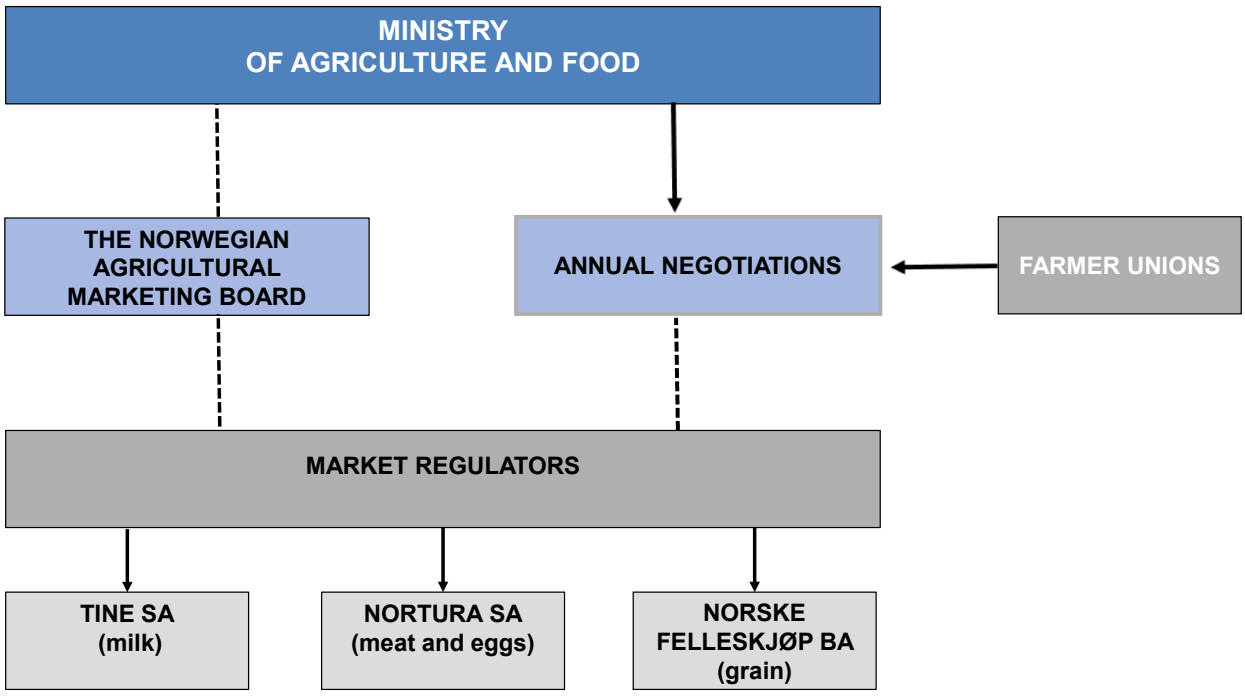
Other key elements of the political platform include: continuation of the milk quota system; introduction of the Act on Good Business Conduct in 2020; following up on the soil protection strategy; encouraging organic farming; reinforcing the focus on animal welfare; strengthening R&D; and continuation of the policy for low antibiotic use and low prevalence of antibiotic resistance in animal husbandry.

The Ministry of Agriculture and Food has prime responsibility for policies relating to agricultural production, food and management of the entire food chain, acting together with the Ministry of Trade, Industry and Fisheries, and the Ministry of Health and Care Services. The Norwegian Agriculture Agency (*Landbruksdirektoratet*) is the implementing agency for the Ministry of Agriculture and Food, while it also undertakes studies and provides advice on policy issues.

The design of agricultural policy involves annual negotiations between the government and the two nationwide farmers' organisations, the Norwegian Farmers' Union (*Norges Bondelag*) and the Norwegian Farmers' and Smallholders' Union (*Norsk Bonde – og Småbrukarlag*). These negotiations set key parameters such as target prices (prices the agricultural co-operatives purchase products from farmers), agricultural policy programmes, including direct support schemes and welfare support programmes for farmers, and market regulation systems (marketing levies paid by producers, milk quotas).[1] Issues which are not negotiated include: tariffs and trade arrangements; tax and levies; and laws and regulations. The main consideration under the negotiations is the implications of support for net farm incomes so farming can be maintained.[2] These annual negotiations (so-called Agricultural Agreement) have been in place since 1950. If no agreement is reached, the government may invite Parliament to set the essential parameters (e.g. overall changes in budget transfers and target prices) and let the negotiating parties work out the detailed allocation of parliament's package. Such was the outcome in 2017.

The system of Basic Agricultural Agreements is underpinned by Norway's border protection measures and domestic market regulations based on the Marketing Act (*Omsetningsloven*) of 1936. This Act regulates the domestic market for certain types of meats (beef, mutton, pork and poultry); milk, butter and cheese; cereals and oilseeds; potatoes, vegetables, fruit and berries; and fur skins. Its key objectives are to balance the domestic market and to stabilise prices in accordance with the target prices established in the Basic Agricultural Agreements. The Act is administered by the Sales and Marketing Council (*Omsetningsrådet*).[3] Agricultural co-operatives, which are owned by farmers and are dominant in most sectors, are responsible for the market balance within their respective sectors (except horticulture) (Figure 2.1). The most important regulatory measures are production and demand forecasts, marketing and promotion, storage, and some exports. Subsidised exports are abolished as of 1 January 2021.

Figure 2.1. Agricultural policy framework in Norway



The mix of specific instruments employed to regulate markets may have varied over time, but the guiding principles for the system have remained largely unchanged. There are three general approaches to balance the market: target pricing; volume-based; and reference pricing (Table 2.1). Under the *target pricing approach*, the Basic Agricultural Agreements set target prices for a number of products (fresh milk, pork, grain, oilseeds, potatoes, apples and some vegetables).[4] Under the *volume-based approach,* the market regulator is obliged to announce "planned average wholesale prices" for consecutive six-month periods. This is used for beef (since 2009) and for sheep meat, lamb and eggs (since 1 July 2013). The *reference pricing approach* entails the establishment of a reference price at the wholesale level in order to calculate the applied tariff. It applies to poultry, for which target prices were eliminated in 2007 and there is currently no market regulation. The target-price mechanisms vary in design.

In the 2016-17 White Paper, the government also made some proposals which, in its view, could make the system more flexible and efficient, and stimulate competition in the processing and distribution sectors. The principal recommendations included: i) the transfer of pork from the "target price" to the "volume" model; ii) fewer milk-producing regions to reduce observed geographical price differences in milk quota sales and leasing; iii) the purchase of goat milk quotas and termination of market balancing for goat milk; iv) the discontinuation of the current market regulation for eggs and grains, leaving the Norwegian Agricultural Authority in charge of future balancing measures; and v) the abolition of welfare schemes in favour of higher deficiency payments per animal. However, most of these proposals remain unimplemented as they have not found a majority in Parliament.

Agricultural producer co-operatives play a prominent role in the supply chain of some sectors, particularly dairy, and their establishment is common practice in Norway (Chapter 4). There are 16 nationwide co-operative organisations, which together form the Federation of Norwegian Agricultural Co-operatives (*Norsk Landbrukssamvirke*). They specialise in either sales, purchasing, or breeding. The three largest producer co-operatives are: Tine SA (dairy), Nortura (meat and eggs) and Norske Felleskjøp BA (grains) (Box 2.1). Tine and Nortura are sole regulators in their respective sectors, while Norske Felleskjøp may undertake market regulation with other grain traders (through tender).

Table 2.1. Market balancing approaches in Norway

Target pricing approach	Volume-based approach	Reference pricing approach
Target price established in the Basic Agricultural Agreement (BAA)	No target price established in the BAA, but market regulator announces the planned average wholesale price for each six months	No market regulator, no market regulation, and no mandatory acceptance or supply provisions
Market regulator ensures that target prices are attained in a balanced market	Storage is subject to ceiling	No attempt to balance the market or regulate the production
If the target price is exceeded, a lower target is fixed for the following year	Exports undertaken in exceptional circumstances (no longer possible from 2021)	A reference price (wholesale) is established, based on the previous year, to determine the applied rate of import duty
The Norwegian Agricultural Authority reduces the import duty if the target price exceeds the upper price limit for two consecutive weeks	Tariff reductions as under target pricing	Tariff reductions effected through administrative procedure when observed market price exceeds upper price limit
Applicable to milk, grain, pork, potatoes, apples and ten types of vegetables	Applicable to beef, sheep/lamb and eggs	Applicable to poultry, commonly known as "the chicken model"

Source: Norges Bondelag, Jordbruksoppgjøret 2017, Ny jordbruksmelding – ny kurs (in Norwegian), viewed at: https://www.bondelaget.no/getfile.php/13764146/Bilder%20fylker/M%C3%B8re%20og%20Romsdal/Dokumenter/2017/Studieheftet%202017%20til%20web.pdf, as reported in WTO (2018[2]).

The market power of co-operatives is formalised by the market regulation system that gives the co-operatives a special role in implementing market regulations to balance supply and demand. Potentially, co-operatives could distort efficiency and competition in the primary sector. Moreover, as the agricultural sector is exempt from competition policy, agricultural support policies may have side-effects in the food supply chain, impeding its productivity growth and competitiveness (Productivity Commission, 2015[3]) (Chapter 5).Market regulation is based on three obligations: i) the acceptance by the market regulator of all produce offered; ii) its obligation to supply all processors on non-discriminatory terms; and iii) the non-discriminatory provision of relevant market information to all parties concerned.

A fee (market balancing levy) from the remittances for farm deliveries is collected by buyers of agricultural products from farmers (e.g. dairies, slaughterhouses, grain buyers). The fees are established by the Ministry of Agriculture and Food on the recommendations of the Sales and Marketing Board**,** normally for each calendar year. Advisory and extension services, consumer information, and promotional activities are also financed by this fee.

The scope of the measures envisaged depends on the applicable market regulation approach and the nature of the product. For meat, the most common measures are temporary storage or early slaughter. The market for eggs (in shell), which experiences seasonal fluctuations in demand, may be balanced through processing for industrial uses or pre-scheduled slaughtering of hens. Food quality produce (e.g. grain, potatoes and apples) may be converted to animal feed or industrial usage. Export subsidies, which were used as a market balancing measure for cheese, butter, pork and processed agricultural products, ceased to be an option as of mid-2020.

Price rebates may be required when commodities are diverted to less profitable uses. Such rebates may be partly financed by the market balancing levy (e.g. for grains) or paid by the government as agreed in the Basic Agricultural Agreements. The latter option is applied to potatoes used in the manufacture of spirits and potato starch, grains, and other domestically produced raw materials used by the processing industry.

Box 2.1. Farmer-owned co-operatives

Tine SA, the market regulator for milk, is Norway's largest producer, distributor and exporter of dairy products with 11 400 members (owners) and 9 000 farms. It purchases and processes milk and dairy products throughout Norway and has diversified into a range of other activities. As market regulator, Tine is obliged to purchase all milk offered to it by milk producers in the country, and to purchase surplus milk fat in the form of butter from entities outside Tine. In 2020, Tine SA moved the production of cheese (Jarlsberg cheese) to other countries (e.g. Ireland and the United States) to meet demand as the phasing out of export subsidies made exports of Jarlsberg cheese unprofitable.

Nortura BA, owned by more than 28 000 farmers, is the market regulator for meat and eggs. The co-operative employs about 6 500 workers at 37 production sites across the country. Its annual turnover is around NOK 17 billion (USD 2 billion).

Norske Felleskjøp is an umbrella organisation owned producers/suppliers of agricultural inputs such as animal feed, seeds, fertiliser, equipment, and machinery. As a market regulator, Norske Felleskjøp prepares forecasts for the production of domestically grown grain and estimated consumption; issues price projections, and fixes price quotations; proposes import quotas and producer levies; and implements measures to dispose of procured grains. Norske Felleskjøp decides on regulatory measures, but market regulation activities for grains may also be undertaken by other grain traders. In such cases, the allocation of grain purchases is managed through tenders.

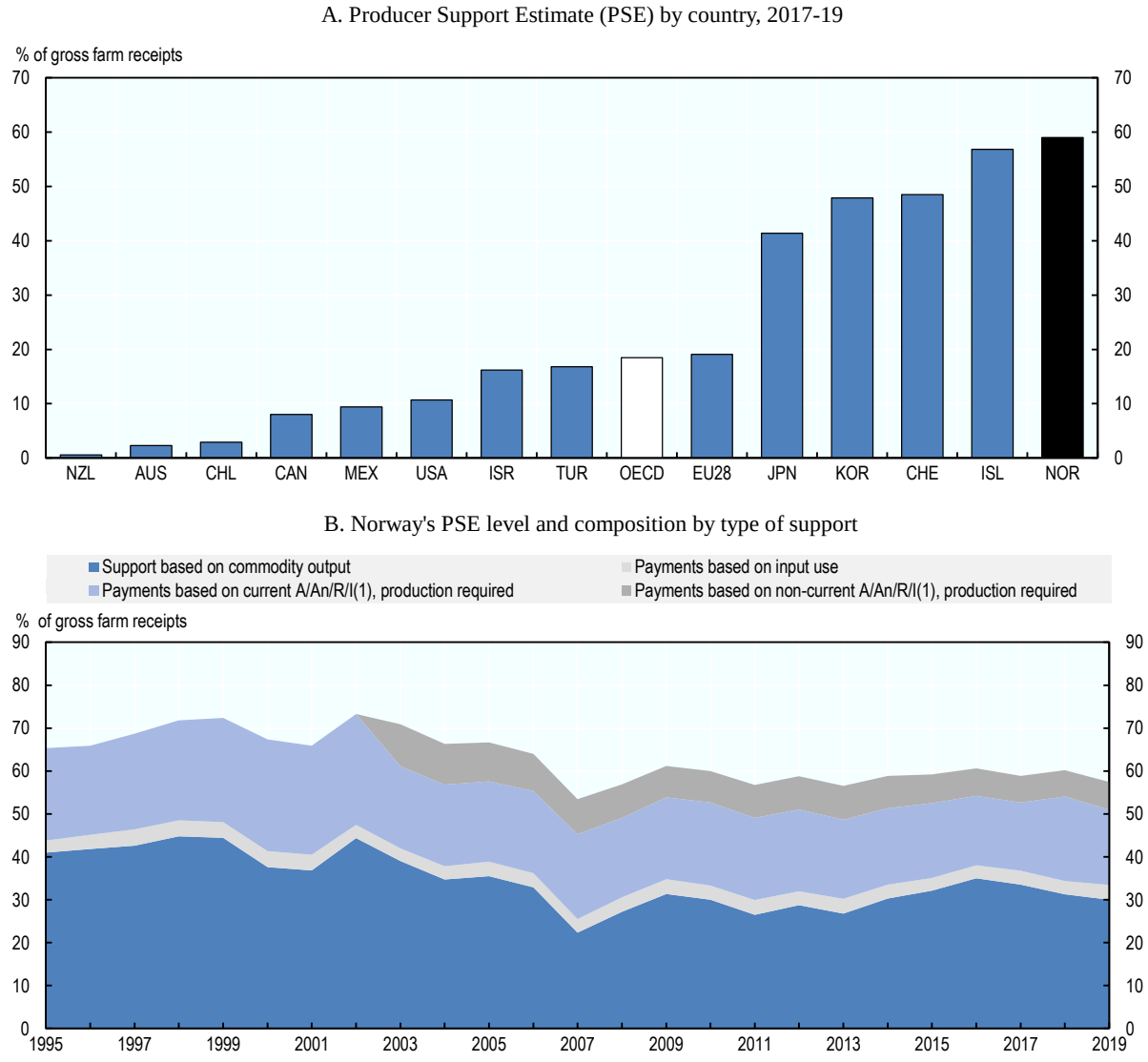
AL Gartnerhallen is the co-operative of fruit, vegetables and berries producers. The co-operative – which has approximately 1 400 growers and an annual turnover of around NOK 1.4 billion (USD 0.2 billion) – sells its goods to industrial users, and wholesale and retail traders. It may occasionally participate with other producers of fruit and vegetables in supply management activities (such as storage) through the Green Growers Co-operative Market Council (*GrøntProdusentenes Samarbeidsråd-GPS*).

In addition to the four co-operatives mentioned above, HOFF SA (which unites some 500 potato growers in the industrial processing of potatoes) and Honningcentralen (owned by some 1 550 beekeepers and engaged in honey processing and marketing) have considerable trading activity.

2.2. Overview of agricultural support policies

Progress in reducing the level of support and in policy reform towards greater market orientation in Norway's agricultural sector has been modest over the last few decades. Measured in Producer Support Estimate (PSE), support to producers (%PSE) has declined gradually since the mid-1980s.[5] In 2017-19, support was around 59% of gross farm receipts, which implies that, on average, the value of support is higher than the value of agricultural production valued at world market prices. Moreover, at 59%, Norway's %PSE is the highest across all OECD and emerging and developing countries for which it is calculated (OECD, 2020[4]), and more than three times higher than the OECD average (Figure 2.2).

Figure 2.2. Norway's support to farmers



Notes: The OECD total does not include the non-OECD EU Member States, nor Colombia which joined the OECD in April 2020.
1. Area (A), animal numbers (An), revenue (R), or income (I).
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

Market price support, mainly due to border protection and domestic market regulation, is the main component of support to farmers and its share in PSE (44%) remained broadly unchanged between 1995-97 and 2017-19. Administered prices for eggs, poultry, beef, and sheep have been removed, but about 61% of production still has some form of administered price. Payments based on output are now around one-third of the 1986-88 level, although payments based on current production factors have increased. While the share of the potentially most distorting forms of support (support based on commodity output and payments based on variable inputs without constraints) has declined significantly, such measures still account for over half of support to farmers due to the continued reliance on market price support. This support is not only potentially the most trade distorting, but is generally found to have a negative impact on productivity and technical efficiency, and to produce negative environmental outcomes (OECD, 2013[6];

Henderson and Lankoski, 2019[7]). Although payments based on non-commodity criteria have increased somewhat over time, they remain trivial, accounting for 0.3% of PSE in 2017-19.

Average support per farm in Norway is substantial. Dividing the total value of producer support by the number of farm holdings suggests that, on average, each farm receives support of around NOK 683 684 (USD 77 700) per year (Table 2.2). Support based on commodity outputs, largely reflecting the customs tariffs, is about NOK 356 158 (USD 40 477) per farm, while among direct forms of financial support, the largest item are payments based on current area or animal numbers, is nearly NOK 207 819 (USD 23 618) per farm.

The cost of support to the population is also significant. On average, total support to the sector (TSE) costs (directly or indirectly) each Norwegian household around NOK 11 857 (USD 1 348) a year (Table 2.2). Support based on commodity outputs (largely due to border protection) costs about NOK 5 685 (USD 646) per household each year. On average, total support to agriculture costs to taxpayers NOK 7 219 (USD 820) per household and to consumers NOK 4 766 (USD 542) per household.

Table 2.2 Scale and composition of Norway's agricultural support, 2019

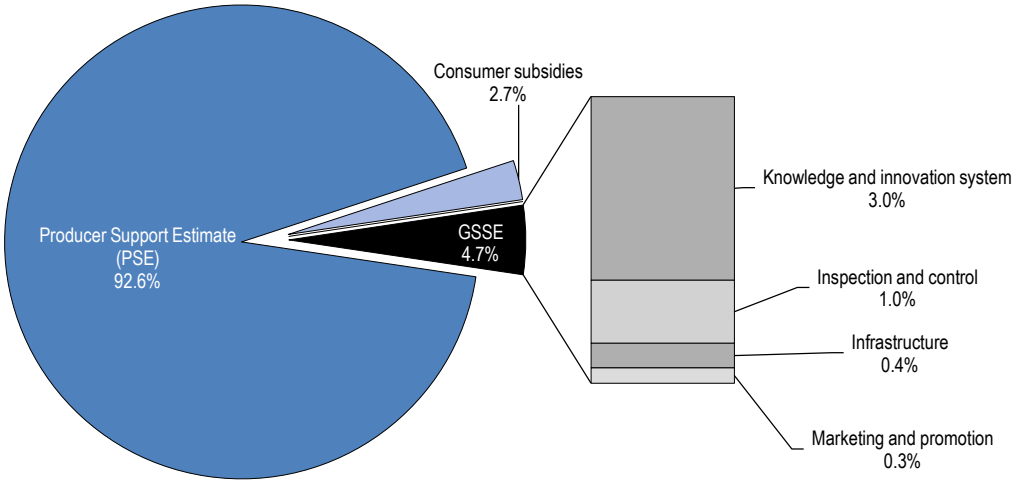
	Total (USD mill.)	Per farm holding (USD)	Per Norwegian household (USD)	Main measures
Producer Support Estimate (PSE)	3 025	77 700	1 240	
Support based on commodity outputs	1 576	40 477	646	Border protection
Payments based on input use	180	4 611	74	Fuel tax concessions; Agricultural Development Fund
Payments based on current area or animal numbers, production required	920	23 618	377	Acreage Support Programme; production subsidy for livestock; subsidy for producing coarse feed; vacation and temporary substitute scheme
Payments based on non-current area or animal numbers, production required	342	8 785	140	Cultural Landscape Payment; Structural income support for milk production
Payments based on non-commodity criteria	8	208	3	Buffer strips
General Services Support Estimate (GSSE)	159	4 071	65	Research and innovation; Norwegian university of life sciences; extension
Total Support Estimate (TSE)	3 287	84 412	1 348	
Transfers from consumers	1 321	33 933	542	
Transfers from taxpayers	2 001	51 394	820	
Budget revenues	-36	-915	-15	

Note: According to Statistics Norway there were 38 938 farm holdings and 2 439 242 households; exchange rate = NOK/USD 8.799 .
Source: Authors' calculations based on OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

Total support to agriculture (TSE) as a share of GDP has declined significantly over time and was slightly less than 1% of GDP in recent years. About 93% of the total support to the sector is provided to individual farms (Figure 2.3). The expenditures for general services (GSSE) relative to total support to agriculture were about three times lower than the OECD average. GSSE relative to agriculture value added was 1.9% in 2017-19, less than the overall OECD average of 5.7%. These expenditures on general services contribute to improving the competitiveness of the sector and its capacity to increase productivity sustainably and resiliently adapt to new shocks and market conditions. They mostly finance the agricultural knowledge and innovation system. Norway's share of GSSE expenditure for the agricultural knowledge and innovation system is particularly high compared to other OECD countries (Figure 2.4), reflecting relatively high expenditure allocated for research and innovation, extension and for agricultural knowledge

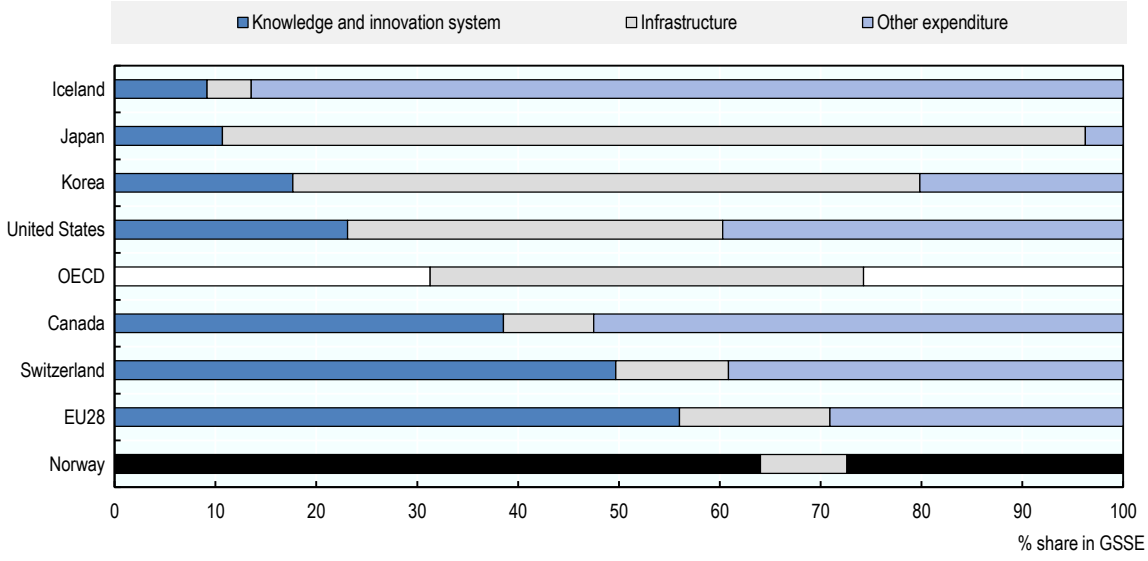
transfer (e.g. public expenditure for agricultural research stations, public expenditure to support research projects at the Norwegian University of Life Sciences, see Chapter 4). However, it remains a smaller share of total support TSE than in other countries: 3% compared with 5.8% in the European Union and 4.2% in OECD (Figure 2.3).

Figure 2.3. Composition of total support to agriculture in Norway, 2017-19



Notes: GSSE: General Services Support Estimate.
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

Figure 2.4. Composition of General Service Support for selected countries, 2017-19

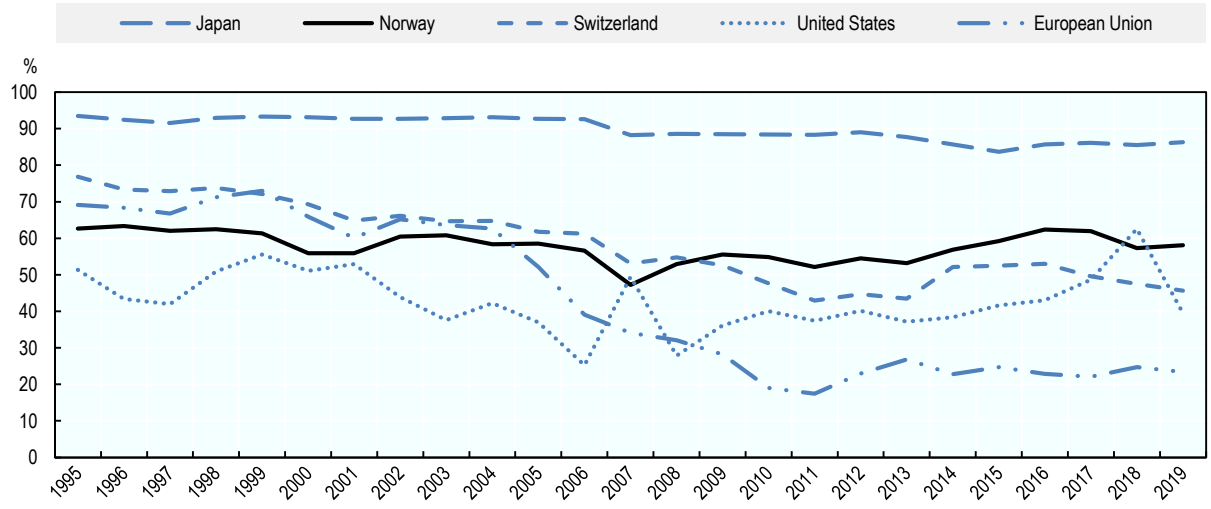


Notes: GSSE: General Services Support Estimate. The OECD total does not include the non-OECD EU Member States, nor Colombia which joined the OECD in April 2020.
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

Looking at product-specific assistance, the Single Commodity Transfers (SCT) accounted for 59% of the total PSE during 2017-19 (Figure 2.5). The share of the SCT in commodity gross receipts is around or higher than 30% for all commodities. Overall, the gap between the prices received by Norwegian farmers and world market prices has narrowed significantly since the mid-1980s, but the current ratio is still close to 2:1. The price gap is largest for poultry, milk, and beef.

Figure 2.5. Single commodity transfers in selected economies, 1995-2019

As a percentage of Producer Support Estimate



Notes: European Union refers to EU15 for 1995-2003, EU25 for 2004-06, EU27 for 2007-13 and EU28 from 2014 onwards. The OECD total does not include the non-OECD EU Member States, nor Colombia which joined the OECD in April 2020.
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

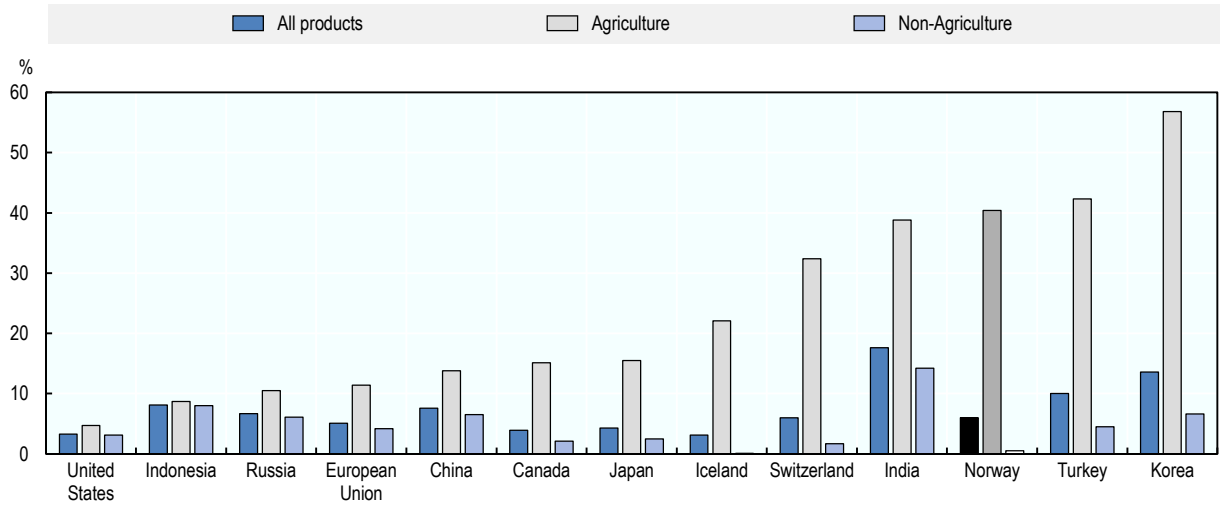
2.3. Agricultural trade policy

2.3.1. Import measures

Border protection through custom duties is one of the most important measures in Norwegian agricultural policy. The import regime for agricultural products is closely linked to domestic market regulations. The main purpose of tariff protection is to ensure that the target prices established in the annual Basic Agricultural Agreements are met but not exceeded. Temporary general tariff reductions are triggered automatically when domestic prices exceed threshold levels for two consecutive weeks. However, the Norwegian Agricultural Authority may reduce tariffs temporarily without waiting for the price limits to be exceeded so as to prevent market imbalances.

Norway's import tariff profile reveals a distinct agricultural bias (Figure 2.6). The simple average applied MNF tariff on agricultural products (WTO definition) was 40% in 2019, compared to an average of 1% for non-agricultural products. Furthermore, the rates vary considerably.

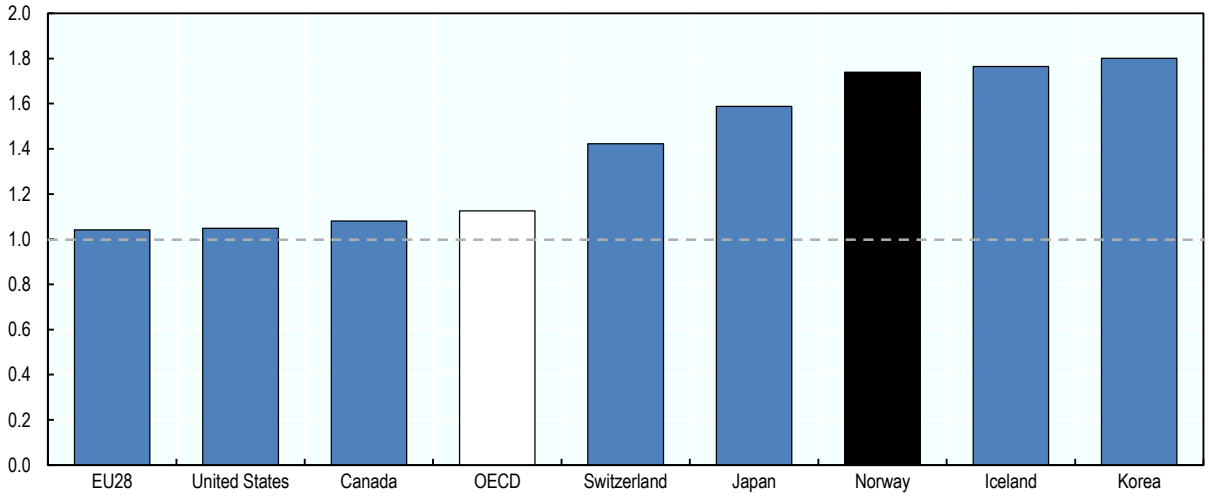
Figure 2.6. Applied tariffs for agricultural and non-agricultural sectors, 2019



Note: Simple average of the ad valorem MFN tariff or AVE HS six-digit duty averages.
Source: World Trade Organization (2020[8]), WTO Data Portal, https://data.wto.org/ (accessed September 2020).

The extensive and high tariffs on agricultural products increase the burden on consumers.[6] In 2017-19, the average price paid by consumers (at farm gate) was 1.7 times higher than the world price (at farm gate) (Figure 2.7).

Figure 2.7. Consumer Nominal Protection Coefficient, 2017-19

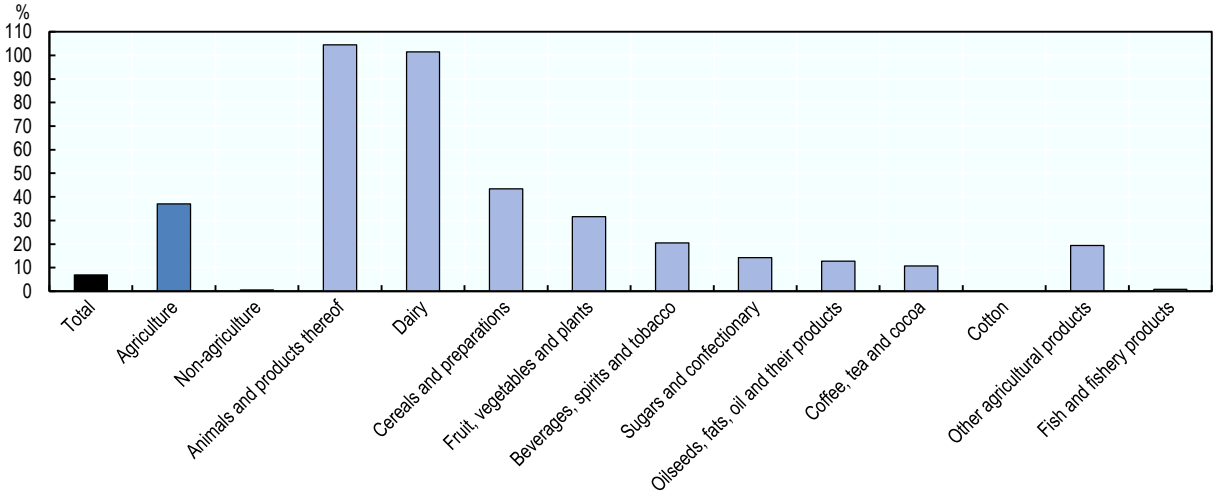


Notes: The OECD total does not include the non-OECD EU Member States, nor Colombia which joined the OECD in April 2020.
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

In 2013, Norway switched from specific to *ad valorem* duties on three agricultural products to strengthen the protection in order to support local food production.[7] The products with the highest tariffs are those produced in Norway (mainly dairy products, meat, and grain), whereas those not suitable for cultivation in Norway are often duty-free (i.e. rice, cotton, bananas, citrus fruits and coffee) (Figure 2.8**)**. Generally, tariffs

on processed agricultural products are low. Although Norway's agricultural tariffs are generally high, most high rates are nevertheless well below the bound levels[8] (WTO, 2018[2]).[9]

Figure 2.8. Applied tariffs in Norway by product groups, 2018



Note: Includes AVEs for non-ad valorem rates. Sugar used for human consumption, tobacco and spirits have no tariffs.
Source: WTO (2018[2]), Trade Policy Review: Norway, https://www.wto.org/english/tratop_e/tpr_e/s373_e.pdf.

Imports are also regulated through tariff quotas, including preferential tariff-rate quotas (TRQs), at no or low rates of import duty. Most of the tariff quotas are auctioned. Many of the TRQs are not fully utilised as the applied tariff is lower or equal to the in-quota rate or, as in the case of poultry and eggs, self-sufficiency and sanitary concerns limit the scope for imports.[10] Other factors may also be at play, for example certain quotas may be too small to be economically meaningful due to transportation and distribution costs, and dominant importers may have market power (Chapter 5).

Concerning non-tariff barriers to trade, such as sanitary and phytosanitary (SPS) measures and technical barriers to trade (TBT) measures, Norwegian food and veterinary legislation has been harmonised with the European Union. This includes food production and safety, animal and plant health, animal welfare, alien organisms, and gene technology. In general, import requirements are the same as in the European Union, and only products coming from the EU list of exporting countries, species, and establishments may be imported into Norway.

2.3.2. Export measures

Norway's WTO commitments has allowed the use of export subsidies with the main objective to balance the domestic market for various commodities. Except for processed agricultural products, these subsidies are financed by producers. Producer levies are adjusted according to the expected domestic market situation: the higher the expected surplus, the higher the levy.

Export subsidies of processed products to the European Union and marketing activities for horticultural products are financed directly by the government. To compensate food processors for high domestic prices, payments are provided through the RÅK-scheme to food processors buying Norwegian agricultural products going into processed products covered by the EEA-agreement. In 2019, this scheme, which is managed by the Ministry of Food and Agriculture in the Agricultural Agreement, provided NOK 237 million (USD 27 million) (Chapter 5). In the dairy sector, the milk quota and other measures to control production

have reduced the surpluses somewhat, and Norway's actual expenditures on export subsidies have been well below the bound levels for most products.

Consistent with the Nairobi Package adopted at the WTO Ministerial Conference in December 2015, Norway has legislated for the elimination of agricultural export subsidies that will be abolished by 2021, at the latest. The government supports international initiatives to limit the use of export restrictions.

2.3.3. Regional Trade Agreements

The European Economic Area (EEA) Agreement, which entered into force in 1994 between the European Union and Norway, Iceland and Liechtenstein, is Norway's most important and comprehensive economic and trade agreement. The EEA has created a single market with free movement of goods, services, persons, and capital, as well as non-discrimination and equal rules of competition. There is also co-operation in many other areas, such as research, energy, education, environment, and tourism. However, areas such as the EU common agriculture and fisheries policies, as well as the customs union, monetary union, and trade and foreign policies, remain outside the EEA remit.

Norway and the European Union have periodically negotiated their bilateral agreement on trade in agricultural products. An agreement was reached in April 2017 on improved market access through lower tariffs and improved tariff quotas. The EEA Agreement (Article 19) calls for the progressive liberalisation of agricultural trade between Norway and the European Union.[11] As a result, around 40 tariff lines have become duty-free for both parties on goods such as live plants, feed maize, and certain alcoholic beverages.[12] Norway has opened new or expanded quotas on several products, including bovine meat, cheese, vegetables, and meat products (sausages, ham, duck meat, etc.). About 75% of Norway's cheese imports (8 400 tonnes) are currently imported at zero duty under the EU TRQ.

As part of the European Free Trade Association (EFTA), Norway has negotiated 29 Free Trade Agreements (FTAs) with 40 partner countries. Negotiations with MERCOSUR was finalised in August 2019.[13] These FTAs and negotiations include processed agricultural products and a range of primary agricultural products.

2.4. Domestic agricultural policy

Historically, agricultural policies are related to food security, farm incomes and regional distribution of production and employment objectives. Today, they also aim to address consumer concerns, including food safety and animal welfare, environmental issues, climate, cultural landscape, innovation, agro-tourism, and small-scale food industry.[14] The principal policy instruments supporting agriculture include border measures, domestic market regulation based on the Marketing Act, and budgetary payments.

Several direct payments to farmers, including area and headage payments as well as payments based on product quantities, are provided. Many of these payments are differentiated by region and farm size in order to provide adequate income support across all types of farms and regions.

The core support mechanisms are augmented by a host of other programmes that, for example, help cover labour costs or compensate farmers in the event of natural disasters and losses due to predators.

Several programmes are designed to stimulate innovation, entrepreneurship in agriculture-based industry, and the creation of alternative businesses on farms and alternative employment in rural areas (e.g. agro-tourism, local food, green care, energy production). National guidelines and regional plans are the basis for financing local business and rural development projects. Funding is primarily provided through the Agricultural Development Fund. The total allocation of funds for rural development in 2019 (within the Agricultural Agreement) was NOK 1 134 million (USD 129 million).

2.4.1. Regional distribution of production

The regional distribution of agriculture has been a stated policy objective since the 1950s. The goal is to sustain agricultural activity in rural and remote areas where economic alternatives are few, and to sustain total agricultural production and self-sufficiency. Norway has little land that is suitable for arable crops, and an abundance of grass and pasture. Therefore, this policy attempts to reserve the most favourable lands to arable crops, while ruminant livestock is allocated to regions with less favourable conditions. As a result, production of cow and goat milk, and bovine and sheep meat occurs in rural areas in the west and north, while the production of grains and vegetables takes place mainly in the southern parts of the country (Chapter 1). Support policies have succeeded in maintaining this regional pattern.

The main instruments of the "production channelling policy" to achieve this objective are: high grain prices; regionally and structurally differentiated payments (deficiency payments and transport subsidies); and, a quota system for milk production. The rural development aspects of Norwegian agricultural policy include several programmes designed to stimulate innovation and the establishment of alternative businesses on farms and alternative employment in rural areas. Most of the funding is financed by the Agricultural Development Fund.

2.4.2. Direct payments

Direct payments are used to complement market regulations such as the target price, volume, and reference systems described earlier. Payments are mainly issued based on output, animals, and farmed land. In addition, there are significant investment programmes and tax allowances for income from agriculture. Payment rates are commonly based on actual rather than historic farm production, and are thus coupled to production decisions. These coupled payments represent a large share of agricultural income, considerably exceeding market-based gross margins in most farming activities despite very high border protection which drives domestic market prices well above world market levels.

Direct payments are provided for certain meats (beef, pig meat, sheep meat), milk, poultry, wool, fruit and vegetables, cereals, eggs, and certain processed products. Transport subsidies are allocated across various programmes to support transport costs of meat, eggs, grains and feed.

Direct payments include area- and headage-based support, and financial assistance with labour input. The most important area-based support include the Cultural Landscape Support Programme, which provides a lump-sum payment per hectare paid on all agricultural area, and the Acreage Support Programme, which provides payments per hectare differentiated between crops and regions. Headage payments for livestock are provided through various programmes for bovine animals, pigs, goats, sheep, horses, and rabbits; payment rates decrease with the number of animals. There is also a Support for Grazing Animals programme which provides per animal payments that are differentiated by animal and land use category.[15]

There are support schemes for dairy farms, such as a "structural payment" based on animal numbers, a fixed per farm payment for dairy farming on mountain areas, and a quota-limited price support (a base payment and a regional payment per litre of milk for a limited output). Budgetary support for labour includes reimbursements for hiring replacement labour during vacation or to cover for employee illness (Welfare Scheme).

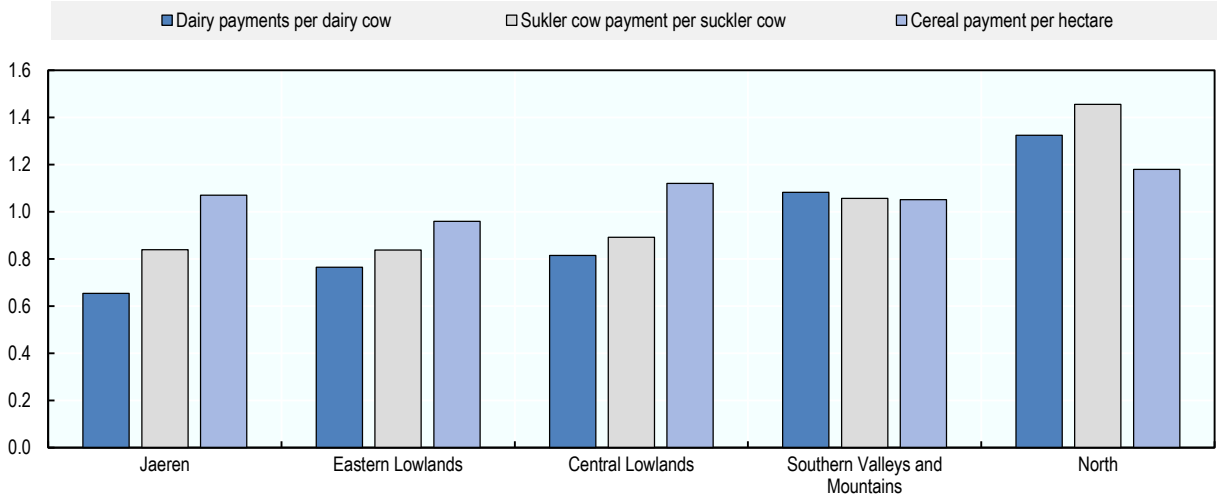
2.4.3. Differentiation of support by farm size and region

Direct payments and transport subsidies are usually differentiated according to region and size of farms. Most payment rates are negatively related to farm size and are higher in remote areas (north) compared to central regions. For instance, the rates of total dairy payments per farm vary from 40% below the national average in Jæren (southwest) to 40% above the national average in the northern region (Figure 2.9). About

half of the payments to producers are differentiated by farm size, and for around 70% of the payments, the rates are differentiated by a combination of farm size and/or region (Mittenzwei and Britz, 2018[9]).

Figure 2.9. Payment rates in Norway by region, 2017

Payment rates compared to national average



Source: Mittenzwei and Britz (2018[9]) and data provided by NIBIO (2020[10]).

Mittenzwei and Britz (2018[9]) found that differentiation of payment rates by farm size has a larger impact on farm structural change than the regional differentiation of payment rates. In addition, milk quotas at the county level prevent regional specialisation of dairy production. In this respect, the current policy regime seems to support the policy objective of maintaining a variety of farms in all parts of Norway. However, agricultural policies for regional specialisation have had significant impacts on farmers' behaviour, resulting in serious environment problems such as soil erosion and water quality in some parts of the country.

Dairy sector

Dairy production is controlled at the market level by the milk quota system. Milk quotas are farm-specific and tradable only at the regional level. There are 14 production regions for quota redistribution and the quota regime is an important tool to prevent concentration of dairy farming in a few more favourable regions. This impacts the majority of the farms given the importance of milk production in a country with limited arable land.

Milk production quotas to regulate the domestic supply of milk were introduced in 1983. The system was made more flexible in 1997 when buying and selling of milk quotas was introduced. Leasing of milk quotas has been allowed since March 2009. New entrants must lease available quotas or buy production quotas from existing farms or the Norwegian Agricultural Agency. Since 2017, farmers selling cow milk quotas have been allowed to sell up to 80% of their quota at a free price directly to other producers within a production region (mainly defined as the county), and a minimum of 20% had to be sold to the government at a fixed price. In the 2020 agricultural negotiations, it was agreed that from the quota year 2022 quotas must be sold at a 40% minimum to the government at NOK 4 per litre (USD 0.4 per litre). The rest can be sold privately at a free price. Each year, the quotas are multiplied by a factor to fix the amount of milk each producer can deliver to a dairy (i.e. actual production possibility).

The second major market balancing measure is a price equalisation scheme that guarantees the milk producer the same price irrespective of his/her location and the end use of the raw milk. In practice, liquid

milk and liquid cream are taxed, while goods such as butter, mature cheeses, and milk powder are subsidised. The scheme, which is entirely financed through equalisation levies,[16] is also used to support transportation costs from farm to dairy, the distribution of milk in northern Norway, and the delivery of milk to schools throughout Norway.

Export subsidies for hard cheeses, principally Jarlsberg, were also financed through this scheme. Although the exported volumes have been declining, cheese exports still absorb approximately 8% of the raw milk produced in Norway.

As a result of the abolition of export subsidies on cheese from 1 July 2020, milk production must be reduced by up to 100 million litres. The government and the Norwegian Farmers Union agreed on a scheme where quotas for up to 40 million litres of milk are removed from the market. The remaining overproduction is to be reduced by lower milk quotas on each farm. For 2020, the basic quotas were initially reduced by 4% in order to balance the market, but then increased twice in response to COVID-19 pandemic.

2.4.4. Investment and credit support

Support for investment expenses comes mainly through schemes run by a special fund (the Agricultural Development Fund). The Fund provides a wide-range support for various investment activities. For example, it provides interest-cost assistance and supports investment in areas such as “traditional” farming, business development connected to other farming activities (local food, agro-tourism and green-care), energy saving, and landscape development.

In general, farmers have sufficient access to credit and finance, although there are some differences especially in the northern parts of the country. To reduce investment risks on farms, the innovation agency, Innovation Norway, provides grants and loans to farmers. Grants are provided throughout the country, while loans are generally provided in regions where loans by the private banking sector are difficult to obtain by farmers.

Bankruptcy is not widespread among farmers. Banking services losses due to farmers unable to fulfil their repayment obligations are insignificant.

2.4.5. Programmes to support farm risk management

As part of the Basic Agricultural Agreement, Norway has a system to provide farmers with financial support for large crop losses due to climatic conditions in plant and honey production. It is a condition that farmers cannot be covered for losses through a publicly available insurance scheme or otherwise.

All or part of the compensation can be reduced if the farmer has acted unprofessionally or in a manner that would normally be expected to prevent losses, or has conducted their business in violation of the regulations governing agricultural activities.

The support scheme is triggered when the crop failure is greater than 30% of a normal year. Upon application and necessary documentation, the farmer can then obtain financial compensation for loss of income up to 70% of a normal year. Saved volume-dependent costs are deducted in the calculation of this compensation.

In a normal year, payments under these schemes are slightly more than NOK 40 million (USD 4.5 million) per year. There is a large annual variation in payments, hot weather and drought in large parts of the country in 2018 triggered the largest pay-outs in the history of the programme. Since its inception, this scheme has disbursed close to NOK 2 000 million (USD 227 million).

Another programme compensates producers for losses and the coverage of certain expenses in connection with imposed measures against diseases, infectious agents, and harmful organisms in animals and plants. Grants under this programme also cover losses in connection with measures implemented as

a result of swine fever antibiotic-resistant bacteria (MRSA), measures to reduce the level of radioactivity in cattle and sheep and includes some other compensations to facilitate compliance with food laws and duties.

Programmes are in place to compensate for predator losses and to provide animal owners with compensation when the Norwegian Food Safety Authority, as a result of the danger of predator attacks, has made a decision on grazing restrictions on cattle and sheep in accordance with the Animal Welfare Act.

OECD work has concluded that effective risk management requires an integrated approach that addresses all risk exposure and incentives, distinguishes between normal, marketable and catastrophic risk layers, and articulates the respective roles of public authorities and economic actors, involving them in the development of risk management strategies based on sound economic analysis of the three risk layers. A holistic approach to risk management instruments extends beyond the traditional boundaries of agricultural policy, emphasising policy coherence.[17] Furthermore, proactive risk preparedness by the farmer could potentially increase resilience significantly; this merits consideration as an alternative to *ex post* disaster payments (OECD, 2020[11]).

For instance, the government could also provide voluntary risk management programmes to help producers manage risks arising from normal variations in production, prices, and weather, while providing protection from more extreme market-related shocks. An example is the voluntary savings account scheme matched with government transfer (Box 2.2). The government and advisory services could also invest in information, skills, and awareness on production and environmental risks.

Box 2.2. Voluntary risk-management programmes to manage normal business risk

The Farm Risk Account is a voluntary savings account which draws on the experience of other OECD countries to manage risk, such as Canada's AgriInvest programme, a government matched producer savings account for moderate income declines or for making investments in farming operations to mitigate risk. A part of a farmer's direct payments could be deposited in the special account, to be drawn on in the case of income losses from operational risks (such as market volatility or unexpected weather conditions). To provide an incentive for farmers to save, deposits of direct payments could be deducted from farmers' taxable income, and do not have to be taxed when disbursed (in the case of losses) or at the closure of the account when used to supplement pension payments. Use of the Farm Risk Account would be mandatory in the event of a temporary shortfall in income from operational risks. Pay-out rules could limit access to the account to losses that lead to an income level below a certain percentage, for example 80%, of the reference income, with losses up to that level to be treated as a normal individual business risk.

Source: OECD (2016[12]).

2.4.6. Tax incentives

Income taxation

Norwegian farmers, most of whom are self-employed, are eligible for tax concessions that are not granted to other self-employed persons (OECD, 2020[13]). For income from agriculture of up to NOK 334 000 (USD 38 000), farmers can deduct 50% from their taxable income, resulting in a maximum tax saving of NOK 36 600 (USD 4 323) per farm. Beyond the NOK 334 000 (USD 39 449) threshold, the share of income that can be deducted is gradually reduced. There are no special tax rules for agro-food companies.

An exemption from general income tax rules is the depreciating tax treatment of direct financial support to farmers for investments in the construction or renewal of farm buildings in less-favoured areas. Subsidies for the renewal of farm buildings in these regions can be up to 33% of the total cost. This tax exemption is used as a way to maintain agricultural activity across the country.

Sales of farms within the immediate family are exempt from capital gains taxes when properties have been in the family for at least ten years. Gains from sales of farms outside the immediate family are subject only to the 22% capital tax. Gains on the sale of machinery and equipment and livestock are subject to general tax rules and are not included in this exception. There is no regional differentiation to these rules.

For many years, there has been a relatively small turnover of agricultural property outside the family. Many who exit farming choose to rent out their land instead of selling the property. There are several reasons for this, with tax rules considered as an explanation. For instance, over the period 2006 to 2016, gains on the sale of agricultural properties outside the immediate family were taxed both as ordinary income and as personal income under the progressive tax, with higher rates applying on high incomes. As a result, taxes on such sales could be up to about 50% of the gain. Since 2016, gains from the sale of agricultural properties is taxed only as capital income. It is unclear at present whether this has had an effect on the turnover of agricultural properties.

Property taxation

Agricultural properties of self-employed farmers (excluding housing and agricultural buildings that are used for other activities, such as processing activities, tourism, or warehouses) are exempt from municipal taxes on the value of the property. “Industrialised” agricultural activity is not exempt.

Tax on goods and services

The value added tax (VAT) regime incorporates several concessions related to agro-food activities. While the standard VAT rate is set at 25%, a reduced rate of 15% applies to food and drinks. For inputs and sales of products from farms, the VAT is set at the standard rate. Small companies with annual sales of less than NOK 1 million (USD 0.1 million) and VAT registered persons within the agriculture, forestry and fisheries sectors can return VAT on a yearly basis, as opposed to the general rule of a monthly basis.

Included in the prices of most agricultural products is a general sales tax on primary products. This tax is set by the Ministry of Agriculture and Food based on recommendations by the Sales and Marketing Council and collected by the producer organisations. It is used for promotional activities and to finance market balancing (i.e. paying for temporary storage or product transformation to prevent excess supply on the domestic market that would reduce producer prices).

Tax incentives for R&D and innovation

A general tax deduction scheme for R&D called “SkatteFUNN” has been in place since 2002 (Chapter 4). All Norwegian companies undertaking research and development can claim tax deductions for R&D project costs subject to the approval of the Research Council. Small- and medium-sized enterprises can claim 20% of project costs and large companies are able to claim 18%.

Agricultural research levy

The purpose of the levy is to secure research funds for agricultural products used in commercial food production or feed for animals (Chapter 4). This tax is levied on imported or domestically-manufactured food and feed products (excluding fish). For domestic products, the tax is levied on 0.35% of the taxable base which is the gross invoice amount not including VAT; this rate is subject to annual changes based on changes in value. Whereas for imported agricultural commodities, it is levied on 0.35% of the taxable base

which is the customs value. For semi-processed and processed food, the levy is 0.25% of the taxable base. The funds collected go into the Research Fund for Agricultural FFL (Chapter 4).

2.4.7. Agriculture and food policy responses in relation to the COVID-19 outbreak

Norway has implemented several measures in response to the COVID-19 pandemic, many of which are relevant to the agricultural sector.

A temporary scheme provides incentives for Norwegians who have been laid-off to take up jobs in agriculture. It allows workers to report only half the hours worked to employment authorities, yet paid by the farmer for all hours worked. This responds to the disincentive that arises from the fact that unemployment benefits per hour are often higher than hourly wages in the agricultural sector.

Farmers who are unable to harvest in 2020 due to lack of seasonal workers will be eligible for payment under the crop insurance compensation scheme.

Innovation Norway offers the opportunity to delay payment of loan instalments for one year, subject to application. As a result of the COVID-19 pandemic and falling NOK exchange rates, Innovation Norway was given the legal authority to exceed the existing ceilings for support for investment and business development in agriculture. It was also given increased flexibility to use the Development Programme for agricultural and reindeer husbandry-based growth and value creation, and to meet the industry's short-term challenges, most notably for local food, tourism and green care businesses, where sales have dropped significantly.

2.5. Agri-environmental policy

Environmentally sustainable agriculture with lower emissions of greenhouse gases (GHG) is one of the four policy goals for agriculture in Norway. More specifically, Norwegian agri-environmental policy has three main objectives: to safeguard the varied and diverse cultural landscape by preserving biodiversity and cultural heritage; to reduce pollution (soil erosion, nutrient losses, water, pesticides and air); and to reduce emissions from GHGs, increase sequestration and support successful adaptation to climate change.

Norwegian agricultural policies are underpinned by the premise that several environmental public goods are positive externalities of agricultural commodity production and that implementation costs of alternative policies are large. The premise is that the existence of these socially valued but non-remunerated joint products of agricultural production activity justifies supporting production of agricultural outputs. To reduce this support would – by precipitating a decline in agricultural commodity production – reduce the provision of the valued public goods. Conversely, if society wished to have more of these positive externalities, the rate of support to commodity production should be increased.

OECD work on "multifunctionality" and other research have demonstrated that this view is valid only if the public good externalities are joint and non-separable outputs (Box 2.3) (Hodge, 2008[14]; OECD, 2003[15]; Gray et al., 2017[16]). There is evidence that some agricultural commodities are technically related as joint products with non-commodity outputs, as well as grounds for believing that there are economies of scope between agricultural commodity and non-commodity production. At the extensive margin of production, if resources are used too little, there is a risk of abandonment. In such cases, continuation of extensive farming practices, such as grazing, would contribute to production and landscape maintenance, without transaction costs in policy design and implementation. However, at the intensive margin of production, as resources are over-used, there are competing relationships between commodity outputs with environmental outputs. In this case, agricultural production policy objectives could be at odds with environmental considerations. Moreover, even at the extensive margin there may be a conflict between agricultural policy objectives and some environmental objectives, such as reducing GHG emissions.

Several studies have demonstrated that it is unlikely that any particular level of commodity price or a flat rate livestock headage or area payment will deliver the desired levels of environmental outputs (Hodge, 2008[14]). Broad-based policies can encourage intensive agricultural production methods that cause commodity outputs to compete with environmental outputs (Henderson and Lankoski, 2019[7]; OECD, 2013[6]). In doing so, broad-based policies may economise on transaction costs, but fail to achieve their objectives. In Norway, the current support system includes some flat rate payments, combined with payments which are differentiated by region and farm size.

Box 2.3. Policy implications of jointness between commodity and non-commodity outputs

Jointness has several policy implications.

- If jointness is weak, public policies should be targeted as a non-commodity output (NCO) and not linked to agricultural commodity production.
- If jointness is strong, then it should be ascertained whether there is also a market failure in determining if policy action is required.
- If there is both jointness and market failure, policies should be conditional on delivery of the NCO, and monitoring measures should be in place to ensure that the desired outcomes are being achieved.
- Policy action should be targeted at the activity or input into production that is most strongly related to the NCO and should avoid unnecessary increases in the intensity of agricultural production.
- Policy action should be geographically targeted unless the NCO is associated with all or a large percentage of the production or agricultural land in a country.
- Policy design should take into account transaction costs
- The level of government at which policy decisions are taken should correspond as closely as possible to the geographical occurrence of the demand for NCOs.

Source: OECD (2003[15])

Brunstad, Gaasland and Vårdal (2005[17]) model multifunctional agriculture in Norway in terms of its provision of public goods, of food security, and landscape preservation. They found that the level of subsidy offered in Norway exceeds the level required to optimise output levels. The simulations show that at most 40% of the support level can be defended by the public good argument. Broad price- or production-based support policies are instruments too blunt to address environmental issues such as landscape and biodiversity preservation, which are often region-specific or even site-specific.There are many ways in which agricultural farming systems can be modified to increase the production of environmental outputs. These relate to the management of farmland, of boundaries around farms, and of land that is not in use for agricultural production. The specific modifications required to attain the highest environmental standards are typically spatially heterogeneous and involve detailed changes to farming systems.

There is generally a trade-off between the targeting of policy instruments and transactions costs. An appropriate balance needs to be found, but must take into account the gains and losses in environmental outputs that are associated with any policy intervention.

General measures (regulations and taxes) and agri-environmental payments could be used to control both intensive and extensive margins (OECD, 2010[18]). For example, at the intensive margin regulations can set mandatory upper limits of fertiliser, manure and pesticide application per hectare, or mandate the adoption and use of certain application methods (injection application of manure and not surface

application), while at the extensive margin regulations can mandate the maintenance of land in good agricultural and environmental conditions. Norway currently has land tenure regulations to ensure that agricultural lands remain under agriculture. Further area payments and payments for grazing livestock support would ensure that lands are not abandoned.

Measures to prevent land abandonment, a key challenge at the extensive margin and a policy objective in Norway, could include: incentives for continued management, agri-environment schemes, cross-compliance, agro-forestry schemes and strengthening broader measures for viable rural areas (e.g. incentives for economic diversification, including tourism; improvements to rural services such as education, health, culture); and improvements to infrastructure (roads, broadband). Agri-environmental payments are the most appropriate way of paying for specific targeted habitat, species and landscape management on high nature value farmland. As the causes of abandonment may vary from place to place and over time, the means of keeping or bringing this land back into management will also vary and require a combination of agricultural, environmental and social policy tools.

2.5.1. Agri-environmental payments

The most important agri-environmental payments include acreage and cultural landscape payments, payments for grazing livestock, support for preserving rare livestock breeds, support for organic farming, regional agri-environmental programmes, payments for environmentally friendly spreading of manure, special environmental measures in agriculture, and payments for selected cultural landscapes (Table 2.3). About half of all farmers undertake measures that qualify for targeted agri-environmental support.

Table 2.3. Economic measures included in the National Agri-environmental Programme in Norway

National level	Regional level	Local level (municipalities)
Area and Cultural Landscape Payment	Regional agri-environmental programme and measures	Special agri-environmental measures
Payment for grazing livestock	Programme on climate and the environment	Payment for drainage of agricultural land
Payment for protected livestock breeds		Payment for infrastructure in grazing areas
Payment for organic agriculture and development measures		Payments to selected cultural landscapes and World Heritage Sites
Payment for delivering manure to bio gas plants		
Programme on climate and the environment		
Project support for the action plan for pesticides		
Project support for management of genetic resources		
Research		

Agri-environmental measures are structured under the National Agri-environmental Programme (NAP), which provides a central framework and national goals and includes key grant schemes for the whole country. The measures are organised at the national, regional and local levels.

The NAP can best be understood as a “pyramid” and contains the main agri-environmental measures, such as the Acreage Cultural Landscape Support, payments to extensive grazing, and payments for grazing livestock. On the other hand, Regional Agri-environmental Programmes (REP) address specific challenges that are not met by country-wide schemes. Measures organised at the local level include more long-term support and commitments, including investment support schemes and support to selected cultural landscapes based on mutual commitments between authorities and groups of farmers.

Measures included in the NAP are not targeted to specific environmental activity of the farmer *per se* but are, in general, conditional on the adoption by farmers of “good agriculture practices”. For example, to

receive the Acreage Cultural Landscape Support payment, farmers must not undertake practices that are harmful to the cultural landscape. They must establish a buffer vegetation zone around watercourses and develop a plan for the dosage of fertiliser to match crop needs.[18] Any violation of these requirements is sanctioned by a deduction in production subsidies.

Regulations on individual farm environmental plans were repealed in 2015, but the agricultural sector maintains its own quality system (KSL). This includes checklists and audits to ensure that requirements are met. About 81% of farmers who have applied for production subsidies have completed a KSL self-audit. The highest share with KSL is found in high-intensity productions such as milk, chicken and vegetables (Norwegian Institute of Bioeconomy Research (NIBIO), 2016[19]). "Enjoy Norway" is an information label for Norwegian food and drink that makes it easy for consumers to choose Norwegian food products and guarantees that the farmer has strictly followed Norwegian rules (Chapter 5).

The Norwegian acreage and cultural landscape support requirements are in general compatible with the EU requirements for ecological focus areas. The main difference is that in Norway regulations do not require that 5% of the area be set aside for ecological focus areas.[19] The NAP is revised every four years. In 2019, a new programme was launched, and will be in place to the end of 2022. In 2020, a total of NOK 5.5 billion (USD 0.5 billion) was granted for different agri-environmental measures.

In the Regional Agri-environmental Programmes (REP), the counties (regions) determine the necessary criteria for farmers to receive support. Each county uses measures taken from a national "menu" and that are adapted to the objectives of the region. Measures eligible for payment under these programmes include those to reduce nutrient runoff to water, management of cultural landscape, environmentally-friendly manure spreading, maintenance of fields with high or special biodiversity in the forest and mountains areas, grazing on islands, and maintenance around heritage sites in the agricultural landscape. The budget for the REP was increased by 7% to NOK 528.1 million (USD 60 million) for 2020. Most of this budget is allocated to measures that seek to reduce water pollution and emissions, and to promote cultural landscape.

Local strategies are tailored to address environmental issues at the local level. They form the platform for "Special agri-environmental measures" operated at the municipal level to support "one-off" measures with longer lasting effects than "REP" measures, which supports practices on an annual basis. Municipalities can prioritise what they value most – within certain limits – and measures are designed and implemented in co-operation with environmental authorities and farmer organisations.

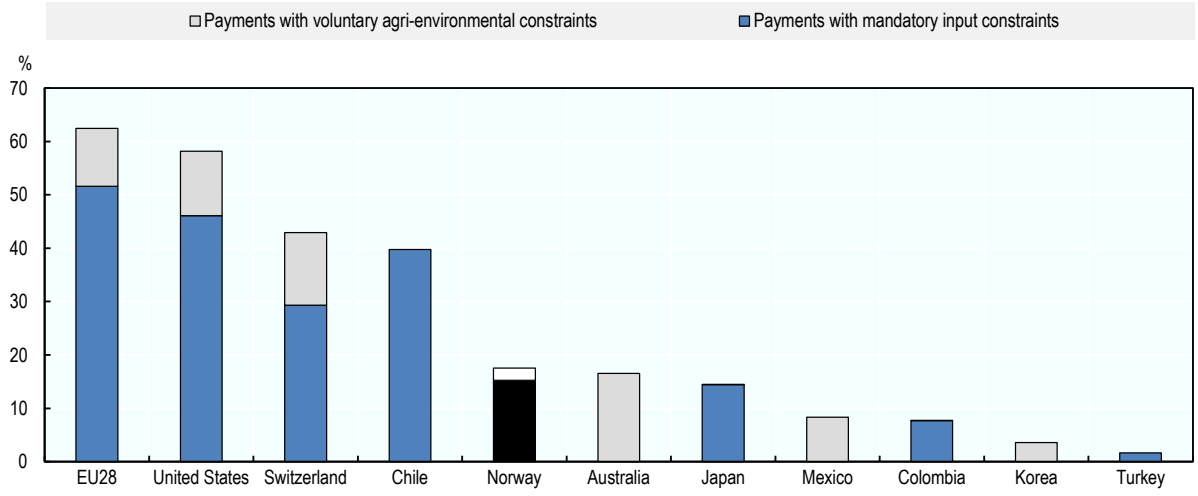
Cross compliance requirements – linking respect of environmental conditions or regulations to the granting of agricultural support payments – have the potential to contribute to improving the environmental performance of agriculture compared to a situation where the same level and structure of payments are made with no conditions attached (OECD, 2010[20]). While cross-compliance conditions increase the coherence of direct payment programmes with environmental policy objectives, the experience in OECD countries shows that such conditionality would not be effective unless it was adapted to the diversity of local farming practices and conditions. In Norway, conditionality is adapted to some extent to local conditions. For instance, there is a requirement to protect waterways, insular elements, and stone hedgerows. There is, however, limited evidence concerning control, sanctions and monitoring of the environmental impacts of these cross-compliance requirements.

Payments to agricultural producers that are specifically targeted to environmental objectives (payments based on non-commodity criteria) cover only about 0.3% of support to producers. The share of the payments with voluntary agri-environmental constraints in producer support was 2% in 2017-19 in Norway, compared to 11% in the European Union and 12% in the United States. The share of payments with compulsory cross compliance is relatively low in Norway (15%) compared to more than 50% in the European Union and 29% in Switzerland (Figure 2.10). In Switzerland, almost all forms of agricultural support are subject to environmental requirements. These requirements go beyond compliance with the

country's existing environmental legislation concerning agriculture, as well as various structural, social and general criteria, as a lever to achieve economic and environmental sustainability (Box 2.4).

Figure 2.10. Payments conditional on the adoption of specific production practices, 2017-19

As a percentage of Producer Support Estimate



Note: This figure presents OECD countries having any payment with voluntary agri-environmental constraints or payment with mandatory input constraints.
Source: OECD (2020[5]), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

Box 2.4. Switzerland's approach to cross-compliance

Cross-compliance requirements were introduced in 1999 as part of the Agricultural Policy Reform Programme for 1999-2003. Almost all forms of agricultural support are subject to environmental requirements. These go beyond compliance with the country's existing environmental legislation concerning agriculture, as well as various structural, social and general criteria as a lever to achieve economic and environmental sustainability. Direct income payments subject to environmental cross compliance are available for all agricultural land, regardless of how it is used. There are, however, exclusion conditions in terms of size (hectares or number of animals) and other criteria relating to age, minimum labour use, and asset ceiling.

The Swiss cross-compliance approach entails respect for environmental legislation and animal welfare requirements, as well as compliance with several supplementary environmental requirements, such as:

- at least 7% of farmland must be used as "ecological compensation areas" (e.g. extensive meadows, low intensity pastures, traditional orchards, hedgerows, wild flower strips, and low intensity cropping strips)
- an appropriate nutrient balance must be maintained (i.e. maximum 10% surplus of nitrogen and phosphorus as shown by a farm's nutrient balance, based on crop requirements)
- crops must be regularly rotated and the soil protected (at least four different crops must be cultivated per year on farms where the arable land area exceeds 3 hectares and maximum

shares of individual crops must be respected; field parcels harvested before 31 August must be sown with main or cover crops by 15 September so that periodical soil erosion is minimised)

- targeted application of pesticides (i.e. restrictions on the use and timing of various herbicides and insecticides, consideration of early warning systems and pest forecasts, frequent tests of sprayers)
- appropriate animal welfare measures must be adopted (i.e. farm animals must be kept according to legal requirements).

These environmental cross-compliance criteria aim to address several environmental objectives, including reduction of nitrogen and phosphorus runoff and leaching, soil erosion and sediment runoff, conservation and promotion of farmland biodiversity, reduction of pesticide runoff and residues, and improved animal welfare. Non-compliance by farmers with standards related to the environment and animal welfare may lead to reduction or withdrawal of their agricultural support.

Source: OECD (2010[20]); OECD (2015[21]).

2.5.2. Organic farming

In 2018, organic agriculture was practised on approximately 4% of the utilised agricultural area. Products from certified organic agriculture account for 2% of the value of the agricultural production.

Requirements for certification of organic agriculture and organic products are similar to those in the European Union. The “Special payments for ecological farming” scheme provides payments based on acreage and headage for the conversion period from conventional to organic farming. Following the 2018 strategy on organic production, a programme to help prioritise measures for organic production over the long-term was prepared, and a separate programme on soil health and soil quality is in process as of July 2020. Organic production is covered by a support scheme, with a budget of NOK 139.8 million (USD 16 million) in 2019. Support is also provided to different projects for research, advice and market promotion of organic farming, totalling NOK 33 million (USD 3.8 million) in 2019.

2.5.3. Measures to reduce pollution

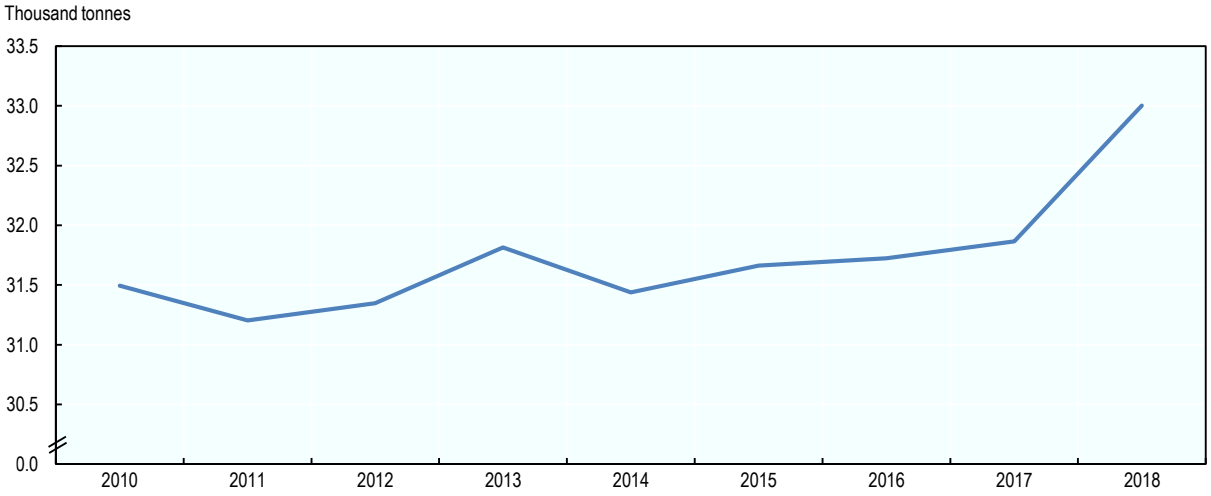
Norway is among the OECD countries with a high nitrogen (N) surplus, which indicates potential environmental problems through N losses to water and air from agricultural soils (Chapters 1 and 6).[20] Although Norway has a very high N surplus, the agricultural area in Norway is small (2.5%).

Under the Gothenburg Protocol Norway’s maximum emission of ammonia - 93% of which comes from agriculture - is 23 000 tonnes. According to the amendments to the Protocol agreed to in 2012, Norway is committed to reducing its national emission of ammonia by 8% from the 2005 level to be achieved in 2020 and beyond. Policy measures to achieve this target include support for specific spreading methods provided through the Regional Environmental Programme (REP). However, despite these policy efforts Norway faces sizeable emission-reduction challenges as emissions of ammonia from agriculture have steadily increased since 2014 and remain above the country’s commitment (Figure 2.11).[21]

Although the support system has been amended and adapted over the years to target high-risk areas of erosion and phosphorus losses, agri-environmental policies and regionally-based policies have focused mainly on mitigation measures for losses of phosphorus, with a side effect on nitrogen. For example, the regulation on manure management, the REP, and the incentives for environmental investments aim primarily to motivate farmers to implement measures to reduce P losses, such as management of manure, changed soil tillage, grass buffer zones along open waters, and sedimentation ponds.[22] In contrast, there are no regulations regarding the amount of N fertiliser to be applied (except for 170 kg N ha-1 in the nitrate

vulnerable zone). In general, measures for improved water quality in Norway target phosphorus and erosion in eastern Norway and manure in the western part of Norway.

Figure 2.11. Emissions of ammonia from agriculture in Norway



Note: Agriculture including hunting.
Source: Statistics Norway (2020[22]), Agriculture and the Environment – State and Development, Report 2020/3, https://www.ssb.no/en/natur-og-miljo/artikler-og-publikasjoner/agriculture-and-environment-2019-state-and-development.

Due to the lower policy priority accorded to nitrogen, nitrogen surpluses are higher per area of agricultural land in some Norwegian areas compared to other Nordic countries (Bechmann et al., 2014[23]).[23] There is potential in some areas for more efficient use of nitrogen fertilisers (with lower nitrogen surplus) at a low cost that would result in a lower nitrogen surplus. Suggested measures include: i) improved nutrient management planning based on average yield instead of highest expected yield as a basis for nitrogen application; ii) split nitrogen application; iii) precision nitrogen application; and, iv) improved efficiency in the use of manure (Bechmann et al., 2016[24]). However, there are no legal regulations for these measures.

2.5.4. Measures addressing biodiversity and cultural landscapes

Norway's biodiversity is very diverse, ranging from the southern deciduous forests to polar ecosystems. Agriculture, as well as fisheries and forestry represent important sources of ecosystem services for the country.

The agri-environmental measures in place aim to reduce the pressures and impacts associated with agriculture, such as land abandonment, and maintaining landscapes with particular historical or biological qualities linked to agriculture. Change in land use is potentially a major driver for biodiversity loss, and many rare and threatened species belong to the cultural landscape. Such species face challenges both at the intensive margin, related to monocultures, intensification and land conversion to other uses, as well as at the extensive margin, related to abandonment.

A considerable amount of the funding provided through these measures is allocated to cultural landscape projects. For example, funding for projects in a set of selected agricultural landscapes and for cultural landscapes that are World Heritage Sites is used to maintain farming activities and to improve co-ordination of the management and maintenance of some particularly valuable areas.

For agriculture, agreements are concluded with landowners who undertake to manage the land in a way that safeguards both the overall cultural landscape and the threatened species and habitats in the areas.

In 2018, payments of NOK 261 million (USD 32.1 million) were given to environmental efforts in the agricultural landscape through the REP. In addition, NOK 64 million (USD 7.9 million) were given through the special measures system (SMIL funds).

Payments were introduced in 2019 for pollinator strips and payments are available to remove invasive species through the SMIL funds. The Norwegian Ministry of Environment also provides payments to farmers and other land owners for the maintenance of species-rich meadows, coastal health, veteran trees, and other threatened nature types to encourage favourable management of these areas. These payments may "top-up" the agri-environment scheme payments.

In 2004, the Norwegian Parliament defined the number of protected predators (wolf, bear, lynx, wolverine and golden eagle) (Strand et al., 2019[25]). The compensation scheme for loss of livestock to protected predators is funded by the Ministry of Climate and Environment (NOK 44 million – USD 5 million – in 2019). In addition, there is funding for mitigating actions to prevent livestock losses to protected predators such as fencing, shepherding and electronic tracking of livestock. Of the 6% of all sheep lost to predators or other causes, roughly 20% is attributed to protected predators. There is no systematic recording of losses to other causes than to protected predator species and there are no longer compensation measures for these losses.[24]

Concerning support to promote *in situ* conservation of genetic diversity, the Basic Agricultural Agreements include grant schemes for farm animal breeds of conservation value, including cattle, sheep, goats and horses. In addition, there is a special payment per dairy cow of particularly rare old national breeds. Norway also supports crop genetic resources.[25]

2.5.5. Measures to control GHG emissions from agriculture

Agriculture is estimated to account for about 8.5% of Norway's GHG emissions. Ruminant animals (dairy cows, cattle and sheep), which are the backbone of farming in the country, account for an estimated 55% of the GHG emissions from agriculture and an additional 30% can be attributed to the cultivation of organic soil (drained peatland).

The dominant GHG emission sources include ruminants, peatlands and nitrous oxides from manure-fertilised soils. Each account for about a quarter of total agricultural emissions. Methane has a global warming potential which is 25 times stronger compared with carbon dioxide (CO_2), although with a much shorter lifespan (IPCC, 2014[26]). Mitigation of methane can make a substantial difference to the feasibility of achieving the Paris climate targets. Agriculture accounts for 75% of the total emissions of nitrous oxide (N_2O).

Emissions from agriculture have been reduced by approximately 5% since 1990 (Norwegian Ministry of Climate and Environment, 2020[27]). The main drivers behind the decreasing trend in GHG emissions include: i) the reduction of nitrogen content in the use of inorganic fertilisers; ii) use of more concentrated feed; and iii) reduction in the number of dairy cows.

Climate change and agriculture is addressed in the White Paper on agricultural policies 2016-17 *Change and Development – A Future-Oriented Agricultural Production* (Det Kongelige Landbruks - Og Matdepartementet, 2016[1]). It states that the most important role for agriculture in the context of climate change is to reduce emissions per unit produced, increase the uptake of CO_2, and adapt production to a changing climate. The 2016-17 White Paper on Climate policy also refers to the mitigation actions on agricultural policy (Box 2.5).

Box 2.5. Mitigation actions in a future-oriented agricultural production

The 2016-17 White Paper on "Agricultural policies change and development – A future-oriented agricultural production" includes the following mitigation actions for the agricultural sector:

- In light of Norway's 2030 commitment, work to reduce agricultural GHG emissions and gradually reform agricultural policy in a more climate-friendly direction.
- Assign greater importance to climate considerations in the annual Agricultural Negotiations.
- Following talks with farmer organisations, develop a plan of concrete measures and instruments to reduce climate emissions from agriculture, where the ambitions for emission reductions are quantified. The plan must respect the country's climate commitments. This materialised in the June 2019 Climate Agreement for agriculture.
- Facilitate increased production of biogas based on livestock manure and waste resources in agriculture.
- Establish a committee for calculating GHG emissions from agriculture, which was established and submitted a report in July 2019.
- Climate measures should not result in increased subsidies to agriculture.

The 2017 White Paper on Climate Policy referred to analyses showing it is possible to reduce cumulative emissions from agriculture in 2021-30 by approximately 5 million tonnes CO_2 equivalents, that is on average half a million tonnes annually, at a low economic cost. More than half of this potential is related to combined changes in the composition of food consumption (including reduced food waste) and production. The estimate also includes the considered ban on cultivation of peatland mires, which are subject to restrictions since June 2020. The government intends to present a White Paper in 2020 on how it plans to meet the 2030 commitments.Emissions from agriculture are not subject to a carbon-dioxide tax nor are they included in the EU ETS as it is more difficult to estimate these emissions than for other emissions (e.g. because they are a result of biological processes, and that the emissions stem from many small units which are difficult to include in an emission trading system). However, Norway will participate in the EU's Effort Sharing Regulation and the regulation on land use and forestry (LULUCF) for the period 2021-30 (Chapter 3).

Norway has in place several other measures affecting emissions from agriculture. These measures are both statutory and financial, in addition to measures related to information (Table 2.4**)**. In particular, policies and practices to control GHG emissions in agriculture include a combination of regulatory, economic and information measures.

An agreement with the food industry to reduce food waste was completed and signed in 2017. The goal is a 50% reduction in food waste by 2030. In the follow-up to the 2014 biogas strategy, funding has been granted for pilot plants and research on biogas through Innovation Norway from 2015. Through the Value Added Programme for Renewable Energy in Agriculture funding is also granted for on-farm biogas projects, and support for the use of manure in the production of biogas is provided (EUR 7 per tonne of manure). The potential of biogas production from manure has been estimated at 25% of all manure in 2030, but currently only 1% goes into a biogas reactor.

Investment support is available from 2019 for manure storage facilities as such investment is not economically profitable under current conditions. A similar investment support is available for environmentally-friendly technologies to spread manure. Other measures include better timing, distribution and storage capacity of manure.

Table 2.4. Agri-environmental policies to reduce GHGs in Norway

Name of mitigation action	GHGs affected	Objectives	Type of policy instrument
Regional agri-environmental programme	CO_2, N_2O	Reduce emissions by no-autumn tillage and environmentally spreading of manure; Several support schemes; differs between regions	Regulatory and economic
Support Scheme Special Environmental Measures in Agriculture	CH_4, N_2O	Reduce emissions by better storage of manure; Several support schemes; storage of manure is mostly related to climate mitigation	Economic
Drainage of agricultural soils	N_2O	Reduce emissions of N_2O caused by better drained soils; National support scheme	Economic
Project Climate Smart Agriculture	CH_4, N_2O, CO_2	Data collection, counselling, sharing knowledge; the project will last for three years (2017-20)	Information
Climate and Environment programme	CH_4, N_2O, CO_2	Develop knowledge	Economic, information
Delivery of manure for production of biogas	CH_4	Support scheme to reduce emissions from manure by increasing the utilisation of livestock manure to biogas production.	Economic
Grant for biogas projects	CH_4, N_2O, CO_2	Pilot project to increase production and use of biogas	Economic

The June 2019 Climate Agreement for agriculture between the government and farmer organisations sets targets for abatement of GHG emissions and removal from agriculture over 2021-30. Improvement in on-farm livestock, manure and soil management is key to delivering the targets, alongside improvements in consumption and reduction in food losses and waste. In contrast to the 2016-17 White Paper, the 2019 agreement does not bind future policy measures or agricultural agreements, and cannot presuppose increased subsidies (Norwegian Ministry of Climate and Environment, 2020[27]).

Achieving a significant reduction in GHG emissions in Norwegian agriculture is challenging. The effects are considered to be relatively minor compared with those in other sectors of the economy (UNFCC, 2018[28]). Blandford, Gaasland and Vårdal (2015[29]; 2018[30]) find there are viable options for doing so, while continuing to achieve the key national objective of food security. In particular, they find that a cut of around 30% in emissions from agriculture can be achieved without undermining the stated policy objective of ensuring a minimum supply of domestically-produced calories, by taking drained peatland out of production and restoring it to wetland. Progressing beyond a 30% reduction would require a more fundamental restructuring of production away from emissions-intensive ruminants and towards less emissions-intensive crop and livestock products. GHG emissions can be reduced by 60% without compromising the country's food security objective, although reductions of that magnitude would require significant changes in consumers' diets. Emissions reductions of over 60% can be achieved with no reductions in national economic welfare, due to reductions in agricultural subsidies. Similar results are reported by Mittenzwei and Øygarden (2020[31]). Their model results indicate that the agricultural sector could deliver on both agricultural and environmental policy objectives if production shifts from grass-based animal production to crop production, inducing a shift towards a more plant-based diet.

The restoration of peatland (its removal from agricultural production and reconversion to wetland) could potentially make an important contribution to reducing agricultural emissions. Land conversion from peatland to cropland has been extensive historically, and approximately 60 000 hectares of croplands (7% of the total cropland area) in Norway are identified as drained organic soils. These soils are a significant source of N_2O and CO_2. Restrictions on the conversion of peatlands to cultivation were imposed in June 2020 (Chapter 3).

2.6. Decoupling is an effective means to design a new generation of policies and rebalance objectives for agriculture

The current policy set with respect to livestock (beef and milk) and grains (wheat, barley and oats) as described in this chapter is largely coupled with production. MPS is the mainstay, along with payments based on animal numbers, output or land use. These policies by design encourage production to varying degrees, but can have other less desirable consequences.

One consequence is the impact on the environment. Payments based on animal numbers can encourage larger herd sizes, leading to higher nutrient surpluses and methane emissions. Higher output can mean more intense production, with greater use of fertiliser and chemicals and more animals per hectare of land. Such consequences of coupled policies have been documented by OECD analysis (OECD, 2005[32]; OECD, 2015[21]) and are relevant for the achievement of a sustainable agriculture with reduced GHG emissions.

It is not evident that the current policy set addresses income issues for farmers nor that it encourages innovation in production. Payments that are highly coupled to production tend to be less efficient in increasing incomes for producers, while constraining them to produce according to the incentives of the policies rather than according to what consumers want (OECD, 2003[33]). This tends to reinforce traditional outputs and discourage production of new commodities and innovation.

Decoupled payments do better at increasing farm incomes. They provide a steady stream of working capital for operations and give farmers more flexibility in their production planning. There are many options for the design of such payments. A common element is to base the payment on current landholdings and to require the recipient to maintain their land in agricultural activity, or at least in agricultural condition where the land could easily re-enter production. Compared to coupled support, this provides a stronger incentive to keep land in the sector and raises the returns from farmland relative to other land uses.

Rebalancing the current policy mix away from payments linked to production to decoupled ones can better tailor policies to the four objectives of the government. The result would be better environmental performance, including with respect to GHG emissions, and a stronger financial basis for the sector, and more market incentives in the value chain. Domestic production will decline, but this need not undermine the resource base for agricultural production, nor affect the amount and distribution of agricultural land. The competitiveness of the sector and of the value chain would improve, while incomes of farmers staying in agriculture would be sustained.

How bold should such a rebalancing be? A better understanding of the nature of the trade-offs between objectives can help policy makers answer this question. The Policy Evaluation Matrix (PEM) model has been used to undertake an analysis of these trade-offs (see Annex A and (OECD, 2005[32]; OECD, 2015[21]) for the details of the model). The model has been adapted to cover regional specificities following the regionalisation used in the Norwegian Farm Accountancy Register and to include indicators that respond to the four main objectives of agricultural policies.. A scenario using the PEM model examined the effect of moving 10% of the current policy mix to a new decoupled payment based on land, conditional on it remaining in agricultural condition.[26] Aside from increasing returns to agriculture land use, such a payment has a small impact on agricultural input and output markets. This scenario considered impacts on distribution and production of agricultural commodities, environmental impact and income and productivity, reflecting the main goals of Norwegian policy.

The overall value of production in this scenario declines by about 7%, with relatively more adjustment in grains production (the milk quota system prevents big shifts in milk production and milk TFP increases). GHG emissions decline by 2.2%, nitrogen surpluses reduce by 1.2%, and farm income increases by NOK 386 million or USD 38.5 million (NOK 474 or USD 47 per hectare) (Table 2.5). The new payment

valorises agricultural land and draws more land into the sector, though a greater share of land is used for crops beyond the main cereals.

Table 2.5. Policy re-instrumentation can rebalance Norway's objectives towards value added and environment

Impact of a shift of 10% of current support to a decoupled payment differentiated by region

Objective	Indicator	Result	Comments
Food security and preparedness	Self-sufficiency (% - energy)	-6.97%	The resource base for agriculture remains intact as the decoupled payment provides a strong incentive to maintain agriculture land. Lower MPS increases domestic consumption of food, which can be considered positive. It also increases consumer welfare by NOK 637 million (USD 63.6 million).
	Farm land per capita (ha/1000 cap)	0.00%	
	Cows per capita (number/1000 cap)	-5.13%	
Agriculture across the country	Share of land use to wheat in central regions	+0.06%	The regional production pattern does not change significantly even though overall production is lower. The decoupled payment draws more land into agriculture use. The decoupled land payment is still regionalised, thus the pattern of existing payment levels does not change by the simulated reform.
	Share of land use to cereals in central regions	+0.01%	
	Share of land use to milk in central regions	+0.08%	
	Share of land use to beef in central regions	-0.04%	
Increased value added	TFP, wheat	-2.38%	Improved market orientation creates opportunities for innovative farmers while the decoupled payment provides working capital. Total factor productivity declines for all commodities except milk as production intensity declines. The income of farmers increases.
	TFP, coarse grains	-2.75%	
	TFP, milk	+0.65%	
	TFP, beef	-1.04%	
	Farm income	+NOK 386 million (+NOK 474 per hectare)	
Sustainable agriculture with reduced GHG emissions	GHG emissions, $C0_2$ equivalent	-2.30%	More extensive agriculture with less chemical inputs, reduced negative impact on ecosystems. Increased use of cross-compliance could further increase benefits. Existing payments based on animal numbers are a significant driver of negative environmental outcomes.
	Nitrogen Surplus	-1.19%	
	Phosphorus Surplus	-0.06%	

Note: The exact nature of the trade-offs between objectives becomes less clear as the amount of support implicated grows larger. However, the economic fundamentals suggest that the indicators for "agriculture across the entire country" objective would not change much even with a very large shift in support type. That is because support levels are not changing, only their form and payment levels can still reflect regional differences. See Annex A for more information on the PEM-Norway model.
Source: OECD PEM model for Norway.

The distribution of land and production across the entire country is little changed by the shift to decoupled payments. This is because the proportional reduction of distorting support, 10% in all regions, does not induce large adjustments across regions. Also, the decoupled payment strongly preserves land and the level of the payment replicates the existing regional pattern of production-channelling payments; the regional distribution of payments are unaffected and therefore reflect the current pattern of regionally differentiated incentives. This pattern could be improved with further adjustments on these decoupled payments rates, responding to the needs and values of each location. Payments based on land tend to be reflected in the price of land over time. In this scenario, agricultural land returns increase on average by 62%, with the largest increase in Jæren (121%) and the smallest in the eastern lowlands (25%). This

means that, apart from the regulations on land use that tend to protect agricultural land in Norway, these policies strengthen the economic incentives to keep agricultural land in use.

The results show that the reform has a minor impact on the objective of agriculture all over the country. This is because payments based on land tend to attract and hold land; if there were more scope for land movement in the model the results would likely show even more conversion of land into agricultural use than they do currently.

The results of the analysis clarify the trade-offs that result from a transformation of a portion of support from a coupled to a decoupled basis, while keeping the production channelling purpose of policy. The larger the share of support moved to decoupled land payments, the larger will be the benefits to farmers and the environment, at the cost of some production due to lower production intensity, but with enhanced possibilities to produce more on available agricultural land whenever required.

The benefits to the environment could be further increased relative to the decline in production if the decoupled payments were to include some environmental conditionality. Such “cross-compliance” is a common feature of agricultural payments in the European Union and other countries and can motivate increased adoption of sustainable practices.

2.7. Conclusions

Norway provides the highest levels of support to agricultural producers among OECD countries, and reforms have been limited. In fact, changes to the policy support system have often been primarily through external pressure rather than domestically driven reform. The main agricultural sectors remain highly insulated from the world market and subject to extensive production-distorting support. Market price support, mainly due to border protection and domestic market regulation, still remains the main component of support to producers.

Border protection is mainly through high tariffs on the most important and sensitive agricultural products, such as meat, dairy, eggs and grains. In addition, there are TRQs for different sensitive products. Export subsidies were abolished in mid-2020.

Norway uses a panoply of policy measures to regulate the market and support agricultural producers, including a complex system of payments which account for a large share of farm income. Farmers also benefit from several tax concessions, such as income-tax deduction and exemption from GHG (methane and nitrous oxide) emission taxes.

Most of the payment rates are negatively related to farm size and are higher in remote areas compared to central regions. The goal is to sustain and channel specific agricultural activity to rural areas throughout the country, where production alternatives are few, and to sustain total agricultural production and self-sufficiency. Norway has a shortage of land suitable for arable crops, but an abundance of grass and pasture. Agricultural land accounts for only 3% of the country’s surface; therefore, the most favourable lands are mostly allocated to arable crops, while ruminant livestock is allocated to regions with less favourable conditions. As a result, production of cow and goat milk, and bovine and sheep meat takes place in rural areas, and production of grains, poultry and eggs mainly takes place in central parts of Norway.

The primary agricultural sector is exempt from standard competition law, and farmer-controlled processing and distribution co-operatives are an important part of the supply chain in some sectors, such as dairy.

Climate change ranks high in the current agricultural policy debate. However, agricultural activities that generate the highest GHG emissions are those that are currently the most heavily supported. Moreover, farmers are exempt from GHG emission taxes and the cap-and-trade system. It would be increasingly difficult to reduce GHG emissions from agriculture without significant policy reform.

2.7.1. Agricultural support

- The removal of the administered price for eggs, poultry, beef, sheep, increased flexibility in milk-quota leasing, and the abolition of export subsidies are steps in the right direction towards reducing the economic distortions associated with these measures.
- The limited reforms agreed by the parliament in 2017, such as the commitment for some simplification in support measures and the rule changes on milk quota, are steps towards enhancing efficiency and reducing policy-related transaction costs and should be accelerated.
- Norway should consider to gradually reduce border protection and commodity-specific support, including welfare schemes, in a predictable way in order to allow markets to play their role in allocating production resources. The current high levels of support are likely to become increasingly untenable over time. External pressures and commitments for Norway to decrease its import tariffs on agricultural imports is unlikely to diminish as future multilateral and regional trade agreements may mean significant reductions in tariff protection. Domestically, with an increasing need for a more low-carbon sustainable economy the support system will come under increasing scrutiny. Agricultural policy needs to help prepare producers for change, guiding them towards more environmentally sustainable and competitive production.
- Agricultural policy in Norway needs to re-orient its focus to develop a coherent agricultural policies leading to long-term productivity growth and environmental sustainability. Agricultural policy should better balance the economic and environmental costs of support (market price support, direct payments and tax concessions) against the claimed benefits of support, such as the arguments on food security and sustaining rural economies. These objectives can be pursued effectively without the use of market distorting measures. Norway is encouraged to consider whether forms of support that are currently closely linked to particular products and particular methods of production could be better linked to delivering general public good outcomes.
- Reforms should centre on achieving goals, while reducing the cost to taxpayers and consumers. Specifically, further policy actions should, *inter alia*, reduce border protection, direct payments for output and inputs to increase exposure to market signals and reduce environmental pressures, and remove measures that impede structural adjustment towards more productive and sustainable units. The efficiency of agricultural support measures in achieving the various stated policy-objectives, such as food security, sustaining rural economies and landscape amenities at lower costs, would be improved if the intended beneficiaries of such measures are identified and policy measures targeted to specific outcomes.
- An assessment of whether the current format of annual negotiations between government and farmer representatives is well suited to promoting reform would also be beneficial. Although the negotiations provide a platform for regular evaluation and adjustment of the system, they mainly focus on annual farm incomes, thereby paying insufficient attention to other societal concerns and long-term objectives.
- The market power of co-operatives adds another dimension of support to farmers and agricultural support policy also distorts efficiency and competition in the agri-food supply chain as a whole (Chapter 5). An assessment of the coherence of agricultural support policies with other economy-wide policies, such as competition policy, would be beneficial.

2.7.2. Environmental sustainability

- Pursuing productivity growth while maintaining environmental protection and sustainable natural resource management should be a policy priority. In this context, re-orienting support towards general services, especially for the agricultural knowledge and innovation system, is an avenue that should be further explored.

- Norway should address the conflicts between agricultural and environmental policy goals. The overall design of the agricultural support schemes results in most support being given to the type of production that results in the highest GHGs emissions per unit of production (i.e. production of red meat, mainly cattle and sheep farming).
- Modelling results show that it is possible to achieve the objective of preserving production capacity and agricultural landscape across the country, while reducing the negative environmental impacts of intensive production and increasing the potential for value creation along the value chain. The core of the objectives of production-channelling policies could be achieved more efficiently through decoupled support with payment rates that are adapted to each location, and subject to the requirement of maintaining the agricultural production capacity of the land.
- Although agri-environmental measures have become more targeted over time, there appears to be a pronounced focus on ensuring continued farming. Payments based on non-commodity criteria account for only 0.3% of producer support, while payments conditional on adopting a specific farming practice for environmental reasons account for 27% of total budgetary support to producers. This contrasts with the majority of payments in the European Union, Switzerland and the United States, which impose such a conditionality. However, experience in OECD countries shows that such conditionality is not effective unless it is adapted to the diversity of local farming practices and conditions. In Norway, some requirements are adapted to local conditions (e.g. requirement to protect waterways, insular elements and stone hedgerows).
- Greening Norway's agricultural sector should include a much greater shift towards less-distorting forms of support, such as payments based on non-commodity criteria (e.g. going beyond environmental regulation). For example, production-linked support without input constraints creates incentives to increase pesticide use, which runs counter to the objective of reducing pesticides and counteracts with the pesticide tax. In addition, tax concessions on road fuels and transport subsidies should be phased out or reduced, as they contribute to emissions of CO_2 and air pollutants.
- More direct payments to farmers should be made conditional on proper implementation of an environmental plan. This approach would also serve to target measures more effectively, based on local and county priorities to achieve the programme's national goals. Such requirements have the potential to increase coherence between agricultural and environmental policies and to contribute to improving environmental performance of agriculture compared to a situation where the same level and structure of payments are made with no conditions attached. However, there is insufficient evidence concerning control, sanctions and monitoring the environmental impacts of these cross-compliance requirements. An inspection and enforcement system should be in place to monitor compliance of farmers and the environmental impact of cross compliance.
- Norway should also re-assess the implementation of an environmental plan at the farm level, as required under the *National Environmental Programme.* A well-designed and implemented environmental plan would make farming more environmentally accountable, particularly if plans are regularly monitored and evaluated.
- Apply the polluter-pays-principle more systematically to hold farmers accountable for all harmful environmental effects from crop and livestock pollution by considering, for example, taxes on fertilisers and penalties where these contribute to water pollution. Strengthen efforts to provide targeted and tailored advice to farmers on sustainable technologies and practices by paying more attention to supporting activities, such as technology monitoring, training advisors, and the production, collection and storage of technical knowledge.
- The design of agri-environmental policy requires the definition of reference levels, and environmental targets play a crucial role in choosing policy instruments. The reference level is the minimum level of environmental quality that farmers are required to provide at their own expense, and environmental targets represent a higher desired level of environmental quality. To establish

a solid framework of agri-environmental policies, Norway should clarify the reference environmental quality as well as environmental targets which are well adapted to local ecological conditions. Norway should advocate the implementation of performance-based agri-environmental policies that reflect the diversity of its agri-environment. Such payments, in addition to increased flexibility provided to farmers, achieve greater environmental benefits than practice-based measures. In this regard, payments to remunerate farmers for the provision of environmental outputs that the Norwegian society want – yet go beyond what is expected of farmers to provide (reference levels) – need to be made available, assessed in terms of costs and benefits, and transparent, within the constraints of overall budgetary provision.

- Establish measurable indicators of performance to regularly monitor and evaluate the achievements of agricultural policies in meeting objectives, and to make course corrections when outcomes fail to meet the policy objectives.

2.7.3. Climate change

- Meeting international commitments related to GHGs and ammonia emissions is challenging. Difficulties stem from the policy objective of separation of support for livestock production and arable crops (regionalisation of support), leading to reduced nutrient efficiency and higher ammonia emissions.
- The co-operative approach used in Norway to develop policies for controlling GHGs and food waste in the agro-food sector is not without merit. The climate change agreement between the government and farmer organisations facilitates the embracement of reform proposals by stakeholders. However, climate measures agreed should be consistent with the mitigation actions stated in the 2016-27 White Paper and should not lead to increased subsidies to agriculture.
- Norway faces a sizeable emission-reduction challenge and should intensify GHG reduction measures in agriculture. It would be feasible to significantly reduce GHG emissions from agriculture by restructuring support schemes and by not exempting agriculture from the cap-and-trade system or from GHG emission taxes. Recent legislation restricting cultivation on peatlands – if applied with enough ambition – can potentially reduce GHG emissions from agriculture in a significant manner and should be carefully monitored.

2.7.4. Risk management

- In 2018, Norway experienced the driest and warmest summer in the last 70 years and several measures were launched to help farmers. In the likelihood of increased extreme weather conditions, it is advisable that drought support measures focus on encouraging drought preparedness and resilience of the sector, rather than on the provision of ad hoc financial aid.
- Consideration should be given to enhancing the role of farmers in managing their business risk by introducing voluntary risk-management programmes such as mutual funds, or a programme that allows farmers to place savings in a special account that is excluded from income declaration and possibly matched by a government subsidy.

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Notes

[1] The government may – subject to certain conditions – conclude an agreement with a single partner. Such was the case in 2015 and 2016.

[2] The negotiations make extensive use of micro-simulations of farm finances. The micro-simulations model the finances of around 30 representative farms using inputs from actual farm accounts and are run by NIBIO. In the negotiations, proposals for parameter changes are programmed into the system and the impact on farm incomes is assessed.

[3] The Chairman of the Council is a representative from the Ministry of Agriculture and Food, while the farmer-owned organisations are in majority on the Council.

[4] Revised target prices normally apply from 1 July in the marketing year.

[5] Definition of OECD indicators of agricultural support can be found in OECD (2020[4]).

[6] Norwegians spend only 11% of their income on food, however.

[7] Two tariff lines covering hard cheeses, two covering lamb carcasses and two covering beef meat (steaks and fillets).

[8] The bound tariff is the maximum most favoured nations (MFN) tariff applied to a commodity line by individual WTO members. When countries join the WTO or negotiate tariff levels, the top level, bound tariff rates, are agreed rather than specific individual rates. In practice, bound tariffs are not necessarily applied by WTO members towards each other.

[9] As of 1 January 2015, Norway unilaterally eliminated import duties on 114 agricultural tariff lines. While these duties were low (and of no significant importance for the protection of Norwegian agricultural production), their elimination resulted in a reduction of customs procedures and administrative costs.

[10] TRQ fill rates are high for beef, deer and elk meat, pears, and fruit preserves; but are under utilised for eggs, chicken meat, red cabbage, and pork.

[11] Article 19 of the EEA agreement concerning trade in basic agricultural products is reviewed periodically. The round of these reviews agreed in 2013 and finalised in April 2017, and changes agreed entered into force in October 2018.

[12] In the 2011 agreement, a list of reciprocal tariff elimination covering around 185 tariff lines on HS8 was included.

[13] There are ongoing free trade negotiations between EFTA and India, Viet Nam, and Malaysia. EFTA has also started re-negotiations of free trade agreements with Chile and the Southern African Customs Union (SACU) (Botswana, Lesotho, Namibia, South Africa, and Swaziland).

[14] For a detailed discussion on the history of agricultural policies in Norway, see (Lundekvam, Romstad and Øygarden, 2003[34]).

[15] There is one payment scheme for animals grazing during a minimum period (irrespective of land use category) and another for animals grazing on unimproved pasture.

[16] The fees are established by the Norwegian Agricultural Authority.

[17] For more information, see www.oecd.org/tad/agricultural-policies/risk-management-agriculture.htm

[18] The specific compliance requirements are: maintain a two-metre buffer zone along waterways; protect natural historic elements, such as waterways, stone fences and trails; follow a fertiliser application plan; and maintain a journal on pesticide use.

[19] The most important difference between the AK subsidy and the EU scheme with "Greening" is the European Union's requirement that farms that employ lands above a certain threshold must cultivate a combination of crops, unless their production is organic or, alternatively, if they mostly have permanent grassland. There are no similar requirements in the Norwegian scheme.

[20] The gross N balance (i.e. the potential surplus of N on agricultural land) is a means to assess nutrient management and efficiency in agriculture. A surplus indicates potential environmental problems, while a deficit may indicate a decline in soil nutrient status. It is estimated by calculating the balance between N inputs (fertilisers and manure, atmospheric deposition, biological fixation and seeds and planting material) and N outputs (fodder/grazing and crop harvest) from the agricultural system per hectare of agricultural land.

[21] The 2020 commitment is not given in absolute levels, but proportionally to 2005 emission levels.

[22] The webpage "Tiltaksveilederen" (www.nibio.no/tiltak) presents information on mitigation measures to reduce nutrient losses from agriculture.

[23] For example, because of the bias on reducing P losses the estimated losses of N from agricultural areas to marine waters increased by 11% from 1990 to 2011 (Selvik, Tjomsland and Høgåsen, 2012[35]).

[24] https://www.miljodirektoratet.no/aktuelt/nyheter/2020/januar-2020/tap-til-rovdyr-holder-seg-pa-lavere-niva-enn-for/.

[25] See a recent government strategy: https://www.regjeringen.no/contentassets/3f5ee035363b44b6b57fe0a2f676ad15/strategi-forrad-av-gener--muligheter-og-beredskap.pdf

[26] This is represented in the model as a payment paid proportionally to land value to all agricultural land uses (crops and livestock land and "other" arable land, but not other land types). Such a payment does not affect the relative price of land between uses, so does not induce land use change within the agriculture sector. These are the typical requirements of decoupled payments in other countries such as Switzerland, the European Union, and the United States.

3 Natural resource management in Norway

Norway has good environmental policy frameworks, strong commitment, and is at the forefront of good practice in many areas of environmental policy. Committed to climate action, it has adopted some of the most ambitious emission mitigation targets of any OECD country and is preparing for carbon neutrality by 2050. However, agriculture is not part of the European Union's Emissions Trading System in which Norway participates. Nor is agriculture in Norway subject to tax on emissions, which makes it an exception compared with other sectors, even as agricultural support exacerbates emissions and other environmental pressures. Norwegian forestry has tremendous potential for growth and contribution to climate change mitigation, but current harvest rates are constrained in part by market demand. Agriculture and forestry land resources are often part of the same property exploited by farmers, yet land use legislation impedes land use changes, in particular land moved out of agriculture use. Improving the incentives for the sustainable use of natural resources could lead to sustainable innovation in both agriculture and forestry, and contribute to a more circular economy.

Key messages

- Norway has relatively high standards in environmental regulation and the stringency of Norway's environmental policy is above the OECD average and increasing. However, other goals of agricultural policies, such as maintaining agricultural production across the country, have prevailed over the environmental objectives as the link between agricultural and agri-environmental policies was rather weak. This policy environment also drives innovation incentives.
- Land and agricultural policies aim to keep farms in operation in all parts of the country and facilitate family ownership. Land regulations such as the Concession Act, the Allodial Act, the Land Act and the Forest Act are essential tools to avoid agricultural land changing to other uses and to achieve these goals. The majority of forestry properties are a mix of agriculture and forestry use.
- The main objective of the current Forestry Act from 2006 is to promote sustainable management of forest resources to promote local and national economic development and to secure biological diversity, consideration for the landscape, outdoor recreation and the cultural values associated with the forest.
- Addressing climate change is a policy priority in Norway, which was one of the first countries to adopt a carbon tax, and in recent years climate change and environmental objectives are playing a growing role in agricultural policies. However, agricultural activities that generate the highest greenhouse gas (GHG) emissions are those that are currently the most heavily supported. Moreover, farmers are exempt from GHG emission taxes and agricultural emission reductions are voluntary. It will be increasingly difficult to reduce GHG emissions from agriculture and meet international commitments in ammonia emissions and water protection without significant policy reform.
- Maximising agriculture's contribution to climate change mitigation objectives requires tackling the structure of livestock production. Taxing livestock emissions (or reducing coupled support) has the potential to reduce the number of animals, increase production per animal and improve the carbon efficiency of dairy and meat production, while decoupled support can keep farm income and land in agriculture use.
- Forests contribute significantly to reducing the net emissions of greenhouse gases in Norway but this uptake of carbon is not fully counted as part of Norway's climate commitments as it is a result of past policy and market actions. Limited market demand is a main barrier to scaling up harvest levels, and innovative new products are needed. Increased carbon stocks in harvested wood products (HWPs) for durable applications will result in carbon being removed from the atmosphere. An important area of recent innovation in Norway has been the development of new HWPs for commercial building construction.
- The national cross-sectoral bio-economy strategy provides an opportunity to increase the sustainability and competitiveness of the agro-food sector through the increase in the efficiency of the use of natural resources, contribute to climate change mitigation, help the agricultural sector to adapt to climate change and foster policy coherence.

The productivity and sustainability performance of the agro-food sector crucially depends on the incentives posed on the use of natural resources. Innovation is a main driver of productivity gains, but it needs the right environmental incentives to ensure that these gains are obtained from reducing pressures on the use of natural resources. The aim of this chapter is two-fold: i) to give an account of recent important developments in Norwegian environmental and natural resource management policies which have potentially significant implications for agriculture, including land management, forestry, water management, and landscape and biodiversity protection; and ii) to discuss Norway's climate change action and policies towards a low-carbon economy such as taxes, emission trading, bio-economy and circular economy.

3.1. Key environmental objectives and institutional framework of environmental regulations

Norway plays a leading role in environmental protection and sustainable development in the international arena. Sustainable development is an overarching policy objective. The main objectives for environmental policies, as summarised in national budgets, are: natural diversity; cultural and historical heritage; outdoor recreation; pollution which includes waste and circular economy; and climate.[1]

The Norwegian Parliament (*Stoërting*) determines Norway's overall environmental and climate policy and the government implements and administers the policies agreed. In addition, municipalities and local governments are responsible for the implementation of policies and climate action plans at the local level.

In order to better adapt environmental policies to local needs and requirements a significant decentralisation of environmental responsibilities to the county and municipal levels has been implemented. While the government implements and administers the most important policies and measures (including economic instruments and regulations), local governments are responsible for implementing policies at the local level, such as those related to waste management, local planning and some transport measures.

By virtue of its membership of the European Economic Area (EEA), Norway's natural resource management approach is strongly influenced by the European Union. With a few exceptions (e.g. fisheries), Norway has transposed EU Directives into national law and its environmental policies are now fully aligned with the requirements of EU legislation. In some areas, such as environmental impact assessment and the provision of information about health impacts of pollution and products, Norwegian requirements are more stringent than required by EU policies.

Norway also plays a leading role in international environmental initiatives and climate negotiations. In particular, Norway has close bilateral partnerships with some developing countries to reduce emissions from deforestation and forest degradation (REDD+), and is the major funder and an active member of the United Nations Collaborative Program on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries (UN-REDD).

3.2. Management of natural resources and ecosystems

3.2.1. Regulations on natural resources

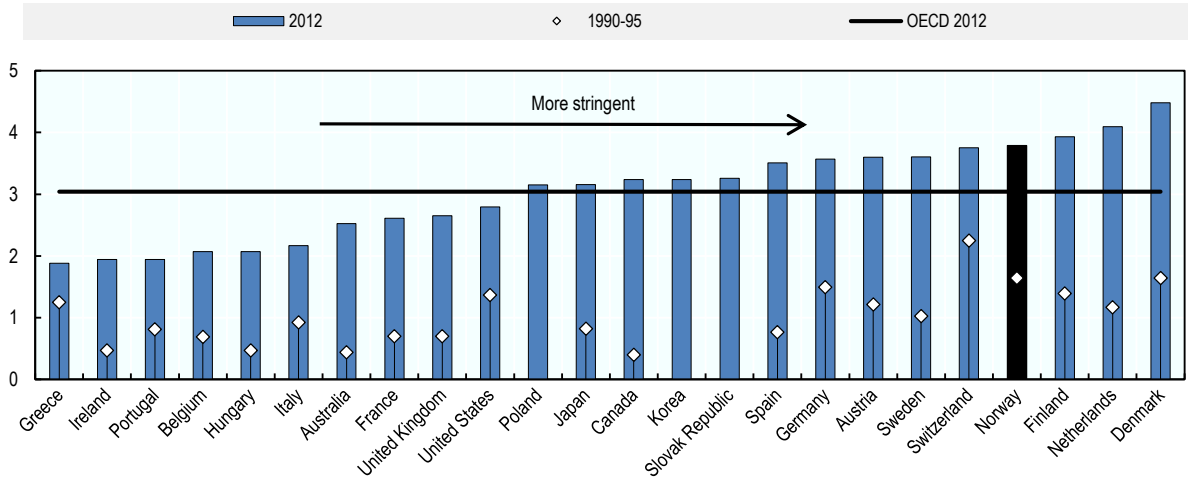
Regulations on natural resources are central to ensuring the long-term sustainable use of natural resources and biodiversity. They also impose limits on the impact of industrial and agricultural activities on the state of the natural resource (e.g. water pollution, soil degradation, GHG emissions). The design of natural resources and environmental policies can influence incentives for agricultural innovation and sustainable productivity growth.

Norway has a relatively high level of environmental regulation compared to other OECD countries. There is a wide range of laws regulating various aspects of environmental policy and the use of natural resources, including specific regulations on pollution controls, wildlife and freshwater fish, municipal health, environmental protection, buildings and motorised vehicles.

Moreover, the stringency of Norway's environmental policy has increased significantly since the early-1990s and, in 2012, was above the OECD average as measured by the OECD's Environmental Policy Stringency indicator, which covers energy and GHG emissions. In this respect, the level of stringency in Norway is the fourth highest after Denmark, the Netherlands and Finland (Figure 3.1).

Figure 3.1. Norway's environmental policy stringency is one of the highest in OECD countries

Environmental policy stringency in OECD countries, 1990-95 and 2012



Note: The stringency of Norway's environmental policy has increased significantly since the early-1990s and, in 2012, was above the OECD average as measured by the OECD's Environmental Policy Stringency indicator. The index includes only policies and regulations related to energy and GHG emissions. For Korea, Poland and the Slovak Republic, 1990-95 average is not available.
Source: Botta and Koźluk (2014[1]).

The most important regulations are the Planning and Building Act and sectoral legislation such as the Water Resources Act, the Watercourse Regulation Act, the Energy Act, the Pollution Control Act, the Svalbard Environmental Protection Act, the Marine Resources Act, the Aquaculture Act, the Petroleum Act, the Forestry Act and the Land Act, applied together with the Nature Diversity Act.

At the sectoral level, agriculture has been subject to several environmental regulations since the 1980s, when specific environmental objectives were incorporated within its agricultural policies. However, other goals of agricultural policies, such as agricultural income, food self-sufficiency and ensuring sufficient of agricultural production across the country, have taken precedence over the environmental objectives as the link between agricultural and agri-environmental policies was rather weak. In recent years, and as an effect of the Paris Agreement on climate, environmental objectives have started to play a stronger role in the development of agriculture and agricultural policies (Mittenzwei and Øygarden, 2020[2]).

Regulatory approaches include standards for environmental outcomes as well as standards for particular activities. Relevant standards for particular activities include, *inter alia*, standards for manure and pesticide management as well as requirements that ruminant livestock shall be kept outdoors to graze for minimal periods each year. Regulations for management of nutrients, run-off and erosion in agriculture is mostly developed nationally, while regulation on plant protection products implements EU-regulations in this area.

Forestry regulations specify many aspects of forestry management activity, for example, the timing of replanting of harvested areas.

Most of the EU's environmental legislation has been incorporated into Norwegian law through the Agreement on the European Economic Area Agreement (EEA). For example, Norway has implemented the ecosystem-based EU Water Framework Directive, with the goal of achieving good ecological and chemical status in all water bodies by 2021. The EEA Agreement also includes a range of legal acts relating to the climate and environment, and these play a part in reducing pressure on the environment. They include legislation on waste, chemicals and air pollution. However, legislation on nature management, including the Birds and Habitats Directives, is not part of the EEA Agreement. Nevertheless, Norway and the European Union co-operate closely in this area as well.[2]

Regulations for manure management have been mostly constant over recent years, while standards for pesticide management and animal welfare have been under constant development. Similarly, regulations for environmental protection in areas such as water quality, air quality and wildlife habitat have been developed over recent years.

For manure and organic fertilisers, the regulation requires, *inter alia*, that farmers must have at least 0.35 ha of agricultural lands per livestock unit (which is the equivalent of a dairy cow) to have enough area to distribute manure, and at least eight months storage capacity, to allow for timing of manure spreading. Management of mineral fertiliser is not covered by this regulation; however, dosage of all types of fertiliser is covered by the regulation to plan the dosage of fertiliser. Farmers' fertiliser plans must be carried out every cropping season to qualify for full payments. The fertiliser regulation is under review. The agricultural and environmental authorities presented their reports and proposals for a new regulation in 2018. The departments are working on a public consultation on new fertiliser regulations.[3]

For controlling soil erosion, the general *Water Resources Act* requires that vegetation be maintained in zones directly adjacent to waterways. However, this requirement is not enforced retroactively, in cases where such zones were cultivated prior to the Act. Instead, there is a cross-compliance requirement – to qualify for the *Area and Cultural Landscape* programme in accordance with the regulation for production support – that farmers must maintain buffer zones on such cultivated land adjacent to waterways. The latter regulation also specifies that the zone shall minimally have a width of two metres. Additional erosion control requirements can be enforced by regional authorities if justified (i.e. if soils and waters are particularly exposed). Such regional requirements have currently been adopted only in particular cases in southeast Norway.

The regulation on plant protection products implements the EU regulations regarding approval of plant protection products. The EU Directive on sustainable use of pesticides is also implemented in Norway. Further, there are requirements for the practical use of plant protection products, including requirements to follow the principles for Integrated Pest Management. There is also a tax on plant protection products, which is differentiated according to the health and environmental risks related to the product. Plant protection products must be approved by the Norwegian Food Safety Authority before such products can be placed on the market in Norway.

3.2.2. Land management

Norwegian agricultural policy with respect to land aims to keep farms in operation in all parts of the country, facilitate family ownership, secure settlement in rural areas and avoid land fragmentation. Judicial measures, such as the Concession Act, the Allodial Act, the Land Act and the Forest Act are essential tools to achieve these goals.

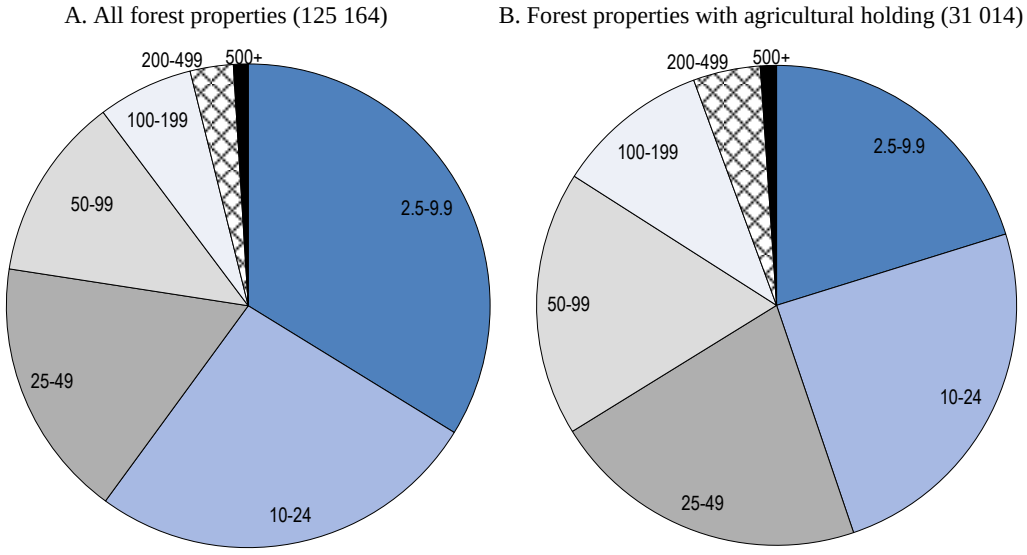
Property holdings are small on average. In 2018, 182 300 properties were registered in the statistical database as agricultural or forest properties, defined as those with at least 0.5 ha agricultural area or 2.5 ha

productive forest area. Of these, 29% are for exclusively agricultural use, and 11% are exclusively forestry. The remaining 60% are a mix of agriculture and forestry use (Chapter 1).

The average size of a forest estate for all landowners is 55 ha and the smallest 60% of landowners own only 10% of the forest land (Figure 3.2). For those forest properties associated with an agricultural holding, average size is larger. Harvest activity was carried out on 18 447 forest properties in 2018, and those land owners earned NOK 49 000 (USD 5 300) on average. Most owners of agricultural or forest properties are individuals rather than companies. Ownership consolidation is slowly reducing the overall number of properties, though many owners choose to rent out their agricultural land rather than sell it upon ceasing operations.

Figure 3.2. Norwegian forest properties associated with agricultural holdings are larger on average

Share of forest landholding in Norway by size class (in ha), 2019



Notes: Forest owners associated with an agricultural operation have larger landholdings on average, but most remain small. The average size of a forest estate for all landowners is 55 ha and the smallest 60% of landowners own only 10% of the forest land.
Source: Statistics Norway (2020[3]), Forest properties (databases), https://www.ssb.no/en/jord-skog-jakt-og-fiskeri/statistikker/stskog (accessed September 2020).

When certain properties change hands the Concession Act (LOV-2003-11-28-98) states that the buyer must apply for a concession.[4] When a contract is signed, an application for a concession is sent to the municipality where the property is located. The application must give information about the acquirer, the property in question and the purpose and all other conditions for the acquisition. The main purpose of the Concession Act is to protect agricultural land.

There are certain exemptions in the Concession Act for transfers within families, and the Allodial Act (LOV-1974-06-28-58) further protects the historical ownership rights of family members during property transfers. This act allows those with the best allodial rights to claim a property if it changes owner. It also gives heirs the right to inherit the entire agricultural or forest property when the owner dies. An owner of an allodial property retains the right to sell or give the property to whoever they choose, but those with allodial rights may reclaim the property from the new owner.

Agriculture and forest lands are subject to the Planning and Building Act (LOV-2008-06-27-71), which aims to promote sustainable development. According to the act, planning will contribute to co-ordinating

governmental, regional (county) and local (municipality) tasks, and make the basis for decisions linked to use and protection of the resources. Municipalities may make, or change, their master plans according to the Planning and Building Act and may do so at their own initiative or that of private persons.

The Land Act (LOV-1995-05-12-23) provides that cultivated land may not be used for other purposes. The farmer may build houses that are necessary to run the farm, but not other buildings. Exemptions to this rule may be granted under certain circumstances, most importantly having to do with improving the structure of agricultural operations.

The state owned company Statskog SF is the largest forest owner, holding approximately 6% of all productive forest area. The Norwegian Forest Owners Federation (*Norges Skogeierforbund*) represents approximately 34 000 owners of forest land representing 80% of the timber market. The Federation represents the interests of forest owners towards the government and other public authorities, politicians and media. The four regional co-operatives assists members, who are mostly farmers that choose to join, to manage their forest holdings. This includes planning, arranging for harvest and sale to mills. They are considered as agriculture co-operatives.

3.2.3. Forestry policy and management

Forestry policy objectives include considerations of economic, climate, biodiversity, landscape and amenity benefits. The current Forestry Act came into force in 2006. Its main objective is to promote sustainable management of forest resources to promote local and national economic development and to secure biological diversity, consideration for the landscape, outdoor recreation and the cultural values associated with the forest. A wide range of measures, including legislation, taxation, economic support schemes, research, extension services and administrative procedures, support the implementation of forest policy, but unlike in the agricultural sector, there is no border support or market regulations to protect price levels.

Norway's forest policy is summarised in a White Paper that was adopted by the parliament in 2017 (Meld. St. 6 2016–2017), which considers forests and forest industries to be important contributors to a modern bio-economy that can aid the transition towards a more sustainable and green economy that is less dependent on oil and gas.

The Norwegian Bioeconomy strategy identifies policies that allow the extraction of biomass from forests to be increased while at the same time safeguarding biodiversity. It states, among other things, that the government will strengthen environmental considerations in forestry through new instruments in the Nature Diversity Act as well as other forestry instruments (Norwegian Ministry of Climate and Environment, 2015[4]). These measures include environmental regulation, knowledge development and the Norwegian PEFC Forest Standard.

The SKOG22 working group was established by the Ministry of Agriculture and Food in 2013 to develop a comprehensive national strategy to contribute to the short and long term development of the forestry sector (Innovation Norway, 2015[5]). It was composed of a wide array of participants representing all parts of the value chain as well as research and development. SKOG22 reflects the perspective of forest sector participants and so is not official government policy. One noteworthy goal in SKOG22 is finding new uses of forest products to secure domestic value added processing and avoid exporting raw materials.

Long-term objectives of the SKOG22 are to increase the annual harvest to as much as 15 million m^3 by 2045. There is also the intention to reduce the share of raw timber materials in exports and increase domestic value added in forest products. In order to achieve the targets for harvesting and increased processing, by 2045 new uses must be found for 5.2 million m^3 per year in wood processing, fuel and biorefining.

A central regulation under the act is the obligation for forest owners of all types to regenerate areas within three years after harvesting. Supporting this regulation is the requirement for forest owners to set aside

between 4% and 40% of the revenues from harvested timber into a government administered fund. The Forest Trust Fund was established to support long term investment in sustainable forestry. The Fund is owned by forest owners, but it may only be used for specific purposes such as planting, road building, management planning, non-commercial thinning and other activities. When used, the money is treated as income for the forest owner, though up to 85% is exempt from taxation when the money is used for approved purposes. At the end of 2018, the Forest Trust Fund had a balance of NOK 1.9 billion (USD 0.2 billion). The tax treatment of the fund makes it an attractive option for forest owners.

Economic support is given for a range of activities that support sustainable forestry. Support for forest roads and timber terminals has been prioritised in recent years, to address areas with relatively low utilisation of forest resources due to sparsely developed forestry infrastructure. This includes coastal areas in western, mid and northern parts of Norway. In 2018, forest owners received a total of NOK 227 million (USD 28 million) in grants for forest road construction, silvicultural activities, forest management planning and other activities enhancing sustainable forestry and climate mitigation. In addition NOK 45 million (USD 5.5 million) was given in grants for the construction of timber terminals to facilitate transport by sea.

Norway is one of the earliest participants in the Programme for the Endorsement of Forest Certification (PEFC), an independent third-party certification system for forest products. Norway first joined PEFC in 1999, and its standard was first endorsed in 2000 and reviewed every five years after that, most recently in 2016. Norway's standard covers activities related to forest manager responsibilities and planning, felling and forestry operations and special environmental values (PEFC Norway, 2016[6]).

3.2.4. Water management

Norway's Water Management Regulation (*Vannforskriften*) incorporated the EU Water Framework Directive (WFD) into Norwegian law in 2007. The WFD was formally taken into the EEA agreement in 2009, granting the EFTA countries extended deadlines for the implementation. Also, under the North Sea Declaration Norway has obligations to limit or reduce nutrient inputs and the local and central governmental authorities are co-ordinating efforts to comply with this obligation.

The main objective of the WFD is to achieve "good conditions" in all waterways as regards to pollution and ecological conditions. The EU WFD divides the country into river basins. The county councils within a watershed are Water Region Authorities and they are responsible for the regional basin management plans including environmental goals and cost indications for the proposed measures for the watershed in focus. The plans must be agreed on by the county government and approved by the Ministry of Climate and Environment. Following this step, individual measures will be processed by the sector authorities.

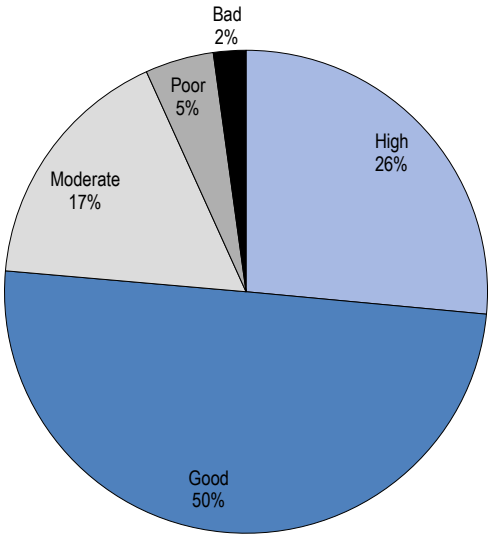
The environmental conditions in Norwegian rivers and lakes are relatively good compared with those in most other European countries. Around 50% of all Norwegian water bodies probably meet the EU objectives for good quantitative status under the EU WFD, while around a quarter of the Norwegian water bodies are at risk for not fulfilling the requirements of good water quality. In 2019, 76% of the identified Norwegian water bodies had high or good ecological status (Figure 3.3).

Agriculture is an important source of nutrients in some areas and has been identified as the third most important factor behind aquaculture and manufacturing influencing the status of Norwegian fresh water bodies. Most of the eutrophication problems in rivers and lakes are related to phosphorus (P) and the measures implemented in Norway are especially focusing on reductions in P loading (Chapter 2).

Measured by nutrient content, 34% of all nitrogen and 58% of all phosphorus used in agricultural farming come from manure Bye et al. (2020[7]). Since 1980, the sales of nitrogen have been quite stable, while the sales of phosphorus and potassium have decreased (Chapter 1). However, in 2008/09, sales of commercial fertilisers decreased significantly, due to a high rise in prices.

Figure 3.3. Around 76% of all Norwegian water bodies had good or high ecological status

Ecological status of classified Norwegian water bodies, 2019



Source: Bye et al. (2020[7]).

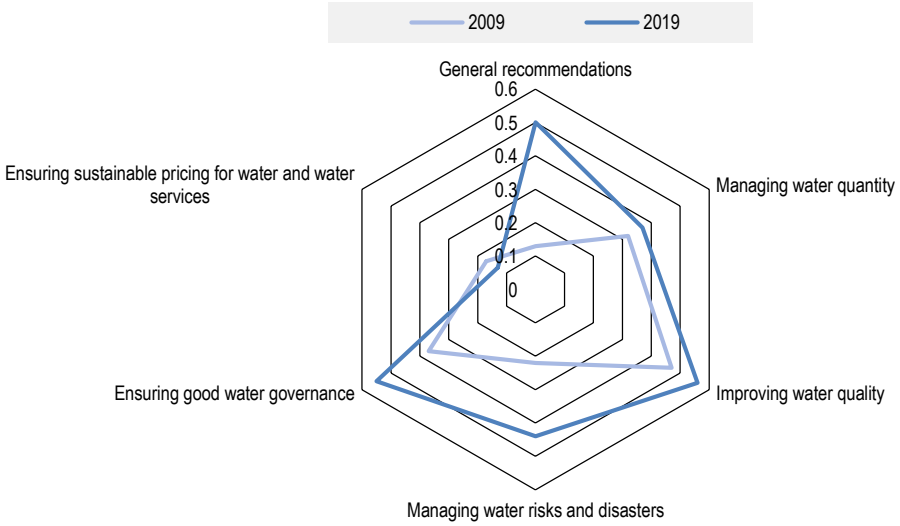
Recent analysis by the OECD Secretariat suggests that, overall, Norway has made some progress in aligning its agriculture and water policies with the OECD Council Recommendation on Water from 2009 to 2019 (Gruère, Shigemitsu and Crawford, 2020[8]). On average, the largest progress was observed with respect to general policy recommendations, followed by water risk and disasters management (Figure 3.4). Norway has upgraded and improved the dissemination of tools to support decision-making on agriculture and water (e.g. implementation of the EU WFD, River Basin Management Plans 2016-2). Within the agricultural policy, mitigation measures entail support payments, legislation on manure management, and regional and local subsidies provided through the *Regional Environmental Programme* (REP) (Chapter 2). Norway has also implemented policies to manage flood risks through a combination of mitigation and adaptation policies. For example, it has developed national flood risk management plans or frameworks that include plans for the agricultural sector.

Despite the introduction of numerous measures, alignment scores remain low: general considerations (0.5), water quantity (0.37), water quality (0.56), water risks (0.44); and water pricing and charges (0.13). Moreover, in the area of pricing the analysis indicates that no progress has been achieved for policies related to water pricing and, at the same time, the score remains very low. Water charges and pricing do not reflect the full supply cost recovery (operation and maintenance costs, and capital costs) and more efforts may be needed to recover water charges and use pricing instruments, in line with the OECD Council Recommendation on Water. In addition, a gap exists between the water quality targets and the current situation (Øygarden and Bechmann, 2017[9]). Furthermore, some of the measures, such as regionally-targeted support to the livestock sector may have encouraged livestock activities and contributed to the deterioration of water quality.

Nutrients run-off is considered a serious agri-environmental concern in parts of Norway, and its effect on water quality is the most important concern. The amount of nutrient discharges – phosphorous and nitrogen – from agricultural activities into the waterways and oceans vary markedly between the different water regions. Agriculture ranks high in relative contribution of discharges in the southeastern areas of the country. For example, the water regions Glomma and Vest-Viken, are the two regions where agriculture accounts for the largest relative contribution of total discharges with 44% and 46% of phosphorous discharges, and 40% and 27% for nitrogen discharges respectively (Bye et al., 2020[7]).

Figure 3.4. Norway has made progress in aligning its agriculture and water policies with OECD recommendations

Overall alignment of Norway's agriculture and water policies with the OECD Council Recommendation on Water, 2009 and 2019



Note: Indices range from 0 to 1, higher indices indicate a higher alignment. Norway has made the most progress with respect to general policy recommendations, followed by water risk and disasters management.
Source: Gruère, Shigemitsu and Crawford (2020[8]).

3.2.5. Biodiversity, species and ecosystems

The major threats to biodiversity include land use change, climate change, invasive alien species and pollution. Changing land use is considered to be the most significant factor impacting Norwegian biodiversity and is estimated to have a negative impact on 87% of the threatened and near-threatened species (Norwegian Ministry of Climate and Environment, 2014[10]).[5] However, as noted earlier, Norway has restrictive legislation for the movement of land out of agriculture.

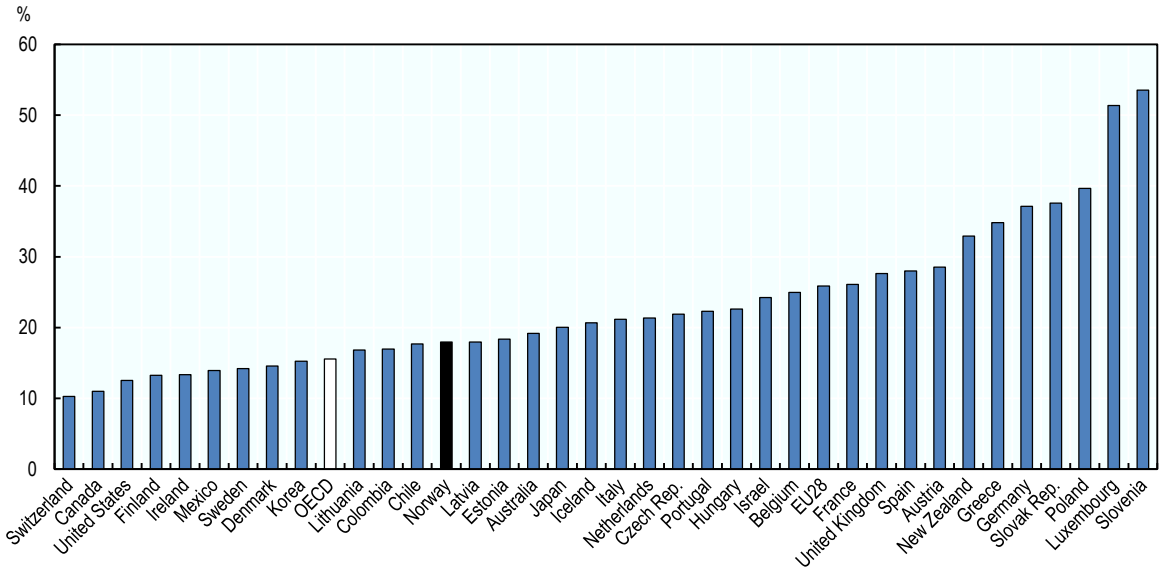
The main national biodiversity objectives, as set out in the 2015-16 Biodiversity Action Plan, are: to achieve "good ecological status" in ecosystems; safeguard threatened species and habitats; and maintain a representative selection of Norwegian nature (the conservation of areas covering the whole range of habitats and ecosystems) (Norwegian Ministry of Climate and Environment, 2014[10]).

Norway just meets the Aichi 2000 target to protect at least 17% of their land as 17.9% of the country's land area is designated as protected areas (Figure 3.5).[6]

The 2009 Nature Diversity Act introduced three key principles for biodiversity protection: the precautionary principle, the ecosystem approach, and the polluter pays principle. The Act applies both on land and at sea. The 2009 Planning and Building Act seeks to better protect the shore zone from construction and to safeguard nature and open spaces for outdoor recreation. It introduces the concept of zones that require special consideration, where restrictions on land use can be imposed. It also provides for climate-related concerns to be addressed in municipal land use planning (e.g. environment-friendly transport in connection with new development).

Figure 3.5. Norway protects more than 17% of its land, meeting the Aichi 2000 target

Terrestrial protected areas as percentage of land area in OECD countries, 2020



Notes: Norway is above the OECD average for protected areas, but below the EU28 average. Data for Turkey are not available.
Source: OECD (2020[11]), Protected areas (indicator), https://doi.org/10.1787/112995ca-en (accessed September 2020).

Norway and the European Union co-operate closely in global and regional biodiversity initiatives, including projects relating to the implementation of the Convention on Biological Diversity, and to mapping and assessing the status of Norway's ecosystems. Norway's large remote areas and extensive coastline present particular challenges in monitoring and tackling biodiversity loss. One challenge for the Norwegian authorities is the lack of clear, agreed management objectives for "good ecological status" in most ecosystems, even though "sustainable" management is specified as a goal and a legal requirement including in the Forestry Act.

In its 6th National Report to the Convention on Biological Diversity (CBD), and post-2010 National Biodiversity Strategy and Action Plan, Norway identifies invasive alien species as one of the major threats to biodiversity (Norwegian Ministry of Climate and Environment, 2018[12]), and has undertaken several legislative, policy and governance actions to control its spread which collectively provide an overarching framework.[7] According to CBD's evaluation entitled "Analysis of Targets Established by Parties and Progress Towards the Aichi Biodiversity Targets", Norway is on track to achieving its national target to combat invasive alien species by 2020.

In situ conservation of *genetic diversity* is part of the overall effort of Norway to safeguard biodiversity. The international framework for this work is set by the Convention on Biological Diversity and the Nagoya Protocol on Access and Benefit-sharing under the Convention, and the International Treaty on Plant Genetic Resources for Food and Agriculture. The Norwegian Environment Agency is responsible for co-ordinating initiatives for *in situ* conservation of genetic diversity.

Norway is involved in international co-operation with the FAO, e.g. through the adoption of global plans of action for genetic resources in food and agriculture. The Svalbard Global Seed Vault is the world's largest seed repository for plants and is vital to global food security.

Programmes for conservation and the sustainable use of genetic resources for food and agriculture have been organised by the Norwegian Genetic Resource Centre, which is part of the Norwegian Institute of

Bio-economy Research. The Centre is responsible for implementing and updating Norway's national action plans for the conservation and sustainable use of genetic resources in farm animals, forest trees and crops, including the wild relatives of food plants. Grant schemes for environmental measures in agriculture and forestry provide important support for these efforts.

3.3. Climate change mitigation efforts

Norway's climate policy is founded on the objectives of the UN Framework Convention on Climate Change (UNFCCC), the Kyoto Protocol, the Paris Agreement, and the Norwegian Climate Change Act. It is based on agreements reached in Parliament in 2008, 2012 and 2017, which are the result of a broad political consensus that Norway should take responsibility for the reduction of greenhouse gas emissions (GHG). These agreements define targets for emission reductions towards the long-term goal of making Norway a low-emission society.

3.3.1. Norway's commitments to reduce emissions

Norway's key commitments on climate change policy as stated in the 2017 Climate Change Act comprise of (Norwegian Government, 2019[13]):

- *2030 target*: An overall target of at least 40% reduction of GHG emissions from 1990 by 2030, as defined under the country's nationally determined contribution (NDC) to the Paris Agreement.[8] Norway will co-operate with the European Union to fulfil this commitment and already participates in the Emission Trading Scheme (ETS). Under an agreement with the European Union, Norway will also participate in the EU's Effort Sharing Regulation and the regulations on land use, land use change and forestry (LULUCF) for the period 2021-30. Norway updated its national determined contribution under the Paris Agreement in February 2020, the enhanced target is to reduce emissions by at least 50% to 55% by 2030 compared to 1990-levels.[9]
- *Climate neutrality* by 2030 was adopted as an objective in 2016 by Parliament. This implies that from 2030, GHG emissions must be offset by climate action in other countries through Norway's engagement with the EU-ETS and through international co-operation on emission reductions, emission trading, and project-based co-operation.
- *A low-emission society* by 2050, with the target to achieving a reduction of GHG emissions of the order of 80-95% from the 1990 level. The government has enhanced the 2050-target to represent an emission reduction of 90–95%.

The 2017 Climate Change Act has an overarching function in addition to existing environmental legislation. In particular, the Act introduces: i) five-year reviews of Norway's climate targets, following the Paris Agreement; and ii) an annual reporting mechanism on the status and progress in achieving the climate targets.

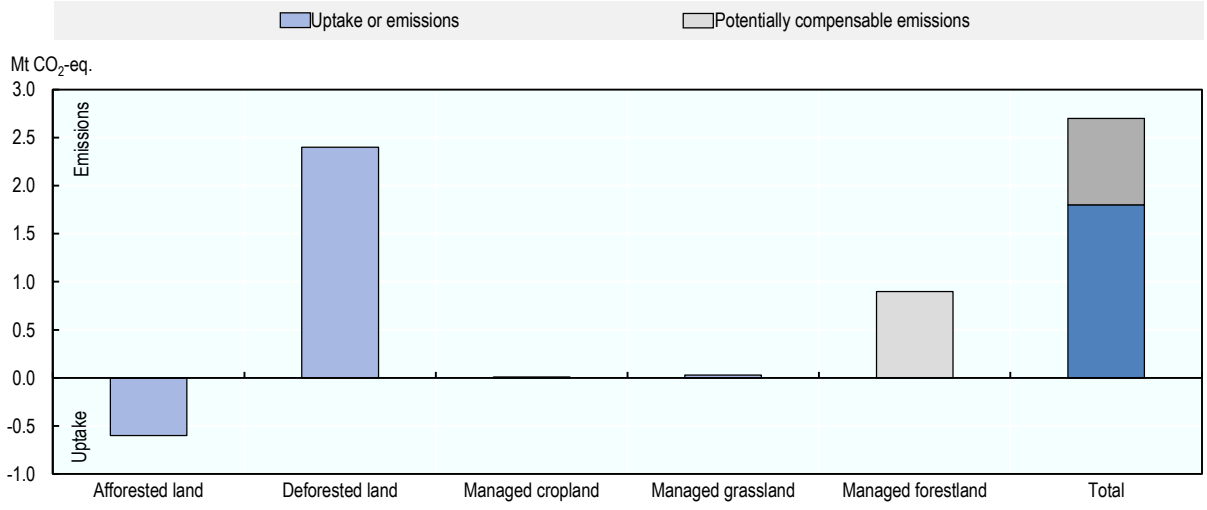
The Ministry of Climate and Environment has the overarching cross-sectoral responsibility for the co-ordination and implementation of climate change policy and commitments. The Ministry of Finance is responsible for tax schemes and the other ministries are responsible for policies in their respective sectors. The Norwegian Environment Agency was appointed by the Ministry of Climate and Environment as the national entity for official reporting. Statistics Norway is responsible for the official statistics on emissions to air. The Norwegian Institute of Bioeconomy Research (NIBIO) (Chapter 4) is responsible for the calculations of emission and removals from Land Use and Land Use Change and Forestry (LULUCF). Three main mechanisms have been used to reduce emissions: carbon taxation; emission credits from participation in the EU ETS; and emissions reductions under other international actions such as the Clean Development Mechanism.

Norway has been a part of the EU ETS since 2008. About 50% of Norwegian emissions are covered by the ETS. More than 80% of domestic emissions is subject to mandatory emissions trading, a CO_2 tax, or both. In October 2019, the European Union, Iceland and Norway formally agreed to extend, for the period 2021-30, their climate co-operation by including the Effort Sharing Regulation and the Regulation on GHG emissions and removals from land use, land use change and forestry (the LULUCF regulation), in the EEA agreement. By this decision, Norway takes part in all three pillars of the EU climate policies.

Under the Effort Sharing Regulation, Norway will need to reduce 40% of GHG emissions from the non-ETS-sectors (agriculture, transport, waste and heating) by 2030 compared to 2005. Under the LULUCF-regulation, Norway will commit to ensure that emissions do not exceed removals in this sector according to the accounting rules set out in the EU's Land Use, Land-Use Change and Forestry (LULUCF) Regulation.

Figure 3.6. Deforested land is the largest source of GHG emissions from LULUCF

Projected total uptake or emissions from LULUCF, 2021-25



Note: LULUCF: Land Use, Land-Use Change and Forestry. Preliminary calculations of the projections of all land use categories in the LULUCF sector. Agriculture uses (crop and grassland) have almost no projected impact on the LULUCF total. Under the EU forest management accounting rules, it is possible to exclude managed forest land emissions (so-called compensation) if the European Union has net removals and for countries with plans to increase removals in forest management.
Source: Norwegian Institute of Bioeconomy Research via Norwegian Ministry of Climate and Environment (2019), Norway's National Plan related to the Decision of the EEA Joint Committee No. 269/2019 of 25 October 2019; and Norwegian Ministry of Climate and Environment (2020), provided data.

According to EU's accounting rules for the LULUCF sector, deforestation is the largest source of LULUCF emissions (2.4 million tonnes of CO_2 per year), partly offset by removals from afforested land (0.6 million tonnes of CO_2 per year). Emissions and removals from forest management are derived from a forest management reference line (FRL) that was finally adopted by ESA on 16 December 2020. Preliminary calculations show that Forest management is likely to end up with emissions (0.9 million tonnes of CO_2 per year), due to the fact that the harvest rate is expected to increase compared to the situation in the reference period (2000-2009). There is, however, flexibility for compensation under the EU forest management accounting rules, that is excluding these emissions (if the European Union has net removals and for countries with plans for increasing removals in forest management). Agricultural lands have only a small impact on the LULUCF net total. Preliminary calculations shows that the projected net emissions from the LULUCF sector are approximately 2.7 million tonnes of CO_2 per year above the reference line for

the period 2021-25, and 1.8 million tonnes of CO_2 per year if emissions from forest management qualify for compensation.

Since under current trends LULUCF is expected to be a net emitter, Norway will have to take action to avoid being in violation of the regulation. As a result, among other measures currently under consideration, the conversion of peatlands to cultivation was restricted in June 2020, potentially saving 450 000 tonnes CO_2-equivalent for the 2021-30 period, based on an assumption that the restrictions prevent cultivation of 200 ha per year.[10]

3.3.2. Agriculture carbon reduction commitments are voluntary and are below those in other sectors

Agriculture emissions in 2019 were 4.4 million tonnes of CO_2 equivalents, a decrease of 6.4% since 1990. In total, GHG emissions from the agricultural sector represent 8.8% of total Norwegian emissions and 16.5% of non-ETS obligations. Objectives for agriculture are to reduce GHG emissions' intensity in production, increase the uptake of CO_2 and adapt production to a changing climate. The role of agriculture in Norway's climate change reduction plans was outlined in a voluntary agreement concluded between the government and the main farmers' organisations, *Norges Bondelag* and *Norsk Bonde- og Småbrukarlag*.

The government's position is that efforts to reduce GHG emissions from agriculture must be balanced with the goal of increased food production and should not lead to carbon leakage with production moved out of Norway (Meld. St. 11 (2016-2017)). For agriculture to continue to be exempt from carbon taxation and other measures applied elsewhere, the sector must make a good-faith effort to reduce emissions.[11] The agreement and plan made by the *Norges Bondelag* is intended to address this and sets out an 8-point plan for emissions reductions over the next decade (Box 3.1).

The plan is under the responsibility of the farmers' union and sets voluntary targets for the abatement of GHG emissions and removals from agriculture between 2021 and 2030. The plan has eight focus areas that if fully implemented can reduce GHG emissions from agriculture by 4 to 6 million tonnes of CO_2 equivalents over the next ten years, equal to about 10% of 1990 emissions on an annual basis.

Box 3.1. Eight focus areas of the Agricultural Climate Plan

- Deployment of a climate calculator and increased investment in climate advice. By the end of the plan, all farms should be using the climate calculator and have been offered climate advice.
- Targeted efforts to improve roughage quality and use of feed additives, livestock breeding in cattle, sheep and pigs, better animal health.
- Adopt machinery that runs on electricity, biofuels, biogas or hydrogen.
- Adopt fossil-free heating sources.
- Better utilisation of fertilisers through more environmentally friendly spreading methods, better storage capacity and timing.
- Increased use of livestock manure for biogas production, to reduce greenhouse gas emissions in both agriculture and other sectors.
- Use of cover crops, biocarbon, and grazing to remove carbon from the atmosphere and store it in plant biomass and soil.
- Development and application of new technologies that reduces greenhouse gas emissions and increases carbon storage.

Source: https://www.bondelaget.no/tema/landbruketsklimaplan/landbrukets-klimaplan.

3.3.3. Maximising agriculture's contribution to climate change objectives requires tackling the structure of livestock production

The main greenhouse gas emissions from the agricultural sector are methane (CH_4) from livestock and nitrous oxide (N_2O) from manure management and agricultural soils. In Norway, agricultural methane emissions come exclusively from animals, in particular from ruminant enteric fermentation and manure management. Therefore, the size of dairy and beef herds, the way they are fed, and the amount of N fertiliser applied to fields are the main drivers of the volume of GHG emissions.

Improved feed efficiency can reduce emissions per animal. Higher productivity also reduces the number of animals required, usually with net benefit in overall emissions efficiency. Milk yields in Norway average around 7 000 kg per dairy cow, which is already quite good and well above the OECD average of 4 300 kg per cow. However, it is still below the most efficient producers such as the United States and Canada (both over 10 000 kg) and Japan (8 600 kg), indicating there may still be room to increase yields.

In Norway, most economic sectors other than agriculture are either obliged to take part in the EU Emissions Trading Scheme or pay the basic tax on CO_2 emissions, which in 2020 was NOK 544 per tonne (USD 54.3 per tonne) of CO_2-equivalent emission. The PEM model was used to hypothesise what the result would be if the agricultural sector was also subject to this tax on its emissions (see Annex 6.A for modelling details). To construct this experiment, the CO_2 tax is applied as a new tax on animals for milk and beef, and on land for crops, amounting to NOK 450 per tonne of CO_2 equivalent emitted by each commodity.

This experiment estimates an overall reduction of GHG emissions of about 7.9%, allowing agriculture to contribute to the effort to reduce emissions. At the same time the value of production of grains, milk, and beef declines by about 3.1%, demonstrating an increase in the carbon-efficiency of production on a value basis. The efficiency gains are more pronounced in the southern valleys and northern Norway, which show a smaller effect on beef production.[12] Milk production is the main driver of the change in carbon efficiency. This is because the milk quota system ensures that milk producers can tolerate some cost increases before output is affected. Regions with a higher share of milk production therefore tend to show more improvement in carbon efficiency.

Paying a carbon tax can be costly for producers. In this experiment, farmers pay NOK 1.5 billion (USD 0.2 billion) in lost producer surplus. The point of an environmental tax is to change the incentive on goods with environmental externalities; however, the resulting income transfer out from producers can be a barrier to implementation. One solution is to compensate producers for the cost of the carbon tax by providing a matching income payment unrelated to emissions. A decoupled payment based on area was combined with the carbon tax to look at some of the resulting trade-offs (Chapter 2). This compensatory payment is revenue neutral, paying out the same amount as raised by the CO_2 tax. But the decoupled payments are less distorting of production, and so more efficient at transferring income. As a result, producers are better off with the compensated carbon tax than they would be without it, even though production levels do not increase (Table 3.1).

A consumption-based tax on carbon emissions in agriculture can help reduce carbon leakage, which happens when reduced domestic emissions are offset by emissions implicit in additional imports.[13] The production-based carbon tax does indeed lead to increased imports as production declines while consumption remains constant. A consumption-based carbon tax has the opposite effect: consumption declines while production remains constant, lowering imports. It is assumed that domestic price-setting arrangements are not affected by the consumption tax, so that all the adjustment happens in the consumer side of the market. The lack of domestic price response is key to the results; if the tax on consumers does not affect the way producer prices are set through market regulations then domestic production is little or not affected, and so domestic GHG emissions do not change. This is the opposite of carbon leakage: all emissions reductions from the consumer tax take place abroad. In principle, a combined consumption- and

production-based carbon tax could be designed which would lower production and consumption equally, leaving imports unchanged and eliminating carbon leakage.

Table 3.1. Applying the basic CO_2 tax to agriculture increases GHG efficiency of production in Norway

GHG emissions (in CO_2-equivalent) and value of production change in %, and producer surplus change in NOK millions

	Carbon tax			Carbon tax with compensation			Consumer carbon tax		
	GHG emissions	Value of production	Producers surplus	GHG emissions	Value of production	Producers surplus	GHG emissions	Value of production	Producers surplus
Eastern Lowlands	-5.9%	-5.3%	-317.9	-5.2%	-5.9%	-5.7	0.00	-1.9%	-67.0
Jæren	-6.7%	-4.9%	-191.6	-6.7%	-5.0%	14.9	0.00	-5.1%	-74.8
Central Lowlands	-5.9%	-4.6%	-153.8	-5.7%	-5.7%	2.3	0.00	-3.1%	-50.1
Other Western and Southern Norway	-8.3%	-1.7%	-770.9	-8.3%	-2.0%	42.7	0.00	-4.7%	-367.9
Northern Norway	-6.6%	-2.0%	-135.1	-6.6%	-2.0%	9.2	0.00	-5.3%	-63.2

Note: See Annex A for information on the PEM-Norway model.
Source: OECD PEM model for Norway.

The scenarios point to the mechanisms by which agriculture can make a larger contribution to Norway's 2030 emission reduction goals without simply reducing production in equal proportion to emission reductions. The model identifies the key factors that determine how a carbon tax would affect the sector. Those factors include the extent to which domestic prices would adjust to a tax, and the capacity of producers to increase output per animal. A carbon tax would have a strong impact on animal numbers, however, it is not the only policy to do so. Payments based on animal numbers are already provided to milk and beef producers and have an impact of increasing emissions. Moving these payments to other forms of more decoupled support could have a similar impact on emissions as would a carbon tax[14] as shown in the "carbon tax with compensation" as hypothesised in the model, increasing the productivity per animal rather than the number of animals.

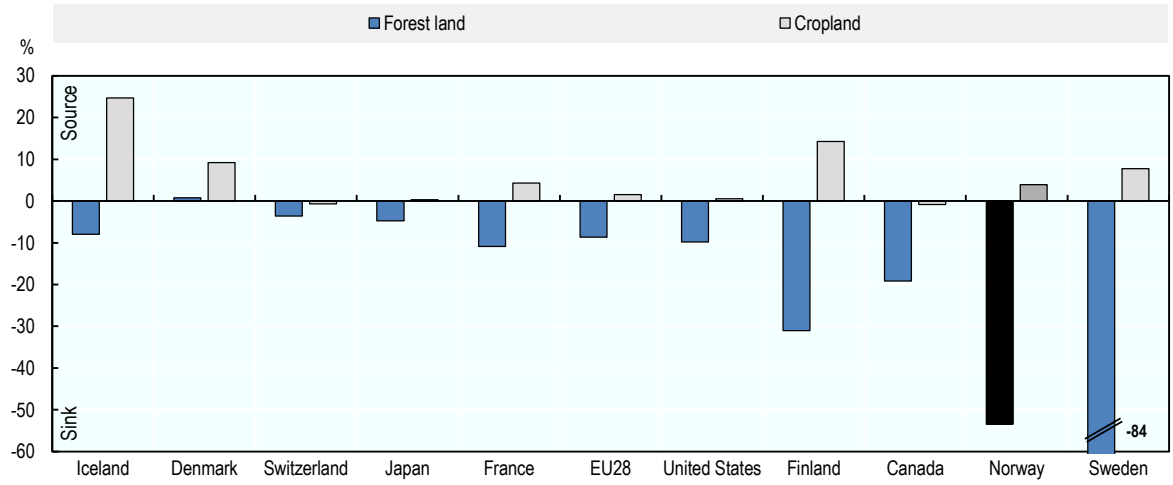
3.3.4. Forestry and climate change mitigation

Forests contribute significantly to reducing the net emissions of greenhouse gases in Norway. A huge amount of carbon is stored in biomass and soil. Annual carbon sequestration in forests is more than 50% of the total annual anthropogenic greenhouse gas emissions in the country, a share that is matched in few other countries (Figure 3.7).

This uptake of carbon is not counted as part of Norway's climate commitments as it is a result of past policy and market actions. Fertilisation of managed forests is currently the only implemented forestry measure that can achieve a significant emissions reduction effect before 2030 that can be counted as part of reduction commitments. A grant scheme for fertilisation of forest as a climate mitigation measure was started in 2016. In 2017, NOK 15 million (USD 1.8 million) was allocated to the grant scheme for fertilisation of forest land. With 5-10 000 ha of forests fertilised yearly, uptake can increase by between 0.14 and 0.27 million tonnes of CO_2 per year after ten years.

Figure 3.7. Annual carbon sequestration from forests land and cropland

Forest land and cropland carbon sequestration compared to total emissions without LULUCF in selected countries in 2018



Note: LULUCF: Land Use, Land-Use Change and Forestry.
Source: UNFCCC (2020[14]), Data Interface, https://di.unfccc.int/detailed_data_by_party (accessed September 2020).

Forests take up carbon from the atmosphere (carbon flux) as they grow, and sequester the carbon in forest biomass (carbon stock). Maintaining a certain level of harvests from the forest is important in order to maintain levels of carbon uptake and sequestration, and to provide climate-friendly raw materials for a range of applications. This is because older forest stands grow more slowly and take up less carbon. The carbon stored in mature stands is also at risk of being released into the atmosphere as older stands have a higher risk of fire or disease outbreak. Converting harvested wood into durable products can increase the amount of carbon sequestered while ensuring high uptake of carbon in the long term.

There are many policies that directly and indirectly affect the carbon mitigation potential of forests. In addition to ordinary support schemes for silviculture and forestry, support schemes for increased seedling density on regeneration sites, enhanced breeding of forest seedlings and fertilisation of forest stands specifically target climate change. In addition, a pilot-project on afforestation has been carried out.

The Ministry of Agriculture and Food offers funding for investments in small-scaled bioenergy projects primarily based on forest biomass. Funding is provided through grants for investments, studies and training measures. The main objective is to encourage farmers and forest owners to produce, use and supply feedstocks for bioenergy or heating.

Using higher seedling densities for forest regeneration increases the growing stock and CO_2 removals. In 2016, a grant scheme was launched to increase the seedling density used for regeneration after harvesting. This measure forms part of ordinary planting after harvesting, and thus does not involve any afforestation.

Norway carries out public research on forest genetics. This involves making use of the genetic variation in forest trees to produce seeds that are more robust and give higher yields. This research has improved tree survival rate, timber quality and rate of growth in volume. It may ultimately be possible to increase the rate of growth in volume by 20% or more, thus increasing CO_2 uptake.

In the period 2015-18, the government tasked the Norwegian Environment Agency to work with the Norwegian Agriculture Agency to carry out a pilot project for planting trees on new areas. Calculations indicate that afforestation of 5 000 ha per year over 20 years (100 000 ha total) has the potential to increase annual removals by 1.8 million tonnes by 2050.

There are several barriers to scaling up harvest levels. Market demand is a fundamental limiter, and innovation spending has rightly focussed on development of new products that can expand the market. The structure of ownership is also an issue, where the large number of smallholdings increases transaction costs and reduces incentives for optimal management of forest stands. For many owners of small woodlots, the income provided from harvesting trees is not substantial compared with overall household income. Encouraging consolidation of ownership of forest land can make market signals more effective and bring economies of scale to stand management.

After harvest, wood outtakes are usually not instantaneously oxidised, but carbon remains stored as harvested wood products (HWP) for a period that varies for several months (paper) to many decades for timber used in buildings. The role played by the global HWP pool can be significant. Innovations in long-lived HWPs and a shift away in demand from pulp and paper to HWP can therefore increase the contribution of the forest products sector to climate change mitigation.

One of the most important recent innovations in this area has been the development of new HWPs for commercial building construction. Laminated timber panels and beams can replace concrete and steel construction for multi-story commercial buildings, displacing those high-emissions building materials and so providing a double-benefit for carbon mitigation. Some of the largest examples of such buildings are in Norway (Box 3.2).

Box 3.2. Wooden buildings as a climate solution

Norway has great potential for climate change mitigation through the use of harvested wood products (HWP). In 2017, Innovation Norway gathered all activities related to the bio economy under the new "bio economy scheme". One of the four strategic areas is increasing the use of wood, in particular as a building material, as a continuation of a series of wood-based innovation programmes (WBIP) started in 2000. During the 2000-16 period, more than 1 000 projects received a total of NOK 600 million (USD 90 million).[1] Most of the recipients were private actors. These pilot projects have demonstrated the viability of replacing fossil-fuel intensive building materials such as concrete.

An evaluation of the 2006-16 WBIP finds that a broad mobilisation effort of the entire value chain has been key to progress on techniques and concepts. Dedicated regional "wood drivers" were tasked with entering construction processes at an early stage to suggest wood as a construction material. Subject to interest from developers, the WBIP would assist with networks and support for feasibility studies. Forest owners and the wood industry jointly founded *Trefokus* (Wood Focus) as a private information company on construction in wood that is available to developers and contractors. At the Norwegian University of Science and Technology (NTNU), a "wood centre" was established with a stronger focus on research and education on wood as a building material.

Early pilots were selected based on their ability to showcase new opportunities for construction in wood, with a special focus on technical challenges such as fireproofing, acoustics and supporting structures. These were some of the most important obstacles to using wood as a material in large buildings. Airport terminals, theatres, libraries and apartment buildings in wood finished in recent years have demonstrated the viability of wood as a material also for larger construction. In 2019, the world's tallest wooden building, *Mjøstårnet*, was completed, standing at 85.4 meters tall and 18 stories.

More recently the focus has been on industrialisation and commercialisation in order to increase the harvested volume of Norwegian forests. Public building projects have been an important early market. Several new student housing complexes have been created with wooden structures, making it at present the most cost-efficient alternative. Over 70% of education facilities built in 2019 had a wooden structure (*Byggfakta rapport okt19*).

Market analysis of the 2006-16 period shows that despite substantial progress in building techniques, the market share for HWP in construction has slightly decreased. Exports of saw logs have increased over the period, mainly to Swedish saw mills close to the border. A project within the new bio economy scheme aims to industrialise the saw mill industry to increase production and value added domestically. Improving forest management and wood building concepts to replace other construction materials remains key for climate change mitigation in Norway.

1. The variation in the USD amount is due to exchange rate movements over the 2000-16 period the programme was active combined with uncertainty about the amount spent in a given year.

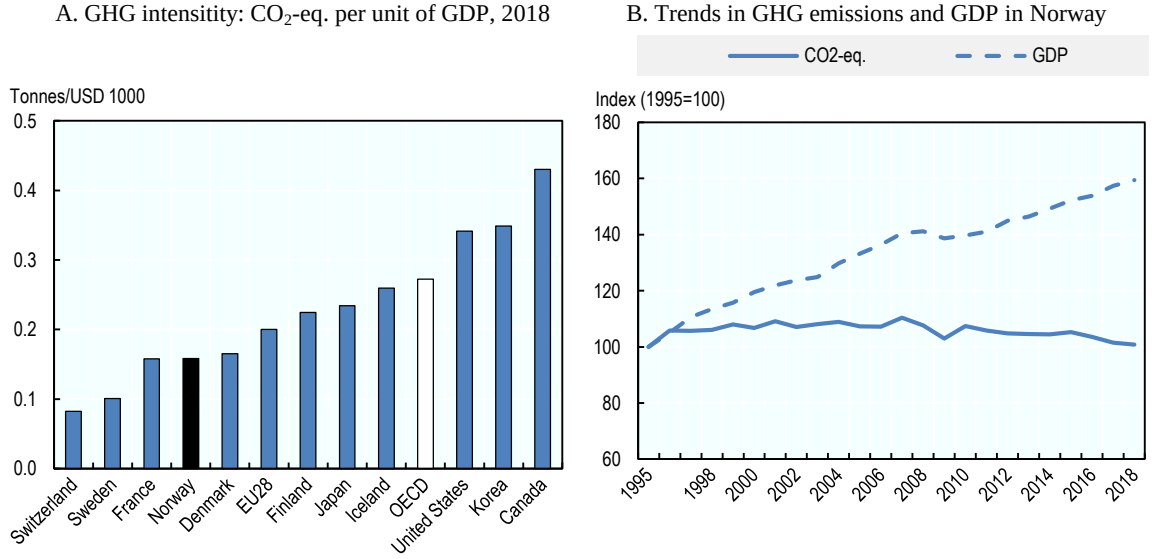
3.4. Moving towards an energy-efficient and low-carbon economy

Norway's economy has been transformed since the discovery of commercially viable offshore oil and gas fields in the late 1960s, which helped the country to achieve a high level of GDP per capita. Besides very high material living standards, Norway scores well on other aspects of well-being, thanks to a good mix of natural resources wealth, good policy making, and inclusive and social egalitarian values (OECD, 2019[15]). Moreover, economic growth has been achieved at the benefit of environmental quality as pollution emissions have decreased over time (OECD, 2017[16]). Further efforts are needed to transform Norway towards a carbon neutral, circular and more diversified economy. Cross sectoral approaches are needed to reduce carbon emissions, improve energy efficiency, innovate, develop a more circular economy, and reduce waste.

3.4.1. Policies for achieving economy-wide CO_2 reduction targets

Norway's economy is less CO_2 intensive than the OECD average due to its lower energy intensity, substantial renewable energy supply from hydroelectric power, as well as progress in energy efficiency (Figure 3.8) (OECD, 2011[17]; OECD, 2019[18]).

Figure 3.8. Norway's economy is less CO_2 intensive than the OECD average



Note: Total emissions excluding LULUCF in million tonnes of CO_2 equivalent; GDP at constant prices and constant purchasing power parities of year 2015.
Source: OECD (2020[19]), Air and Climate and Annual National Accounts Climate databases, http://dotstat.oecd.org/ (accessed September 2020).

In developing environmental, as well as energy policy, Norway strives to formulate the policy on the polluter pays principle and to have a market-based approach where prices reflect costs including externalities. Norway is also using cross-sectoral economic instruments to an increasing extent in climate policy, which contributes to cost-effectiveness.

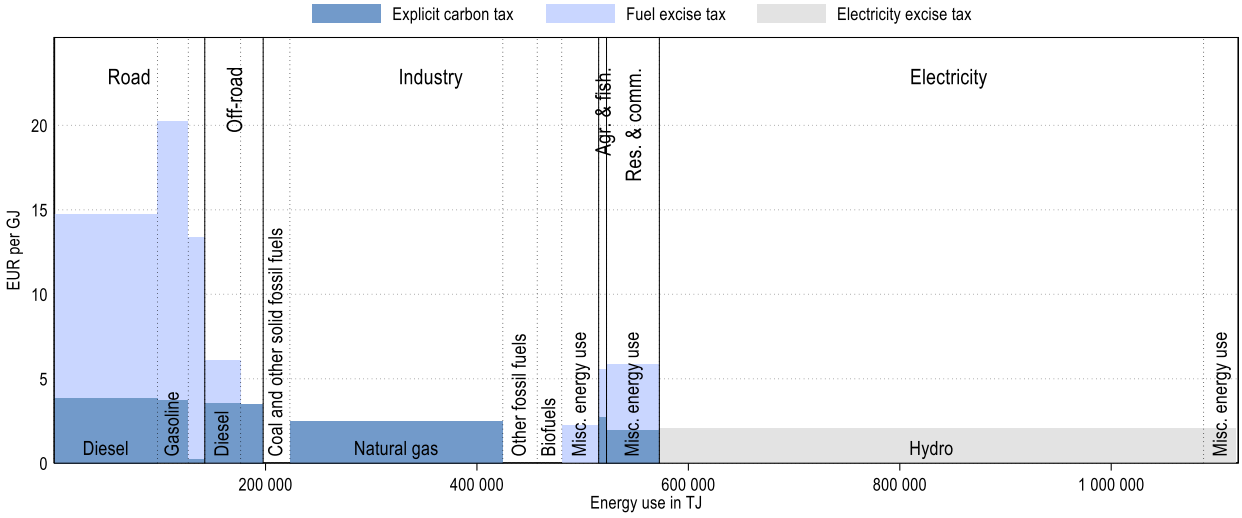
Environmentally-related taxes

Environmentally-related taxes (or charges) are policy measures imposing a tax relating to pollution or environmental degradation, including taxes on farm inputs (or outputs) that are a potential source of environmental damage. Environmentally-related taxes, by influencing the behaviour of producers and consumers, constitute an important instrument for governments to internalise the environmental externalities of economic activity ("pricing externalities") and raise revenues. Specific taxes on energy, for example, alter the relative prices of different forms of energy and thus alter patterns of energy use, with important economic and environmental consequences. They also affect net income and have important distributional implications. Some of the environmental taxes are levied on products that result in CO_2 emissions and have a climate motivation.

In Norway, environmental taxes result in effective tax rates that can differ across energy products and uses (Box 3.3). Figure 3.9 provides an overview of how energy taxes apply across the economy.

Figure 3.9. Environmental tax rates differ significantly according to use, with road uses paying the most

Effective tax rates on energy use in Norway, average by sector and energy category



Note: Tax rates applicable on 1 July 2018. Energy use data is for 2016 and adapted from IEA (2018), *World Energy Statistics and Balances*. Energy categories (labelled at the bottom) that represent less than 2% of the horizontal axis are grouped into "miscellaneous energy use" and may not be labelled.
Source: OECD (2019[18]).

Box 3.3. Norwegian environmentally-related taxes, 2019

The main environmentally-related taxes in Norway are the following:

- CO_2 tax on mineral products with a standard tax rate of NOK 510 (USD 58) per tonne of CO_2 equivalents levied on liquid and gaseous fossil fuels (petrol, diesel, natural gas, LPG and mineral oil)
- CO_2 tax on petroleum activities on the continental shelf. The tax rate varies from NOR 406 (EUR 41) per tonne of CO_2 for light fuel oil to NOR 462 (USD 52.5) per tonne of CO_2 for natural gas
- Road usage tax on: petrol (NOR 5.25 per litre – USD 0.6 per litre); auto diesel (NOR 3.81 per litre – USD 0.4 per litre); LPG (NOR 2.98 per kg LPG – USD 0.3 per kg LPG)
- Tax on lubricating oil (NOR 2.23 per litre – USD 0.3 per litre)
- Tax on HFC and PFC (NOR 508 of CO_2 equivalents – USD 57.7 of CO_2 equivalents)
- Tax on nitrogen oxide (NOx) emissions (NOR 22.27 per kg – USD 2.5 per kg)
- Environmental tax on pesticides (rate varies)
- Environmental tax on beverage packaging (rate varies)
- Electricity tax (rate varies)
- Base tax on mineral oil (standard rate NOR 1.665 per litre – USD 0.2 per litre)
- Taxes on motor vehicles (registration, annual) (rate varies)
- Tax on health- and environmentally damaging chemicals (rate varies).

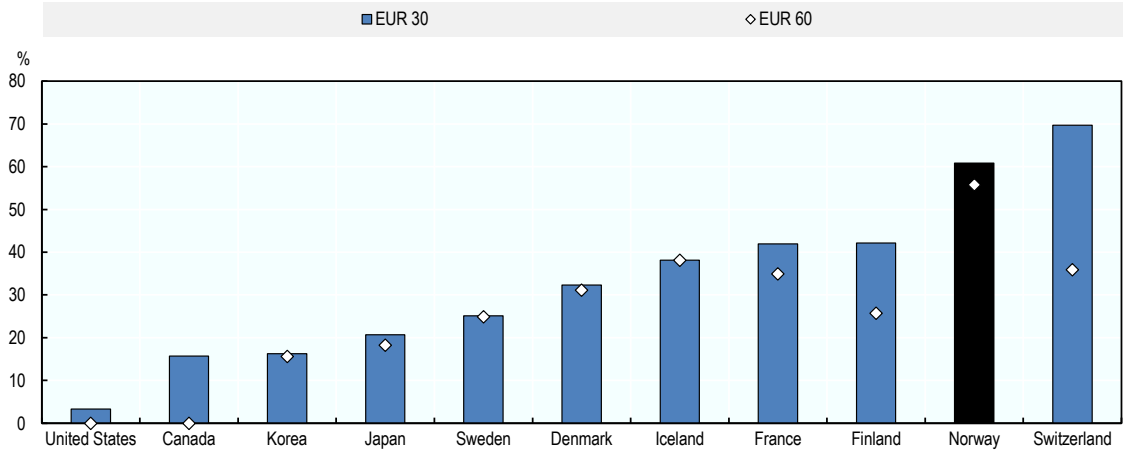
Source: (Norwegian Ministry of Climate and Environment, 2020[20]).

A CO_2 tax was introduced in 1991. The tax rate varied considerably by fuel type and sector, with a number of important sectors more or less exempted from the tax due to the perceived danger of so-called carbon leakage.[15] Some of these sectors which are exempted from the tax are part of the EU ETS, and thus at the margin, face a price on their carbon emissions approximately in line with the average CO_2 tax rate. Agriculture is exempted and not part of ETS. In the 2020 Budget the rate of carbon tax was increased, and some exemptions and concessions were abolished. In 2020, the standard rate of CO_2 taxes will amount to approximately NOK 545 (USD 54.4), corresponding to EUR 55 per tonne of CO_2 (petrol, diesel, natural gas, LPG and mineral oil).

Notwithstanding Norway's stronger track record in pricing GHG emissions than most OECD countries (Figure 3.10), there is room for improvement. Most emissions are priced above EUR 60 per tonne (USD 67 per tonne) of CO_2 equivalents (EUR 60 is a mid-range estimate of the climate cost of CO_2 emissions in 2020). However, emission pricing and taxation could be more even. Around 20% of emissions are not priced by tax or by ETS. For instance, agriculture is not part of the EU ETS, nor subject to taxes on emissions of methane or nitrous oxide (Norwegian Ministry of Climate and Environment, 2020[21]). However, standard rates of CO_2 tax and base tax on mineral oils apply to agriculture.

Figure 3.10. Most CO_2 emissions in Norway are priced above EUR 60 per tonne

Proportion of CO_2 emissions from energy use priced at or above EUR 30 and EUR 60 per tonne of CO_2 in 2015



Notes: The effective carbon rate is the sum of three components: specific taxes on fossil fuels, carbon taxes and prices of tradeable emission permits. All three components increase the price of high-carbon relative to low- and zero- carbon fuels, encouraging energy users to go for low- and zero-carbon options. Data include emissions from the combustion of biomass in the emission base.
Source: OECD (2018[22]), Effective Carbon Rates (database), http://www.oecd.org/tax/effective-carbon-rates-2018-9789264305304-en.htm (accessed September 2020).

Environmentally-related taxes in agriculture

Only a few countries have levied taxes and charges on farm inputs as a way of addressing environmental issues in agriculture (OECD, 2015[23]). These have mostly been applied to environmentally damaging chemicals, such as those associated with commercial fertiliser and pesticide use.

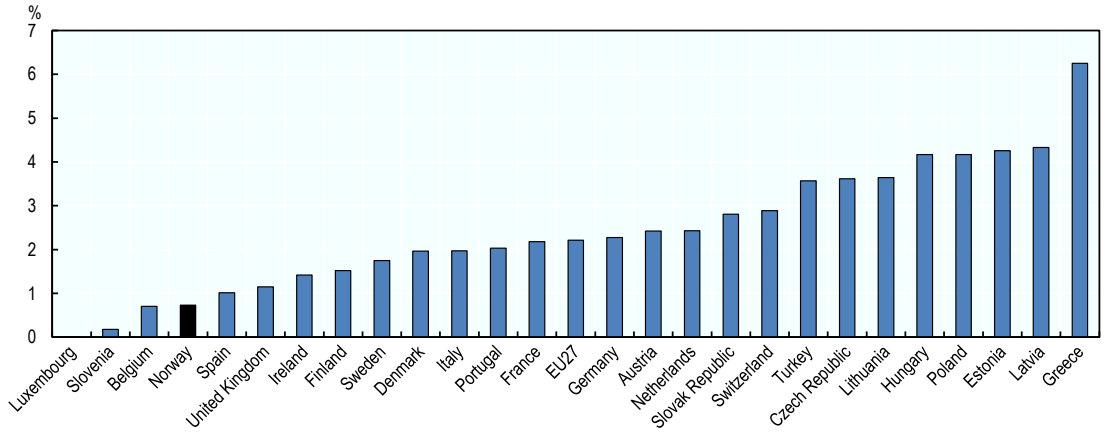
In Norway, the contribution of environmentally-related taxes in agriculture to total environmentally related tax revenues is less than 1% (Figure 3.11). Looking at the contribution of the individual tax categories, revenues from energy are the most important.[16] Notably, while the agricultural sector in Norway pays around 1% of energy taxes, it accounts for about 8% of GHG emissions in the economy. This is due to the fact that in this sector only CO_2 emissions from fossil fuels are taxed with the carbon tax.

Norway is one of the few countries taxing pesticides. A tax on pesticide sales was introduced in 1988 and until 1999 the same tax rate applied to all pesticides. The tax was levied as a percentage (11%) of the retail price. The tax is area-based and, from 1999, differentiated by toxicity to encourage farmers to switch to pesticides with lower health and environmental risks, which is more economically effective (Sud, 2020[25]). Pesticides are divided in seven tax classes depending on the health and environmental risks.[17] Proceeds go to the state budget. In Norway, although the quantity of pesticides sold has slightly declined since the introduction of the tax, there has been a shift towards the use of pesticides with lower health and environmental risks. Total pesticide usage, measured in active substances, was about 19 percentage points lower in 2017 than in 2001 (Bye et al., 2020[7]).

A tax on mineral fertilisers (nitrogen, phosphorus, potassium) was also introduced in 1988. It was removed in 2000 out of concern for competitiveness to reduce the costs imposed on Norwegian agriculture (Sweden, Austria and Finland have also abolished their fertiliser taxes). The effect of the fertiliser tax in Norway was negligible because the rate was rather low, 15% (compared to 20% in Sweden) (Hellsten et al., 2017[26]).

Figure 3.11. The agricultural sector in Norway pays around 1% of energy taxes, but accounts for about 8% of GHG emissions

Environmentally-related tax revenues in agriculture as a share of total revenue from environmental taxes, 2017



Note: Agriculture refers to crop and animal production, hunting and related service activities (NACE Rev. 2).
Source: Eurostat (2020[24]), Environmental taxes by economic activity (NACE Rev. 2) (database) [env_ac_taxind2], https://ec.europa.eu/eurostat/data/database (accessed September 2020).

Diesel used in agriculture is subject to the CO_2-tax with the general rate (NOK 500 per tonne of CO_2 – USD 57 per tonne of CO_2) and the Base tax on mineral oil (OECD, 2019[18]). Natural gas and LPG used in the agricultural sector is subject to the CO_2 tax, except for gas in greenhouses. Diesel for use in agricultural machinery and other construction machines that are not used on public roads is exempt from the road user tax which is applied for diesel, while they meet the Base tax on mineral oil. Commercial greenhouses are exempt from paying electrical power consumption taxes.

Removing inefficient fossil fuel subsidies

Fossil fuel subsidies are environmentally harmful, costly, and distortive. Not only do they undermine global efforts to mitigate climate change, but they also aggravate local pollution problems, causing further damage to human health and the environment. Despite repeated pledges to phase out fossil fuel subsidies, the latest estimates of support for fossil fuels show that across the globe progress in reducing subsidies and government support for fossil fuels has been modest (OECD/IEA, 2020[27]). In most countries, support for fossil fuel consumption remains widespread.

Norway is a member of the Friends of Fossil-fuel subsidies Reform Group (a group of nine countries formed in 2010 to support the efforts of the G20 and APEC to phase out IFFS). The latest estimates indicate a slight decline in support, mainly brought about by the changes in Norway's CO_2 taxation on mineral oil adjusting to parity on the tax level on petrol. Exemptions and reduced rates of energy taxes comprise consumer support. Total support to fossil fuel consumption is estimated at NOK 7.8 billion (USD 0.9 billion) in 2017. This equals around 0.2% of total tax revenue, below the OECD average support to fossil fuel consumption (0.5% of total tax revenue in 2016).

The high proportion of hydropower in the Norwegian electricity generation mix makes it more difficult at the margin to switch from fossil fuel to renewable forms of energy. The government is making efforts to ensure that demand is met from low-carbon sources by encouraging the development of combined-cycle gas power plants fitted with carbon capture and storage (CCS), along with renewables and energy efficiency.

3.4.2. Energy efficiency and renewables

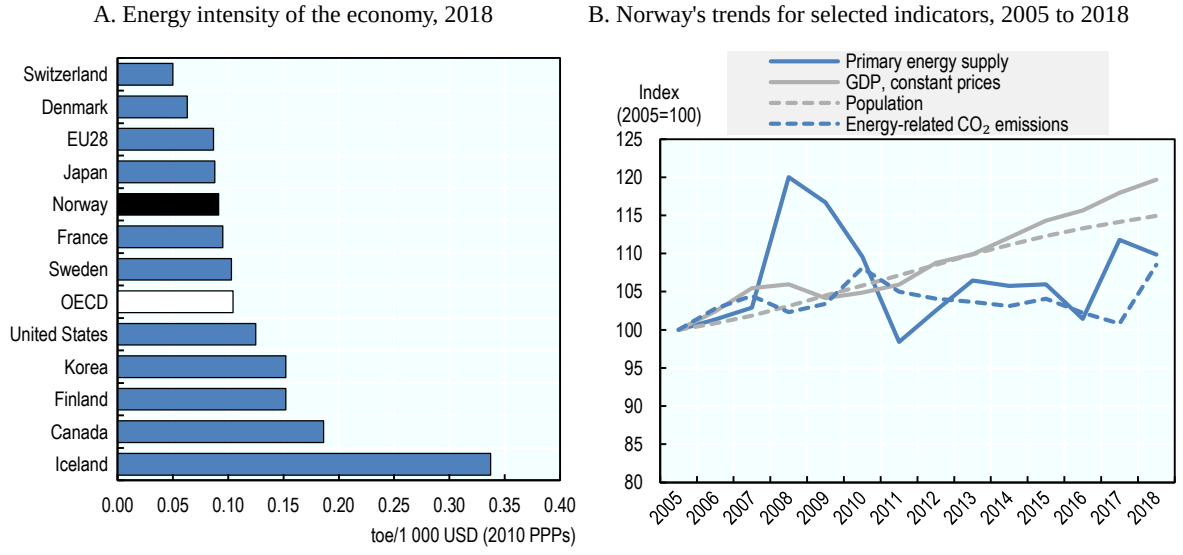
The energy sector is the most important sector in Norway, with regard to GHG emissions, accounting for 73% of the total emissions.[18] Norway is a major producer, and net exporter, of energy products, in particular fossil fuels. Since the first oil discovery in the North Sea in 1969, oil and gas extraction has become by far the largest export industry and an important source of revenue. Norway has decoupled energy use from GDP growth; the energy intensity of the economy has declined by 20% since 2005 and its level is among the lowest in the OECD (Figure 3.12). Industry, the residential and commercial sector, and transport account for most of the total final consumption (TFC) of energy. Agriculture, including food processing, accounts for about 3.5% of TFC (OECD, 2017[28]).

Despite the large production of fossil fuels, Norway is one of the leading OECD countries in terms of share of renewable energy sources in total domestic primary energy supply (Figure 3.13). Norway is in a unique position as regards renewable energy. Unlike most other countries, nearly all of Norway's electricity production (96%) is based on hydropower.

Norway is applying most, if not all, of the EU energy legislation via the European Economic Area (EEA). Since 2009, Norway has adopted the EU Renewable Energy Directive and has committed to ambitious national target for renewable energy equivalent to 67.5% in 2020 (excluding energy use in gas and oil sector), which according to the Norwegian Ministry of Climate and Environment already exceeded in 2018 (72.8%). In the same year, the share of renewable energy in the total energy supply in Norway was about 49%, being second highest among OECD countries (Figure 3.13). The contribution from renewable electricity production constitutes an important part of this. The Renewables Directive also requires Norway to achieve 10% renewable energy in the transport sector in 2020. Norway also set a target of expanding annual biomass production to 14 TWh by 2020. The target seems to have been achieved already in 2017.

In order to meet these targets, the government has increased the scope of measures and instruments related to development of renewable energy and energy efficiency, including broad efforts in research and development.

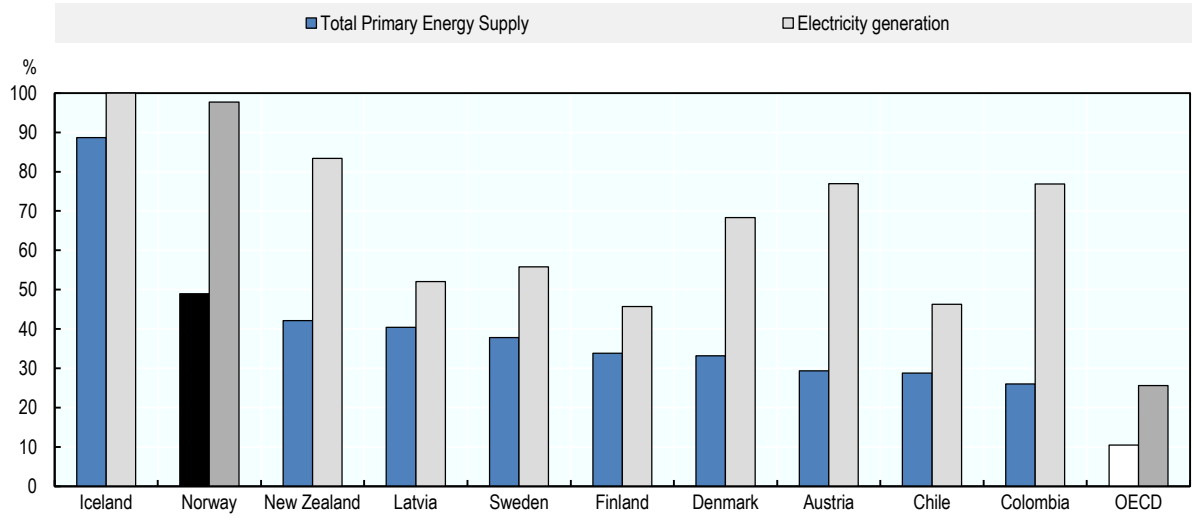
Figure 3.12. Energy intensity is low and energy use has been decoupled from growth



Notes: EU28 data refer to year 2017. OECD total does not include Colombia.
Source: IEA (2020[29]), "Indicators for CO2 emissions", IEA CO2 Emissions from Fuel Combustion Statistics (database), https://doi.org/10.1787/data-00433-en (accessed September 2020).

Figure 3.13. Norway is one of the leaders in use of renewable energy sources

Share of renewables in the Total Primary Energy Supply and electricity generation, 2018



Note: Top 10 OECD countries in terms of share of renewables in the Total Primary Energy Supply (TPES).
Source: IEA (2020[30]), IEA World Energy Statistics and Balances (database).

Norway also provides strong incentives for zero emission vehicles, both tax advantages and other user incentives. Because Norway's electricity generation is almost 100% hydroelectric power, a transition to electric vehicles would decarbonise the transportation sector almost entirely (OECD, 2015[23]). Norway now has the highest number of electric vehicles per-capita in the world, but questions were raised concerning the cost-effectiveness of these incentives as the cost of CO_2 abatement implied by the incentives is very high (OECD, 2019[18]).

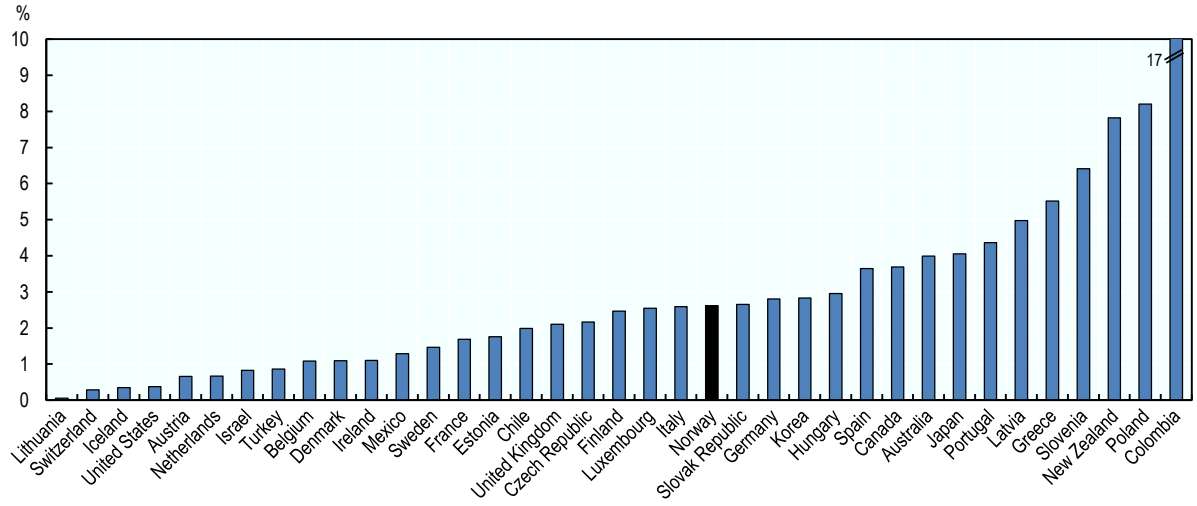
Public support to energy efficiency and flexibility solutions for the energy system is also provided through the state-owned agency, Enova. Enova prioritises working toward flexible solutions that help reduce the need for energy and peak demand. This includes developing technology and business models that stimulate the utilisation of latent flexibility resources, better efficiency and storage.

3.4.3. Eco-innovations

Norway's good economic performance contrasts with its mediocre performance on conventional innovation environment-related indicators, such as R&D government budget (GBARD) devoted to the environment and patents on specialisation in environmental technology among OECD countries (Chapter 4). This apparent "Norwegian puzzle", as it is known, is related to the exceptional productivity generated by non-R&D-based (non-technological) innovation in the services sector. At the same time, Norway has experienced fast productivity growth in the services sector – fuelled by high-skill levels in the workforce – which implies quite robust innovation.

Figure 3.14. Norway has only moderate environmental R&D investment

Government budget allocation on environment R&D as a share of total GBARD in OECD countries, 2017-19



Notes: Government budget allocation for R&D (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It enables linking these budget lines to policy considerations through classification by socioeconomic objectives.
For Estonia, France, Israel, Korea and Poland, data refers to 2016-18 average, while for Canada, Chile, Iceland, New Zealand and Switzerland, to 2015-17 average.
Source: OECD (2020[31]), OECD Research and Development Statistics (database), https://stats.oecd.org/ (accessed September 2020).

Box 3.4. Cross-sectoral approaches for GHG reductions: Enova and Nysnø

Enova[1] is a state-owned enterprise, which was established in 2001. Its purpose is to contribute to reduced GHG emissions and strengthened security of energy supply, as well as technology development that also contributes to reduced GHG emissions in the longer run. Enova is financed through the Climate and Energy Fund, by direct government budget allocations, and a levy on electricity use. Enova provides financial support to industry, households, local and regional governments. A four-year rolling agreement with the Ministry of Climate and Environment governs its activity. In 2020, financing totalled about NOK 3.2 billion (USD 0.3 billion). Enova has programmes aimed at reducing emissions from the transport sector and other sectors, which are not part of the ETS with solutions that could succeed in the market without government support.

Nysnø Klimainvesteringer AS (Nysnø) is an investment company wholly owned by the Norwegian State, through the Ministry of Trade, Industry and Fisheries. Nysnø was established in 2017 in order to contribute to reducing GHG emissions through investments in the transition from technology development to commercialisation. Together with private investors, Nysnø provides both capital and competence. In the budget for 2020, the government allocated NOK 700 million (USD 70 million) in additional capital to the company.

1. https://www.enova.no/.
Source: Norwegian Government (2019[13]).

In terms of eco-innovation policies, energy and environment represent some 20% (NOK 7.7 billion - USD 0.9 billion) of Norway's total R&D expenditure, with oil and gas extraction accounting for more than half. Through different programmes, the Research Council and Innovation Norway grants about NOK 1.8 billion (USD 0.2 billion) per year to environmental research and innovation. Each year, the Ministry of the Environment receives around NOK 450 million (USD 54 million) in R&D appropriations, an amount that represents less than 3% of total government R&D appropriations. In 2017, the government presented a national strategy for green competitiveness. The aim of the strategy is to provide more predictable framework conditions for a green transition in Norway, while maintaining economic growth and creating new jobs.

In terms of eco-innovation priorities, Norway is focusing its efforts on particular technologies, notably carbon capture and storage (CCS) and offshore wind energy. Norway has a long and unique experience in geological storage of CO_2 and puts considerable effort into developing technology to reduce the cost of capturing and storing CO_2 at gas-fired power plants. CCS is one of five priority areas for enhanced national climate action. Feasibility studies show that realising a full-scale CCS chain in Norway by 2022 is possible and at lower costs than for projects previously considered in Norway. The aim is to capture CO_2 from different emission sources in eastern Norway. The CO_2 will then be transported by ship to an onshore transport and storage terminal at Kollsnes on the Norwegian west coast. From the onshore terminal, CO_2 will be sent in pipeline to a safe geological storage location under the seabed, close to the Troll oil and gas field.

Box 3.5. CCS from waste incineration: The Fortum Oslo Varme project

Fortum Oslo Varme waste-to-energy CCS plant at Klemetsrud in Oslo aims to capture CO_2 from waste incineration. The waste heat from the incineration is used to produce electricity, district heating and cooling to the city of Oslo. The emissions from the plant contains steam and CO2. The flue gas is currently cleaned out of dioxins, NOX and CO. Now Fortum wants to capture the CO2. A pilot demonstrated the possibility to capture 90% of all CO2 in the flue gas. Fifty-eight per cent of the waste incinerated at the plant is of biological origin, making the plant carbon-negative. Carbon capture from waste incineration helps to solve two major global problems: the waste problem and the climate problem. The CO2 will be transported by ship from the capture plant to an onshore facility on Norway's west coast for temporary storage. The CO2 will then be transported via a pipeline to a subsea reservoir in the North Sea for storage. Equinor, with its partners Shell and Total, are responsible for the planning of the storage facility. The objective is to capture approximately 400 000 tonnes of CO_2 per year, which is equivalent to removing 60 000 cars from the road for a year. The total cost (investment and operating costs for five years) is NOK 13.1 billion (USD 1.4 billion).

In September 2020, the government launched the "Longship" project for CCS in Norcem's factory in Breivik. The project, which is considered a milestone in the government's industry and climate efforts, also comprises funding for the transport and storage project Northern Lights, a joint project between Equinor, Shell and Total. Northern Lights will transport liquid CO2 from capture facilities to a terminal at Øygarden in Vestland County. From there, CO2 will be pumped through pipelines to a reservoir beneath the sea bottom. The total cost of the project is estimated at NOK 25.1 billion (USD 2.7 billion) for ten years of operation – NOK 17.1 billion (USD 1.8 billion) for investments and NOK 8 billion (USD 0.9 billion) for operating costs. Longship will receive state aid in accordance with negotiated agreements. The state's share of these costs are estimated to be NOK 16.8 billion (USD 1.8 billion). For Longship to be a successful climate project for the future, other countries must also start using this technology.

Source: https://www.fortum.com/media/2018/11/full-scale-carbon-capture-and-storage-ccs-project-initiated-norway; https://www.regjeringen.no/no/aktuelt/regjeringa-lanserer-langskip-for-fangst-og-lagring-av-co2-i-noreg/id2765288/.

Besides R&D, eco-innovation in Norway has been promoted with other policy measures, such as regulations, economic incentives, negotiated agreements, public procurement and eco-labels. Norway has experience with eco-labels. The Nordic Swan label now applies to 71 product groups; for instance, nearly all paper and detergent products carry it. The EU's Flower eco-label is also present in the Norwegian market. Together with other countries in the European Economic Area, Norway has introduced an energy label for home appliances, such as refrigerators and washing machines.

3.4.4. Bio-economy and circular economy

The bio-economy – which is based primarily on biogenics instead of fossil resources – is gaining prominence in the policy debate across the globe as technical progress in microbiology provides new opportunities to use natural resources sustainably. Most OECD countries, including Norway, are developing holistic national bio-economy strategies to decouple economic growth from its dependence on fossil fuels, and as a pathway to supporting some of the UN Sustainable Development Goals and commitments under the Paris Climate Agreement (Diakosavvas and Frezal, 2019[32]). Bio-economy-related strategies particularly in Europe also highlight the contribution of the bio-economy to circular economy approaches (e.g. Norway, Finland, France, Italy, Latvia, Spain, and the United Kingdom).[19]

In Norway, the bio-economy sector accounts for 6% of the economy (of which 46% is due to agriculture and food). Moreover, more than a three-fold increase in total GDP is estimated in 2050 (from EUR 33 billion to EUR 110 billion), with the agriculture and food sector's contribution estimated to rise from EUR 15 billion to EUR 27 billion (Bardalen, 2016[33]). The bio-economy sector in Norway with the largest value added is the food and drink industry, and with NOK 37 billion (USD 5.9 billion) in 2014 it was nearly three times as high in terms of value added as the second largest, agriculture, at NOK 13 billion (USD 2.1 billion).

The share of jobs in the bio-economy varies across regions, with some mid- and northern-regions of Norway over 22.5% of the working population is employed in the bio-economy. Looking at bio-economy jobs, an overall higher proportion of jobs – up to 16% – are in new bio-economy sectors outside the traditional sectors of agriculture, forestry and fisheries. The proportion is particularly high in mid-Norway. At the same time, most regions in mid-Norway witnessed negative development in jobs in the bio-economy. In northern Norway the situation is very different and the number of jobs in the bio-economy has increased.

The Norwegian bio-economy is characterised, as for other Nordic countries, by a relatively low share of workers employed in bio-economic sectors and, at the same time, by a very high labour productivity (Capasso and Klitkou, 2020[34]). This is due not only to a high productivity across all bio-economic sectors, but also to a strong increase in productivity in fishing and aquaculture, whose value added has evolved massively during the last ten years.

As a whole, the Norwegian bio-economy has strongly increased its productivity in recent years (Capasso and Klitkou, 2020[34]). Sectors connected to food and beverages, which already had a high weight within the Norwegian bio-economy, are still increasing their contribution to the Norwegian value added; at the same time, pharmaceuticals are experiencing a dramatic shift toward bio-based production and thus contributing also to qualitative changes in the Norwegian bio-economy.

In 2016, the Norwegian Government published the national strategy on bio-economy, *Familiar resources, undreamt of possibilities* (Norwegian Ministries, 2018[35]; Bardalen, 2016[33]). This was a broad cross-sectoral strategy, developed by eight ministries, including the Norwegian Ministry of Agriculture and Food. National institutions such as Innovation Norway, the Research Council of Norway and the Norwegian Environmental Agency were especially important advisers in the process. The strategy covers a ten-year period and is subject to mid-term evaluation.

The strategy points out three overarching objectives – increased value creation, reduction in GHG emissions, increased resource efficiency and sustainability – and four focus areas: co-operation across sectors, industries and thematic areas; markets for renewable bio-based products; efficient use and

profitable processing of renewable biological resources; and sustainable production and extraction of renewable biological resources.

The strategy aims to provide a common understanding of the opportunities and challenges associated with the development of the bio-economy in the country. The strategy specifically addresses goal conflicts and opportunities to minimise them, for example by minimising waste and optimising efficiency of use. In this respect, bio-refinery development in the food, feed and wood industry is considered a promising route in Norway.

The Research Council of Norway, Innovation Norway and Siva have developed a common Action Plan for the implementation of the recommendations and instructions in the strategy has been drawn up. The Action Plan was published in February 2020 (Research Council of Norway, Innovation Norway and Siva, 2020[36]). Work on developing a strategy on circular economy is in progress, with nine ministries involved in the process, including the Ministry of Agriculture and Food (Box 4.3, Chapter 4).

With a view to promoting innovation, the strategy supports public R&D and encourages innovation projects along the bio-economy value chain. Innovations in agriculture, forestry and fisheries/aquaculture are considered necessary to achieve climate-resistant plants and improvements in soil fertility/quality. In particular, the strategy emphasises the promotion of key enabling technologies (including biotechnology, nanotechnology, precision farming and ICT) to facilitate the development of new bio-based processes, products and services, such as the microbial production of food and feed ingredients and the anaerobic fermentation of biogas, as well as sustainable farm practices.

Several policy instruments have been introduced to support industrial and commercial development. Given Norway's experience in environmental taxation, the government proposes several regulatory improvements to create a level playing field for bio-based products, for example taxes or quotas for fossil-based products to account for negative environmental and climate effects. In addition, a revision of fertiliser regulations and an increase in the use of organic fertilisers/sludge, including regulations for deposing, storage and spreading, are on the agenda (Norwegian Ministries, 2018[35]).

The strategy highlights increased collaboration within and between value chains. However, the structure of industry within the production of primary resources is characterised by many small industries and SMEs. This can be a challenge for effective production and advanced technology development and emphasises the need to bring together the many research and innovation communities across sectors.

Several studies have been undertaken on forest-based supplies. In general, the studies point out that there is a large surplus of biomass from forestry in Norway, which can be made available if it is profitable in terms of market price. As for agricultural sources, a 2016 study from the Norwegian research centre NOFIMA provided an overview of the amounts of agri-food residues resulting from Norwegian industrial processing of cereals, livestock, oil plants, fruits and berries, and vegetables and potatoes. The study found that the industries processing raw material, including agricultural sectors, produce 415 000 tonnes annually of agri-food residues.

Building regional and national bio-economies is challenging and many countries are struggling with how to create both sustainable and commercially viable value chains and related innovation ecosystems (Philp and Winickoff, 2019[37]). New products in the advanced bio-economy are often faced with immature markets and competition from cheaper, but less sustainable alternatives. A key policy conclusion of two recent case studies on value chains based on carbon waste gases and marine residuals is that for stimulating growth in the bio-based industries it is essential to have consistent, long-term policies that give the industries predictability for their investments into projects which often have a longer payback time. These policies, as well as the underlying national and societal ambitions, should be communicated clearly to the industry. Public involvement in establishing industrial networks/clusters and other measures (e.g. cross sectoral workshops) to stimulate new interactions between companies, has been identified as another important catalyst for innovation in bio-based value chains.

Box 3.6. Increasing value creation in Norwegian aquaculture and agriculture: The case of Foods of Norway

Foods of Norway is a Centre for Research-based Innovation (CRI) at the Norwegian University of Life Sciences, funded by The Research Council of Norway and the Centre's industry partners.[1] Foods of Norway uses new technology to increase value creation in the Norwegian aquaculture, meat and dairy industries. It targets three key research areas: biomass, feed efficiency, and product quality. A key research area is the use of novel biotechnology to develop sustainable feed resources from blue and green biomass (trees, seaweed and animal-co-products). New feed products will be developed from forestry, agriculture, and marine resources through industrial exploitation of cutting-edge research on processing and (bio) technology. Foods of Norway consists of a multidisciplinary research team with academic partners from Europe, Australia and the United States, as well as 19 industry and innovation partners.

1. https://www.foodsofnorway.net/.

3.4.5. Waste management

The main objectives and targets related to waste management as set out in the 2016-17 White paper on *Waste as a Resource – Waste Policy and Circular Economy*[20] are i) significantly decoupling the growth in total waste generated from the rate of economic growth; ii) reducing the amount of waste delivered for final treatment to 25% of total waste generated; and iii) assuring appropriate treatment of all hazardous waste within Norway, either by recycling or sufficient and safe treatment and disposal. The White Paper also contains an overall plastic strategy, which reviews all planned and initiated measures against marine litter and the spread of micro-plastics. Waste management in Norway is governed by the 1981 Pollution Control Act, the unified Waste Regulations, which entered into force in 2004. The regulations covered landfilling, incineration, hazardous waste management and transboundary shipment of waste.

In 2018, 17 900 tonnes of plastic waste were collected for recycling from agriculture. Main waste constituents are round bale packing (plastic sheeting) and fertiliser and seed bags (Bye et al., 2017[38]). In 2017, delivery of hazardous waste from agriculture is estimated to around 242 tonnes, whereof 44% is oil-containing hazardous waste and 30% is waste containing heavy metals.

In 2017, the Norwegian government and the food industry have signed an agreement to reduce food waste in Norway by 50% by 2030. Food waste in Norway refers to the edible part of food waste. This reduction target is in line with the UN Sustainability Goal 12.3, stating that global food waste should be halved by 2030, and, in fact, is a bit more ambitious because the goal applies to the entire food value chain from primary production to consumers. The agreement is voluntary, but binding for the contracting parties.

3.5. Conclusions

Norway has good environmental-policy frameworks, strong commitment and is at the forefront of good practice in many areas of environmental policy. Norway has made progress in decoupling its economic growth from environmental degradation, decarbonising its economy, with the energy sector playing a key role. It ranks among the OECD countries with the lowest energy intensity and is one of the leaders in use of renewable energy sources. The government places great emphasis on increasing supply of renewable energy.

Norway is committed to an ambitious climate policy and has adopted some of the most ambitious emission mitigation targets of any OECD country, and is preparing for carbon neutrality by 2050. Its climate targets for 2030 and 2050 made legally binding in the 2017 Climate Change Act. Meeting these targets is a formidable challenge and would require further policy measures. The high relative size of the agricultural emissions (8.5%) and the enormous potential for carbon sequestration in forest and carbon storage in wood requires that these two sectors become a cornerstone of Norway's climate change mitigation polices.

The polluter pays principle is a cornerstone of the Norwegian policy framework on climate change, as well as energy policy. Use of economic policy instruments has been pioneering in many areas, for instance environmental taxation. In addition, innovative technical solutions have also been encouraged, for instance in carbon-capture technology. Furthermore, as a member of the European Economic Area (EEA), Norway has transposed most EU environmental directives and often imposes more stringent requirements than those required.

Norway was one of the first countries to adopt a carbon tax, and it joined the EU Emission Trading System (ETS) in 2008. More than 80% of Norway's GHG emissions are now either covered by ETS or subject to environmental taxes. It has achieved some success in combining these two instruments to set a common price on emissions, though the effective carbon price still varies by sector, and exemptions granted to certain sectors have weakened the overall effectiveness of the carbon tax in reducing emissions. The reduction of divergences of rates in the GHG tax across sectors brought in the 2020 Budget would help ensure consistent and economic incentives to abate.

Agriculture is not a part of the EU ETS, nor is it subject to tax on emissions of methane or nitrous oxide. Therefore the sector is an exception and not regulated as other sectors on climate change mitigation. However, standard rates of the CO_2 tax and the base tax on mineral oils apply to agriculture. In addition, agriculture in Norway will be part of the EU Effort Sharing regulation (ERS) from 2021. For ESR, the target is to reduce GHG emissions by 40%. The government has an ambition of a 45% reduction in ESR.

Norwegian forestry has tremendous potential for growth. Current harvest rates are constrained in part by market demand for newsprint, which is in long-term decline, and for durable wood products (HWPs), which have nearly unlimited growth potential but which have yet to take a large share of the market for larger buildings. Harvest rates are also constrained on the supply side by a fragmented ownership structure that does not always respond to market signals and which makes executing a national harvest strategy challenging.

- Despite progress, environmental challenges persist. The country struggles to reach international commitments within the agricultural sector related to GHG emissions, ammonia emissions and water protection. Norway's reduction commitments for GHGs are ambitious compared with domestic mitigation opportunities as there is already a carbon tax in place and domestic electricity production is hydro-electric.
- Norway should consider making further steps to reduce pollution from agriculture and to increase alignment with the OECD Council Recommendation on Water. In spite of several policies put in place over the past decade to control nitrogen pollution, Norway still faces excessive levels of nitrogen discharges into its coastal waters. One-quarter of the Norwegian water bodies are estimated to be at risk for not fulfilling the requirements of good water quality. In addition, more efforts may be needed to recover water charges and use pricing instruments, in line with the OECD Council Recommendation on Water.
- Norway should ensure that agriculture and forestry land use planning is well-co-ordinated and clearly addresses the potential trade-offs and synergies between the two sectors. The application of the land use regulations should combine the protection of the amount of agricultural landscape with flexibility for land owners to maximise the value of their holdings. The fact that farmers own a large share of forest properties, and that their holdings are larger on average, should be seen as an opportunity for jointly maximising the value of forestry and agriculture land use.

- Norway should ensure that land policies are conducive to innovation. By definition, innovative land uses are unforeseen, so land use regulation must be flexible enough to handle unexpected cases. Regulation can also encourage innovation, for example with differential regulatory treatment of innovative land uses. This is already successfully applied in Norwegian salmon aquaculture, where innovative production systems get special access to production permits.
- Norway should pursue policies to bring wood-based construction products to price parity with traditional concrete and steel. This could include changes to building codes to decarbonise construction, mandates for use in public buildings, and tax credits. The evolution of electric vehicle, solar and wind power markets may serve as a model in this regard, where price-parity with conventional alternatives creates a tipping-point and rapid adoption.
- Forest policies are active on both the demand and supply sides to remove barriers to growth. Logistics are facilitated by an active programme for forest road building and other infrastructure needs. Co-operative systems provide an easy turnkey solution for landowners for harvesting and replanting, and reforms to the tax system have made income from forest land more attractive. The extent to which this system may discourage landowners from considering innovative new methods to use their forest land deserves and independent assessment to evaluate how the current system of forest harvest and replanting services and the replanting regulation may be reformed to encourage innovation, especially by small landowners.

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Notes

[1] See, for example, https://www.regjeringen.no/no/dokumenter/prop.-1-s-20192020/id2671327/?ch=2) (annual budget). Other recent documents that define objectives and measures can be found at the following government reports: https://www.regjeringen.no/en/dokumenter/meld.-st.-14-20152016/id2468099/ (natural diversity); https://www.regjeringen.no/no/aktuelt/kulturmiljo/id2697943 (cultural and historical) heritage); https://www.regjeringen.no/no/dokumenter/meld.-st.-18-20152016/id2479100/ (outdoor recreation); https://www.regjeringen.no/en/aktuelt/the-norwegian-government-steps-up-the-efforts-to-turn-waste-into-resources-and-reduce-marine-litter/id2558322/ (waste and circular economy); https://www.regjeringen.no/en/dokumenter/meld.-st.-41-20162017/id2557401/ (climate); https://www.regjeringen.no/en/dokumenter/meld.-st.-13-20142015/id2394579/ https://www.regjeringen.no/en/dokumenter/meld.-st.-10-20102011/id635591/, and https://www.regjeringen.no/en/id4/ .

[2] See for example: https://www.regjeringen.no/en/topics/european-policy/areas-cooperation/environment-climate/id686218/

[3] https://www.landbruksdirektoratet.no/no/miljo-og-okologisk/jordbruk-og-miljo/gjodsling/regelverk/forslag-til-nye-forskrifter-levert-gjodsel-storre-ressurs-mindre-ulempe
https://www.regjeringen.no/en/topics/european-policy/areas-cooperation/environment-climate/id686218/

[3] https://www.landbruksdirektoratet.no/no/miljo-og-okologisk/jordbruk-og-miljo/gjodsling/regelverk/forslag-til-nye-forskrifter-levert-gjodsel-storre-ressurs-mindre-ulempe

[4] See https://www.landbruksdirektoratet.no/en/property/the-norwegian-concession-act for more details.

[5] Land use changes are mainly from: housing; infrastructure development; forestry activities; and land-use changes in agricultural areas (arable land, including sown grassland, meadows and pastures), which include changes in farming practices and the abandonment of farmland.

[6] The indicator for open lowlands and cultural landscapes has shown a slight negative development for biodiversity since 1990. https://miljostatus.miljodirektoratet.no/miljomal/naturmangfold/miljomal-1.1/miljoindikator-1.1.7/.

[7] Key elements include: developed a legal framework to combat invasive alien species (IAS), which consists of the Nature Diversity Act and regulations relating to alien organisms; conduct surveys to combat and to surveil IAS in selected conservation areas; established the Norwegian Biodiversity Information Centre, which conducts ecological risk assessments; and conducted risk assessments of IAS by the Norwegian Scientific Committee for Food and Environment; participation in European research programmes to compile and harmonise information about IAS within Europe.

[8] This is the same target as the European Union. Norway's NDC covers all sectors and GHGs.

[9]
https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Norway%20First/Norway_updatedNDC_2020%20(Updated%20submission).pdf

[10] Wetlands will not be included in the commitment until 2026, and many measures are put in place. More details will be presented in the White Paper on climate policies that is expected to be presented by the end of 2020. The White Paper will be based on the comprehensive report "Climate Cure 2030" (Klimakur 2030)" published in January 2020, https://www.miljodirektoratet.no/klimakur.

[11] Chapter 5, Economics, Taxation and Sustainability of the Granavolden platform of the ruling party states: "The exceptions for agriculture and fisheries are removed if the party's composition the Committee on Fisheries and the negotiations between the State and the agricultural organisations on a climate agreement does not come up with measures that provide real and adequate emissions reductions."

[12] Relative differences in the price of pasture land keep more land in beef production in these two regions.

[13] Carbon leakage occurs when a domestic tax on carbon results in increased imports of the taxed product from countries where such a tax is not applied. Part of the carbon emissions resulting from consumption take place elsewhere, so the net carbon reduction is smaller than the domestic reduction.

[14] See Chapter 2 where a "decoupling" scenario converts payments based on animal numbers (among other things) to a historical entitlement payment. Reduced livestock numbers decrease GHG emissions even more in that scenario, though production also decreases more.

[15] Carbon leakage effects occur when country efforts to reduce GHG emissions are, partially or completely, offset by increased emissions from countries without mitigation policies (OECD, 2020[39]).

[16] For the methodology and definitions of the different tax categories, see https://ec.europa.eu/eurostat/documents/3859598/5936129/KS-GQ-13-005-EN.PDF/706eda9f-93a8-44ab-900c-ba8c2557ddb0?version=1.0

[17] An evaluation in 2003 of the National Plan for Pesticide Risk Reduction (1998-2002) revealed that farmers were shifting to less environmentally harmful pesticides. Later, the Action Plan for Pesticide Risk Reduction (2004-08) increased the number of tax classes from three to five for better differentiation by health and environmental risk. The pesticide tax rates were increased by about 25% in 2005, with no further changes since.

[18] The energy sector includes the energy industries (including oil and gas extraction), the transport sector, energy use in manufacturing and constructing, fugitive emissions from fuels and energy combustion in other sectors. Road traffic and offshore gas turbines (electricity generation and pumping of natural gas) are the largest single contributors, while coastal navigation and energy commodities used for the production of raw materials are other major sources.

[19] The concept of bio-economy is closely related to the circular economy. The main objective of the bio-economy is the production and use of biomass, while the circular economy is focused on the use and reuse of products and on closing the loop within the value chain (Diakosavvas and Frezal, 2019[32]).

[20] https://www.regjeringen.no/en/aktuelt/the-norwegian-government-steps-up-the-efforts-to-turn-waste-into-resources-and-reduce-marine-litter/id2558322/.

4 The agricultural innovation system in Norway

The Agricultural Innovation System (AIS) in Norway is part of a broader innovation system that has contributed to the economic and social transformation of the country. However, the principle of sectoral responsibility for the different ministries does not facilitate the responsiveness to new cross-sectoral challenges such as climate change or the diversification of the Norwegian economy. The AIS is dominated by public funding and good quality research institutes, and has a bias towards publications and research rather than patents and adoption by the private sector. Regulated agricultural markets contribute to isolating the AIS from market signals and innovation opportunities. There is potential to export knowledge and technological capacity that are the comparative advantage of Norway, rather than focusing on the production of commodities. The levy fund (FFL) provides an opportunity to involve the private sector on innovation in partnership with the government that could be assessed in conjunction with the Agriculture Agreement funds (JA) to improve their capacity to respond to new demands in agri-food value chains and to further bring together public and private efforts.

Key messages

- Norway's economy-wide innovation system has performed well in the past and scores above the OECD median on ICT infrastructure and skills, but below the median on patents and international co-inventions. Cost efficiency is limited due to high expenditure compared to other countries. The system needs to improve its responsiveness to a more diversified economy with new societal demands, and to address long-term priorities.
- The Agricultural Innovation System (AIS) follows a sectoral approach with the Ministry of Agriculture and Food at the summit. The Long Term Plan (LTP) for Research and Higher Education does not play the role of main driver for priority setting across sectors. Meanwhile, the Research Council of Norway plays a unique role in providing advice to the government, cross-sectoral co-ordination, implementation and research evaluation.
- The AIS has two specific innovation funds involving farmers: the research fund financed from the agricultural agreement (JA) and the fund for research from fees (FFL). These provide an opportunity to involve the private sector. Project implementation is dominated by sectoral institutes such as NIBIO, Ruralis and the Veterinary Institute.
- Public investment in AIS is only 3% of total support to agriculture, compared to 5.8% in the European Union and 4.2% across OECD countries, but reaches 4.2% of agricultural value added, well above other OECD countries. In agro-food, the private sector plays a relatively small but growing role in R&D funding. The tax incentives programmes SkatteFUNN contributes to this outcome.
- Norway is better at producing agri-food publications than at applying research to patentable uses for the private sector, revealing a bias towards basic rather than applied research.
- Norway should strengthen cross-sectoral innovation, engaging farmers and cooperatives in priority setting beyond the sector. The independence and cross-sectoral approach of agri-food research institutes should also be strengthened, and the performance and governance of the JA and FFL funds should be jointly assessed.
- Agricultural support policies should shift from maintaining historical activities to embracing innovation. Improving cost-efficiency requires a more demand driven approach focused on applied entrepreneurial outcomes.

The agricultural sector is small for the size of the economy in Norway but attracts a significant amount of policy support covering 59% of farmers' revenues, the highest share among OECD countries, hindering market signals and incentives for innovative transformations. The share of knowledge and innovation[1] policies in total government support to the sector is only 3%, one of the smallest among OECD countries, which have an average of 4.2%, 5.8% in the European Union and 5.3% in Switzerland[2] (Chapter 2). The chapter analyses the actors and governance of the agricultural innovation system AIS (Section 4.2), the policies facilitating the flow of knowledge (Section 4.4) and international co-operation (Section 4.5). In order to frame and benchmark the AIS in the broader innovation system (IS), this chapter briefly discusses the general economy-wide IS (Section 4.1), and compares AIS investment with that of the whole Norwegian economy in terms of expenditures (Section 4.3) and performance (Section 4.6).

4.1. General Innovation system

Norway is a high-income country with good framework conditions in terms of macroeconomic stability and performance and strong tradition on consensus-based decision making. Norway has a satisfactory system of universities and research institutes that collaborate with the business sector on innovation. The Norwegian workforce is highly skilled and able to engage in innovation processes. Despite its successes, the economy wide innovation system in Norway is currently confronted with significant transformation challenges.

4.1.1. Norway has a history of good economic performance underpinned by innovation

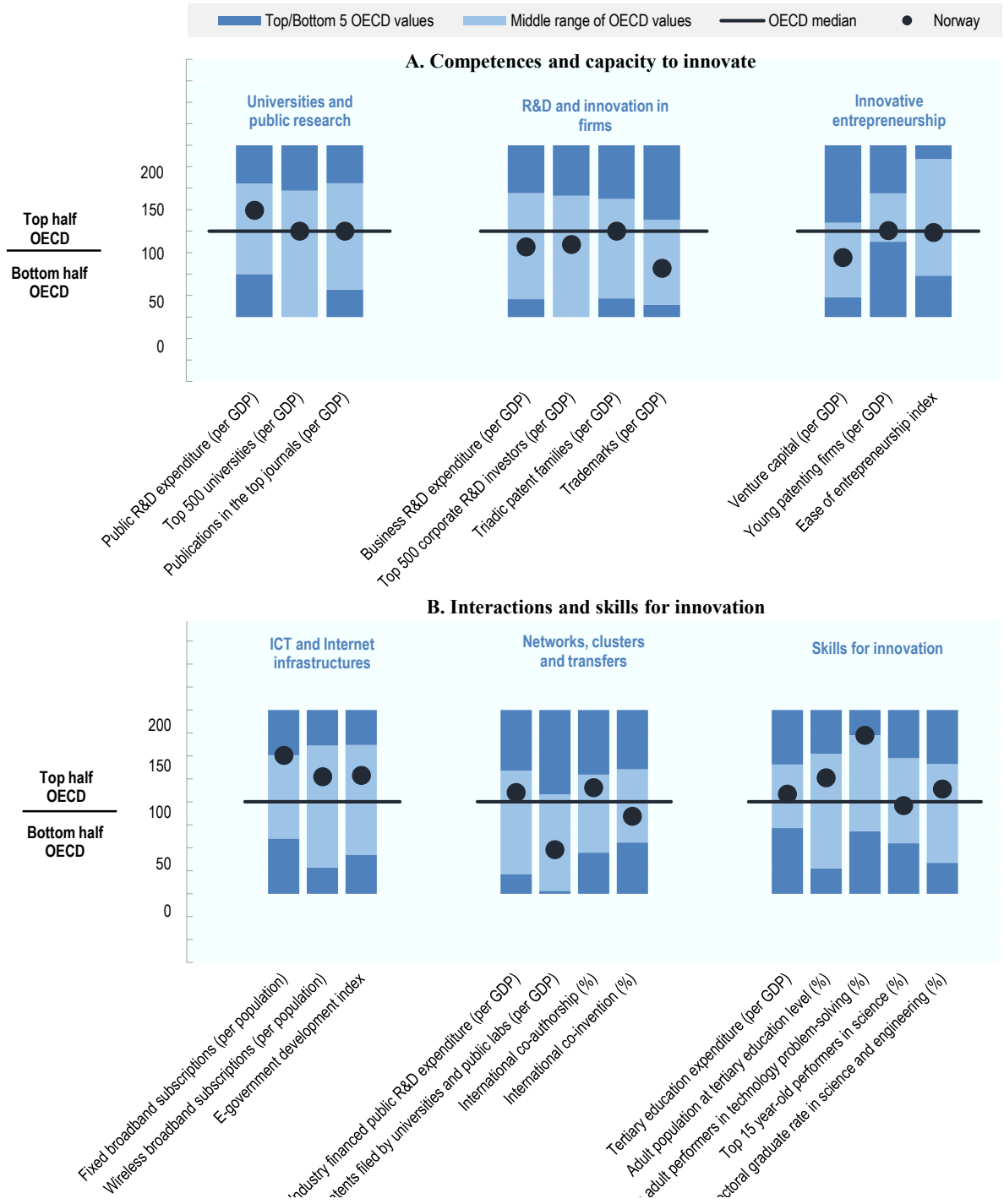
The economic history of Norway in the last century is a story of a remarkable transformation that has reshaped the country into one of the richest in Europe. Norway has demonstrated its ability to take advantage of opportunities to develop resource-based sectors pursuing an active industrial policy after World War II, developing successful clusters on oil and gas, shipbuilding, fisheries and aquaculture. Technology and engineering service companies supported these developments, maintaining a close relationship with universities and specialised research institutes. These dynamic sectors became a driving force in growth and innovation and building strong, interlinked research and innovation capabilities as analysed in the last *OECD Review of Innovation Policy in Norway* (OECD, 2017[1]).

…but the innovation system is challenged by its limited cost-effectiveness…

According to general indicators of the Science and Innovation system, Norway's relative performance is not far from the median values of OECD countries (Figure 4.1). Universities and public research score at the median value in terms of top world-ranking institutions and publications per GDP, but it does so at a higher level of expenditure compared to the median. Norway scores below the OECD median in most indicators on R&D and innovation in the firm, and on venture capital. These results are well below Sweden's which is among the five top performers among OECD countries in most of these indicators (OECD, 2018[2]). Norway has a strong ICT infrastructure and a highly skilled workforce for innovation, with scores above the OECD median values for all related indicators. However, patents by universities and international co-inventions also score well below the median OECD values (Figure 4.1).

Figure 4.1. Science and innovation performance in Norway

Comparative performance of Norway's science and innovation systems, 2016



Note: Normalised index of performance relative to the median values in the OECD area (Index median=100).
Source: OECD (2018[3]).

Concerns have been raised about persistent challenges in the Norwegian innovation system, in particular on the limited cost-effectiveness of the research and higher education system (OECD, 2017[1]). On the research side, the system produces "good but not excellent" science results at a relatively high cost in terms of total expenditure;[3] on the education side, the higher education pipeline has a high rate of student dropouts and overly long periods of academic studies, even if this is less the case within agricultural studies; the overall research performance is less than excellent with only few "peaks of excellence" in the university system (OECD, 2017[1]). The performance of the higher education sector, which lags behind those of the other Nordic countries on a number of key indicators, is not in line with the annual level of public expenditure, which is well above the OECD average.

…and there are new needs associated with the transition towards a more diversified economy

Norway is increasingly facing a "triple transition imperative" in its innovation system (OECD, 2017[1]). First, a shift towards a more diversified and robust economy, as Norway is still highly dependent on the fossil fuels exporting sector. Second, moving towards a more competitive, effective and efficient innovation system, with sufficient incentives and checks and balances for better performance in the higher education sector and in the links between research and innovation. Finally, these structural transformations must be achieved with higher responsiveness of the innovation system to an array of demanding societal challenges such as those related with climate change, aging and health. Economy-wide innovation policies should contribute to this triple transition by improving the excellency of the academic communities, enhancing competitiveness, responding to major societal challenges and improving the governance of the innovation system (Box 4.1). The agriculture, food and forestry sectors are a relatively small part of the economy, but through value chains (with a growing food processing sector) and the bio-economy, they need to be interlinked with these upcoming innovative transformations (Chapters 2 and 5).

Box 4.1. Policy recommendations for an innovation transition in Norway

The *OECD Review of Innovation Policies in Norway* (OECD, 2017[1]) identifies the following recommendations to enhance the overall innovation system. They are indicative, as some developments have taken place since 2017.

- *Improving the governance of the Norwegian national system of innovation*. Use the Long-Term Plan for Research and Higher Education process and its regular revisions to gradually enhance the level of multiannual financial commitment and STI priority setting, and improve strategic and operational inter-ministerial co-ordination. Provide Research Council of Norway (RCN) with a more independent budget to run inter-ministerial strategic programmes and incentives to reduce the number of funding programmes. This recommendation was also in the previous report (OECD, 2008[4]) to correct the weaknesses in priority setting in the public innovation funds and consider the impact of earmarking funds for the RCN, which removes its ability to act as an agent of change. Since 2019 RCN has started a portfolio management approach, still to be assessed, and Norway has engaged in Mission Oriented Innovation Policy Initiatives (OECD, 2021[5]).
- *Enhancing competitiveness and innovation*. Strengthen targeting and reorientation of innovation support funding, towards identified priorities. Increase the block funding for the institutes showing good performance. Ensure that the funds distributed directly by ministries to the research institutes are related to strategic projects, in line with the government's defined priorities. Encourage knowledge-transfer activities of research institutes and increase incentives for external engagement of academics with industry, and also broader stakeholders.

- *Developing excellence in academic communities*. Continue to focus on excellence and critical mass in the higher education (HE) sector and to roll out an internationally competitive career development model. Continue funding centres of excellence as an effective external driver of change for the public research sector and maximising the benefits from the internationalisation of R&D.
- *Tackling major societal challenges*. Devise broad integrated programmes that prioritise addressing societal challenges, based on inclusive processes that engage a broad array of stakeholders. Align the higher education and technical and vocational and educational training (TVET) system with the competence and skill base needed to address societal challenges. Address governance issues to improve co-ordination across ministries and policy domains of efforts towards solving societal challenges.

Building on these OECD recommendations, the Research Council of Norway (RCN) commissioned a specific study to guide their implementation (Technopolis, 2019[6]).

Source: OECD (2017[1]), OECD (2008[4]) and OECD (2021[5]).

4.2. Actors, institutions and governance of the Agricultural Innovation System

The Norwegian Agricultural Innovation System (AIS) consists of a network of many actors, both public and private, including universities, research institutes, public funders, farmers' co-operatives, food, feed and agri-tech industry and extension services. The interactions among them are the result of both authority and funding linkages, and of a diversity of partnerships and exchanges. There are many examples of farmer-owned companies undertaking advance research and innovation (e.g. Norsvin and Geno), but the small fruits and vegetables sector depends mainly on public research. The AIS is part of an overall Innovation System (IS) that is structured through a sectoral approach by leading ministries including the Ministry of Agriculture and Food (LMD).

4.2.1. A sectoral focus with many actors and three cross-sector implementing agencies

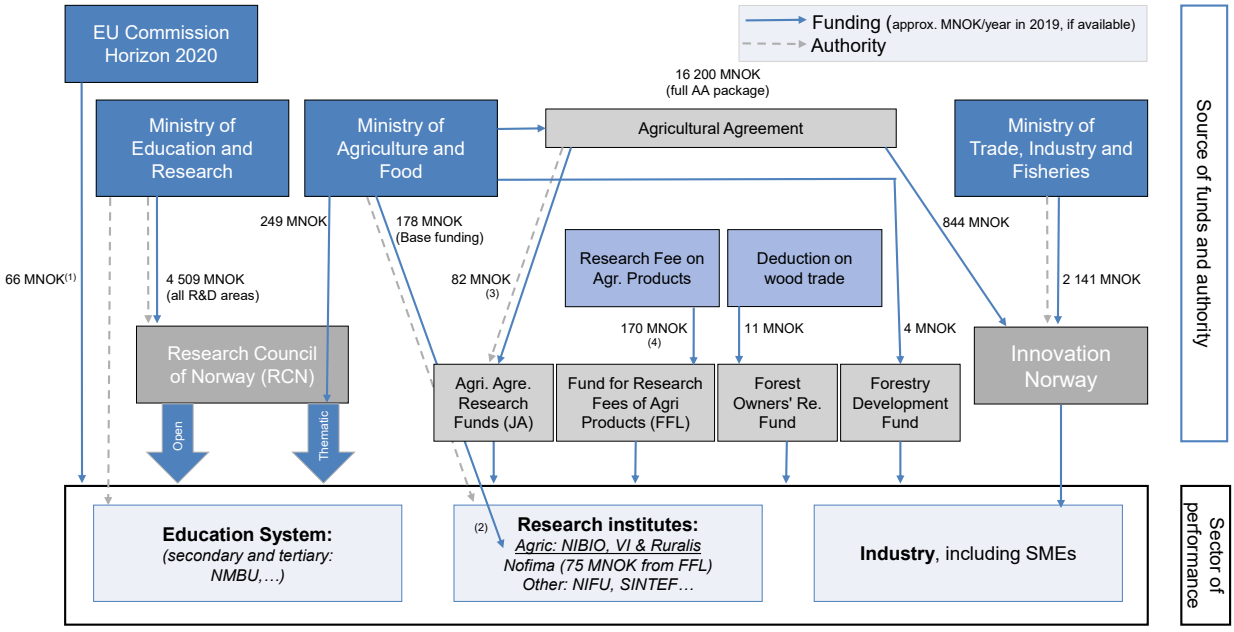
At the level of government, the building principle is that of a sectorial responsibility of the 15 ministries for funding in their policy domains. There is not a strong priority-setting body of process to guide research and innovation activities. Each ministry is responsible for formulating policy and long-term knowledge development in their respective areas. Ministries have a great deal of independence in terms of policy formulation and execution, and on the allocation of resources to research and innovation. The Ministry of Education and Research is responsible for universities, university colleges and some institutes, and for co-ordinating R&D policy. The Ministry of Trade, Industry and Fisheries is responsible for developing and implementing policies and framework conditions for business innovation, industry and trade and dedicates support for innovation. The Ministry of Agriculture and Food's' sectorial responsibility has areas of overlap with the Ministry of Trade, Industry and Fisheries (specifically on growth and increased innovation activity), the Ministry of Climate and the Environment (specifically on environment, biodiversity, climate adaption and mitigation, and energy-related issues) and the Ministry of Health and Care Services.

Despite a concentration of R&D in agriculture in one university (NMBU) and four research institutes (NIBIO and VI under the authority of the Ministry of Agriculture and Food, the foundation Ruralis and NOFIMA company) as illustrated in Figure 4.2, many other actors participate in the Norwegian Agricultural Innovation System. The last survey on the Norwegian AIS (NIFU, 2020[7]) identified more than 200 organisations conducting research and development activities, including 26 units within the system of

education (universities and university colleges), 23 research institutes, and 240 companies in industry, including Small and Medium Enterprises (SMEs).

There are three main policy agencies, not specific to agriculture, which implement priorities, channel funds and select projects to be conducted by the implementing organisations: the Research Council of Norway (RCN), Innovation Norway, and Siva – the Industrial Development Cooperation of Norway (the latter is not in Figure 4.2). The sources of this funding are mainly in the different ministries. Additional financial resources come through agriculture or forestry-specific funds from the research fees on agricultural production and the deduction on forest trade. The European Commission through its Horizon 2020 programme is also an important source of funds.

Figure 4.2. The Norwegian System of Research and Innovation for Food, Agriculture and Forestry in 2019



Notes: This is a stylised not fully comprehensive diagram. The Industrial Development Cooperation of Norway (Siva) is, together with with Research Council of Norway (RCN) and Innovation Norway (IN), one of the three national-wide implementing agencies, even if it is not reflected in this Figure. The Ministry of Trade, Industry and Fisheries (MTIF) provides almost one-fourth of all RCN funding, but rarely finances agricultural related projects and this flow is not reflected in the Figure.

1. Amount for a single year 2019. Total for SC2 for agri-research in 2014-19 was 700-750 MNOK.
2. The Ministry of Agriculture and Food (LMD) has authority on Norwegian Institute of Bioeconomy Research (NIBIO) and Norwegian Veterinary Institute (VI) only.
3. The Board of Agricultural Agreement Research Funds (JA) has a member from LMD, and one from each of the two main Farmers' Unions. The RCN participates as an observer.
4. The Board of Fund for Research Fees of Agricultural Products (FFL) has a member appointed by LMD, one from each of the two main Farmers' Unions, and one from each of Confederation of Norwegian Enterprise (NHO), Norwegian Agricultural Cooperatives (Norsk Landbrukssamvirke), Enterprise Federation of Norway (Virke) and Norwegian Food and Allied Workers Union (NNN). The RCN participates as an observer.

Source: Adapted from Biennial Science Indicators Report 2017, (Rørstad et al., 2017[8]) and informal information form the Ministry of Agriculture and Food.

4.2.2. Vertical governance with the Ministry of Agriculture and Food at the summit

The sectoral governance principle of innovation policy is a key characteristic, not unique, but particularly strong in Norway. It has the advantage of the inclusion of all ministries on R&D policies and tasks, but this comes with a cost as horizontal policy approaches to tackle societal challenges with cross-silos co-

ordination and integrated strategic priorities are more difficult to employ (OECD, 2017[1]; OECD, 2021[5]). The multiyear White Paper on research, the Long-Term Plan for Research and Higher Education, first 2015-24 and updated to 2019-28 or LTP, provides strategic cross sectoral direction and is the basis for the Inter-ministerial Committee on Research Policy that meets monthly and other inter-ministerial co-ordination mechanisms (Norwegian Ministry of Education and Research, 2018[9]). The LTP has three overarching broad goals, five long-term priorities and horizontal escalation plans (e.g. on technology), none of them directly linked to food and agriculture.[4] Despite these mechanisms, Norway's STI system is dominated by the vertical sector approach. Ministers (principals) delegate the main task of horizontal co-ordination to agencies, in particular RCN, through the annual allocation letters of the ministers. Although it has a ten-year horizon, the LTP is not a 10-year planning document and, in practice, it works on a four-year rolling planning. Furthermore, even if most ministries align their research strategies with LTP priorities, they do not earmark or commit their budgets through the LTP process. During the first four years of the LTP, interdepartmental groups were formed within each of the four thematic priorities to exchange information on different ministries' initiatives and monitor progress. Unfortunately, these groups have not met since the last revision of the LTP. The process and interaction between the LTP and the priority setting at each ministry deserves further follow-up and assessment. This vertical governance with sectoral priority setting differs significantly from the AIS in neighbouring Sweden (Box 4.2).

In this context of ministries being at the summit of the priority setting in their respective sectoral areas, the role of the three main innovation cross-sectoral policy agencies is crucial for the implementation of the priorities defined by the Ministry of Agriculture and Food (LMD) and the co-ordination with other ministries. Following the Parliament's White Paper, LMD defines the priorities and finances research and innovation through earmarked funds to RCN and IN, and through direct basic funding for three research institutes (NIBIO, the Veterinary Institute and Ruralis). These funds constitute the bulk of the funding for agricultural research and innovation. Agricultural related projects can also be financed by the open calls of RCN and other activities of IN. There are also four specific funds for agriculture and forestry.

Box 4.2. Different approaches to integrate AIS in broader innovation systems in Norway and Sweden

Sweden as a neighbouring country has some geographical similarities with Norway but significant policy and institutional differences, including EU membership and its Common Agricultural Policy (CAP). Both countries actively co-operate through the Nordic co-operation.

Sweden has, overall, a more horizontal innovation system that covers all sectors in a single strategic policy framework led by the Ministry of Education and Research, and, with fewer resources, the Ministry of Enterprises and Innovation. The four-year horizon Research and Innovation Bill is the main planning document defining the different strategic innovation areas. Subsequently, Strategic Innovation Agendas and the Strategic Innovation Programmes are defined for each area. The AIS in Sweden is fully integrated into general innovation and institutional framework, although research is not well connected with the needs of the agriculture and food sector. On the other hand, Norway's AIS is governed in a vertical structure with earmarked funding coming from the sectoral ministries. The Norwegian Long-Term Plan for Research and Higher Education attempts to set broader cross-sectoral innovation priorities but the main strategic responsibility on agriculture and food is in the sectoral ministry. Furthermore, Norway has specific agriculture and forestry funds financed by product fees and governed by producers and the ministry.

The main public research actors in Sweden's AIS are the universities, which are well placed in global rankings. In the Norwegian AIS sectoral research institutes have a larger relative importance in

innovation; they have followed a consolidation process such as the merging of three institutes into NIBIO in 2015, but are still numerous.

The participation of the private sector in the AIS through farmers and agro-food business is organised through the collaboration between farmers and the agro-food industry. In Norway, farmers' co-operatives are strong and play a dominant role in some value chains and, hence, in the innovation process. The Swedish Farmers' Foundation for Agricultural Research (SLF) funds some of the applied research on agriculture. The Norwegian FFL fund allows farmers to use fees on agriculture production for innovation projects. In Norway, the programme *SkatteFUNN* has already a history of providing tax credit for R&D projects for all firms including all sectors. The tax relief system in Sweden is more restrictive and plays a comparatively small role in research, not covering the development part of the innovation process.

Source: (OECD, 2018[2]).

4.2.3. Differentiating the roles for the three main innovation policy implementation agencies

Three nation-wide and cross-sectoral agencies are the corner stones of the Norwegian innovation policy (OECD, 2017[1]). Their competencies are to a great extent associated with their different historical origins. First, the Research Council of Norway (RCN) is the dominant operational actor in research and innovation policy. RCN was created in 1993 as a single council gathering together a diversity of previous councils and covering all scientific fields. In 2004, the RCN was supplemented by Innovation Norway (IN), an innovation agency with a pronounced regional mission that was created by joining together several rural, regional and industrial development funds, and focused on private sector innovation. Finally, the industrial Development Corporation of Norway (Siva) founded in 1968 and focused on physical infrastructure.

The Research Council of Norway is a research-funding agency with a unique role to advise the authorities on research policy, and to ensure that research structures and policy tools are coherent across sectors that are led by different ministries. It is also responsible for research evaluations. The RCN manages research funding from the 15 Norwegian ministries and, following their priorities and guidelines, allocates funds to basic and applied research and research-based innovation within all fields and disciplines. Its comprehensive mandate is unique by international standards. In the last decade, RCN has made an effort to rationalise its activities and reduce the number of programmes and initiatives. Its budget per capita is larger than in similar institutions in Austria, Finland or Switzerland[5] (OECD, 2017[1]).

RCN is an administrative agency with special powers under the Ministry of Education and Research that provides about 40% of its funds. The Ministry of Agriculture and Food (LMD) is the fifth largest provider of funds (NOK 427 million or USD 49 million in 2019) after the Ministry of Education and Research (NOK 4 509 million or USD 512 million), Ministry of Trade, Industry, and Fisheries (NOK 2 104 million or USD 239 million), Ministry of Petroleum and Energy (NOK 862 million or USD 98 million) and the Ministry of Climate and the Environment (NOK 472 million or USD 54 million). In 2019, the Ministry of Agriculture and Food (LMD) allocated through the RCN around NOK 249 million (USD 28 million) to programme activity and NOK 178 million (USD 20 million) to base funding of the research institutes in the agriculture and food sector. The Ministry, in an annual assignment letter, sets priorities based on overall policy orientations for the agricultural sector set by Parliament. Within this framework, the Research Council makes calls for proposals that are peer reviewed by international experts. The projects with the highest quality and relevance are financed within the open call budget. The Research Council is responsible for the follow up of ongoing projects.

The bulk of the ministry's (LMD) funding of programme activities in the Research Council goes to the BIONÆR programme (Research Programme on Sustainable Innovation in Food and Bio-based Industries), highlighting the priority given to the bio-economy (Box 4.3). The programme is financed by several ministries, but LMD is the main funder. RCN manages also a funding scheme for independent projects (FRIPRO), an open, national competitive source of funding for projects in all fields of research. The fund is very selective (only 10% of the projects proposed by researchers are granted support) based on scientific excellence rather than innovation impact.

RCN cannot act freely given the numerous earmarks and steering processes from the ministries that could decide to spend their funding through other channels. This may weaken the external advisory capacity of RCN that is below the ministries in the vertical co-ordination system. "For RCN the priority is to balance the various ministry demands and to get sufficient funding without too much earmarking" (OECD, 2017[1]).

Box 4.3. Selected bio-economy research programmes in Norway

The bio-economy is a priority area of research for the Ministry of Agriculture and Food as shown by the resources dedicated to selected RCN programmes.

The Research Programme on Sustainable Innovation in Food and Bio-based Industries or BIONÆR is the main research programme financed by the Ministry of Agriculture and Food with around NOK 200 million (USD 23 million) per year. The BIONÆR funds research and innovation to create value in Norwegian land-based bioindustries and the bioeconomy, including new bioresources and the food processing industry. The programme also receives funding from the Ministry of Climate and Environment towards an initiative on "Low Emissions 2030". The focus is on solutions that can provide significant emissions cuts, mainly in the non-ETS sector (ESR sectors as defined in Chapters 3 and 6), with transport and agriculture as a particular priority.

According to an evaluation report of the programme (Oxford Research, 2017[10]), BIONÆR contributes greatly to strengthening and developing knowledge and skills for bio-based industries. The programme has created an extensive co-operation ecosystem across institutions, sectors and countries, including with the Foundation for Research Levy (FFL) and the agricultural agreement funds (JA). The programme has been somewhat less successful in triggering patents, licenses and establishment of new firms (Oxford Research, 2017[10]).

The Large-scale Programme for Energy Research (ENERGIX) receives approximately NOK 12 million (USD 1.4 million) a year from the Ministry of Agriculture and Food. ENERGIX was launched in 2013 to invest in solutions that promote the long-term sustainable development of the energy system, increasing use of renewable energy, more flexible and energy-efficient solutions, and closer energy integration with Europe.

The Large-scale Programme on Biotechnology for Innovation (BIOTEK2021) receives approximately NOK 5 million (USD 0.6 million) from the Ministry of Agriculture and Food. The BIOTEK2021 programme provides funding for research and innovation to promote responsible development and application of biotechnology in the agricultural, marine, industrial and health sectors.

Some cross-sectoral approaches for innovation on environmental issues (eco-innovation) such as reductions in GHG emissions (e.g. Enova) and carbon capture and storage (CCS) are discussed in Chapter 3.

However, in recent years some ministries have given increasing flexibility to RCN to bundle financing in common programmes in their letters of assignment, so that RCN can bundle financing in common programmes. The Ministry of Agriculture and Food has increased the share of funds that are targeted to long term sectoral priorities and only around 10% of the funds are earmarked for short term projects. RCN

is both the main organiser and customer of evaluations. RCN has developed evaluation practices and the system is professionally organised involving well-known Norwegian and international groups and experts. The combination of the two roles (funder and evaluator) in a single agency could be criticised but there is no sign that this has led to a positive bias in the evaluations.

Innovation Norway (IN) supports innovative projects in enterprises and industry with the objective of developing value-creating business throughout the country. The Ministry of Trade, Industry and Fisheries owns 51% of this public agency and 49% is owned by the 11 county (regional) authorities. IN has a central office in Oslo, and offices throughout all regions in the whole country and in more than 30 countries worldwide. IN provides loans, guarantees and grants and other business advisory services such as mentoring, export services and networking to make start-ups, companies with capacity for growth and innovative business environments, more competitive.

Compared to RCN, IN focuses more on bottom up business and market driven innovation and development. Most of the funding provided by Innovation Norway is not dedicated to any specific sector. Beside agriculture, there are earmarked budgets for enhancing tourism (Visit Norway) and profiling Norway as a location for foreign investments. In addition, there is a mission for the development of business and industry in rural areas, where the counties are the main stakeholders, and Innovation Norway is the national office promoting global opportunities. Nearly half the budget of IN is allocated to the agriculture and marine and maritime sectors, but the bulk goes to the marine and maritime sectors (OECD, 2017[1]). The other half of the funding goes mainly to the knowledge-based industries and services. IN's new strategy points at working more on missions, societal challenges and high potential global opportunities. .

IN receives funding from 8 ministries and 11 regional municipalities. The three largest funders of IN in 2019 were the Ministry of Trade, Industry and Fisheries with NOK 2 141 million (USD 243 million), exclusively loans, the Ministry of Agriculture and Food with NOK 844 million (USD 96 million) and the Ministry of Modernisation and local affairs (NOK 150 million or USD 17 million).

The Industrial Development Co-operation of Norway (Siva) is a governmental enterprise, owned by the Ministry of Trade, Industry and Fisheries, facilitating national infrastructure for innovation consisting of incubators, business gardens, catapult centres, innovation enterprises, innovation centres and industrial real estate. Siva has equity in more than 100 innovation companies and is present across the whole country.

Norway has 11 administrative regions or counties and 356 municipalities after some recent mergers among these decentralised administrative units. The counties are also developing regional plans related to innovation policies, while municipalities are responsible for business planning and land use and they do not receive innovation funds. Both IN and Siva have a strong regional focus. Despite some overlap between objectives of IN, Siva, RCN and the counties, there is evidence of good communication and co-operation between these actors at national level, with a less clear division of responsibilities at regional level (Oxford Research, 2016[11]). There are also cross-agency schemes such as the Green Platform Initiative and Pilot-E that support clean transport and energy solutions combining various means and interventions. The "Pilot-X model" is being progressively streamlined in other thematic areas (health, circular economy…).

The government has initiated a comprehensive review of all industry-targeted policy instruments, which is to be completed by the end of 2020. The goal is to improve competence, co-operation, the division of labour and the interfaces between different actors, as well as the usability and efficiency of the support system. As part of this review, the Ministry of Finance and the Ministry of Industry and Fisheries mandated an external report on the range of instruments that stimulate business innovation in Norway (Deloitte, 2019[12]). This report does not have an agriculture specific focus and concludes that the set of instruments in Norway is too complex with too many actors. In particular, it proposes that the Research Council of Norway and Innovation Norway (with Siva incorporated as a separate division of IN) should be given a clear responsibility for active portfolio management within their own area within the framework of

management of documents and assignments from the ministries. RCN should have primary responsibility for all instruments in research driven innovation, while IN should have primary responsibility in all instruments related to business and customer driven innovation. It is also proposed to pivot towards broad, non-thematic instruments to increase the ability of these actors to conduct more efficient portfolio management and to reduce the number of schemes.

In line with these proposals, the Research Council of Norway and, to a lesser extent, Innovation Norway are evolving from traditional programme management towards broader portfolio management. The Ministry of Education and Research, which is responsible for RCN, has introduced a management system based on goals and results ("management by objectives" or MRS) with five goals that guide the activities of RCN and are common for all ministries that allocate funds to RCN: increasing scientific quality, increase value creation in the business sector, meet major societal challenges, well-functioning research system and good advice. The Ministry of Trade, Industry and Fisheries, which together with the counties is responsible for IN, has also introduced an MRS system with three goals: more good entrepreneurs, more expansive companies and more innovative industrial clusters. Since 2017, RCN has reduced its 50 programme boards into 15 portfolio boards with continuously adjusting investment plans. This implies that AIS main innovation areas could be part of broader innovation challenges, mixing funding from different ministries.

4.2.4. Agriculture and forestry specific funds jointly governed by producers and the Ministry of Agriculture and Food

LMD implements the bulk of its agricultural policies through the annual Agricultural Agreements (JA) between the government and the two farmers' unions, including about NOK 16 000 million (USD 1 818 million). The Agricultural Agreement Research Funds are a small part (about NOK 82 million or USD 9 million) of this agreement. The funds are earmarked to cover the needs for knowledge for the ministry and the farmers through research, committing annual amounts for research in the agricultural and food sector and instructions and priorities for their use. The Fund board has a member appointed by the Ministry of Agriculture and Food, and a representative from Norwegian Farmers' Union and the Norwegian Farmers and Smallholders' Union. The Research Council participates as an observer. The Agricultural Agreement Funds provide financial support to develop businesses in traditional agricultural production and other farm business. In recent years, priorities have shifted to knowledge on climate adaptation to reduce GHG emissions and carbon storage in soil and forest.

Norway has two specific funds for research on agriculture (Foundation for Research Levy on Agricultural Products - FFL) and forestry (*Skogtiltaksfondet*) financed through levies to be paid per unit of product. This model of engagement of the private sector on research has shown successful results in other countries like the Rural Research and Development Corporations (RDC) in Australia (OECD, 2015[13]). Unlike in Norway, RDC receive matching finance from the government, creating incentives for private funding. The experience shows that these instruments can be successful for the short-term needs of the primary sector, but longer term innovation priorities require the engagement of processing and retailing stakeholders in their governance and decision making.

The Foundation for Research Levy on Agricultural Products (FFL) was established in 1970. The Fund's capital is built up through a research fee on agricultural products, both imported and nationally produced. A similar scheme exists for aquaculture products, the Norwegian Seafood Research Fund (FHF). The FFL finances research projects through annual open calls for proposals. A part of the fund is also set aside for basic funding of the research institute Nofima. The board sets the priorities for the annual calls, based on the needs experienced in the industry. The members of the board are: a representative appointed by the Ministry of Agriculture and Food, Norwegian Farmers' Union, Norwegian Farmers and Smallholders Union, Confederation of Norwegian Enterprise (NHO), Norwegian Agricultural Cooperatives (Norsk Landbrukssamvirke), Enterprise Federation of Norway (Virke) and Norwegian Food and Allied Workers Union (NNN). The Research Council participates as an observer. The Fund is in the national budget

estimated at about NOK 170 million (USD 17 million) in 2020. However, recent years have shown that the actual revenues from the levy are much higher than the estimates due to increased consumption.

The Norwegian Agriculture Agency (NAA), the government agency in charge of implementing agricultural policies including payments, imports and property, is also in charge of co-ordinating the board for the Fund for Research Fees of Agricultural Products (FFL) and the board of the Agricultural Agreement Research Funds (JA). The NAA is the Secretariat of the boards of both funds. These boards take decisions on which projects to finance, and the RCN handles the application and evaluation process. The two boards are already rather intertwined having the same chair and same members from the two farmers unions. Following the model of RDCs in Australia, further merging these two funds from levies and from the government budget (FFL and JA, respectively) may have advantages. It would increase their joint capacity for innovation thanks to larger size; with appropriate matching requirements, it could create incentives to increase innovation funding both from the government and the private sector; and broadening the scope of stakeholders in the governance of both funds would improve the innovation focus on long term priorities and new demands from consumers and society.

Skogtiltaksfondet or Forest Owners' Joint Research Fund, established in collaboration with the Ministry of Agriculture and Food. The fund aims to increase R&D involvement in the forestry industry, and focus on R&D tasks that are of importance to forest owners. *Skogtiltaksfondet* secures financing for research and development projects on Norwegian forestry through the deduction of NOK 1 (USD 0.1) per cubic meter of traded timber, an obligation regulated by law. In addition, the fund includes returns from its accumulated capital. The Norwegian Forest Owners' Association acts as the secretariat.

The Forestry Development Fund (*Utviklingsfondet for skogbruket*) aims to promote research, development, information and training in the forestry sector, as well as other measures of interest to the forestry industry. The funding will primarily support applied R&D activities. The Norwegian Agricultural Agency is the secretariat for the fund. The fund is managed by a board of five members appointed by the Ministry of Agriculture and Food.

4.2.5. Competitive research institutes are the dominant players, but overall strategic management could be improved

Norway has a competitive university (NMBU) and research institutes with a special focus on food agriculture and forestry. They are mostly public institutions or depend on the Ministry of Agriculture and Food for basic funding and authority, which is implemented through the RCN.

The Norwegian University of Life Sciences (NMBU) is fully located in Ås, a pole of excellence of agricultural knowledge, since 2020. The formulation and co-ordination of education policies is the responsibility of the Ministry of Education and Research. NMBU has expertise in life sciences, environmental sciences and in the area of sustainable development. The university was established in 2014, from a merger of the Norwegian School of Veterinary Science (NVH, presently located in Oslo) and the Norwegian University of Life Sciences (UMB). It has 5 200 students and 1 700 employees. The new university has seven faculties from Biosciences to Veterinary Medicine. NMBU has an innovation strategy from 2019, with three overall objectives: contribute to innovation and entrepreneurial activities for students and staff, innovation and value creation in society by increasing co-operation with external players and ensuring that new knowledge and research-based ideas are developed for the benefit of society.

The Centres for Research-based Innovation (SFI) is a scheme mainly financed by the Ministry of Education and Research and aimed to develop expertise in fields of importance for value creation. Long-term research is conducted in SFI centres in close collaboration between research-performing companies and prominent research groups, enhancing technology transfer, internationalisation and researcher training. Foods of Norway is a SFI at NMBU, funded by the RCN and the Centre's industry partners. The centre aims to increase value creation in the Norwegian aquaculture, meat and dairy industries by developing

novel feed ingredients from natural bioresources. Other recent SFI centres are: Smartforest aiming to contribute to a digital revolution in the forest industry; and EarthresQue (Centre for Rescue of Earth Materials and Waste in the Circular Economy) on the sustainable use of soil materials.

The Norwegian Institute of Bioeconomy (NIBIO) is also located in Ås and was founded in 2015 by a merger of three institutes Bioforsk (*Skog og landskap* and NILF). NIBIO is one of the largest research institutes in Norway with approximately 700 employees. The goal of the institute is "to contribute to food security and safety, sustainable resource management, innovation and value creation through research and knowledge production within food, forestry and other biobased industries". NIBIO is subject to the Ministry of Agriculture and Food as an administrative agency with its own supervisory board.

The Norwegian Veterinary Institute (VI) is a national biomedical research institute, established in 1891, in the fields of animal health, fish health and food safety. It provides independent research-based advice to the governing authorities. The basic financial resources come from the Ministry of Agriculture and Food and the Ministry of Fisheries and Coastal Affairs. The most important function of the Veterinary Institute is contingency planning and competence development to prevent threats to the health of fish, animals and human beings.

The Institute for Rural and Regional Research (Ruralis) has a national responsibility on rural sociology and applied social research. Ruralis has a multidisciplinary staff, including about 28 researchers with backgrounds in sociology, geography, history, business economics, social anthropology, political science, agronomy and fisheries.

NOFIMA is a business oriented and applied research institute organised as a limited company, owned by the Ministry of Trade and Fisheries, the Agricultural Food Research Foundation and *Akvainvest Møre og Romsdal*. The institute works on research and development for the aquaculture, fisheries and food industry and present in all major regions in Norway. Digital Food Quality is a SFI centre in Nofima focused on digital transformation of food production. A major part of Nofima's strategic research is financed by the FFL levy fund.

The Nordic Institute for Studies in Innovation, Research and Education (NIFU) is an independent social science research institute, organised as a non-profit foundation, specifically focusing on studies of innovation, research and education at all levels. NIFU collect, analyse and disseminate national statistics and indicators for R&D and innovation.

SINTEF is a broad, multidisciplinary research organisation in the fields of technology, natural sciences, medicine and social sciences. SINTEF conducts contract R&D as a partner for the private and public sectors, and is one of the largest contract research institutions in Europe. One of SINTEF's focus areas is circular economy, combining technological expertise with economic and environmental expertise into multidisciplinary solutions.

In 2018, the RCN published a report on the evaluation of the primary sector research institutes including Ruralis, NIBIO, VI and Nofima, together with SINTEF-Fisheries, the Marine Technology Institute, and the fish nutrition institute NIFES (Research Council of Norway, 2018[14]). The report highlights the key role of these institutes as dominant players in the R&D systems and the need for better co-ordination among financing ministries and calls for more strategic management by RCN and the institutes' boards. Some institutes have strong dependence on a single source of funding. The report highlights the risk of potential conflicts of interest in research and the need to ensure ethical standards and principles for scientific independence and research integrity, a topic that has recently attracted the attention of publications (Ingierd, Bay-Larsen and Hauge, 2019[15]). According to the report, the Research Council and the financing ministries should continue ongoing efforts towards broader thematic programmes, where cross-sectoral research on topics such as bioeconomy, food and sustainable utilisation of marine resources can be financed. Increasing competition from higher education institutions for RCN funding requires the institutes

to embrace this broader thematic approach to projects, while a new basic funding system is proposed to better guarantee long-term needs.

4.2.6. Innovation initiatives by the private sector

The private sector plays an important role in the innovation system. Private enterprises, firms and farms are the core actors of the adoption of technology and organisational innovations. They have the incentive to innovate and they do so to improve economic performance. In Norway, through the Skattefunn programme, all firms can benefit from a tax credit for R&D projects (Section 4.4). The main private players in the agro-food sector have their own research and innovation departments. Only a few examples are mentioned here.

As Norway's largest producer, distributor and exporter of dairy products with 11 400 members (owners) and 9 000 co-operative farms TINE has an active role both in research and extension services (Chapter 2). TINE has its own R&D department and invests in innovation activities such as the digital platform Mimiro (Box 4.4).

In the meat sector Nortura, a co-operative owned by 18 300 egg and meat producers, undertakes R&D through Animalia (Chapter 3). Animalia is financed mainly by FFL funds from the sales fee, the Research Council of Norway, and from the Agricultural Agreement, Innovation Norway and the European Union. Norilia is a bioeconomy subsidiary of Nortura aiming to preserve and utilise the residues ("plus" products) from the meat and egg industry that do not go directly to food. For instance, Norilia in a joint project with Felleskjøpet Agri and Nortura, has implemented a new biological process called enzymatic hydrolysis in a new biorefinery, Bioco, which will produce high-quality proteins and fats from poultry plus products.

Box 4.4. Mimiro: A digital knowledge platform for dairy producers

Mimiro is a digitalisation and technology company owned by the Norwegian dairy co-operative TINE and the feed co-operative *Felleskjøpet Agri*. This initiative aims to develop an open data platform that collects and shares data to develop management and decision support systems for farmers. Mimiro is creating an ecosystem for data that external service providers can use as a digital innovation space based on the farmer's premises. The ambition of Mimiro is to combine comprehensive knowledge of agriculture with cutting-edge technology. Based on optimisation and analysis of farmers' data, Mimiro will develop digital end-to-end decision support solutions that give concrete advice to farmers rather than just show information.

An important principle is that farmers own their own data. Data that the famer wants to share anonymously becomes available for external service providers, who can use that information to deliver better services back to the farmer but also for research. Mimiro launched its first application in 2019 and a sophisticated management tool for field operations was launched in 2020 focused on a full dataflow dashboard with animal production accounting, settlement and payment, including decision support based on AI machine learning from sensor data.

Mimiro is one of several Norwegian partners to DEMETER, an EU Horizon 2020 project on digital transformation of the agri-food sector. The pilot is co-ordinated by the research institute SINTEF.

Borregaard is a Norwegian industrial group that produces biochemicals based on timber: lignin, special cellulose, vanillin, bioethanol and microfibrillar cellulose for a variety of applications in agriculture, fisheries, construction, pharmaceuticals and cosmetics, foodstuffs, batteries and biofuels. Borregaard invests considerable resources in research and development at research centres and universities in Norway, Spain, South Africa and the United States.

BAMA is the Norwegian market leader in fresh fruit and vegetables, gaining steadily on the market share on other fresh products including flowers, drinks and sandwich products active in many countries. BAMA has made major joint investments in research and development along the entire value chain.

Food and drink Norway is the largest employer and business policy organisation for the food, beverage and bio-industries in Norway, and is a member of the Norwegian Confederation of Norwegian Enterprise (NHO).

Research and innovation on plant and animal breeding

Norway has a significant set of private firms focused on improving the genetics of plants and animals: Graminor for plants, and Norsvin, Geno and Tyr for animals. A prerequisite for breeding is access to a wide variety of genetic resources that need to be conserved and made available to breeders and farmers. The efforts of the breeding industry are supported through the national strategy for genetic resources launched by the Ministry of Agriculture and Food in December 2019. The Svalbard Global Seed Vault is the largest safety backup of the world's crop diversity. The Seed Vault is a publicly-owned Norwegian facility and is managed and operated in a partnership between the Norwegian Ministry of Agriculture and Food, the Nordic Genetic Resources Centre (NordGen) and the Global Crop Diversity Trust (Crop Trust). The Svalbard Global Seed Vault is the world's largest seed repository for plants since 2008. It received the support of the FAO Commission on Genetic Resources.

Graminor is the main plant breeding company in Norway, responsible for developing new plant varieties of field crops and horticultural plants suitable for Norwegian and Nordic growing conditions. They also test and represent imported varieties and produce pre-basic seeds for further research.

Norsvin is a breeding company owned by Norwegian pig producers focused on the development, production and sale of pig genetics. Norsvin's genetics are exported globally through the company Topig's Norsvin. Around 30% of Norsvin's total turnover is used for R&D. Geno is the breeding organisation of Norwegian Red, the main dairy breed in Norway. It is a farmer co-operative conducting research and development for cattle breeding since 1935. Geno's investment in research and development of the Norwegian Red breed has resulted in several biotechnology companies owned by Geno and exploiting specific products, including GENO Globas AS, SpermVital AS and CryoGenetics AS. Geno sells genetic material to more than 30 countries worldwide (Box 4.5). Aquagen is the leading breeding company for fish in Norway.

Biobank is a small private company owned by Norsvin, AquaGen and Geno providing integrated services around a biorepository. These include DNA extraction and storage of genetic material, and linking samples with data as a tool for breeding animals, fish and plants. Biobank is part of the NCE Heidner Biocluster supported by Innovation Norway (Section 4.4).

Box 4.5. Does Norway have a comparative advantage in dairy cow breeding?

Norwegian dairy farmers, through their breeding co-operative Geno,1 decided three decades ago to diversify its breeding target to add emphasis on fertility and health traits at the expense of faster progress on milk yield (Walsh et al., 2008[16]). The resulting innovation is a breed that is a world leader in health and fertility, traits which are in increasing demand worldwide (Dobson et al., 2008[17]). Norwegian Red (NRF) has been the most sold red breed on the world market since 2014, with exports to over 30 countries.

This is the result of a nation-wide breeding programme that since the 1970s prioritised traits such as fertility and mastitis resistance in addition to milk and meat yield. Because health traits have low heritability and are antagonistic to yield, achieving genetic progress on both fronts requires scale and

precision. Despite its small size, the Norwegian dairy sector developed the NRF breed thanks to the Norwegian Dairy Herd Recording System (NDHRS). Introduced in 1975, the NDHRS is a centralised database managed by the dairy co-operative TINE recording a wide range of production and health parameters of 96% of all cows in Norway, information that is shared among key stakeholders such as researchers, advisors and government. A central part of the NDHRS is the mandatory recording of any veterinarian intervention – only veterinarians can administer antibiotics – in each cow's individual "health card". Health data for Norwegian cows has been complete and reliable for almost 50 years.

The breeding co-operative Geno has maintained a strong relationship with research institutions from its inception, with the majority of its R&D staff located within the animal sciences faculty of NMBU. This symbiotic relationship provides resources to NMBU for research, while Geno receives access to novel research and methods such as genomic selection, which was adopted for the selection of bull calves as potential sires in 2013. Knowledge distribution at the farm level is carried out in partnership with TINE, whose advisors assist farmers in developing breeding plans for each individual cow.

The co-operative structure of Geno has also helped overcome some challenges of the scale required for genetic progress on low heritability traits. Members of the co-operative share the costs and risks by using 40% test sires in each farm. Farmers agree to this because they trust to reap the benefits in the long run thanks to the co-operative (Borgen and Aarset, 2016[18]).

Geno members face equal prices for semen irrespective of geographical location and the government provides payments of about NOK 80 million (USD 9 million) a year to breeding organisations and veterinaries for insemination services in remote areas. Geno leads a project to reduce methane emissions by 20%, investing in measuring cows' individual methane emissions and investigating its potential as a trait in the breeding target for NRF. This project has received NOK 15.5 million (USD 1.8 million) from the Agricultural Agreement Research Funds and matching funds from Geno and other actors. The use of a breeding goal with multiple objectives helps to maintain genetic diversity within the breed (FAO, 2007[19]). Geno also acts as a distributor of semen for rare livestock breeds (Chapter 2).

In 2010, cattle breeding co-operatives in Denmark, Sweden and Finland merged to create Viking Genetics. They also market their exports focusing on a wide set of traits and emphasising health. Despite competing in some export markets, exchange of knowledge and sires between Geno and Viking Genetics has been widespread. As new technologies such as genomic selection reshape how breeding is conducted, maintaining competitiveness as an independent national co-operative like Geno will be challenging.

1. https://www.norwegianred.com/.

4.2.7. Extension services have evolved towards business advice

The Norwegian farmers' advisory system has evolved over the last decades from a government-driven strategy into a commercialised business with farmers in the focus. Recent trends in farming have increased the demand for specific competences and technical advice, moving away from recipe-based problem solving towards broader business advice and coaching. Advisory services for farmers in Norway used to be almost free of charge, but now farmers have to pay and there is increasing competition among a diversity of advisory service providers in a more pluralistic advisory system (Klerkx et al., 2017[20]). The Norwegian Agricultural Extension Service and the Forestry Extension Institute are partially financed by government grants. The other advisory services are privately financed mainly provided by co-operatives, and normally with a combination of annual fees and fees per specific services. Co-ordination and communication are essential for successful innovations and adoption in agriculture requiring trust when knowledge is to be exchanged. The Norwegian advisory developments through co-operatives respond to

this need of social trust, but a systematic evaluation of extension services compared with other countries is missing (Straete et al., 2018[21]).

The Norwegian Agricultural Extension Service (NLR) is an umbrella and service organisation for ten regional advisory units with a total of 24 000 members and 330 employees nationwide. The NLR is a private organisation chaired by a board of directors. Services are paid through fees, but NLR receives close to NOK 100 million (USD 11 million) from the government to ensure comprehensive, independent and knowledge-based advisory services and professional links between agricultural research and producers. Nearly 800 field trials are performed annually by NLR with its members. The areas of advice and capacity building are mainly agronomy, plant production and plant protection, and expanding to agricultural buildings, mechanical engineering, hydromechanics, greenhouses, business development, and the environment.

The Forestry Extension Institute is a non-governmental organisation founded in 1958. The institute is organised as a partnership between 37 forestry organisations and scientific institutions with 20 to 25 staff, half of them being professional foresters and extension specialists. The main purpose of the institute is to provide continuous education and training in the forestry sector and related fields, as well as to raise public awareness to the importance of forestry. The institute receives public grants for their educational and training activities amounted to NOK 14 million (USD 1.4 million) in 2020.

There are other private extension services, in particular provided by co-operatives. Both Tine and Nortura provide extension services to their members in their respective sectors.

The Norwegian Agricultural Purchasing and Marketing Co-operation (*Felleskjøpet*) is the largest purchasing co-operative, and the third largest farm co-operative organisation with two regional co-operatives: *Felleskjøpet Agri* (FKA) and *Felleskjøpet Nordmøre og Romsdal* (FKNR), with a joint membership of about 45 000 farmers. These co-operatives provide advice from the input supply perspective.

The Norwegian Forest Owners' Federation was founded in 1913. It is the umbrella organisation of four regional co-operatives that cover almost the whole of Norway and represent about 35 000 family forest owners and has a joint market share of approximately 80% of the timber market. The regional co-operatives offers professional forestry and land management guidance and to take on the management of forest operations for members if required.

4.3. Public and private investment in R&D&I

Both private and public resources invested in research, development and innovation (R&D&I), and the evolution of these funding sources are a good indicator of the country's efforts to innovate. The comparison of these indicators for the whole economy and for the agro-food sector provides some basis to assess the effort made by the AIS. Several indicators are used to analyse the source of the funding, the sector that performs the investment and the thematic focus (Figure 4.3, Panel A for the whole innovations system and Panel B for the AIS) and to measure the expenditure intensity Table 4.1).

4.3.1. Across all sectors, R&D funding in Norway is increasingly financed and performed by the government

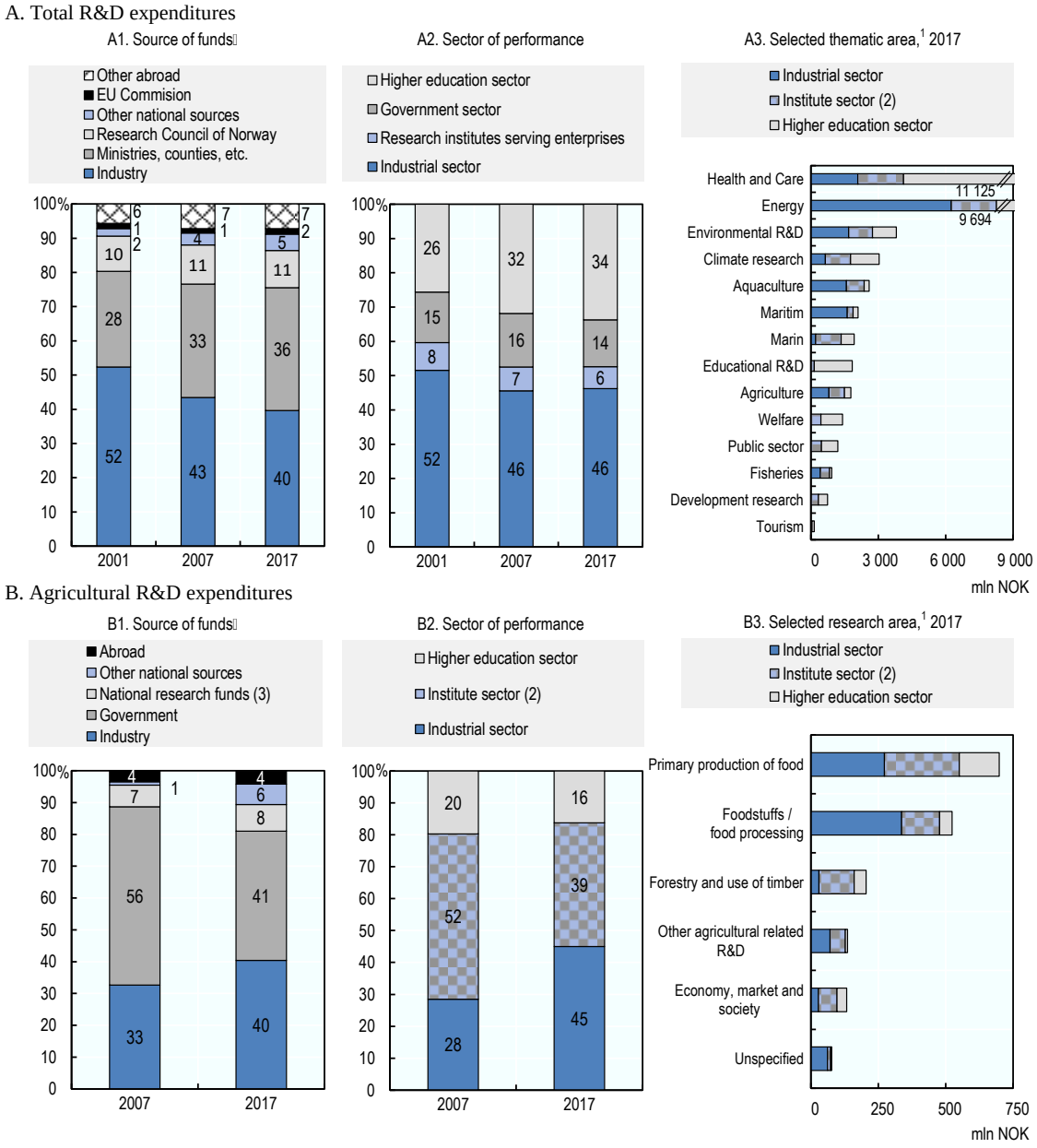
Focusing first on the whole innovation system across all sectors, Norwegian gross domestic expenditure on research and development (the GERD covering both private and public) has more than doubled over the last 16 years reaching NOK 69 billion (USD 6.9 billion PPP) in 2017. This level of resources is comparable with those of Finland (USD 7.0 billion PPP) and the Czech Republic (USD 7.2 billion PPP), however lower than the average for Nordic countries (USD 8.2 billion PPP) (OECD, 2020[22]). The intensity of this effort as a percentage of GDP is 2.1%, lower than the OECD average of 2.4% and well below other Nordic countries (2.7%) and the United States (2.8%), also influenced by its high GDP (Table 4.1).

These funds come from different public and private sources. A large but decreasing share of the Norwegian R&D funding comes from private funds: 40% or NOK 27.4 billion (USD 3.3 billion) in 2017 compared to 52% in 2001 (Figure 4.3, Panel A1). Over the last ten years government, including central and local authorities, the Research Council of Norway (RCN) and, increasingly, the tax incentive SkattenFUNN programme, have become the main source of R&D expenditure with NOK 32.3 billion (USD 3.9 billion) or 47% of the total in 2017 compared to 28% in 2001. Funding coming from abroad (NOK 6.1 billion or USD 0.7 billion in 2017), and in particular from the European Commission (NOK 1.1 billion or USD 0.1 billion), remains relatively less important but increasing. Compared to the countries with a similar level of GERD, Norway has a lower share of the funding coming from the European Union (2% compared to 3% for Finland) (OECD, 2020[22]; Samfunnsøkonomisk analyse, 2019[23]).

The higher education system – mostly public – performs an increasing share of the funds up to 34% in 2017. The business sector, including the industry and research institutes serving enterprises, remains the main sector of performance in Norway with 52% of R&D expenditures, but it has decreased since 2001 (Figure 4.3, Panel A2.). The share of the business sector in R&D activities in Norway is low compared to other Nordic countries (65% in 2017) and OECD (60% in 2017) averages. This can be partially explained by the structure of the Norwegian economy based on exploitation of natural resources, including petroleum and fish, and low share of industries and sectors that are more R&D intensive (OECD, 2017[1]).

With NOK 11.3 billion (USD 1.4 billion), Health and Care, is the most important thematic area in terms of the operating expenditure on R&D (excluding capital expenditure, e.g. on scientific equipment or buildings) in 2017 and the activity is mostly performed in educational establishments (Figure 4.3, Panel A3). Energy is the second largest area (NOK 9.7 billion or USD 1.2 billion) with a high involvement of the industry sector. It is followed by Environmental R&D (NOK 3.8 billion or USD 0.5 billion) and Climate research (NOK 3 billion or USD 0.4 billion). Aquaculture and Agriculture occupy lower places in this classification – fifth and ninth position – with the operating expenditures on R&D of NOK 2.6 billion (USD 0.3 billion) and NOK 1.8 billion (USD 0.2 billion) respectively. The research focus on the environment is low compared to other OECD countries (Chapter 3 on eco-innovation). Agriculture represents around a fifth of the expenditure dedicated to energy.

Figure 4.3. Norwegian gross domestic expenditure on R&D



Notes: Gross domestic expenditure on R&D (GERD) is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy.

Numbers may not add up to 100 due to rounding.

1. R&D expenditures for thematic/research areas cannot be summarised, as they may be overlapping and do not cover all R&D.
2. Institute sector includes government sector and research institutes serving enterprises.
3. National research funds include Fund for Research Fees of Agricultural Products and Agricultural Agreement Research Funds.

Source: NIFU (2020[7]), R&D statistics bank (accessed February 2020) and data provided directly by NIFU.

4.3.2. In the agro-food sector, the private sector plays a small but growing relative role in R&D funding

Focusing now on the AIS, unlike the total gross domestic expenditure on R&D (GERD), the GERD funding on agricultural sciences (including forestry in all the statistics) has decreased by 0.5% per annum in real terms, between 2007 and 2017. This reduction was mainly due to fewer funds sourced from the government, only partially offset by increases in financing provided from various national private sources, as well as the Fund for Research Fees of Agricultural Products and the Agricultural Agreement Research Funds (National Research Funds in Figure 4.3, Panel B1). In 2017, industry and government were the two main sources of funds (NOK 719 million and NOK 716 million, or USD 86.9 million and USD 86.6 million, respectively) for agricultural R&D. The role of foreign-financing remains weak (NOK 72 million or USD 9 million; out of which NOK 66 million or USD 8 million is provided by the EU Commission/Horizon 2020[6]) even if steadily increasing and its share is lower in the agricultural sector than in the Norwegian economy as a whole (4% compared to 9%; Figure 4.3, Panels B1 and A1).

Among the categories of institutions and sectors implementing R&D activities in agriculture, private industry is the only one having increased operating expenditures over the last ten years. The private sector used to have a lower share in agriculture than in the whole economy, but it became the main sector of performance (NOK 797 million or USD 96 million) in 2017 with a share of 45%, still below but very near the 46% for the whole economy (Figure 4.3, Panels B2 and A2). This catch-up by the private industry sector is undertaken by companies of diverse sizes engaging in a broad spectrum of activities among which, Tine and Kveik Yeastary, a young business developing yeast for breweries. Industry expenditure is largely financed by companies' self-financing (around 80%) and, to a lesser extent, by contributions from governmental agencies and tax funds.

Agricultural research institutes receive mainly public funds and focus on primary production, while R&D on non-primary production is driven by private industry

The institute sector, with NIBIO, Ruralis, Nofima and the Norwegian Veterinary Institute, account for 39% of the operating expenditures on agricultural R&D (NOK 687 million or USD 83 million). The activities of these institutes are mainly financed by the Research Council of Norway and the Ministry of Agriculture and Food, but some additions come from the Fund for Research Fees of Agricultural Products and the Agricultural Agreement Research. Finally, the higher education (HE) sector, represented primarily by the Norwegian University of Life Sciences (NMBU), spent NOK 288 million (USD 35 million) in 2017. The financial sources of this HE sector come mainly from the Research Council of Norway and basic grants (Rørstad et al., 2017[8]).

R&D in agriculture is divided into five main thematic research areas (Figure 4.3, Panel B3). The primary production of food is the largest research area in terms of attributed funds (NOK 699 million, or USD 85 million, corresponding to 39% of all resources) in 2017. R&D on foodstuffs and food processing is the second largest research thematic area receiving NOK 524 million (USD 63 million or 30% of the funds). For the thematic area of forestry and use of timber, expenditure amounts to NOK 204 million (USD 25 million), with NIBIO being a leader in this field (Rørstad et al., 2017[8]).

4.3.3. R&D intensity is higher in food and agriculture than in other sectors and in other countries

In order to stimulate innovation and economic performance, the Norwegian Government has set ambitious targets for R&D intensities of 3% of GDP by 2030 for the whole innovation system, with spending split between public and private institutions at the ratio of one to two. Although research intensity has slowly increased from 1.6% in 2007 to 2.1% in 2017 reaching comparable levels to the EU28 (2.0%) and OECD (2.4%) averages, it remains lower than in other Nordic countries (2.7%) and the United States (2.8%)

(Table 4.1) and below the government target. While the government allocations for R&D (GBARD) reached 1% of GDP already in 2016, business is still far from achieving its part of the goal. Levelling up to the target or to OECD and Nordic countries averages (around 1.7% in 2017) might require a substantial restructuring of Norwegian industry (OECD, 2017[1]). However, low business R&D intensity in Norway is partly explained by its industrial structure (OECD, 2015[24]).

The Norwegian Government has been highly supporting R&D aiming at promoting agriculture, forestry, fisheries and food production. Allocations to this objective sum 8% of the entire R&D budget over the last two decades (NOK 3.2 billion or USD 0.4 billion in 2017) which is a much larger share than the averages for Nordic countries (6%) or OECD (5%), also reflecting the importance of the fishing sector in Norway. This is reflected in agriculture public research intensities (government budget allocations for agricultural R&D as a share of the sector value added) which is 4.3% in Norway, well above other OECD countries (Table 4.1). Agriculture Innovation Systems (AIS) is also the main area of expenditure in the General Services Support Estimate (GSSE) with 64% in 2017-19. However, as discussed in Chapter 2, most of the agricultural policy effort of the government is made on supporting individual producers through the Producer Support Estimate (PSE) and Norway has one of the lowest shares of GSSE in Total Support Estimate (TSE) of 5% compared to the OECD average of 13%. Expenditure on AIS represents only 3% of the TSE, one of the lowest among OECD countries.

Agriculture and food R&D efforts of the business sector have also been considerable in Norway with research intensity in both the agriculture and food and beverage sectors (1.2% and 1.9% of the respective sectoral value added) being among the highest in the OECD countries, and above the Nordic average (0.5% and 1.7% respectively) (Table 4.1).

Table 4.1. R&D expenditure intensities

Innovation system	All sectors		Agriculture innovation		All sectors		Agriculture innovation		All s ectors		Agriculture innovation		Agriculture innovation	
Source of funds	All sources		All sources		Government		Government		Business		Business		Business	
	GERD[1] total as a % of GDP		Public GERD on Ag. science[2] as a % of sector's value added		GBARD[3] total as a % of GDP		GBARD on Agriculture[4] as a % of sector's value added		BERD[5] total as a % of GDP		Agriculture BERD[6] as a % of sector's value added		Food and beverage BERD[7] as a % of sector's value added	
	2007	2017	2007	2017	2007	2017	2007	2017	2007	2017	2007	2015	2007	2015
Norway	1.56	2.09	5.31	4.49	0.74	1.03	4.11	4.33	0.82	1.10	1.08	1.15	1.95	1.87
Canada	1.90	1.59	..	..	0.58	0.50	2.77	1.61	1.06	0.82	0.59	0.30	0.71	0.51
Denmark	2.52	3.05	5.60	5.15	0.79	0.89	2.83	1.60	1.76	1.97	0.20	0.18	1.47	1.30
Finland	3.35	2.76	2.69	2.11	0.93	0.84	1.99	1.20	2.42	1.80	0.01	0.03	2.47	2.68
France	2.02	2.19	..	..	0.73	0.64	0.68	1.06	1.28	1.42	0.38	0.58	0.64	0.87
Iceland[8]	2.55	2.10	4.06	1.10	0.81	0.60	2.97	0.26	1.39	1.35	..	0.28	..	0.53
Japan	3.34	3.21	5.87	4.41	0.66	0.64	2.29	1.68	2.60	2.53	0.16	0.04	2.21	1.65
Korea	3.00	4.55	2.25	2.77	0.90	1.06	2.04	2.91	2.29	3.62	0.05	0.09	..	..
Sweden	3.25	3.40	1.92	3.30	0.75	0.79	0.62	0.62	2.37	2.42	..	..	1.11	1.03
Switzerland	2.71	3.37	..	3.92	0.70	0.95	1.46	2.83	2.00	2.34	..	..	1.15	..
United States	2.63	2.79	0.45	0.26	0.81	0.65	1.45	1.44	1.86	2.04	..	..	1.57	2.89
EU28	1.69	1.97	..	..	..	..	..	..	1.06	1.30	..	..	..	..
OECD	2.20	2.37	..	..	..	..	..	..	1.52	1.67	..	..	..	..

Innovation system	All sectors		Agriculture innovation		All sectors		Agriculture innovation		All s ectors		Agriculture innovation		Agriculture innovation	
Source of funds	All sources		All sources		Government		Government		Business		Business		Business	
	GERD[1] total as a % of GDP		Public GERD on Ag. science[2] as a % of sector's value added		GBARD[3] total as a % of GDP		GBARD on Agriculture[4] as a % of sector's value added		BERD[5] total as a % of GDP		Agriculture BERD[6] as a % of sector's value added		Food and beverage BERD[7] as a % of sector's value added	
	2007	2017	2007	2017	2007	2017	2007	2017	2007	2017	2007	2015	2007	2015
Nordic countries[9]	2.65	2.68	3.92	3.23	0.80	0.83	2.51	1.60	1.75	1.73	..	0.45	..	1.72

Notes: 2007, 2015 and 2017 or the nearest available year.

1. Gross domestic expenditure on R&D (GERD) is defined as the total expenditure (current and capital) on R&D carried out by all resident companies, research institutes, university and government laboratories, etc., in a country. It includes R&D funded from abroad, but excludes domestic funds for R&D performed outside the domestic economy.

2. Gross domestic expenditure on R&D (GERD) for agricultural and veterinary carried out by government and higher education organisations (government and higher education).

3. Government budget allocation for R&D (GBARD) is a funder-based approach for reporting R&D, which involves identifying all the budget items that may support R&D activities and measuring or estimating their R&D content. It enables linking these budget lines to policy considerations through classification by socioeconomic objectives.

4. Government budget allocation for R&D (GBARD) on Agriculture covers all R&D aimed at the promotion of agriculture, forestry, fisheries and foodstuff production, or furthering knowledge on chemical fertilisers, biocides, biological pest control and the mechanisation of agriculture, as well as concerning the impact of agricultural and forestry activities on the environment. This also covers R&D aimed at improving food productivity and technology. It does not include R&D on the reduction of pollution; on the development of rural areas; on the construction and planning of buildings; on the improvement of rural rest and recreation amenities and agricultural water supply; or on energy measures.

5. Business Expenditure on R&D (BERD) is the measure of intramural R&D expenditures within the business enterprise sector (regardless the sources of R&D funds).

6. Business Expenditure on R&D (BERD) on Agriculture, forestry and fishing.

7. Business Expenditure on R&D (BERD) on Manufacture of food products, beverages and tobacco products.

8. GBARD intensities are not comparable between years due to a break in time series.

9. The Nordic countries aggregate is the unweighted average of indicators for Denmark, Finland, Iceland, Norway and Sweden.

Source: Authors' calculation based on OECD (2020[25]), Research and Development Statistics (database), [Gross domestic expenditure on R&D by sector of performance and field of R&D (FORD); Government budget allocations for R&D; Business enterprise R-D expenditure by industry (ISIC 4)]; MSTI Main Science and Technology Indicators (database), [BERD as a percentage of GDP]; and National Accounts (database), [Value added and its components by activity, ISIC rev4], https://stats.oecd.org/ (accessed February 2020).

4.4. Policies facilitating the flow of knowledge

The flow of knowledge and its application in the private sector requires creating the right incentives to innovate while protecting the rights of the innovator. Many policies in Norway aim at improving the adoption of technological and organisational innovations and partnerships.

4.4.1. Tax incentives for innovation in the firm

SkatteFUNN is the largest public support programme for business R&D in Norway and one of the most important non-thematic demand driven instruments. The programme is a tax incentive scheme designed to stimulate research and development (R&D) in Norwegian trade and industry. The incentive is a tax credit in the form of a deduction from a company's payable corporate tax. The volume of this tax credit has more than doubled in the last decade. To be eligible to apply for SkatteFUNN, the company must seek to develop a new or improved product, service or production process through a dedicated R&D project. The project must generate new knowledge, skills and capabilities within the company. In order to be eligible, the company needs to be liable to pay corporate tax in Norway. If the tax credit for the R&D expenses is greater than the amount the firm is liable to pay in tax, the remainder will be paid out in cash to the firm. If the applying company does not generate a taxable income, the entire SkatteFUNN credit is paid out in cash.

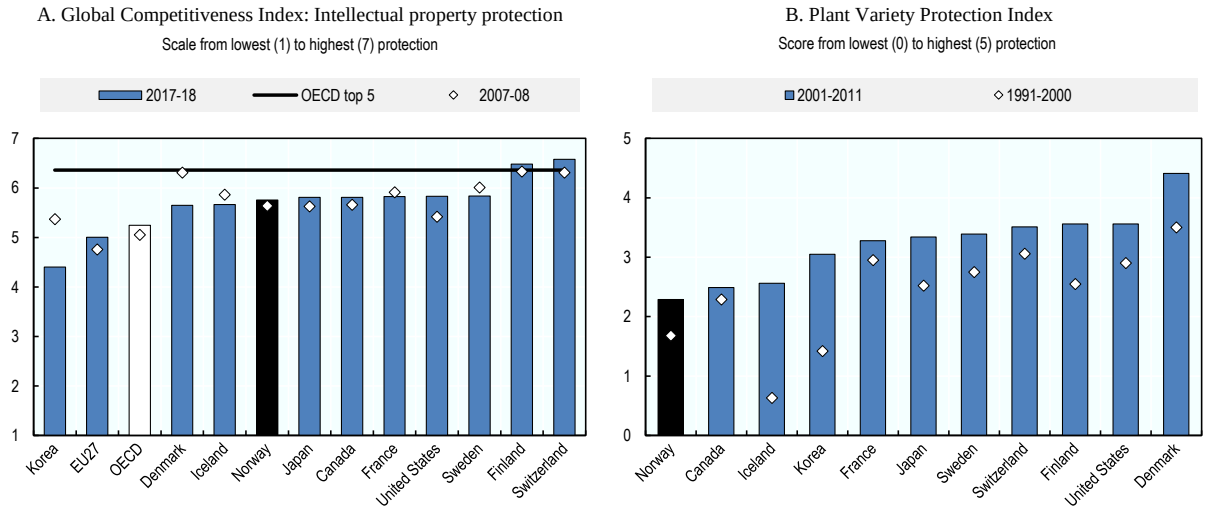
All SkatteFUNN project applications are processed and evaluated by the Research Council of Norway, with special emphasis on its R&D content. Only projects approved by the RCN are eligible for the actual tax credit, which is granted by the Norwegian Tax Administration after assessing eligible costs.

Originally targeted to Small and Medium Enterprises (SMEs), but expanded to all firms since 2003, the main beneficiaries of this programme are still enterprises with fewer than 50 employees. All branches of industry and all types of companies can apply for support from the SkatteFUNN. SME can receive a tax credit of up to 20% (18% for large firm) of the eligible expenditures of approved projects. The ceilings are higher if there is collaboration with universities and research institutes. Compared with other similar programmes in other countries, SkatteFUNN is among the most generous for SMEs and one of the easiest to manage in terms of administrative requirements for the firms (European Commission, 2014[26]; OECD, 2019[27]). The tax exemption policy benefits all regions in Norway and there is evidence that being in a peripheral location is not a disadvantage (Isaksen, Normann and Spilling, 2017[28]).

4.4.2. Strong protection of intellectual property rights

Norway is a member of the European Patent Organisation (EPO) and has a strong protection of intellectual property rights as shown by the high index of patent protection of the Wold Economic Forum, very near the top OECD countries (Figure 4.4, Panel A).

Figure 4.4. Intellectual property protection index



Notes: Indices for EU28 and OECD are the simple average of member-country indices. OECD top 5 refers to the average of the scores for the top 5 performers among OECD countries in 2017-18 (Switzerland, Finland, Luxembourg, New Zealand and Netherlands).
Source: Panel A: WEF (2017), The Global Competitiveness Report 2017-2018: Full data Edition, http://reports.weforum.org/global-competitiveness-index-2017-2018; Panel B: Campi and Nuvolari (2015[29]).

Norway has implemented the EU directive on the legal protection of biological innovations (entered into force in February 2004). The Ministry of Justice is in charge of this. Norway became a member of the International Union for the Protection of New Varieties of Plants (UPOV) in 1993 and has a law on plant breeders' rights, based on the 1978 Act of the UPOV Convention, rather than in the latest UPOV 1991 Convention. The Ministry of Agriculture and Food is responsible for the plant varieties protection legislation. Both the patent and plant breeders' rights laws include provisions on disclosure of origin in order to facilitate mutual supportive implementation with the Convention on Biological Diversity (CBD) and its Nagoya Protocol and the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA).

According to the Plant Variety Protection Index, Norway scores below other OECD countries like Switzerland, Finland and Sweden (Campi and Nuvolari, 2015[29]). The late adoption of the UPOV convention may have contributed to this low score.

4.4.3. Policies to improve technology adoption

The adoption of new technologies or organisational innovations is a complex process that needs to link new knowledge with the potential adopters in the private sector. For that purpose, the main national actors (such as Innovation Norway or Siva) interact with initiatives at county and municipality levels. Norway has several initiatives to "incubate" innovations and facilitate technology and knowledge transfer. Digital initiatives also facilitate the transfer and use of knowledge and information and many innovation initiatives in Norway have this focus on digital (Box 4.6).

Box 4.6. Initiatives to improve access and use of digital data in agriculture and forestry

The Source (Kilden) is NIBIO's primary map service providing valuable digitalised geo-information. The data is organised in five sets: Land Information (displayed at start-up), Landscape, Soil, Reindeer Herding and Forest Portal. Map layers can be made transparent in order to view multiple comprehensive map layers simultaneously. Digital maps over potential for vegetable cultivation are provided based on a model built on soil properties, weather data and vegetables' requirements for growing season. The data set is in a 1x1 km grid for all agricultural land in Norway. The maps are published on NIBIO's map portal Source and freely available.

Since 2005, *Digital Farm maps (Gårdskart)* provides area resources maps for a single agricultural property linking information from several sources: farm and utility numbers from the Agricultural Register; property boundaries from the Matric; and area types such as fully cultivated soil, surface cultivated soil and field grazing from NIBIO maps. Both the administration and the farmers use the service for calculating area-based subsidies and simplifying administrative processes.

Norway makes all information about individual farmer's subsidies and agricultural activities publically available in a very transparent manner. There is high potential for using this and other geo-localised information for evaluating agri-environmental policy and farm performance and improving policy design.

The National Forest Inventory (NFI) was established in 1919 as the first nationwide forest inventory in the world. NFI conducts a systematic sample-based survey of the Norwegian forest. It records variables that provide information about growing stock and annual increment, and operating and environmental conditions. The content of the inventory is regularly updated to meet new demands from society.

In ten years, the number of barns with *dairy robots*, has increased from just under 300 to over 1 800. This means that almost half of all Norwegian cows are in barns with automatic milking systems. Today, Norway is the country where the largest proportion of dairy farmers are using this technology. The technology enables monitoring of udder health, hygiene conditions and milk quality. Increased efficiency and opportunities to have a more organised leisure are important factors emphasised by the farmers. Mimiro is one of the actors working on exploiting the potential of dairy robot data for better farm management.

Within the agricultural value chains, Innovation Norway has in recent years paid special attention to assisting agri-tech companies in their business development, innovation and market entrance both on a national and international level. In most of these programmes all industries, including food but excluding primary agriculture, are eligible for aid. The *National Innovation Aid Scheme* primarily covers the needs of small and medium sized enterprises (SMEs), but it is also open to large ones; grants and risk loans can finance projects relating to entrepreneurship and innovation, restructuring, development and

internationalisation. The *Environmental Technology Scheme* aims at promoting Norwegian environmental technology in national and international markets; the scheme is intended to support pilot and demonstration facilities in the development of new environmental technology. The *Research and Development Contracts Aid Scheme* aims to increase value creation in Norway by contributing to the development of competitive goods and services with international potential. The *Bio-economy Scheme* focuses on value creation in bio-based industries through a market-oriented and sustainable utilisation of the bio-resources from the sea, soil and forest.

The government enterprise Siva has the operator responsibility for the incubators programme. An incubator is an innovation company that offers entrepreneurial businesses and consulting in business development and commercialisation at a subsidised cost. They also offer office space, a professional environment and a network where entrepreneurial businesses can connect with other companies, academia, R&D environments and investors. The current programme started in 2012 and will expire in 2022. From 2020, the county municipalities took over the financing responsibility from the state.

Norwegian universities, colleges, research institutes and health enterprises have their own companies (Technology Transfer Offices TTO) that ensure that research is turned into new profitable products, companies and workplaces. Since 2003, universities have the right to capitalise on intellectual property (IP) developed by their employees. According to Norwegian law, the universities and the other collaborating research institutions are obliged to assist with this transfer of innovative technology. In 2020, there are ten TTOs that receive funding from RCN's FORNY2020 programme focused on increasing the commercial use of R&D results, financed by the Ministry of Trade, Industry and Fisheries. At least three of these TTOs are highly relevant for agricultural innovation systems: ARD Innovation, Kjeller Innovation and Validé.

ARD Innovation is a continuation of NMBU Technology Transfer Office and has been the commercialisation actor of NMBU since 2014. Owned equally by NIBIO and NMBU, ARD is their catalyst for innovation. The company assists students and employees with the commercialisation of research and promotes innovation and entrepreneurship in general.

Innovation Norway finances the Norwegian Innovation Clusters (NIC),[7] a programme that aims to contribute to value creation through sustainable innovation in well-defined clusters of highly interconnected actors. There are three levels within NIC – Arena, Norwegian Centres of Expertise (NCE) and Global Centres of Expertise (GCE).

4.4.4. Innovation partnerships and networks

There are many examples of dynamic partnerships for innovation in the agro-food and forestry sector in Norway. Some of them have a national scope while others are regional in nature. Two important national partnerships are the projects on Climate Smart Agriculture and the Network Bio economy for the People.

The project "Climate Smart Agriculture" aims to reduce the climate impact of Norwegian agriculture by ensuring better information and good tools for climate smart operation on Norwegian farms. The project is led by Agriculture's Climate Company owned by the two main Norwegian Farmers' Associations, the Norwegian Agricultural Advisory Council, and a diversity of stakeholders such as TINE, Nortura and GENO. The project was supported with NOK 20 million (USD 2 million) for 2020 through the Agricultural Agreement. Climate smart Agriculture aims to develop a new system and tools for calculating climate footprints and mitigation practices adapted to each individual farm.

At the regional level, Klosser Innovasjon provides knowledge-based business development throughout Innlandet county. They assist the business community with innovation projects, business development and research projects to develop a new industry based on local natural resources. NCE Heidner Biocluster, with more than 50 partners, aims at improving sustainability in food production through innovation, with a special focus on essential inputs such as genetic material, feed and fertilisers, as well as utilising and

adding value to the residual materials. The Wood Cluster of Central Norway is an Arena initiative for the use of wood and wood-fibers in existing and new products and market areas. It has 50 partners from the industry, research and public sectors. Arena for fruit and berries (AFB), a regional project on the west coast, to increase the value creation in fruit and berries with 23 enterprises and industry actors. Another interesting partnership at regional level focused on social and health innovation in rural areas is Green Care, a network of services that can increase farm household income and promote social entrepreneurship (Box 4.7).

Box 4.7. Green Care: Innovative social and health services on the farm

Green Care services are health promoting activities and services provided on farms in Norway and other Nordic countries. Farm-based Green Care (*Inn på tunet*) is the generic term for welfare services taking the farm site as the starting point for activities in education, adolescence, work training, health care and social integration. Green care services are provided to children and youths with learning disabilities, people with challenges related to substance abuse problems, elderly people with dementia, and disabled people. Green care services are often financed by the local government but can also be contracted by private individuals. To be able to offer green care services and generate this additional household activity and revenue, the farm and the farmer need to be certified by Matmerk, an independent foundation. In Norway there are more than 400 certified farms offering green care services around the country. According to the literature, they provide positive activities for the target group through contact with animals, supportive natural environments, social acceptance and fellowship with other participants and meaningful and individually adapted activities in which mastery can be experienced (Steigen, Kogstad and Hummelvoll, 2015[30]).

The County Governor of Nordland has established an interdisciplinary collaboration between its departments of agriculture and food, health care and social services, and the private network *Inn på tunet Nordland AS* to improve and promote Green Care services. The network represents Green Care small farms in Nordland and is financed by Innovation Norway. The goal of the network is to assist with small firm development and practical matters related to contracts and billing. The farmers taking part in the network are all co-owners of the network.

4.5. International co-operation

International co-operation of agricultural R&D is a priority for the Ministry of Agriculture and Food, as mentioned in the assignment letter to the Research Council. Norway is a small country, and international co-operation is important for Norwegian research groups with respect to benchmarking, networks and pooling of limited resources. The participation of Norway in European programmes is the main tools of international co-operation in agri-food and forestry. There are also specific co-operation initiatives with Nordic countries. Finally, there are several other specific research co-operation initiatives.

4.5.1. Norway is fully integrated in the European Research Area and EU programmes

Norway has participated in the framework programmes on research and innovation as an associated country since 1994, due to the EEA Agreement. Participation in the framework programmes and in the European Research Area is a core element in Norwegian research policy. Norway has a strategy for research and innovation co-operation with the European Union, which was launched in 2014 at the same time as Horizon 2020.

The EU Horizon 2020 programme (H2020) is the EU research and innovation framework for 2014-20, in which Norway fully participates. The ERA-net Cofund instrument allows national research funders (e.g. Research Council of Norway) to collaborate in joint calls with EU co-funding to the national contribution. In the Horizon 2020, the ERA-Net Cofunds in which Norway has participated include more than 10 networks on food and livestock production, organic production and consumption, animal health and forestry.

The share of competitive funds from the European Union that went to Norwegian actors under the EU's Seventh Framework Programme for Research (FP7) was 1.67%. The ambition for Horizon 2020 is that 2% of the competitive funds shall go to Norwegian actors. The OECD Review of Innovation Policy (OECD, 2017[1]) found the low levels of application and participation in the EU framework programme as one of the weaknesses of the Norwegian Innovation System. However, Norway is among the countries that has increased its share the most from FP7 to H2020.

According to eCorda (the Common Research Datawarehouse of the European Commission), as of November 2019, Norway received NOK 9.1 billion (USD 1.0 million), which is 2.2% of all allocated funds in H2020, above the 2% goal. Norway participates in over 90 projects based on, or related to, land-based resources (projects based on marine resources are not included). The vast majority are within the SC2 thematic area (Societal Challenges 2: Food Security, Sustainability, Agriculture and Forestry, Marine, marine, Maritime and Inland water Research and the Bio economy), but there are also projects within LEIT (Leadership in Enabling and Industrial Technologies). About 15% of these projects are co-ordinated in Norway and there is a good mix of research and innovation actions (RIAs), SME instruments and M.S. Curie research mobility projects.

In total, Norway receives more than NOK 1 billion (USD 0.11 billion) in "green" bioeconomy projects. This corresponds to approximately 12% of all funds returned to Norway from H2020. For the entire SC2 thematic area, the return rate is higher than average: 5.1%, corresponding to EUR 122.2 million (USD 137 million), but this includes marine projects several of which are Norwegian-co-ordinated.

The *EU Joint Programming Initiatives* (JPI) are public-to-public partnerships with public research funding organisations/programme owners. The main objective of the JPI participation is the alignment of innovation strategies and the development of joint calls. Norway participates in all ten JPIs, and two of them are relevant in the food and agriculture sector, notably JPI FACCE (Food security, agriculture and climate change) and JPI HDHL (Healthy diet for a healthy life). In JPI FACCE the Research Council of Norway has been an active partner investing approximately NOK 75 million (USD 8.5 million) in the period 2011-19 and chairing the Governing Board for 2020-22. In JPI HDHL Norway has participated in 10 projects, and invested approximately NOK 22 million (USD 2.5 million) in these projects, half of this is funded by the Ministry of Agriculture and Food, and the rest is from the Ministry of Health and Care Services and the Ministry of Trade, Industries and Fisheries.

4.5.2. The Nordic co-operation leads innovation initiatives in specific areas

The Research Council of Norway is responsible for Norway's membership of the *Nordic Committee for Research in Agriculture and Food* (NKJ). Both the Research Council and the Ministry of Agriculture and Food have a representative in the board. NKJ's purpose is to identify strategic research agendas and promote a knowledge-based agriculture and food sector, organising joint calls for networking activities in the Nordic countries.

Nordic Forest Research (SNS) is funded by the Nordic Council of Ministers to promote research into the various functions of forests within a sustainable forestry industry. SNS funded networks are beneficial in a Nordic context and include researchers from at least three Nordic countries. Networks have an even gender distribution and are co-financed. SNS also finances other activities, such as research projects, centers, etc.

The Nordic Bioeconomy programme is a joint investment between Sweden, Finland, Iceland and Norway, with the purpose of producing more knowledge to facilitate the transition to the bio-economy. The research is organised in three Nordic Centres of Excellence, including NIBIO, where researchers from at least three Nordic Countries participate. Norwegian participation is financed through the Research Council of Norway.

4.5.3. Other international co-operation initiatives

Bioeconomy in the North implements transnational calls for proposals for research, development and innovation in the forest-based bio-economy sector relevant for the northern part of Europe. The primary objective is to support research and innovation leading to new products and supply services from non-food/non-feed biomass resources. The consortium currently consists of partners from Finland, Germany and Norway. The Research Council of Norway participates from Norway.

Finally, there are several bilateral innovation initiatives, e.g. with Sweden on Equine Research, antimicrobial resistance with India, and food safety with the People's Republic of China (China).

4.6. R&D performance

There is no available in-depth evaluation of the Agriculture Innovation System in Norway. Kjølseth and Pettersen (2012[31]) provide a succinct account of agricultural innovation issues and make a positive assessment of performance based on productivity outcomes, both total factor productivity and labour productivity, compared to other countries and sectors (Chapter 6). In that sense, agricultural innovation in Norway has a history of specific successes on technology adoption and application of knowledge in an economy that is abundant in capital and energy. However, the report does not analyse broader R&D outcomes and impacts, such as environmental outcomes. This and other reports (Borgen and Aarset, 2016[18]) state that Norwegian farmers and their organisations and co-operatives have a significant participation in innovation along the food chain.

Some of the outcomes of the agriculture and food science R&D are shown in Table 4.2. Norway has a slightly higher specialisation of research on agriculture and food than other OECD countries, leading to a significant contribution of the Norwegian AIS to main R&D outcomes (patents and publications). Patents and publications are not the only way in which innovation takes place, but are available and comparable indicators of performance.

Norway has a system of research and development that is more specialised in agri-food than most OECD countries, including most Nordic countries. Patents specialisation in agri-food has been generally reduced worldwide over the last quarter of a century (4.7% vs. 3.5%). This trend has been even more pronounced in Norway, where the share of agri-food patents to the country total has decreased from 8.0% at the beginning of the 1990s to 5.5% in the mid-2010s. However, this share is higher than the OECD average of 3.7%. The agri-food specialisation is even higher if measured in terms of scientific publications, 6.8% of which are on agri-food sciences in Norway, one of the highest among OECD countries for which the average is 4.9%.

Norway's contribution to the world's agri-food patents has remained relatively stable over the last 25 years and was 0.4% in 2012-16. The share of publications was higher at 0.6%, highlighting that Norway is better at producing publications than at applying research to patentable uses for the private sector, revealing a bias in favour of scientific publications rather than industry solutions, which could be due to the structure of incentives. Unlike Norway, many OECD countries including the United States, the European Union, Sweden or Denmark have higher shares in patenting than in publishing (Table 4.2).

Similarly to the OECD and EU27 averages, around 13% of all citable agricultural and biological sciences publications are in the top 10% most cited between 2012 and 2016. It remains, however, below the average for Nordic countries (15%). Norway also has around 20% more citations in agricultural and biological

sciences than the world average; however, the average for Nordic countries is even higher with 36% over their global average of citations.

Norway has a high degree of collaboration with other countries in publications on agri-food sciences; 43.5% of these publications are joint with other partners. This is frequently the case in relatively small countries but is lower than in Sweden and Switzerland.

Table 4.2. Agriculture and food science R&D outcomes, 2012-2016

	Specialisation: Agri-food science outputs as a share of the country's total (%)		Contribution: Country's share of world agri-food science output (%)		Collaboration: Agri-food outputs with foreign partners as a share of the country's total agri-food outputs (%)	
	Patents[1]	Publications[2]	Patents[1]	Publications[2]	Patents[1]	Publications[2]
Norway	5.5	6.8	0.4	0.6	..	43.5
Canada	5.7	5.6	2.6	2.9	22.1	32.1
Denmark	12.6	5.7	1.6	0.7	30.4	47.8
Finland	3.4	6.0	0.6	0.6		38.6
France	4.1	4.2	4.4	2.5	29.1	44.3
Iceland	..	8.5	..	0.0	..	55.6
Japan	1.9	4.2	15.1	3.5	3.4	19.9
Korea	1.8	3.8	5.2	2.0	5.9	19.4
Sweden	3.7	4.8	1.0	0.8	29.8	44.6
Switzerland	7.6	4.5	2.3	0.8	40.6	49.5
United States	5.0	4.3	26.9	15.7	16.9	24.3
EU27	4.9	5.2	29.6	22.9	14.5	35.5
OECD[3]	3.7	4.9	89.2	59.0	10.8	30.7

Notes: Shares for economies having less than 100 patents in a given period are shown.

1. Patents field under the Patent Co-operation Treaty (PCT) by earliest filing date and location of inventors using fractional counts for Specialisation and Contribution, and using whole counts for Collaboration. Agri-food includes patents from IPC classes: A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22 and G06Q 50/02.

2. Publications in the field of agricultural and biological science refer to the SCOPUS 2-digit All Science Journals Classification (ASJC) and include the following categories: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behaviour and systematics, food science, forestry, horticulture, insect science, plant science, soil science, and miscellaneous agriculture/biological sciences. Data are based on the fractional counts.

3. OECD does not include Colombia.

Source: Authors' calculation based on OECD (2018[32]), STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats (accessed December 2018); and OECD (2019[33]), OECD STI calculations based on Scopus Custom Data, Elsevier, Version 1.2018; and 2018 Scimago Journal Rank from the Scopus journal title list (accessed March 2018, indicators provided January 2019).

4.7. Conclusions

Norway has a well-developed agriculture and food innovation system. The AIS is part of a satisfactory but not excellent performing economy-wide innovation system that in the past has contributed to the transformation of the country into a dynamic economy with one of the highest income per capita and low inequalities. However, the innovation system now requires an additional transformation towards a more diversified economy beyond oil and gas, and to more responsiveness to new challenges, in particular climate change. These new challenges require cross-silos strategic priorities and implementation for which the principle of sector responsibility may be a barrier. Some recommendations are proposed to improve the agricultural innovation system performance and its interconnection with the economy wide priorities.

Strengthening cross-sectoral innovation prioritisation and continuing to explore gradual evolution towards a more mission oriented portfolio approach, would help to better interconnect agriculture, food and forestry innovation into broader societal demands. The public sector and the public research institutes remain the core of the agricultural innovation system in Norway. The system is organised by sector with the

corresponding ministries – including the Ministry of Agriculture and Food – earmarking the R&D funds' priorities to the main objectives of their respective policies. Several reports have recommended institutional improvements towards a more strategic approach across different disciplines and sectors. The Long-Term Plan (LTP) for Research and Higher Education process and the interactions with the priority setting at each ministry deserve a systematic follow-up and assessment. The LTP could be more actively contribute to broader cross-thematic priority setting, rather than the current dominance of sectorial prioritisation and earmarking. In the absence of such stronger prioritisation in the LTP, RCN and IN play a pivotal role and need more responsibility and freedom in active portfolio management and strategic planning from the different ministries including LMD. There have been signs of improvement in this direction and RCN has moved towards a more portfolio management approach since 2017, ministries are increasingly limiting their earmarking and focusing it to long-term priorities and there are efforts to apply a mission-oriented approach to innovation policy. These developments deserve to be pursued and assessed, and the agricultural innovation system should actively embark on the broader innovation prioritisation policy process.

A more coherent policy support package for agro-food. The AIS in Norway is highly supported with public policies. However, compared to the high level of total support to the agri-food sector, innovation is only a small part of this support (Chapter 2). High support to the sector that keeps traditional activities and practices, and particularly market price support, hinders the dynamics of transformation and innovation. Increasing the incentives to innovate from the private sector in agri-food requires higher incentives and signals from the markets to identify opportunities to innovate. Incentives to innovate need to come from the whole set of support measures, including incentives to respond to societal and market demands. A larger share of the agricultural agreement expenditures could go to finance innovation.

Strengthening the scientific independence and cross-sectoral approach of agri-food research institutes. There is a high density and diversity of institutes and universities that provide high quality research such as NMBU, NIBIO, VI, Ruralis and Nofima. Some of them are already the result of some consolidation. The challenge is to keep high incentives for research excellence, while maintaining basic funding for the long-term strategic plans and responding to new demands; ensuring both scientific independence and relevance to respond to the current challenges for the sector, in particular contributing to climate change mitigation and adaptation. The institutes that receive direct basic finance from the LMD should be encouraged to actively embrace cross-sectoral research with other actors. Following the conclusions of the report by the RCN (Research Council of Norway, 2018[14]), ways to enhance their independence to achieve their objectives should be explored.

Improving cost-effectiveness and demand driven approaches. Low cost effectiveness is a concern in the whole innovation system in Norway. In the AIS public R&D expenditure intensity is higher than in other sectors and in other countries, and performance in terms of one of the indicators of applied innovation, patents, is not as good as in terms publications. This latter may be due to a bias towards basic research and against applied outcomes usable by the private sector. This reflects to some extent a predominance of the supply driven approach in an agro-food sector that is not fully connected to market price signals and demand. Policies should continue to invest more in non-thematic instruments that respond to new demands rather than to specific industries. Despite the growing role of the private sector in financing innovation, the participation of the industry is below two-thirds of all expenditure, which is the government target for the whole economy. This is also the case in the agri-food sector. For a country well endowed with skills and capital, and with a relatively well-financed research system, the performance of innovation in the firm is not outstanding. The tax incentives programme for innovation SkatteFUNN is effective and reaches SMEs and remote regions. It is recommended to undertake an assessment of the impact of SkatteFUNN on agro-food and forestry.

Assess the performance of the FFL levy fund and JA innovation funds and propose improvements in their governance. Norway has two private sector funds financed through levies, one for agriculture and one for forestry. This formula has the strength of potentially involving the private sector into a more demand driven

innovation with participation of farmers and stakeholders from the processing and retailing parts of the value chain, which are also part of the board. An assessment could evaluate the outcomes of the FFL and JA funds and explore the opportunity of broadening the focus of both funds towards longer-term innovation challenges, including consumer and environmental concerns. The possibility of channelling the agricultural agreement research funds JA and the levy fund FFL, through a single merged fund on agricultural research could also be assessed, exploring alternative modalities for funding such as linking the amount of government funding to that from the industry. This could strengthen the existing synergies and create incentives for additional private funding. For instance, in the financing of RDCs in Australia the government matches the funds raised by the industry. With good governance, a larger single fund is more likely to follow a more strategic long-term approach to innovation and to create incentives to private innovation.

Engage co-operatives and farmers' organisations with actors in other sectors on broad economy wide priority setting. Norway has a strong co-operative sector that allows farmers to be linked to value chains and engaged in innovation. These large co-operatives are a significant part of the private investment on research and innovation and provide advisory services that, in the past, were dominated by the public extension service. Co-operatives have the advantage of creating trust for adoption, and they are also dominant players in the food market (Chapter 5). They are an opportunity for change and focus innovation on main societal challenges like climate change and the environment.

Strengthening international co-operation for innovation. Norway is a small country and research and innovation requires enough critical mass to create clusters of knowledge and competition among research teams. The participation of Norway in international research and innovation is even more important than for bigger countries. Norway should keep and strengthen its participation in the European Research Area and related programmes and partnerships on agricultural innovation. This includes collaboration and partnerships for funding, project design and implementation, publications and adoption of innovation. Norway's national research funds, including for agriculture, should create strong incentives to co-finance international joint teams. All opportunities for further international co-operation deserve to be explored, including among Nordic countries (e.g. NKJ).

Norway has a comparative advantage on research and knowledge with high levels of human capital in research and in the agri-food value chains. The sector does not have a comparative advantage on producing agricultural commodities and *policies should better shift some of its focus on the production of agricultural goods towards producing and even exporting technology and knowledge*. Some specific areas deserve particular attention in Norway's AIS:

- Building on the comparative advantage in specific scientific areas such as *breeding*, particularly in animals where there is research capacity, knowledge and well positioned private enterprises like GENO and Norsvin. Identifying such areas could allow focussing the development of the agri-food sector in producing knowledge rather than commodities. Norway has done this in other areas such as oil and gas technology and engineering.
- Enhancing the focus on the *bio economy and the interlinkages with other sectors and climate change* to contribute to a circular economy with low emissions that makes a sustainable use of natural resources, in particular forests. Innovation efforts, including prioritising bio economy projects, have contributed to improve the productivity of the sector, but so far have not translated into significant improvements in the agri-environmental performance (Chapter 6). Improving agriculture sustainability and co-ordination with forestry and aquaculture should be an innovation priority.
- Norway has a good set of geo-localised information from different sources and a tradition of transparent information systems. There is scope for improving the use of *digital information systems* for the monitoring of the agri-environmental performance of farms and for the redesign of agri-environmental policies, creating incentives for innovation that respond to the climate and

environmental challenges. Policy design and implementation should increasingly rely on such digital tools, in particular for targeted agri-environmental policies.

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Notes

[1] As defined by the Oslo Manual (OECD/Eurostat, 2018[36]), innovation in the OECD Productivity – Sustainability – Resilience Framework is a broad concept (OECD, 2020[34]). It is more than research and development (R&D) and encompasses both the creation and adoption of innovation, which can be "new to the firm, new to the market or new to the world".

[2] Share of the expenditure on Agriculture Innovation Systems (part of the General Services Support Estimate GSSE) on the Total Support Estimate (TSE).

[3] Government expenditure as a percentage of GDP is well above the OECD median, while innovation outcomes are not (OECD, 2020[35]), Figure 4.1.

[4] However, some agro-food related areas are specifically mentioned in the LTP as subsections.

[5] However, responsibilities of these agencies are not fully comparable across countries.

[6] Amount for a single year 2019. Total for SC2 for agri-research in 2014-19 was NOK 700-750 million (USD 80-85 million).

[7] https://www.innovasjonnorge.no/nic.

5 Agro-food value chains in Norway

Agro-food value chains in Norway are largely shaped by the primary market regulation provisions of agricultural policies, including target prices and production quotas (for dairy) and import tariffs and quotas. The agro-food industry is highly concentrated in Norway, particularly at the wholesale level but also at the retail level. Agriculture is an exception for both competition policy and for trade policy. Attempts by the government to increase the number of competitors in the dairy industry by subsidising the purchase of domestic primary production are unlikely to deliver significantly more competitive and innovative domestic markets. There are costs in terms of high food prices, low variety and lack of innovation associated with the market regulation policies; these costs deserve to be compared with the potential gains in terms of other agricultural policy objectives. A gradual reform to increase responsiveness of the agro-food value chain to market signals and generate innovation opportunities warrants consideration as part of the agricultural policy debate.

Key messages

- Well-functioning markets are key drivers for innovations' demands and signals to be transmitted along the value chain. Unlike other sectors of the Norwegian economy, agriculture is exempted from the free trade provisions of the European Associations Agreement (EAA) with the European Union, and competition law does not prevail over market regulations on agriculture under the Sales and Marketing Law.
- Agro-food value chains have evolved from local family-owned supermarkets in the 1970s, through a horizontal integration process to a retail sector that has been dominated by three companies since the late 1990s (NG, Coop, Rema). They are vertically integrated or highly co-ordinated from wholesale to retail. Market concentration is high, food prices are higher than in neighbouring countries, and price differentials have increased partly due to tariffs and market regulations.
- The primary sector is dominated by market regulating co-operatives in charge of implementing administered prices and market balancing on behalf of the Agricultural Marketing Board. There has been a reduction in the number of commodities subjected to target prices, but these policies still affect 61% of the value of agricultural production. The Agricultural Agreement specifies target prices and budgetary support measures while tariffs are not subject of negotiation
- The raw milk market is dominated by the co-operative TINE, which purchases 94% of the milk, is the market regulator implementing target prices and also dominates dairy processing with more than 70% of the market. The red meat and pork chain is dominated by the co-operative Nortura with 65% of the primary market and 45% of processing, and is in charge of market balancing regulations. The grain market depends on imports for more than half of domestic demand, and the co-operative Felleskjøpet has a variable share of the market.
- The current regime has negative consequences for consumer surplus, value added and innovation. It creates high and growing price disparities with other countries and generates barriers for creating value along the chain and for product diversity. The future circular bioeconomy requires global competitiveness and convergence. Norway is a small market and border measures are a barrier for competition, while the TRQ system may also create market power.
- A gradual reform towards more responsive value chains with a 5-10-year horizon is possible and would boost investment, productivity and innovation. With appropriate measures, it could be compatible with other agricultural policy objectives. Recent incremental changes are not delivering the needed clear policy path towards price convergence with neighbouring countries. The current EEA with the European Union and its commitment to negotiate ways to increase trade in agriculture is an opportunity to develop policies that gradually put Norway in a more competitive position.

5.1. The agro-food sector is an exception in Norway because of its highly regulated primary markets

The existence of well-functioning markets and market signals that are transmitted along the whole value chain have been identified as key drivers of innovation and productivity (OECD, 2019[1]).[1] Unlike other sectors of the Norwegian economy, the agro-food sector is exempted from the free trade provisions of the European Associations Agreement (EAA) with the European Union. However, the Norwegian food sector applies most of the EU regulations that are relevant for their products. Imports face prohibitive tariffs in most products that compete directly with Norwegian primary producers, and foreign products mostly enter the Norwegian market through import quotas with zero tariffs (e.g. TRQs for cheese and meat products) (Chapters 1 and 2). These import quotas have expanded in recent years. Domestic market regulations were introduced in 1936 and have just been gradually adjusted along the years, mainly to comply with international constraints. For instance, the WTO constraints on agricultural export subsidies in the 2015 Nairobi agreement required adjustments in market regulations to avoid surpluses that could previously be exported. This is the case of cheese that used to be exported with subsidies but now cannot, and domestic dairy markets need to balance. As a consequence, milk quotas were reduced, while the Norwegian firm has been investing out of Norway in Ireland (and the United States) to produces Jarlsberg cheese that otherwise could not be exported. Domestic demand increased during the Covid crisis in 2020, allowing an increase in quotas.

Market competition in the main categories of dairy, meat and egg products is limited to actors using Norwegian agricultural inputs, despite the marginal increase on imports. In 1996, the dairy monopoly in each region disappeared and federal branches of the co-operatives were merged, on dairy in 2002 into TINE, and on meat in 2002/2006 into Nortura. Additionally, there was an attempt to clearly separate the role of co-operatives as market actors as opposed to their role as provider of regulatory services.

Most imports, with grain, fruits and vegetables, as the primary exceptions, enter in the form of processed products. To create competition in the value chains, the government subsidises some product lines that use Norwegian agricultural inputs with the RÅK price equalisation schemes. The objective of the RÅK system is to expose processing while enabling the industry to use Norwegian agricultural inputs on equal price terms as EU-food processors. This system thus allows some “managed” competition between Norwegian processed agricultural products with RÅK compensation payments, and imported processed agricultural products. Norwegian processors can also, to a limited extent, make use of outward processing and import at low tariffs. Hence, there is an attempt of allowing some international competition at the processed product level.

In the late 1970s, two local family-owned supermarket chains started growing; Rema1000 out of Trondheim, and Rimi800 out of the Oslo-region. Following a horizontal integration process, the retail sector is currently dominated by three companies mainly shaped in the 1990s (NG, Coop, Rema), each of which has integrated vertically or developed strict co-ordination of wholesale and retail. These national grocery chains created centralised national procurement offices. There is one independent retail chain and, more recently, some net-based food retailers, that rely on the major retailers to perform effective wholesaling. In 2018, Iceland, an international specialised frozen food retailer, started its first outlet in Norway. The future developments of these new retailers is, so far, uncertain.

Since the 1990s, the government tried to marginally strengthen competition in all domestic supply chains. Firstly, with particular provisions for increased domestic competition in the dairy sector. More recently, with a strengthened emphasis on structural issues relating to food distribution and grocery trades and vertical relations between major suppliers and distributors.

Major technical transformation and automatisation of storing and handling facilities has taken place in wholesale/retail and in major processing companies like TINE, during the 2010s, with implications in terms of taking advantage of economies of scale. In terms of contracting, retailers work increasingly with long-

term partnerships and contracts with provisions in several areas including private labelling. This has created opportunities for marketing through several retail chains for most products. The exceptions are a handful of food processors with dominant market shares that stick to their basic food branding policies; TINE, Kavli, Mills and Orkla are important examples.

“Enjoy Norway” is an information label for Norwegian food and drink that makes it easy for consumers to choose Norwegian food products. The label guarantees that the raw materials are Norwegian and from Norwegian farms, that the farmer has strictly followed Norwegian rules, and that the food is produced and packaged in Norway. One hundred and two companies are using the label on approximately 3 800 products, mainly related to meat and vegetable products. In addition to this, there are two other labels to guide consumers to Norwegian products of special geographic origin: “Specialty” and “Protected designations”.

5.2. Market concentration is high and food prices are higher than in neighbouring countries

5.2.1. Primary markets are dominated by market regulating co-operatives, with high concentration in primary sectors

Most primary markets are regulated and typically a co-operative provides the regulatory services on behalf of the market regulator (by delegation from the Agriculture Marketing Board). The objective is to ensure target prices for producers by avoiding surpluses. Import regulations are managed by the state. A large market share of the regulating co-operative is a pre-requisite for being effective as regulator controlling big enough volumes to have an impact on prices. Agricultural policies are a key determinant of the concentration in the value chain at primary level (Olsen and Pettersen, 2020[2]).

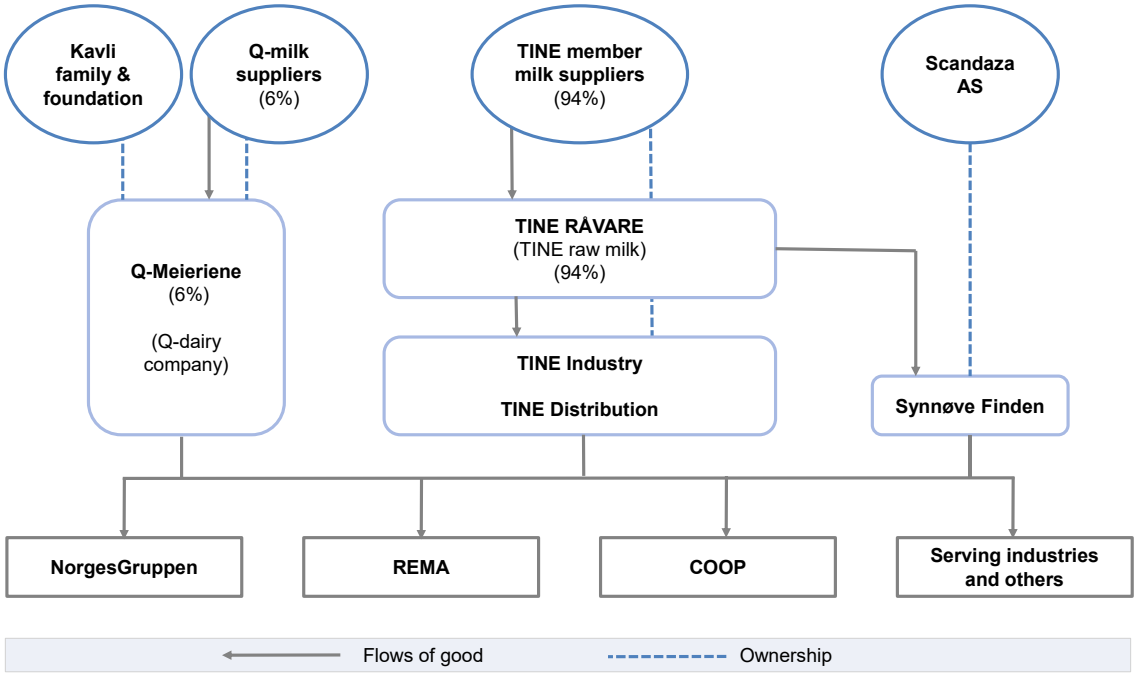
The raw milk market is dominated by the co-operative TINE with 94% of the market (Figure 5.1). TINE is the market regulator implementing the target prices and also dominates the dairy processing industry with more than 70% of the market. This allows efficient collection of highly dispersed primary production and some economies of scale in processing at the expense of reduced competition. There have been marginal increases in competition to TINE in the last two decades, but they have not contributed to reducing dairy prices to consumers. Norwegian relative dairy prices to consumers have been rising over time.

Red meat and pork primary production is dominated by the co-operative Nortura, in charge of implementing volume-based market balancing regulations, with 65% of the primary market (Figure 5.2). The share of Nortura in processing is reduced to 45%. Nortura is the supplier to around 100 independent small and medium-sized meat processing companies through the regulated meat wholesale market.

The grain market depends more on imports that typically cover more than half of the Norwegian demand. The co-operative *Felleskjøpet* has a very variable share –between 20% and 65% of grain supplies for human consumption, depending on the quality and volume of harvest from year to year and the corresponding import requirements. There are only two flourmill companies, however there are several bakeries serving the main retail chains. Each retail chain has their own vertically integrated industrial bakery, together supplying more than 75% of the market.

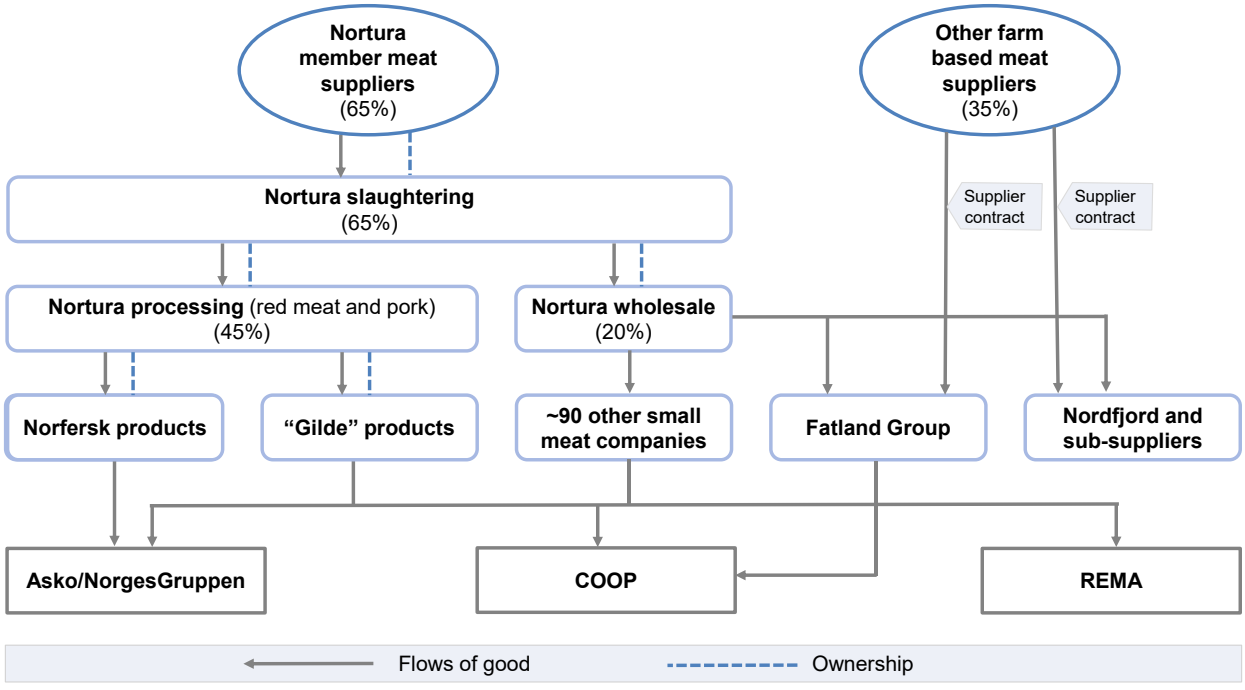
Fruits and vegetables are seasonally protected and 70% are imported. Bama, owned by Rema and NG, is the dominant player.

Figure 5.1. The main structure of the dairy value chain in Norway



Source: Olsen and Pettersen (2020[2]).

Figure 5.2. The main structure of the meat and pork value chain in Norway



Source: Olsen and Pettersen (2020[2]).

5.2.2. There are barriers to entry to the retail-wholesale market structure, but concentration is not higher than in other countries

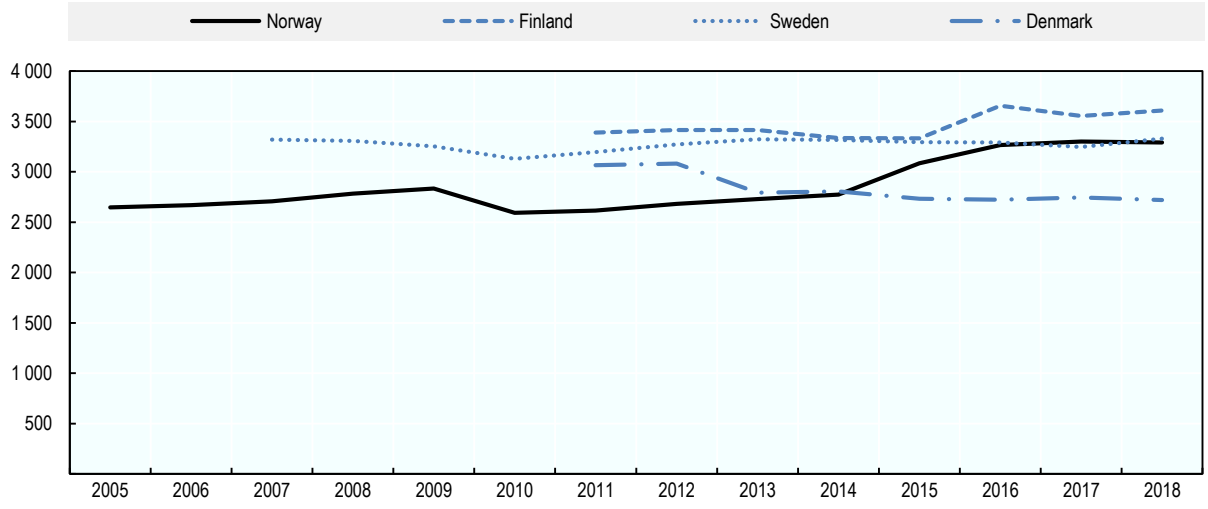
Import barriers make it difficult for international retail companies to enter the Norwegian food market. There have been two attempts to enter into the Norwegian retail-wholesale market; the Swedish-Dutch ICA/Ahold retail group in 1992-2014 and German Lidl in 2004-08. Both cases failed and were finally absorbed by the local players. ICA relied on a fragmented structure of suppliers and struggled to establish longer-term agreements with producers as their competitors had done; eventually, Coop acquired ICA. Lidl tried to establish as a hard discount actor, but struggled to find Norwegian suppliers that preferred the established retailers.

As a consequence, the concentration index in retail in Norway has increased in the last years but is in line with the index in Sweden (Figure 5.3). However, the degree of concentration is higher at regional level in particular in the eastern highly populated areas, unlike in Sweden where the concentration is higher in low populated regions. The average shop size is substantially larger in Sweden, mainly due to the legal limit on the time for shopping during weekends in Norway, which increases the incentive for proximity shops.

Cross border trade with Sweden is large representing 4% of the food retail market leading to large supermarkets being stablished in Sweden near the Norwegian border. Half of this shopping relates to food, soft drinks and household products. Tobacco and alcohol represent more than 30% of this trade because of high taxes in Norway. Import barriers that create price difference, together with exchange rate movements play very significant roles in motivating this trade.

Figure 5.3. Grocery retail market concentration

Herfindahl-Hirschman Index in selected Nordic countries



Notes: "The Herfindahl-Hirschman Index (HHI) provides a measure of market concentration and asymmetry in market shares. Both have been found to be able to influence competitive pressure in a market. Technically, it is calculated as a sum the squared market shares: HHI=$\sum_{i=1}^{n} s_i^2$, where i refers to company/enterprise and s to market share. As the formula shows, this means that the maximum value of HHI is a monopoly where s = 100 and HHI = 10 000. The Herfindahl-Hirschman index has several advantages since it takes into account both concentration and asymmetry in concentration. Both high concentration and high asymmetry can lead to reduced competitive pressure in a market." (Friberg et al., 2020[3]).

Source: Reproduced from Friberg et al. (2020[3]) based on statistics from AC-Nielsen.

5.2.3. Food prices are substantially higher than in other countries

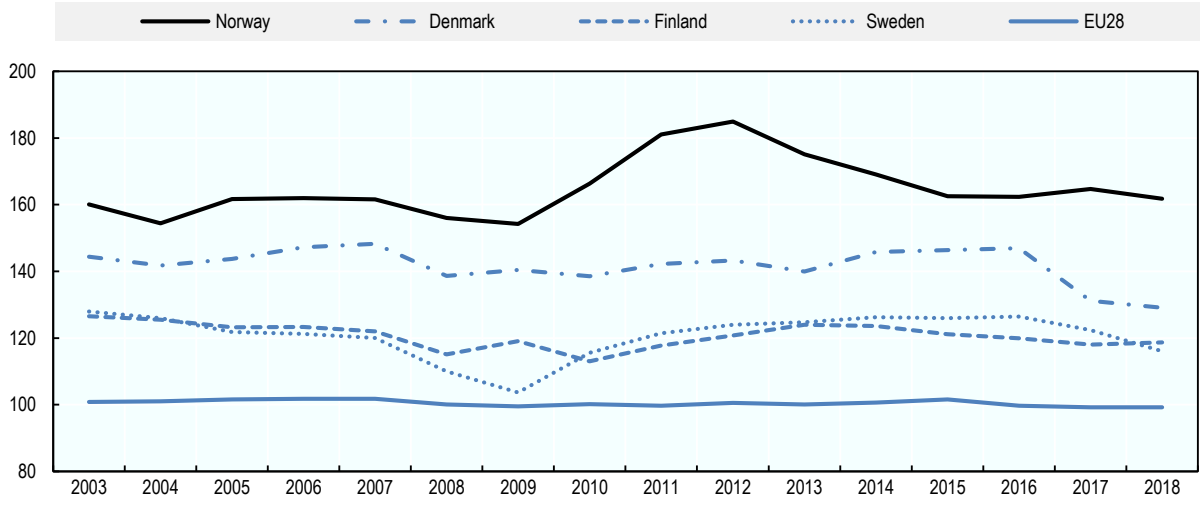
Food prices in Norway are substantially higher than in neighbouring Nordic countries with a rising price differential compared to other consumer goods. Norwegian food prices are 30% higher than in Denmark and Sweden (Figure 5.4), 51% higher for dairy and eggs, 29% for meat. From 2005 to 2018, price differentials increased for all major food and beverage categories except meat. The main contribution to food price differentials is the support to primary agriculture, while retail margins have increased productivity sufficiently to contribute to reducing the differential (Olsen and Pettersen, 2020[2]).

Productivity has grown in the agro-food sectors at a decreasing rate, like in other sectors of the Norwegian economy. Productivity growth was higher in distribution and primary production than in processing.

On the other hand, price volatility at consumer level is similar to other European countries, however, unlike any other country in Figure 5.5 produce prices are much less volatile than consumer prices. Furthermore, the relation between producer and consumer prices which is almost linear in Sweden, shows much less linear transmission in Norway (Olsen and Pettersen, 2020[2]).

Figure 5.4. International comparisons on the level of food prices

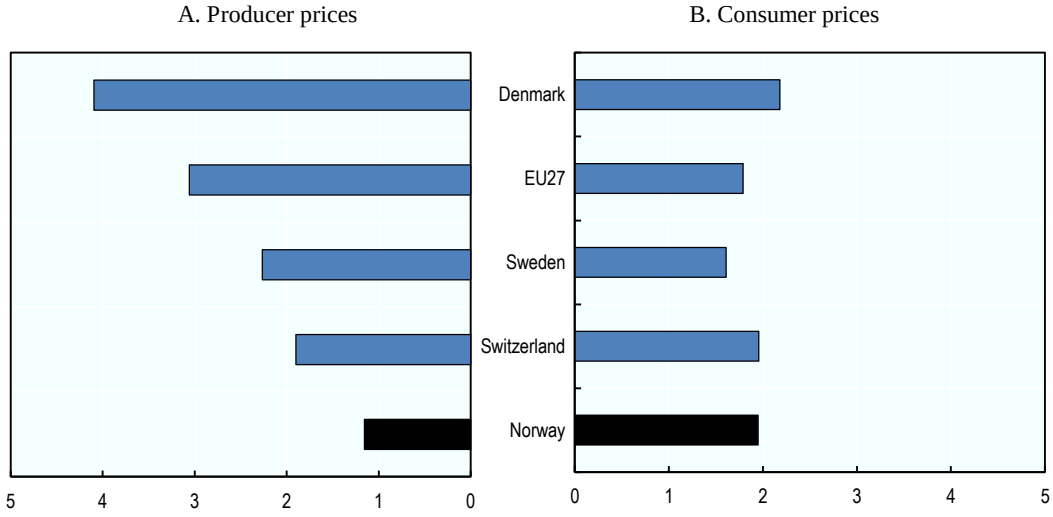
Purchasing power parity indexes including VAT for food and non-alcoholic beverages in selected Nordic countries, compared to the European Union



Source: Pettersen, Steen and Ulsaker (2020[4]); and Olsen and Pettersen, (2020[2]), based on Eurostat data.

Figure 5.5. Price volatility in Norway is lower for producers than for consumers

Standard errors of harmonised price indexes compared to a linear trend for selected economies



Note: Based on monthly prices from 2005 to April 2020.
Source: Olsen and Pettersen, (2020[2]) based on Eurostat data.

5.3. Market regulations and "managed" competitions at the expense of consumers

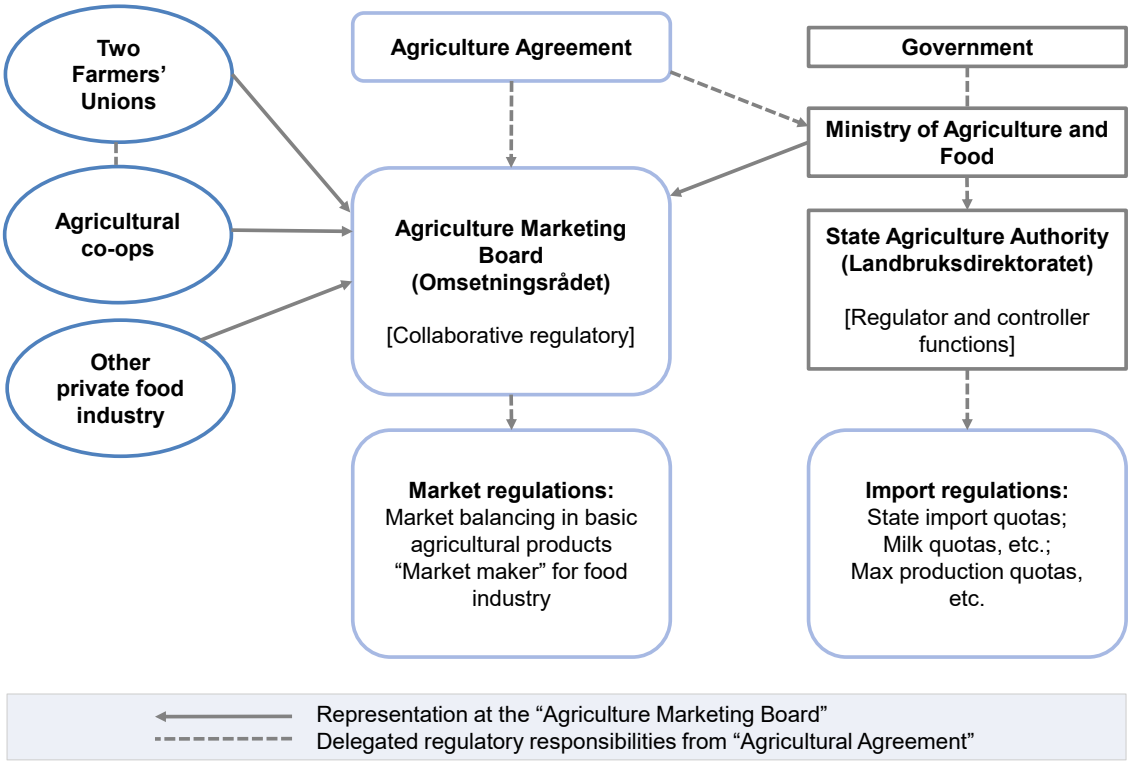
The governance system for the agro-food supply sector is rooted in two different laws. One is the "Sales and Marketing Law" (*Omsetningsloven*) from 1936 that concerns the sales and marketing regulations related to agriculture, and the other is the "Competition Law" (*Konkurranseloven*), which is derived from EU regulation. Apart from the particular exception of farmers' market co-operation with their agricultural supply co-operatives, the competition law applies to the agro-food value chain and markets as to other markets in Norway. In addition, all food and feed safety regulations follow more or less directly from EU-law, while the Sales and Marketing Law is outside the competence of common EEA-regulation.

5.3.1. Market and import regulations limit the role of the market

There has been a reduction in the number of commodities subjected to target prices in favour of other marketing balance arrangements, but the share of the value of agricultural production subject to target prices is still 61% The Agricultural Agreement negotiated annually between the government and the farmers' unions specifies target prices and budgetary support measures (Chapter 2). Customs tariffs are not a subject of negotiation, but nevertheless are critical for achieving the price targets and income levels budgeted. Common understanding between parties is that if changes in custom tariffs within obligations set by the WTO or EEA agreements are expected, this needs to be clarified before negotiations take place (Figure 5.6).

Meeting these targets depends on collaborative efforts based on an overriding division of tasks: the government provides legal frameworks, import protection and budgetary allocations while the farmers, through their co-operatives acting as operational market regulators, take responsibility for achieving price targets. The market regulation implementation by co-operatives is financed based on turnover duties on each of the primary sectors, and managed by the semi-public Agriculture Marketing Board in accordance with the Sales and Marketing Law.

Figure 5.6. Regulatory institutions and the agricultural political system in Norway



Source: Olsen and Pettersen, (2020[2]).

5.3.2. Competition law does not prevail over regulations on agriculture under the Sales and Marketing Law

The Competition Law of 1995 applies similarly to all sectors except primary agriculture. The exception to competition law applies only to farmers' capacity to collaborate through their own first processing co-operative companies, to which they supply their production, with agreed prices and other conditions. This provides farmers' co-operatives with increased market power and is the legal basis for these co-operatives having roles as market regulators related to pricing. The arrangement is subject to continuous fine-tuning and monitoring from the government and the Marketing Board.

In some cases, however, agricultural policies and the market balancing regulations could enter into conflict with competition policy settings. In 2003, the competition authorities investigated Felleskjøpet's acquisition of Norgesmøllene, a flourmill company, and the government supported the view of the competition authority, leading to a duopoly. In 2004, TINE, the co-operative that dominates the primary dairy market, won a case against its price practices. In 2005/06, the government approved the merger of different branches into Nortura despite the negative opinion of the competition authority. All large suppliers to the retail chains are currently under investigation as part of the government's investigations into the effects on competition of discriminatory vertical terms of purchases favouring large grocery groups. Sales terms of major suppliers including farmers' co-operatives are being investigated.

The Ministry of Agriculture and Food commissioned a report to evaluate the market balancing arrangements (Ministry of Agriculture and Food, 2015[5]). The report finds that the obligation to buy gives the primary producers sales security, creating incentives for overproduction and weakening the scheme's efficiency in achieving price targets and stability. The report also highlights that these arrangements create

potential sources of distortions in competition and opportunities for strategic utilisation of the system, and question the co-operative's dual role as regulator and commercial actor.

Only agricultural production is supposed to be protected through the agricultural policy, not the other parts of the value chain. The Norwegian policy seeks to allow other parts of the value chain to be competitive and regulated by the competition law. However, co-operatives like TINE and Nortura are also dominant processors, which is seen as a prerequisite for their price setting role and market regulator obligations. This is why the regulatory framework in primary markets inevitably spills over into the processing industry and causes doubt about the extent to which the exception on the application of competition law also has implications for competition and innovation downstream.

The Governmental White Paper on grocery distribution, wholesale and retailing launched a broad set of initiatives in order to improve competition in the value chain (Royal Department of Trade and Industry, 2019[6]). These initiatives add to the newly adopted law on fair trading practices in grocery distribution and the supervisory body established to help implement the law. The main emphasis of these initiatives is on avoiding suppliers' price discrimination towards different wholesale groups and on potential constraints on effective competition arising from vertical integration. These initiatives do not tackle the impact of trade policies which differ fundamentally from those in Nordic countries with similar structural characteristics.

5.3.3. There are negative consequences for consumer surplus value added and innovation

The current regime implying high and growing price disparities with other markets, forms barriers for creating value along the value chain. Meat and horticulture production of unique qualities are prevented from international marketing due to the heavy weight of price support. Temporary supply surpluses add costs to farmers and consumers. Additionally, distortions arising from current polices add risks for wasted opportunities related to Norway's strengths on knowledge and human capital, including the future Norwegian circular bioeconomy.

The future circular bioeconomy holds potential for a growing, more valuable sector based on Norwegian resources, but requires convergence with global markets. The sectors subject to policy-regimes that shelter them from international exposure, will increasingly share and exploit the same technologies, competencies, natural resources, feed materials and markets with other more open sectors. The basis for enhanced value creation will be predominantly international. Widening and deepening the policy gaps between the forest- and marine bases on the one side and the agro-sector on the other, both nationally and in comparison with the European Union, risk more severe distortions of innovation and competitiveness that hamper welfare effects. Aiming for a growing, more competitive bioeconomy requires reducing such policy disparities and the price gaps of the agro-food sector with other countries.

Consumer prices are higher due to a scattered population, but also to market regulations and high import barriers, which increases disparities with neighbouring countries and between sectors. Norway is a small market and border measures are an impediment for the development of competition in the value chain. There are also indications that importers may have market power due to structural and regulatory features like vertical integration of domestic wholesale and importation, the TRQ system. This may cause higher import prices than in international markets. There is evidence that product variety and product innovation was lower in Norway than in the European Union in the 1990s, even if it has significantly improved since, driven mainly by retail and processing rather than from primary suppliers (Olsen and Pettersen, 2020[2]).

Highly regulated markets and import barriers are known to be impediments for innovation and productivity growth (OECD, 2019[1]). Apart from the historical lower product variety, there are no clear examples of how these market regulations may have reduced innovation in Norway. Recently, innovation seems to have taken place more in processes than in products or services. However, productivity growth in the processing industry in recent years has been low compared to the protected primary sector and the concentrated

retail-wholesale sector. There are also examples of good performance in areas of innovation such as genetics and breeding, with links to the rapidly growing aquaculture sector. There has also been investment on digital in agriculture, including precision farming, digital interchange of data and widespread use of milking robots. The performance in terms of biosafety and veterinary medicine, has also been remarkable. However, innovations that are sustainable over time usually respond to market signals and opportunities that are not fully working upstream in the value chain. Innovation in products has declined in Norway, with many local small shops having low incentives.

5.4. Conclusions

5.4.1. The Norwegian exception on agro-food may hinder competitiveness and innovation in the value chain

Co-operatives in main agricultural value chains in Norway play the combined role of wholesale market regulator on behalf of the Sales Marketing Council, and a dominant position as a first buyer and processor. Having a large share of the primary market empowers these co-operatives to implement market regulation actions to reach target prices for primary agricultural products. However, there is an intrinsic difficulty in trying to increase competition in the processing industry and keeping the market regulatory capacity of co-operatives. The current system has the advantage of being trusted after incremental adjustments over time and can be effective in implementing the current market regulation policies. However, these regulations distort market signals and impede opportunities to reach farmers and investors, and cause extra costs to consumers and the society related to prices and variety, and downstream investment and innovation.

Agricultural trade policies and market regulations are a main driver of high food prices in Norway. They also contribute to creating some dysfunctions in the value chains such as high levels of cross border shopping, low incentives to invest in the domestic production and processing of potentially competitive products with foreign demand such as branded cheese and high quality horticulture, and distorted raw material prices that favour high degrees of processing (RÅK-products) compared to less processed foods. The high costs of milk production are both a cause and a consequence of high regulated prices for both feed and raw milk. These high costs are actually prohibitive to profitably export cheese or Norwegian specialties in the meat and horticulture sector. The current regulated system does not create private incentives for innovative solutions to this conundrum, while, as mentioned, the price disparity between Norway and its neighbours is still rising

There is high concentration in the retail-wholesale food market and even higher concentration in primary agricultural markets, which are an exception on competition policy. Competition policies are protecting societal interests that deserve to be balanced compared to agricultural interests when implementing the agricultural exception. There is also high concentration in markets that are not regulated or where the agricultural co-operatives play minor roles such as in beverages and fruits and vegetables. These high levels of concentration in the agro-food value chains are part of the current government investigation. Regulations and TRQs may also be creating market power by importers damaging consumers. The main problem here is the vertical integration of import business with the retail chains. The implications and causes of this high concentration deserve further investigation and assessment.

The government has tried to “kick-start” competition in dairy, incentivising private investors through support policies. The objective is to move the dairy sector towards a structure similar to that of the meat market where there is some competition for milk supplies from the farmers and a regulated raw milk wholesale market that supplies small and medium sized processing companies at the supported regulated price. Competing for farmers’ supplies is a challenge due to “systemic advantages” of TINE from having a co-ordinated milk distribution and primary processing structure. However, compensating potential competitors with further subsidies is unlikely to be an effective way to increase competition in supported

industries. Dependence on government support rarely fosters investment and innovation and runs the risk of further concentration such as in country-wide distribution of foods.

The volume based market balancing system in beef has eliminated target prices. The liberalisation of the poultry sector has eliminated traditional market balancing. Some price convergence with other countries have been observed for meat. The meat-market, as well as fruits and vegetables, shows that less regulation and lower price disparities may go hand in hand with high product standards, sustained production volumes and productivity growth. The recent developments in the Norwegian meat value chain shows that a more ambitious policy to increase competitiveness is indeed feasible.

5.4.2. Upcoming opportunities for the sector may be lost

The Norwegian agricultural food sector and the agro-food value chain are in a challenging and gradually more constrained position due to increasing competitive disadvantages compared to neighbouring EU countries and increasing consumer price differences. The Norwegian agro-food sector may not be able to develop its potential, despite a continued strong policy to maintain and also to expand arable land and domestic agro-food production. The globally emerging bio-economy is likely to add competitive pressures in the coming years, with a globally competitive industry where Norway's ability to protect its domestic market will be contested. To meet these challenges, Norwegian agricultural production, as well as the entire value chain, may benefit substantially from becoming more internationally competitive in the years to come, and more complementary and consistent with the growing sectors of the Norwegian bioeconomy.

There has been substantial growth in local entrepreneurship and industrial product diversity from the early 2000s, and willingness and ability to invest in state of the art technologies at all stages along the value chain. As a result, there has been improved productivity growth in particular in primary production and in retailing. However, productivity growth as well as product innovation are now in decline, and Norway should consider new policy goals and approaches to turn productivity and innovation growth levels to a level that can ensure long-term sustainability and more value creation.

Norwegian agricultural production has a number of valuable characteristics and demonstrates high levels of scientific and technological capabilities. For example, advanced breeding systems, attractive natural attributes, rich bio-diversity, solid control of plant and animal diseases and very limited use of antibiotics in production. These are competitive strengths that are hard to assess because the high level of state protection prevents Norwegian agro-food products from being put to the test in global markets that may highly value these benefits. Hence, Norway has a potential for globally sustainable value creation in food as well as in the broader, evolving bio-resource based industry.

5.4.3. A gradual reform towards a more responsive value chain is possible

Agricultural policies, and particularly market regulations that are based on long, lasting legislation, are very difficult to reform because they have generated trust, stability, institutions and path dependence based on a deeply rooted perception that this is the preferred way of responding to societal and policy concerns. This is the reason why an ambitious trade liberalisation (most likely through integrating the Norwegian agro-sector into the EEA agreement) seems unlikely to raise consensus. However, the current status quo of minor, almost invisible incremental changes is not delivering a clear policy path that boosts investment, productivity and innovation along the agro-food value chain.

There is a possibility to map out a much clearer policy path in the right direction with a 5-10 year horizon. This path could build on some of the experiences in the meat sector and new entrepreneurial spirit of the 2000s to exploit the many new technological opportunities and to renew and raise the political ambitions to improve the competitive position and economic efficiency of the agro-food value chain. The policy direction would focus on price convergence targets *vis-à-vis* neighbouring Nordic and EU countries and cost reduction. At the same time, Norway has options to intensify the use of targeted support to maintain

all policy objectives, social values and non-market goods provided through country-wide, sustainable farming. This policy reform needs market, institutional and policy innovations while increasing the competitive pressures in domestic supply chains and their international trade activities.

The current EEA with the European Union and its commitment to negotiate ways to increase trade in agriculture is an opportunity to develop policies that gradually put Norway in a more competitive position. It can be used to increase competitiveness of domestic actors through reduced import tariffs and to develop more sustainable approaches to export food and bio-resource based products to niche markets. Innovation policy should focus on scalable products that exploit Norwegian competitive advantages and strengths given by nature or rooted in particular knowledge and experience.

The main benchmark driver of this change in policy should be ambitious and realistic convergence towards international (EU) prices to improve opportunities for value creation in the agro-food chain. The reform would include clear targets and a timeline for converging consumer prices and cost on all categories of food and non-alcoholic beverages. Reaching these targets will require extended competition, structural improvements, investments and creative policies. The new gradual reform path could include some of the following elements with specific targets adapted to the specificities of the different sectors.

- *Trade policies:* Gradually reducing import protection to support a clear policy path towards price convergence. Prohibitive tariffs could be reduced in the first place and import quotas expanded for a larger number of agricultural products. Farm income to less competitive farms could be persevered with direct decoupled payments and instruments targeting more precisely societal priorities like marginal arable land, long-term food supply security, landscape, biodiversity and regional development.
- *Other taxes and duties:* A gradual harmonisation of product taxes with neighbouring countries in addition to the effects of a gradual price convergence for food products and beverages would certainly help normalising cross-border shopping.
- *Market regulations*: Transform, as a first step, target prices into indicative prices, liberating co-operatives from some of their market regulation roles by moving towards ordinary open spot and forward markets for basic agricultural commodities in wholesale markets. The elimination of target prices could be done moving into reference prices or volume based systems for market balancing such as for poultry and beef. Then, gradually reduce import tariffs to facilitate the long term convergence, for instance towards a maximum 20% price difference, net of VAT-effects, to average market prices in Denmark and Sweden for each sector. This will require a more substantial price convergence for dairy products, other highly processed food and non-alcoholic beverages than for meat products, grain based products and fruits and vegetables.
- *Competition policy*: The Norwegian government is currently undertaking a major effort to explore how competition may be ensured in the future domestic food value chain – in particular in the most concentrated segments of suppliers and retailers. Competition in imported consumer food products should also be investigated more thoroughly since there are indices that consumers may suffer higher prices than what would follow from import tariffs. An ambitious policy to converge price levels should also consider reducing entry barriers for foreign retailers such as hard discount actors. The Norwegian agricultural policy is not meant to protect processing, wholesale and retailing, but there are obvious indirect effects of import protection downstream and policies need to be more ambitious in terms of reducing barriers to entry sufficiently to make entry possible. Entry of international competitors in food retailing would in particular improve competition in import markets where the Norwegian market structure is highly concentrated and vertically integrated. There is a need to care for diversity in value chains, and the distribution sector, today highly dominated by discount retailing with relatively narrow product lines.
- *Product innovation*: The domestic market for niche products and food specialties has expanded to reach more Norwegians. The upscaling of such ventures in the current policy environment is,

however, challenging. Norway should renew and further develop its quality brand policy for food from Norway, and in particular, building on existing initiatives such as “Enjoy Norway”, seek to promote products and producers that have already reached a high level of qualitative success at a small-scale level. Consumers should be able to distinguish the specific attributes of Norwegian food in terms of farming practices – such as animal health and welfare and low use of antibiotics – and production of landscape to create an additional willingness to pay for Norwegian products. This should allow for high prices for Norwegian products with fewer border measures and market regulations and also open opportunities for future export of high quality niche products.

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Note

[1] This chapter relies heavily on a background report prepared by Professor Per Ingvar Olsen and Ivar Pettersen. For a more detailed discussion of the evolution of market structures in Norwegian agricultural value chains, see Olsen and Pettersen (2020[2]).

6 An evaluation of Norway's agricultural policy performance in achieving its national objectives

Norway's agricultural policy has four main objectives: food security and preparedness; maintaining agriculture across the country; increasing value added; and sustainable agriculture with lower greenhouse gas (GHG) emissions. Norway has achieved the first two objectives. However, the emphasis on total production as a means to achieving these two objectives has resulted in high costs and is achieved at the expense of environmental performance and value added in the value chain. Recent productivity growth in agriculture is driven by economy-wide trends with a movement of labour out of the sector and a slight decrease in agricultural land, while nitrogen fertiliser usage and livestock numbers have remained stable over the past two decades. Overall, this results in above average productivity growth but poor trends in environmental performance. As interpreted through the Productivity-Sustainability-Resilience framework and compared with the rest of the OECD, Norway's sustainable productivity performance is mixed. Furthermore, an analysis of the relationship between productivity and sustainability suggests there are opportunities to exploit unrealised complementarities between agricultural total factor productivity (TFP) growth and environmental sustainability.

Key messages

- Norway is delivering unevenly across its four agricultural policy objectives. Objective on agricultural production around the country and food security are achieved. However, the emphasis of policy on total production as a means of achieving these first two objectives results in high costs and occurs at the expense of improved environmental performance and value added in the value chain.
- *National objective 1: Food security and preparedness*. Norway benefits from very high levels of food security, and trade ensure the resilience of its value chains with respect to systemic risks. Norwegian authorities have undertaken a thorough investigation and have not identified any high risk. Some isolated events, such as a crop failure, can have serious consequences for food production, but would not generate large consequences for the food supply to the population thanks to well-functioning international markets.
- *National objective 2: Production across the entire country* means keeping land with production capacity even in regions with low comparative advantage. This objective is achieved through both the legal protection of agricultural land and costly agricultural policies designed to "channel" specific production to specific locations. As a result, the composition of products and activities varies significantly across regions, with crops mostly produced in eastern lowlands and meat and dairy more spread up to the north of the country.
- *National Objective 3: Increased value added***.** The dynamics of the food value chains in Norway are to a great extent determined by trade protection and market regulations in the primary sector. There is evidence that support to primary agriculture has increased consumer price differentials and reduced product diversity and innovation. Despite high concentration, the primary and retail sectors have increased their productivity, while the processing sector has experienced lower increases or even decreases in some periods.
- *National objective 4: Sustainable agriculture with lower GHG emissions*. The agri-environmental performance of Norway in the last two decades has been mixed. GHG emissions from agriculture have not been reduced significantly, translating into increases in emissions per hectare and declines per unit output. Total nitrogen balance has been stable since 2000, while the phosphorous balance has been reduced, but both nutrient balances are well above the OECD average.
- Norwegian agriculture has experienced some of the highest annual *Total Factor Productivity* Growth in the OECD since 2000, at an average annual rate of 2.2%. This achievement is mainly driven by reduction is labour rather than innovations that encourage more efficient use of intermediary inputs. While labour and machinery use have declined substantially, nitrogen fertiliser and livestock per land area have increased.
- Statistical techniques can be used to compare and benchmark OECD countries' performance on TFP, GHG emissions and nutrient balances. Across these three dimensions, Norway has not achieved strong sustainability in its productivity growth (i.e. with improvements which exceed the OECD average on each dimension), nor even weak sustainability (whereby the average across the three indicators exceeds the OECD average). Thus, increases in TFP are outweighed by a weak environmental performance compared to other OECD countries.

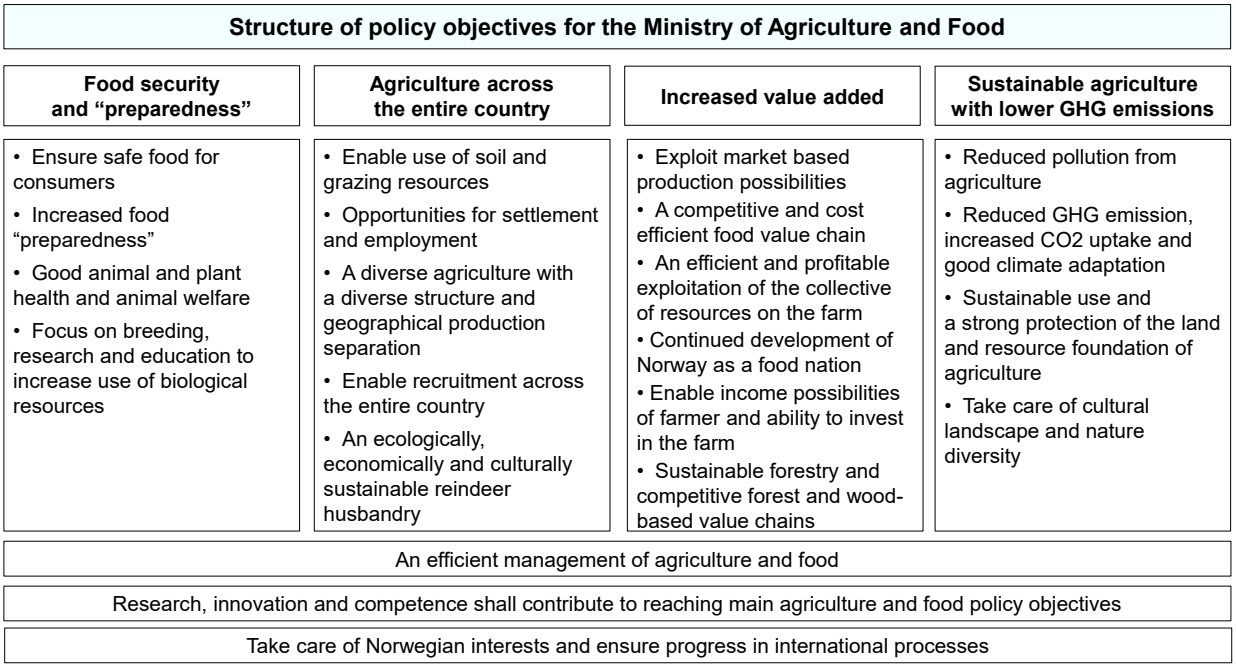
The OECD country reviews assess policies in terms of their potential to contribute to a productive, sustainable and resilient food system, following the OECD Agro-Food Productivity-Sustainability-Resilience (PSR) Policy Framework (OECD, 2020[1]). This framework derives from the Declaration of the 2016 OECD Agricultural Ministerial in which all OECD member countries agreed on shared goals for the agriculture and food sector: provide access to safe, healthy and nutritious food, improve the standards of living of producers, improve inclusiveness and, in order to achieve those goals, contribute to the sustainable productivity growth and resilience of the sector. Norway, like all other OECD countries, also has its own objectives for its agricultural policies. This chapter seeks to (i) make an assessment – based on evidence and indicators – of the extent to which Norway has achieved its policy objectives and desired outcomes using available metrics; and (ii) benchmark Norway's progress in achieving a more productive, sustainable and resilient food and agriculture sector, relative to other OECD countries. First, the objectives and outcomes are measured through available indicators and existing analysis. Then a specific analysis of the trade-offs and complementarities between productivity and sustainability is undertaken using econometric techniques to compare Norway with other OECD countries.

6.1. Policy objectives and outcomes performance

According to the White Paper on agricultural policy, (Ministry of Agriculture and Food, 2016[2]) and the annual budget, there are four objectives for agricultural policies in Norway: food security and preparedness, maintaining agriculture across the entire country, increasing value added, and sustainable agriculture with lower GHG emissions. The objectives and their more specific components are elaborated in Figure 6.1. In general, agricultural policy in Norway dictates that consumers are to be provided with nutritious, high quality products, and the production process should be mindful of aspects related to the environment, public health, and animal welfare. Norway's agricultural policy aims at safeguarding agricultural resources, developing know-how, and contributing to the creation of employment and value added in farming and farm-based products throughout Norway.

Broadly, these objectives are aligned with the Declaration of the 2016 OECD Agricultural Ministerial and the OECD Agro-Food Policy Framework (OECD, 2020[1]) provides a tool for analysing policies to improve productivity, sustainability, and resilience. However, not all the elements of the structure of objectives in Figure 6.1 are fully reflected in the PSR outcomes and the set of indicators used in the OECD Framework. But the main features of these objectives are reflected: productivity growth is a useful proxy for the creation of economic value; OECD agri-environmental indicators can be used to assess Norway's environmental sustainability objectives; and the risks of food insecurity and preparedness are reflected in the need for a more resilient sector. The set of indicators that are used to measure outcomes in the PSR Framework include: Total Factor Productivity (TFP) growth; agri-environmental indicators such as nitrogen and phosphorus balances, agricultural GHG emissions, on-farm energy consumption, and the farmland bird index;[1] and indicators of resilience for which there is not a set of internationally comparable indicators, though national sources can be used to infer different aspects of resilience such as likelihood, consequences and uncertainty of selected systemic food security risk. While not all of Norway's objectives can be evaluated using available indicators, particularly landscape, these indicators capture a variety of important metrics that are useful for cross-country comparisons. Further, these indicators are particularly relevant in Norway, where limitations in available arable land underscore the importance of maintaining the short and long term viability of the soil.

Figure 6.1. Four policy objectives for agricultural policies in Norway



Source: Agriculture Budget Committee (2019[3]).

6.1.1. Policy objective 1: High food security resilience of the value chains to cope with systemic risks, facilitated by fluent trade

According to the White Paper (Ministry of Agriculture and Food, 2016[2]) food security is to be achieved through national production, trade and safe warding of the production base. In other documents, such as the 2020 budget, this objective is more narrowly identified with increasing food production and strengthening the competitiveness of the agricultural sector (Agriculture Budget Committee, 2020[4]). Overall, Norway is a country with high income per capita and low inequalities, that provides a high stability of access to nutritious food to all of its population. The system is highly resilient to systemic shocks, ensuring food security for all the population and livelihoods to producers. Recent analysis and the experience with COVID-19 suggest that Norway's food system is highly prepared for disasters and supply disruptions, has the capacity to meet the nutritional needs of the population, and has a high level of preparedness. This capacity is particularly enhanced by the ability to trade with other countries through the food system. Norway is a net food importer and its food security objectives are achieved to a great extent through trade and globally interlinked value chains. Other aspects of food security are also the result of regulations in areas such as food safety and health.

In 2017, the Norwegian Directorate for Social Security and Preparedness (DSB) produced a report on Risk and Vulnerability of Norwegian Food Supply (Directorate for Social Security and Preparedness (DSB), 2017[5]). Mandated by the Ministries of Agriculture and Food and of Industry, Trade and Fisheries, this report undertakes an assessment of the risks and vulnerabilities affecting Norway's food system and makes suggestions for policy changes. The main focus of the report is on the capacity of the system to absorb and cope with systemic shocks that could affect food security. However, other aspects of resilience such as the capacity of the system to recover and adapt to the new risk environment and to be transformed by learning from the lessons of the shocks, are not evaluated.

Using a diversity of expertise, the report identifies and evaluates six scenarios of systemic shocks affecting the Norwegian food system for the next fifty years in terms of two outcomes: "weakened nutrition" of the

population and possible related societal instability. Two of the six scenarios have their origin in the agricultural sector: animal or plant disease and crop failure. The other four scenarios are more systemic social and economy-wide shocks. Each scenario is characterised in detail and then an assessment of the likelihood, vulnerability, consequences, uncertainty and controllability is made on a scale from 1 to 5 (very low, low, moderate, strong and very strong).[2] The study measures vulnerabilities on a full supply system basis considering national production, resources, the trading system and logistics.

The systematic assessment of all scenarios in the study and their consequences are summarised in Table 6.1. All six scenarios are assessed to have low or very low consequences on food security. With the exception of power supply failure (scenario 2), the likelihoods of each scenario are considered to be low. The total risk is calculated by combining the likelihood, consequences and uncertainty (unknown risks). Across all scenarios, total risk is evaluated to be between low and very low while the controllability – understood as the availability of effective measures and tools for the government and the private sector – is assessed to be between strong and moderate. For the scenarios related to the agricultural sector, the controllability on animal and plant diseases and on crop failure are assed to be strong.

Table 6.1. Assessment of six scenarios of risk for the food system in Norway

	A. Likelihood	B. Consequences	C. Uncertainty	D. Total risk A, B&C	E. Controllability
1. Failure in electronic communication	2	1	4	2	3
2. Power supply failure	5	1	2	1.7	3.3
3. Animal and plant diseases	2	1	2	1.5	4
4. Atomic incident	1	1	2	1.3	3.7
5. Failure to supply grain	2	1	2	1.6	3.6
6. International military conflict	1	2	3	1.7	3

Note: Scores 1 to 5 correspond to very low, low, moderate, strong and very strong.
Source: Direktoratet for samfunnstryggleik og beredskap (DSB) (2017[6]).

As a result of this assessment, “DSB has not identified any high risk for Norwegian food supply. There may be various types of disturbance in food supply for example logistics problems and short-term scarcity of some goods. The events in isolation can also have serious consequences for the conditions for Norwegian food supply, for example national production, but do not get large consequences for the food supply to the population. An important prerequisite here is that functioning international trading systems make it possible to import food” (Directorate for Social Security and Preparedness (DSB), 2017[5]).

Overall, the DSB report has four main cross cutting conclusions and recommendations about the food security resilience of Norway. First, ensure alternative communication and power solutions for the food supply in the case of emergency. Second, the possibility of importing food is a key prerequisite for Norwegian food security, and the Directorate for agriculture should monitor the risk of international supply failure and ways to diversify these potential risks. Thirdly, develop a common “planning foundation” to handle supply challenges in case of a military attack on Norway or other complex incidents. Finally, investigate the ability of the authorities and industry to co-operate to prevent and handle plant, animal and fish diseases.

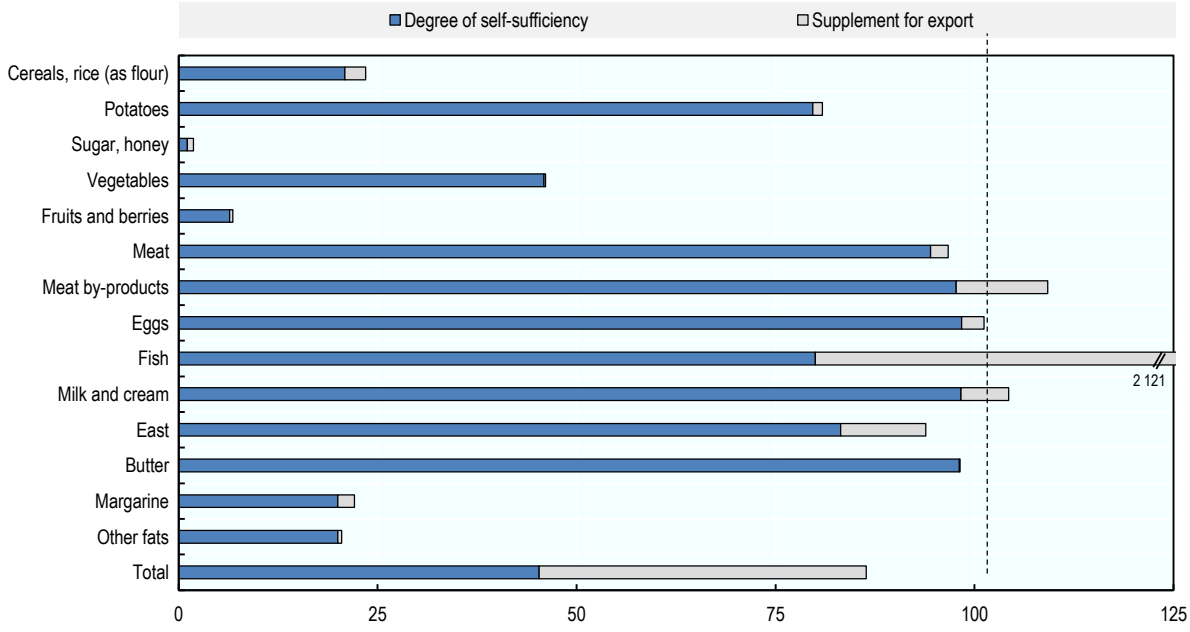
The DSB report did not consider a risk scenario of a pandemic like COVID-19. However, the food security resilience of the Norwegian food system is being validated during the current crisis. The complex impacts of the response to the pandemic on production, incomes and intermediary inputs, on consumption habits and the composition and channel of demand, and on the transport and logistics, have not questioned the continuity of the supply chain, farmers’ income and the access to food. The government has taken measures to facilitate the supply of farm labour, creating incentives for laid off workers to work on agriculture and compensating farmers suffering the lack of seasonal workers (Chapter 2). The DSB

recommendations are aligned with the first analysis of COVID-19 global food and agriculture policy responses by the OECD, which emphasises the critical role of trade and open, transparent and predictable international markets (OECD, 2020[7]).

Another report, "Performance check for the implementation of agricultural policy", delivered by the budget committee in April 2020 to inform the agricultural agreement annual negotiations, calculates two different indicators: the degree of self-sufficiency and the coverage ratio. Self-sufficiency is defined as the percentage of Norwegian produced food relative in the country's consumption (consumption minus imports divided by consumption), all at the wholesale level and calculated on energy equivalent terms. Coverage ratios are calculated as production divided by consumption. Figure 6.2 shows the values of these indicators in 2019 for selected products. The degree of self-sufficiency was 45%, down from 50% in 2017 due to a severe drought in Norway. There are high degrees of self-sufficiency for animal products, and low degrees for crop products including fruits and grains. In terms of coverage ratios, production of fish covers 2121%, or more than twenty times Norwegian consumption and is mainly exported. In total, food calories produced in Norway reach 86% of total food calories consumed while trade opens opportunities for exporting fish production surpluses and importing mainly grains and vegetable products (Chapter 1). These results underscore the capacity of Norway to produce sufficient calories but highlight its reliance on trade to provide a more diverse and balanced diet for its citizens. Some Norwegian institutes such as the Productivity Commission also find little merit in focusing the discussion on agriculture self-sufficiency, excluding the sea-food production that is exported (Productivity Commission, 2015[8]).

Figure 6.2. Norway has high degrees of self-sufficiency for animal products, and low ones for crop products

Rate of calories self-sufficiency in Norway in 2019



Notes: Self-sufficiency is defined as the percentage of Norwegian produced food relative in the country's consumption (consumption minus imports divided by consumption), all at the wholesale level and calculated on energy equivalent terms. Coverage ratios are calculated as production divided by consumption (sum of degree of self-sufficiency and supplement for export).
Source: Agriculture Budget Committee (2020[4]), based on data from NIBIO.

Finally, a third report, (Bullock, Mittenzwei and Wangsness, 2016[9]) applies the Norwegian Jordmod model to analyse the provision of public goods (food security, biodiversity and GHG emissions) by the agricultural sector and the trade-offs between outcomes under different policy scenarios.[3] The study finds that the use of current tariffs, subsidies, and milk quotas lead to levels of food security above minimum requirements, and an under-delivery of two public goods: biodiversity and reductions of GHG emissions. The minimum requirement for each public good is defined as a level robust against irreversible degradation. Following the National Nutrition Board definition of minimum daily food requirements, the authors estimate the minimum production requirements for a "crisis menu" of energy, proteins and fats (additional to those coming from normal fish consumption and grain stocks). The minimum biodiversity is measured in terms of two indicators: area in semi-natural grassland and high nature value farmland. Two alternative measures to reduce GHG emissions are considered: an emission cap at 20% reduction and an emission tax. In the baseline scenario based on the current subsidy and import tariff regime. This study finds that Norway is supplying 90% more calories than the minimum required, while other public goods such as biodiversity and GHG emission reduction are estimated to be delivered below minimum requirements. According to this modelling work, there is large scope for optimising the agricultural policy package to ensure the delivery of the minimum requirements on food security while delivering on biodiversity and reduced GHG emissions well beyond the 20% target. Furthermore, this could be achieved with a reduction of 35% of the support to agriculture, primarily through a reduction in farm subsidies and import tariffs. Similar results are found in (Brunstad, Gaasland and Vårdal, 2005[10]) that estimate that a better provision of public goods could be achieved with land extensive production techniques rather than focusing policy on production per se.

6.1.2. Policy Objective 2: In Norway agricultural production is present in all regions of the country, including the North

The Norwegian landscape and climate conditions combined with national support policies determine the allocation of agricultural activities across the country. The agricultural areas with the best growing conditions are dedicated to grain cultivation, while those with less favourable ones are used for animal husbandry. The objective of keeping land opened with production capacity even in regions with very low comparative advantage on production is enforced through both legal protections of agricultural land (Chapter 3) and costly agricultural policies – mainly location specific rates of price support and coupled payments – that have been designed to "channel" specific production to specific locations (Chapter 2). This agricultural policy set – sometimes called "production channelling" policies – has succeeded in preserving both agricultural land and the cultural landscape. The regional distribution of agricultural production has been a policy objective since the 1950s and has been supported by policy instruments including high grain prices, regionally and structurally differentiated payments (including transport subsidies), and a quota system for milk production (Chapter 2). In addition to agricultural production, this set of policies is aimed at broader regional development through entrepreneurship and the growth of ancillary industries such as agri-tourism, processing, and the promotion of local food. As a result, Norway achieves the objective of agricultural production in all regions in Norway, resulting in a regional pattern of production and increased cultivated land, but with high costs including direct production costs, transportation costs, and payments to producers.

The composition of different products and activities varies significantly across regions (Chapter 1). There are five major regions that are distinguished in Norway based on their common geographic characteristics and mode of production. The Eastern Lowlands are concentrated on cereals and contribute to 68% of agricultural land in Norway used for this purpose as well as over two-thirds of overall production volume. The small southwest region of Jæren is dedicated primarily to intensive livestock and has 10% of the Norwegian cows and the highest productivity in milk production. The central lowlands are not specialised and have a mix of crops and animal husbandry. The southern valleys and mountains produce extensive livestock and sheep and account for nearly 70% of national sheep production. Finally, the North region spreads beyond the Arctic Circle with harsh natural conditions and produces mainly dairy and beef (and

reindeer) at a relatively low productivity compared to other regions. While there is regional specialisation, such as animal husbandry in the north and grain production in the southern parts of the country, all main agricultural products are produced to some extent in the each of the different main regions of Norway. In 2018, roughly one-third of the agricultural area in use was used for growing crops and this share has declined by 5 percentage points over the last twenty years (Statistics Norway, 2020[11]). The remaining agricultural area in use was attributed to pastures, meadows and other permanent grasslands typically used for grazing-pastures or harvesting of grass (Chapter 1).

6.1.3. Policy Objective 3: Productivity has grown in Norway contributing to the sector's value added, led by labour-saving structural change and high capital intensity

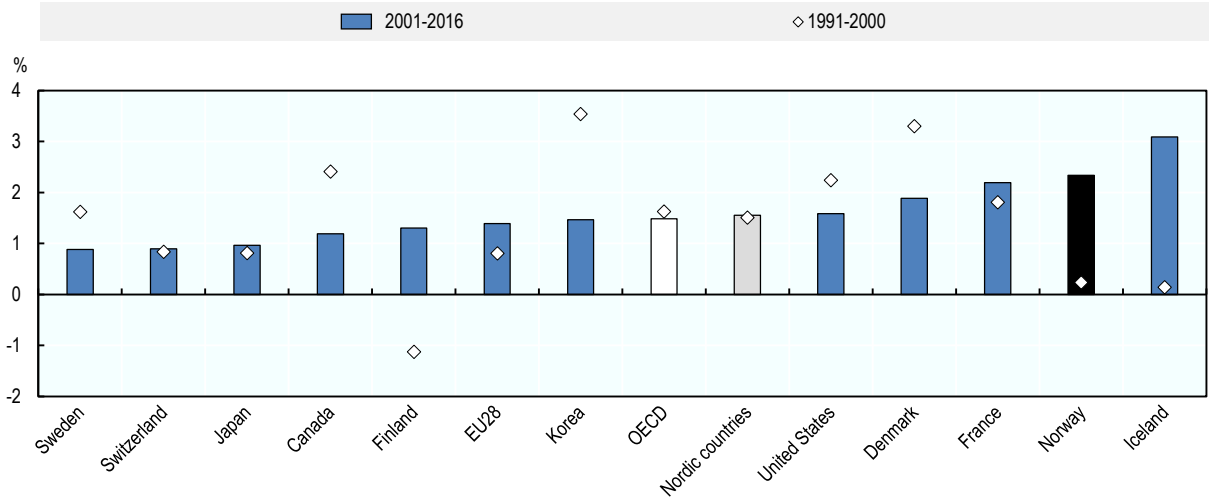
Norway is a wealthy economy with a welfare state based on abundant energy and natural capital but a scarcity of agricultural land and available labour (Forbord and Vik, 2017[12]). Oil and gas account for nearly 20% of Norway's economy, and hydropower, fishing, forestry and minerals are also important sectors. The size and revenues from natural resources have important ramifications for the overall economy as well as farmers. The revenues from oil and gas are deposited into the world's largest sovereign wealth fund which helps finance a generous welfare state. The growth of the overall economy, also driven by oil prices, has resulted in strong local labour markets, bolstered by co-operation between unions, employers and government and increasing urbanisation. This 'tripartite' system has led to relatively low wage inequality and low unemployment for both men and women (Nilsen, 2020[13]), and generates strong pull factors away from agriculture.[4] Over a long period, the number of active farmers has declined by around 3% annually (Forbord, 2014[14])) and agricultural labour productivity has risen correspondingly.

After a period of stagnant total production and total factor productivity (TFP) growth through the 1990s, Norwegian agriculture has experienced some of the highest annual TFP growth in the OECD since 2000, at an average annual rate of 2.2%. This is on par with the G20 average and well above the Nordic and OECD averages (1.6% and 1.4%, Figure 6.3) (USDA Economic Research Service, 2019[15]). Among the Nordic countries, Finland and Iceland experienced a similar development, while Sweden and Denmark had weaker TFP growth. Labour reductions led to fast growth in gross total output per worker and TFP. Both total output and productivity growth have been above the OECD and Nordic averages since 2000, reflecting Norway's achievements on production.

The breakdown of output growth into its components of output, inputs and TFP helps to understand the acceleration of TFP growth since 2000 (Table 6.2). Both total agricultural output and the use of inputs remained relatively stable in the 1990s in Norway. However, since 2000 total agricultural output increased while the use of labour and machinery inputs declined, leading to fast TFP growth. Agricultural labour declined precipitously with a much larger reduction than in machinery and other inputs. Unlike its Scandinavian neighbours, which saw larger reductions in the 1990s, Norway's reduction in agricultural labour was more rapid in the period 2000-10. Despite this high TFP growth since 2000, nitrogen fertiliser usage has increased alongside declines in total agricultural land and stable livestock numbers, resulting in little improvement in environmental outcomes (USDA Economic Research Service, 2019[15]; Statistics Norway, 2019[16]).

Figure 6.3. Norway has had strong TFP growth compared to other countries in 2001-16, after a decade of stagnation

Agricultural total factor productivity growth



Note: Average annualised TFP growth over the specified periods.
Source: USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), https://www.ers.usda.gov/data-products/international-agricultural-productivity/ (accessed December 2019).

Table 6.2. The reduction of labour is the main contributor to agriculture's TFP growth

Annual average growth in agricultural TFP, output and inputs

	Norway			OECD		
	1991-2000	2001-2010	2011-2016	1991-2000	2001-2010	2011-2016
TFP	0.2%	2.9%	2.7%	1.6%	2.1%	1.2%
Output	-0.1%	0.7%	1.9%	1.4%	0.8%	1.4%
Input (-)	-0.3%	-2.2%	-0.9%	-0.2%	-1.3%	0.2%
Contributions to input change:						
Primary Factors	-0.4%	-1.5%	-0.8%	-0.6%	-0.8%	-0.3%
Labor	-0.3%	-1.0%	-0.4%	-0.5%	-0.6%	-0.2%
Land	0.0%	-0.1%	0.0%	-0.1%	-0.1%	-0.1%
Livestock	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Machinery	-0.2%	-0.4%	-0.3%	0.0%	-0.1%	-0.1%
Intermediate Inputs	0.1%	-0.7%	0.0%	0.4%	-0.4%	0.4%
Animal materials (feed etc.)	0.3%	0.3%	-0.3%	0.3%	-0.1%	0.1%
Crop materials (fertiliser etc.)	-0.2%	-1.0%	0.3%	0.1%	-0.4%	0.3%

Source: USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database).

Agriculture's share of employment halved from 2000 to 2016. This reduction was stronger than in most other comparable countries reaching one of the lowest shares of agricultural employment in the OECD, 2.1% in 2016 (1.6% in agriculture and forestry excluding fisheries). Compared to other sectors in the Norwegian economy, agriculture and forestry have also seen one of the largest reductions in labour. Capture fisheries and aquaculture saw a similar reduction of its labour force in the period 1990-2010, but the trend has since reversed as a result of the high growth in the export-oriented aquaculture industry, with relatively little government support (USDA Economic Research Service, 2019[15]).

Reduction in farm labour is part of a long-term structural change that has occurred alongside declines in the number of farms, increasing farm sizes and legal changes that facilitated access to rented farmland (Chapter 1). Since 2000, the consolidation process accelerated and the number of farms with over 50 ha has increased from 2 000 to 5 000. Low profitability and long hours of work combined with a strong urban labour market have sustained the steady decline in the number of active farmers. Despite significantly higher levels of support to producers in Norway, this trend is common to other OECD countries (Forbord, 2014[14]). These developments also cement Norwegian agriculture's position as one of the most capital-intensive in the OECD area. Norway has the lowest number of workers per machinery among all European countries (a ratio of 0.6 workers per tractor equivalent compared to 1.0 in the EU28 and 2.3 in the OECD) (USDA Economic Research Service, 2019[15]).

While labour and machinery use have declined substantially, nitrogen fertiliser and livestock per land area have increased since 1990 due in part to slight declines in total agricultural land area. Norway's fertiliser usage intensity continues to be amongst the highest in the OECD and 20% higher than the OECD average (102 vs. 91 kg/ha on average since 2000). In the past two decades, Norway's nitrogen fertiliser intensity (kg/ha) grew at a similar rate to the OECD average (1.8% vs. 1.9% annually) while other Nordic countries experienced declines of 1% annually (USDA Economic Research Service, 2019[15]) The total amount of nitrogen fertilisers experienced declines between 2000 and 2005, and are currently at the same level as they were in 2000 (Statistics Norway, 2019[16]).[5] In contrast, total phosphorus fertilisers have declined by half since 1990, reflecting policies targeted towards reductions. Phosphorus fertiliser intensity declined by 1.6% annually over the same period in Norway and declined by over 1.8% annually in the OECD and other Nordic countries. At the same time, total livestock numbers have been steady while density grew nearly three times faster than the OECD average. Only five countries in the OECD area had greater livestock density growth, including Korea, Ireland, and Israel (USDA Economic Research Service, 2019[15]).[6] Further investigation should be done to understand which farmers are most likely to leave the sector and how to incentivise those that stay to improve their productive efficiency and environmental impact.

The dynamics of the food value chains in Norway are to a great extent determined by the structure of the primary sector, with farmers organised in strong co-operatives with market power in some stages of the value chain. Examples include both the meat and dairy sectors. It is difficult to measure the increase in value creation in the whole industry, but there is evidence that support to primary agriculture has had an impact on increasing consumer price differentials that disadvantage Norwegian consumers, processors and retailers compared to their neighbours. Agricultural policies and the annual agreements with farmers have focused on ensuring that income for a representative farm (including policy transfers) follows a similar evolution as salaries in other sectors. These policies do not generate incentives for innovative market value creation to exploit new opportunities in the value chain and constrain farmers' decisions. Despite high concentration of the retail sector, it has contributed to reducing margins in recent years. On the contrary, the processing sector has experienced lower increases in labour productivity (negative in some periods) and it has contributed to some degree to increases in price differentials (Chapter 5).

1.1.1. Policy Objective 4: Sustainability performance is a concern in terms of emissions, biodiversity and nutrient balances

The agri-environmental priority areas for the government in Norway include landscape, biodiversity, clean water and clean air. The specific objectives outlined by the Ministry of Agriculture and Food are to reduce pollution and GHG emissions, maintain sustainable land management, and ensure the cultural landscape and biodiversity. While policy towards land management and the cultural landscape has had some success, achieving reductions in nutrient balances and both domestic policy goals and international commitments related to GHGs, ammonia emissions and water protection have proved challenging (Chapter 3). Difficulties stem from various potential sources including farmer support without sufficient environmental conditionalities, a lack of adoption of environmentally sustainable technologies and

techniques, and the separation of livestock production and arable crops (regionalisation of coupled support), leading to reduced nutrient efficiency and higher ammonia emissions.

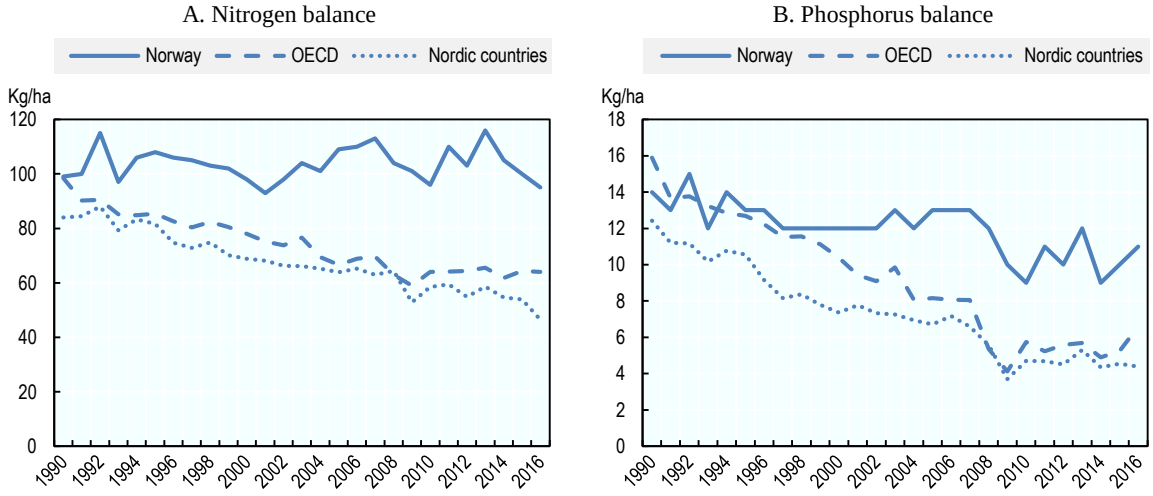
The Agriculture and the Environment report of Statistics Norway (Snellingen Bye et al., 2019[17]) undertakes an updated overall agri-environmental assessment of the country covering most of the policy objectives. According to this report, more than 2 000 endangered species are threatened, with the number of nesting couples of most common birds being significantly reduced in the last decades. The number of animals, and the quantity of manure –which represent respectively 38% and 58% of all nitrogen and phosphorous used in farming- has decreased slightly in the last decade, but sales of these nutrients in fertilisers have been relatively stable. The consumption of electricity in agriculture has fallen by 25% since 2001, but the use of diesel is stable. Discharges of nutrients from agriculture to waterways vary markedly between different regions but account for up to 40% of such discharges in southeastern parts of the country; in the last two decades fish farming has overtaken agriculture as the main source of discharges, particularly for phosphorous (Snellingen Bye et al., 2019[17]). GHG emissions from agriculture have remained relatively stable, while the country has difficulties to reach international commitments related to GHG emissions (Chapter 3), ammonia emissions and water quality. In 2017, agriculture represented 75% of total emissions of nitrous oxide (N_2O), out of which 77% came from manure and fertilisers. Agriculture also emits 51% of methane (CH_4, mainly from animal husbandry) and 94% of ammonia (NH_3), which are slightly above the OECD averages (45% and 90%) (OECD, 2018[18]).

Based on available data, Norway's water quality is relatively good, while trends in agricultural production at the regional level put coastal and groundwater at risk. Amongst European countries, Norway has the lowest concentrations of nitrogen and phosphates in fresh water on average, though this conceals large heterogeneity at the regional level. Phosphorus loading presents the largest threat to eutrophication and water quality, and policy measures have been adopted to mitigate this threat with reasonable success. Specific policies include production subsidies, manure management legislation, and local subsidies administered through Norway's regional environmental programme (RMP) and specialised measures in agriculture (SMIL). These measures have targeted a number of practices including the reduction of spring tillage and manure application since 2005 (Hellsten et al., 2019[19]; Bechmann, 2016[20]). Mitigation techniques and regulations on tillage to improve water quality have been found to have a pronounced impact on erodible soils, particularly in autumn-tilled land (Skøien, Børresen and Bechmann, 2012[21]). However policy changes in the past decade have led to a fall in the area under reduced tillage between 30% and 40% since 2012. Even if policies and uptake have been more targeted to regions with more needs, these developments deserve to be monitored to ensure the improvements in eutrophication and soil erosion are not reversed.

The OECD agri-environmental indicators provide further insight into the potential environmental effects of input intensity with respect to water quality and air pollution (OECD, 2019[22]). Notably, Norway's nutrient balances are amongst the highest in the OECD and have not significantly declined in recent years in contrast with the OECD overall and other countries with high nutrient surpluses (Figure 6.4). Norway's nitrogen surpluses declined by just 0.2% annually since 2000, compared to the OECD median of 0.8% and declines in other Nordic countries of 1.4% (OECD, 2018[18]). Total nitrogen inputs from all sources have been stable since 2000, and the composition by source was stable as well. Norway is amongst the countries with the highest nitrogen fertiliser usage per agricultural land area: 100 kg/ha since 1990, in contrast with the OECD median which is currently below 50 kg/ha due to sustained reductions. Only Germany, Belgium, Luxembourg, and the Netherlands have higher application rates per area in the OECD, though they all achieved strong improvements in application rates since 2000. Roughly half of Norway's nitrogen inputs are generated by fertilisers and 41% come from manure. Nitrogen outputs in Norway are composed predominantly of pastures (70%) and cereal crops (26%) (OECD, 2018[18]). The use efficiency ratio is also low in Norway at only 50% of inputs embedded in the outputs. Though nitrogen surpluses do not directly capture environmental damages, high nitrogen surpluses are associated with potential environmental problems due to nitrogen runoff and air pollution from the soil. [7]

Figure 6.4. Nutrient surpluses remain high in Norway despite declines across the OECD

Nutrient surpluses per agricultural land area



Notes: Manure accounts for 57% of phosphorus inputs and 47% of nitrogen inputs. Nutrient surpluses per agricultural land area (in hectare) are measured as the difference between the total quantity of nutrient inputs entering an agricultural system (mainly fertilisers, livestock manure), and the quantity of nutrient outputs leaving the system (mainly uptake of nutrients by crops and grassland).
Source: OECD (2019[22]), OECD Agri-Environmental Indicators (database).

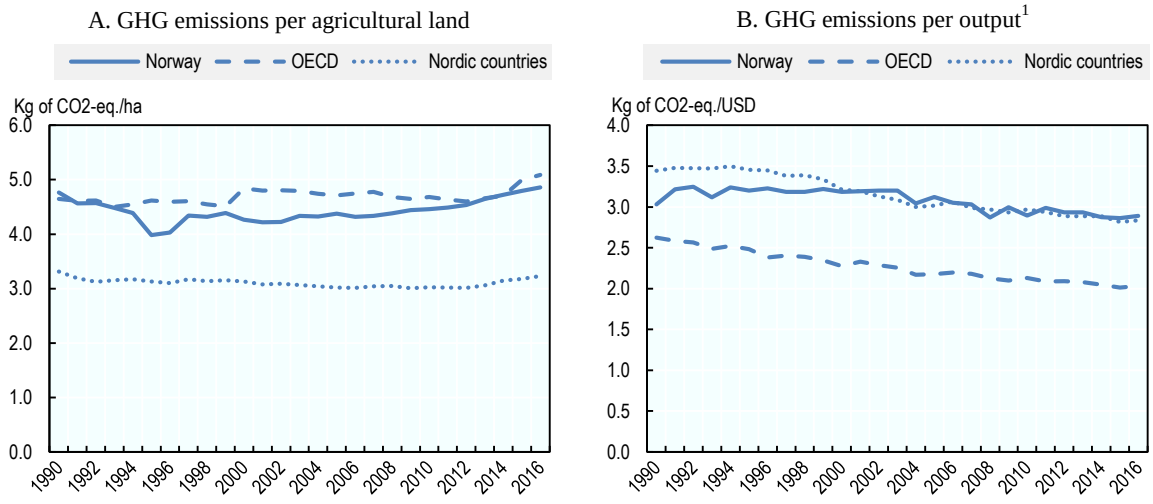
Similarly, Norway's phosphorus surplus is surpassed only by Japan and Korea in the OECD.[8] Norway has the highest phosphorus usage intensity (kg/ha) in Europe, followed closely by Italy, Germany, and France, and nearly twice as high as in Denmark and Finland. Some progress has been made in improving its phosphorus balance which fell from 13 kg/ha in 2005 to 10 kg/ha in 2015. This decline of half a percentage point annually was much smaller than the 60% reduction in the OECD median, and the use efficiency ratio remains very low at 55 (OECD, 2018[18]). Since 2000, most countries have reduced their phosphorus surpluses considerably. The share of phosphorus inputs has changed over time, with an increasing share of manure (mainly cattle) from 47% to 57% at the expense of fertilisers. The specialised agricultural production in different regions breaks the P cycle between animals and crops and aggravates problems with P surpluses. Areas with high livestock densities have high levels of soil P as the application of animal manure often exceed crop P requirements, while specialised arable farming regions have to import mineral P fertiliser to compensate for the lack of manure. Rebuilding the P cycle by transporting manure has some potential for environmental gains (Hanserud et al., 2017[23]; Hanserud et al., 2016[24]).

Agricultural activities impact air quality mainly through ammonia emissions and greenhouse gas emissions. Globally, agriculture accounts for nearly 90% of total ammonia emissions due to volatilisation from livestock manure and synthetic mineral N fertiliser application (Bouwman, 1997[25]). In Norway, the agricultural sector contributes 93% of ammonia emissions (Chapter 2). This is comparable to the OECD average despite the smaller size of the sector in Norway. Between 2005 and 2016, agriculture emitted 31 000 tonnes of ammonia, almost 5% more than the previous decade (OECD, 2018[18]). Despite a 20% decline between 1990 and 1995 to 27 tonnes per hectare, ammonia emissions intensity per hectare grew steadily to above pre-1990 levels at an average annual rate of 0.8% per year. Over the same period, the OECD average remained at 1995 levels, growing at just 0.05% over two decades. Furthermore, since 2000, Norway's total agricultural ammonia emissions have remained constant, similar to the rest of the OECD and other Nordic countries (OECD, 2018[18]).

The increase in total factor productivity has been accompanied by increases in greenhouse gas emissions per hectare of agricultural land (including methane and nitrous oxide from animal husbandry and fertilisation) and declines in emissions per output. Agricultural GHG emissions in the OECD area are rising due primarily to higher agricultural soil emissions (OECD, 2019[22]). Norway's performance follows a similar trend, with GHG emissions per hectare increasing since 1995 and the fastest growth occurring since 2010.[9] In contrast, emissions intensity per unit of output has been declining for the past two decades in the OECD (Figure 6.5), but only began declining in Norway after 2004.[10] Despite the relatively small size of the sector, both in terms of value and total land area, agriculture accounts for about 8.4% of Norway's emissions of greenhouse gases (Norwegian Ministry of Climate and the Environment, 2018[26]). Since 1990, Norway's agricultural sector has only reduced its total GHG emissions by 5% and its ammonia emissions by 3%. This is far from the overall objective of reducing emissions by 40% in 2030 and current plans do not envisage agriculture making a significant contribution to the 2030 commitment (Norway's Intended Nationally Determined Contributions).

Figure 6.5. Agricultural greenhouse gas emissions in Norway

Agricultural greenhouse gas emissions intensities



Note: 1. Greenhouse gas emissions (GHG) intensity per gross agricultural production value (per thousand USD, in constant 2004-06 prices).
Source: Authors' calculations based on OECD (2019[22]), OECD Agri-Environmental Indicators (database), for emissions and agricultural land; and USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for the total value of output.

The changes in GHG emissions intensity (both per hectare of agricultural land and unit of output) are on par with average trends in other Nordic countries and similar to those in the rest of the OECD, though Norway is amongst the worst emitters both per land area and unit of output. Due to having a predominant livestock sector and poor performance in emissions abatement relative to other livestock producing countries, Norway remains in the top half of OECD countries in terms of greenhouse gas emissions per hectare and amongst the top five in emissions per unit of output, on par with countries that have large livestock sectors including Luxembourg, Ireland, Iceland, and New Zealand. Norway's greenhouse gas emissions are made up primarily by enteric fermentation due to the digestive process of livestock (51%) followed by agricultural soils (37%) and manure management (6%) (OECD, 2018[18]). In the livestock sector, the emissions intensity declined by 24% for pig and dairy production since 1990, though there was no improvement in emissions intensity in cattle production.

Since the 1990s, Norway has used a system of regulations and economic instruments that target reductions in soil erosion and phosphorus losses rather than nitrogen losses and ammonia emissions (Chapter 2). These measures have proved insufficient: payments to agricultural producers for environmental objectives cover only 0.3% of the total support to farmers and the potential spill-overs from phosphorous on nitrogen that did not materialise. In contrast, Sweden and Finland target both nutrients and already have half the N balance of Norway (Hellsten et al., 2019[19]). Denmark, the Nordic country with the most success in achieving both nitrogen reductions and emissions reductions, did so primarily through legislation, and has recently begun transitioning towards voluntary incentive schemes.

One measure that has been identified to efficiently reduce ammonia emissions in Norway is the use of low emissions manure spreading techniques, including band spreading and injection, with the potential to decrease emissions by between 45-90% by minimising surface exposure. In Norway, however, 88% of slurry fertiliser is applied through broadcast spreading, while 35% and 28% of slurry is applied through broadcast spreading in Finland and Sweden, respectively (Hellsten et al., 2019[19]). This technique has been banned in Denmark since 2002, and other Nordic countries have used a mix of regulation and economic incentives to encourage the adoption of injection manure, for example.

Agricultural intensification can harm biodiversity, though this can be difficult to assess. The farmland bird index, based on trends in selected groups of breeding bird species depending on agricultural land for nesting or feeding, is often used as a proxy. Similar to the rest of Europe, the index for Norway has declined over the last two decades, but with a small rebound in recent years. However, the index value for Norway (53% of the 2000 base level in 2018) remains one of the lowest in Europe (Eurostat, 2018[27]). A recent report by the Norwegian Environment Authority attributes reductions in key bird species, particularly ground-nesting birds, to a number of factors including land management, mowing frequencies and techniques, and agri-environmental practices such as slurry band spreading. While some practices show promise for increasing bird species such as minimum tillage and buffer strips, the reversal in current trends are unrealistic given current agricultural practices (Eggen, 2020[28])

6.2. Benchmarking Norway's productivity and environmental sustainability performance compared with other OECD countries

In order to achieve the goal of sustainable productivity growth, countries will need to both increase their productive efficiency while simultaneously improving their sustainability performance. Throughout the twentieth century, agricultural output increased through a mix of both extensification (to bringing new lands into production) and intensification (increasing the use of labour, machinery, energy, fertiliser and other inputs to raise yields). In recent decades, however, growth in TFP, rather than extensification or intensification, has been the principal means of increasing agricultural output, due to more efficient use of land, labour, capital and inputs (Coomes et al., 2019[29]). TFP growth has the potential to encourage efficient food production with fewer negative environmental externalities and more positive feedback to ecosystem services. For instance, advances in genomic science or precision agriculture that allow for a more judicious application of fertilisers provide opportunities for sustainable productivity by improving TFP through reductions in inputs with negative environmental externalities. Though, productivity growth alone is not a panacea. Recent TFP growth in agriculture has been driven more by labour-saving technological change with only marginal impacts on environmental outcomes. This is particularly true in the case of Norway, where TFP growth driven by labour reductions has not been accompanied by declines in nitrogen fertiliser usage or livestock density, partly due to agricultural policies that are not targeted to specific environmental outcomes and market price support without conditionality.

While the consequences of extensification and intensification on environmental outcomes are well understood, the relationship between TFP growth and environmental sustainability has been difficult to identify.[11] This section first analyses the relationship between individual agri-environmental indicators and

productivity growth across the OECD to provide evidence on the potential complementarities between environmental outcomes and productivity and different productivity-sustainability pathways. Norway's performance in achieving improvements in each indicator along with agricultural productivity are assessed relative to performance in the rest of the OECD. In the second part of the section, these indicators are combined into single scores to provide a more complete picture of Norway's relative performance in achieving sustainable productivity as outlined in the PSR framework.

Environmental performance can be assessed using a variety of metrics that capture short- and long-term impacts of agricultural production. These potential measures include farm-level environmental management strategies, or direct measures of environmental impacts when they are available (e.g. reductions in nutrient runoff). To measure sustainability in this section, in line with the indicators outlined in the PSR framework, three OECD agri-environmental indicators are used to capture direct environmental outcomes that are by-products of agricultural production: GHG emissions per unit per hectare (and unit of output) as proxy for the impacts on climate change and air quality; Nitrogen surplus (NS) in kg/ha which measures the potential water quality impacts of nitrogen runoff and leaching as well as long term productivity; and phosphorus surplus (PS) in kg/ha which measures potential water quality impacts of phosphorus runoff. While these metrics do not capture the full picture of environmental costs and benefits, they are consistently available across countries, capture many of the relevant environmental costs and are used for international benchmarking (OECD, 2018[18]; OECD, 2020[30]).

6.2.1. Norway's TFP growth is coupled to increasing GHG emissions intensity per area and reductions in nutrient balances are below the OECD median

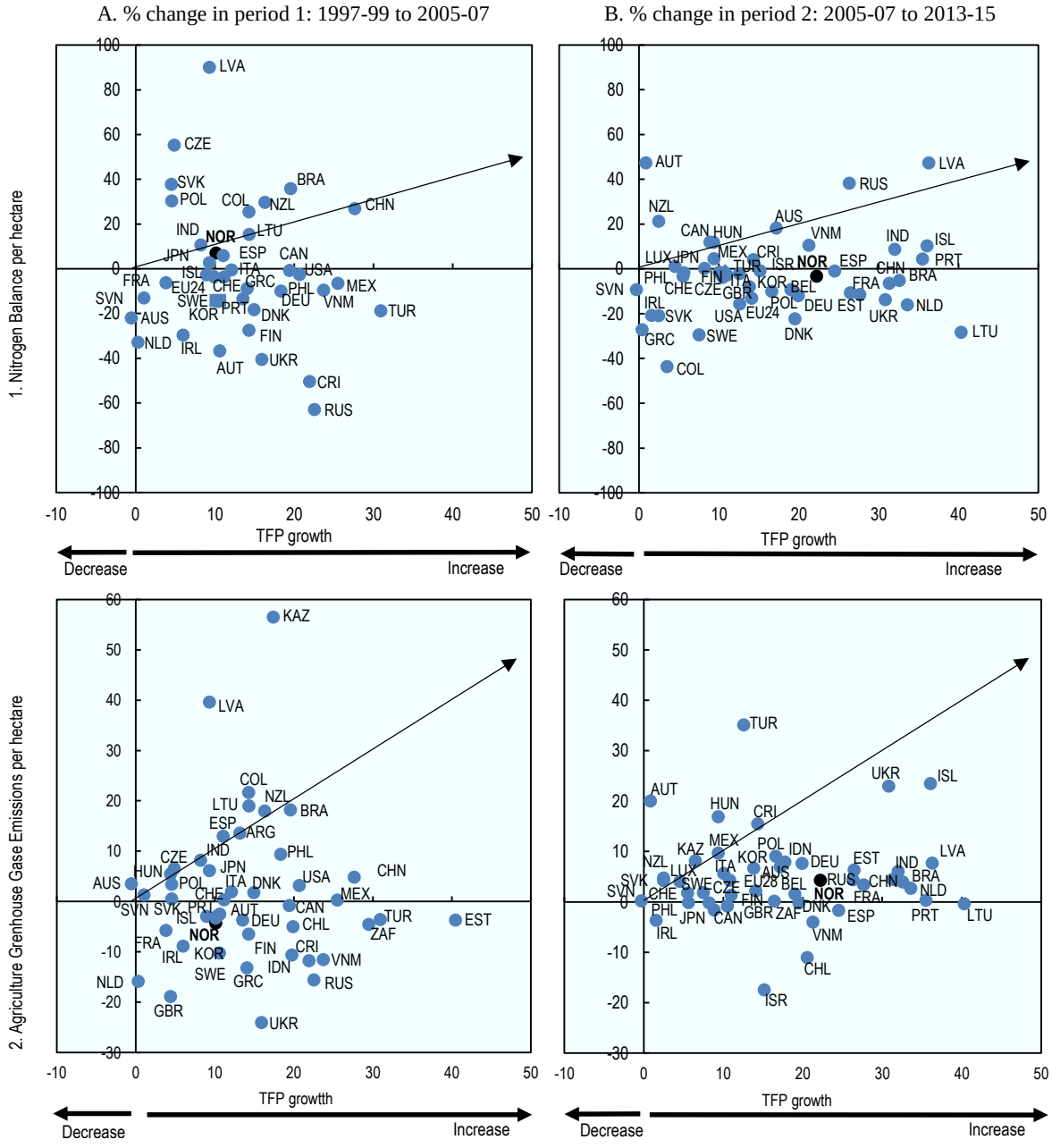
The performance in OECD countries and selected emerging economies in terms of changes in TFP as compared with changes in nitrogen balance per hectare and GHG emissions per hectare is plotted in Figure 6.6. Two periods are considered: 1997-99 to 2005-07 (Panel A) and 2005-07 to 2013-15 (Panel B). Norway follows a general trend observed across OECD countries, in particular in the most recent period, of relative decoupling between nitrogen balances and productivity growth, and relative coupling of GHG emissions per area and TFP (OECD, 2020[30]). Relative decoupling in this case means that the relevant environmental parameter is increasing at a slower rate than TFP. Norway's productivity growth was below average in the first period and above average in the second while the percentage change in nitrogen balance shifted from being positive to negative in the most recent decade. However, as in many OECD countries, the improved productivity performance of the sector has come with increases in GHG emissions per hectare during the second period. Norway performed below the OECD median on these two agri-environmental indicators. These correlations between productivity and sustainability trends do not imply causality but provides insights on observed TFP growth paths.

Since 1990, the productivity-sustainability path across OECD countries shows annual growth in agricultural productivity that tends to occur alongside reductions in nutrient balances and increases in GHG emissions per area. Using annual data between 1990 and 2016, Figure 6.7 and Figure 6.8 plot these paths as the estimated relationship between annual agricultural total factor productivity growth and growth in nitrogen balance, phosphorus balance, and GHG emissions (per area of agricultural land and unit of output).[12] The negative slopes in Figure 6.7 between nutrient balance growth (nitrogen or N, and phosphorus or P) and TFP growth imply that during periods of increasing TFP growth countries also experience lower nutrient balance growth. Moreover, at positive TFP growth rates, N and P balances tend to be declining (have negative growth rates), that is, environmental outcomes improve during periods of productivity growth, as it occurs in the right lower quadrant of panels A and B in Figure 6.7. While these estimates cannot disentangle the source of productivity growth, they suggest that there are complementarities between TFP and sustainability over the past two decades in high income countries that may be driven partially by more efficient nutrient application and improved technology. The estimated shapes and slopes also suggest that the complementarity between TFP growth and nitrogen balance are lower than those for phosphorus

balance, raising the potential need for more direct policy interventions targeted towards nitrogen abatement.

Figure 6.6. Evolution of productivity, nitrogen balance and GHG emissions per hectare

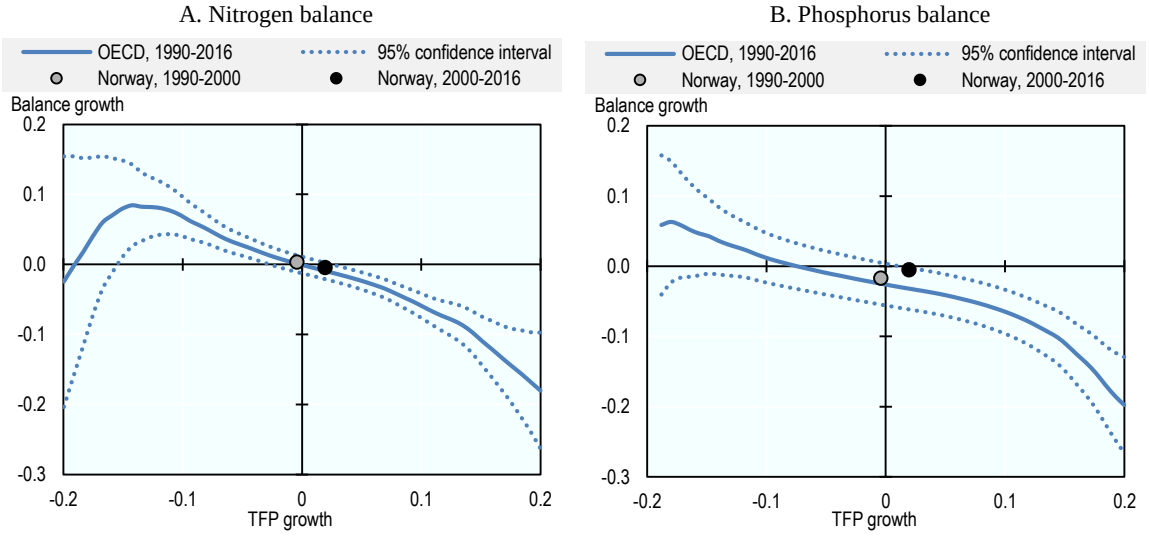
Changes in agricultural total factor productivity, and nitrogen balance and greenhouse gas emissions per agricultural land area



Source: Adapted from OECD (2020[30]), "Agricultural Policy Monitoring and Evaluation 2020", Chapter 1, based on OECD (2019[22]), OECD Agri-Environmental Indicators (database); and USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database).

Figure 6.7. TFP growth occurs alongside declines in nutrient balances per hectare

Non-parametric regressions (and confidence intervals) of the relationship between agricultural productivity and nutrient balances

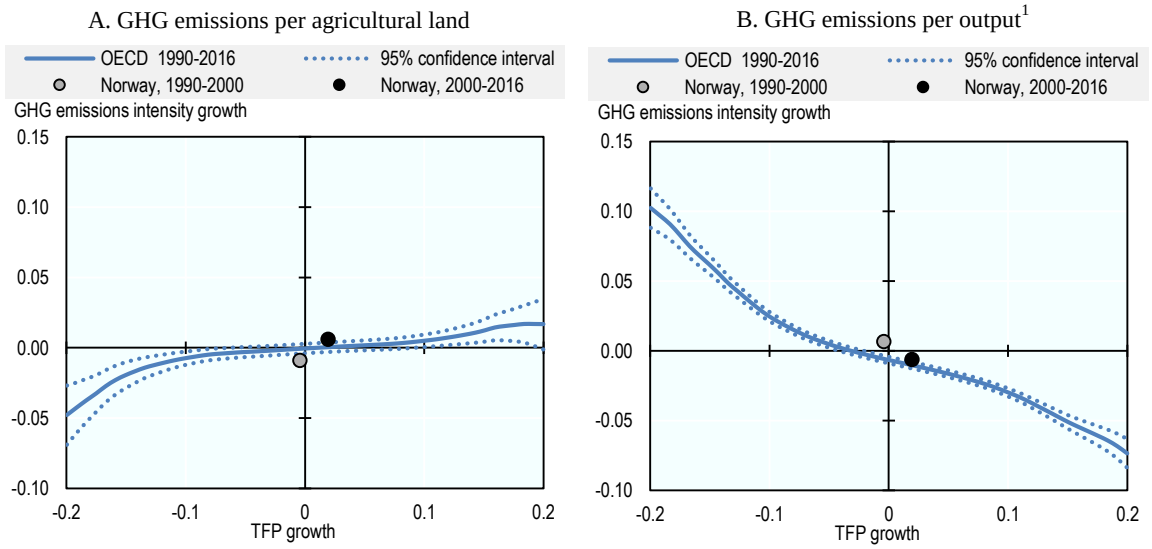


Notes: Both nutrient balances per agricultural land area and agricultural total factor productivity (TFP) data refer to the annual growth rates in the indicated periods. The full methodology and sample behind the graphs are explained in Annex 6.A.
Source: Authors' calculations based on USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth; and OECD (2019[22]) OECD Agri-Environmental Indicators (database), for nutrient balances (measured in kilogrammes per hectare).

The productivity-sustainability path in the case of Norway leads to estimated relationships between nutrient balance growth (N and P) and TFP growth over the same period are also negative but the slopes are flatter.[13] In Panel A of Figure 6.7, the average performance of Norway with respect to this curve in 1990-2000 and 2000-2016 shows a significant improvement in productivity growth but only minor improvements in N balances. In both periods, Norway is located above the estimated curve, implying higher N balance growth than the average for its level of TFP growth, though the average growth is within the 95% confidence interval. In Panel B, the performance of Norway with respect to this curve in 1990-2000 and 2000-2016 shows that during the recent significant improvement in productivity growth, P balance growth was positive in contrast to most of the OECD countries. Norway is located above the estimated curve, particularly in the period 2000-16 when Norway is in the highest extreme of the 95% confidence interval, implying higher P balance growth than the average for its level of TFP growth. These results are consistent with TFP growth that is being driven by factors other than technological change or management practices that decrease the use of fertilisers or improve their efficiency. Norway's performance relative to the OECD averages suggest that Norway is not taking full advantage of opportunities for more sustainable (in terms of nutrient balances) productivity growth as seen in other countries.

Figure 6.8. Greenhouse gas emissions tend to rise with TFP growth

Non-parametric regressions (and confidence intervals) of the relationship between agricultural productivity and GHG emissions intensities



Notes: Both greenhouse gas (GHG) emissions intensities and agricultural total factor productivity (TFP) data refer to the annual growth rates in the indicated periods. 1. GHG emissions intensity per gross agricultural production value (in constant 2004-06 dollars). The full methodology and sample behind the graphs are explained in Annex 6.A.

Source: Authors' calculations based on USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth and the value of total output; and OECD (2019[22]), OECD Agri-Environmental Indicators (database), for greenhouse gas emissions.

The productivity-sustainability path (in terms of GHG emissions) across OECD countries is depicted in Figure 6.8. This figure plots the estimated relationship between annual growth in GHG emissions (per hectare and per unit of output) and TFP growth across OECD countries. In contrast to nutrient balances, there is a positive and significant correlation between productivity growth and emissions intensity per hectare. The positive slope in the graph (Panel A) suggests that annual increases in productivity have been coupled with increased growth in GHG emissions intensity per hectare. For years with positive TFP growth, GHG emissions growth rates per hectare are often positive. This implies that despite faster TFP growth, drivers of emissions such as manure management and agricultural soils continue to rise, albeit at a slower rate than output, leading to worsening overall emissions. The average performance of Norway with respect to this curve in 1990-2000 and 2000-2016 shows a significant improvement in productivity growth together with a relative deterioration of GHG emissions performance per area in the second period. Norway was below the curve at the 1990s – with negative growth of GHG emissions per hectare – but above the curve after 2000, with increases in GHG emissions per hectare well above those in other countries with similar TFP growth, due in part to declines in agricultural land. Furthermore, Norway is above the highest extreme of the 95% confidence interval. At the same time, total emissions have slowly declined and emissions growth per output is declining during periods of TFP growth amongst OECD countries (Panel B). This trend is consistent with TFP growth being driven by reductions in inputs, technologies, or management practices that produce emissions, though the primary source of this relationship cannot be identified. Taken together, while Norway, and the OECD overall, have made progress *in reducing emissions growth intensity per output*, their goal of substantially reducing *total emissions* is not being achieved through improved TFP and the existing policy environment.

6.2.2. Norway achieved weak sustainable productivity growth, but failed to achieve more stringent threshold of sustainable productivity growth

In the following analysis, Norway's environmental performance and productivity growth are benchmarked with respect to the rest of the OECD using a combined measure of sustainable productivity rather than its individual components. Given that inputs into production may have both short- and long-term impacts on the environment and productivity and can act either as substitutes or complements in production, countries can follow different productivity-sustainability paths with potential trade-offs between individual measures of sustainability and productivity as shown in the previous section.

Several thresholds for *relative* sustainable productivity growth are used in this analysis to benchmark Norway, following previous OECD analysis (OECD, 2019[31]). The three thresholds (or measures) used here combine an *index of environmental performance* (including N and P balance and GHG emissions) with the TFP growth rate and they vary both in their trade-offs within environmental outcomes and between environmental outcomes and productivity. All of the indices, including productivity growth, are standardised using the full set of OECD countries. Therefore, each index and the corresponding thresholds represent each countries' performance relative to the rest of the OECD.

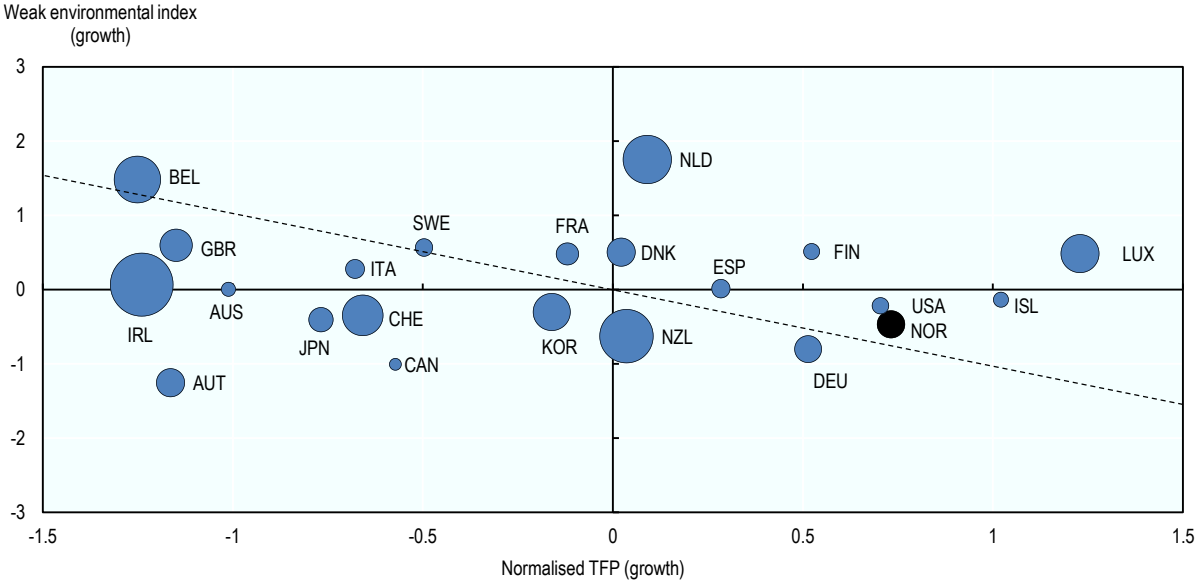
- Weak sustainable productivity (SPW), the least stringent threshold, is measured as the average performance of all sustainability and productivity indicators. By taking the average of the environmental index and TFP, this measure allows for substitution both between environmental outcomes and between these outcomes and productivity.
- Strong sustainable productivity (SPS), the most stringent threshold, is calculated as the worst performing indicator out of both the environmental outcomes and productivity. Measuring sustainable productivity using the worst performing indicator does not allow for substitution either between the different environmental outcomes or productivity and therefore bad performance in one indicator cannot be compensated or substituted with better performance in another.
- Semi-strong sustainable productivity (SPSS) is the average of the worst environmental indicator and TFP. This measure does not allow for substitution among environmental outcomes but does allow for some substitution between productivity and environmental outcomes (OECD, 2019[31]).

Following these definitions, the indicators of productivity and environmental outcomes (nitrogen and phosphorous balance and GHG emissions for the purpose of this analysis) are combined to provide a benchmark of sustainable productivity growth across OECD countries, following the scoring method in Chapter 3 of OECD (2019[31]). Given the sensitivity of GHG emissions performance to the choice of the particular outcome (per hectare, per output, or total emissions), all three are considered in the analysis to provide a full picture of Norway's performance. Further, it should be noted that the following analysis is in terms of *relative* performance compared to other OECD countries which allows for comparisons of how changes in Norway's indicators perform relative to those in other countries. The full methodology is discussed in Annex 6.B. In the following analysis, first Norway's performance at achieving sustainable productivity growth in recent decades is benchmarked relative to other OECD countries over the period 2000-16. Second, environmental indices are assessed at current levels (2014-16) and combined with TFP growth to capture where Norway stands moving forward as a result of their recent performance.

Figure 6.9 plots the weak environmental index measured in growth rates against normalised TFP growth over the period 2000-16. The metric of GHG emissions per hectare is used as the measure of GHG intensity. The weak environmental index is the average of the standardised environmental outcomes and higher numbers means better environmental outcomes. Norway outperformed two-thirds of OECD countries in terms of TFP growth since 2000, with TFP growth rates similar to those of the United States and slightly behind Iceland. In contrast, Norway's environmental performance is below the median in the environmental index (black bubble in lower right quadrant). Countries that are located to the right (or above) the dashed line achieved weak sustainable growth over the period 2000-2016.[14] This line represents where

the average of the environmental index and normalised TFP are zero. While Norway's performance in average environmental growth rates were below the OECD median, the good performance in TFP compensated for the poor environmental performance and they achieved weak sustainable productivity growth. Only two countries had both fast relative growth (in the top ten countries in terms of TFP growth) and above median improvements in average environmental sustainability performance: Finland and Luxembourg. Denmark and the Netherlands also achieved substantial improvements in sustainability while being near the median in TFP growth.[15] Compared to other countries with high livestock density and similar production structure, Norway's progress in terms of environmental outcomes has been mediocre, while still maintaining strong productivity growth. These findings are similar when considering other measures of emissions. Norway performs marginally better when including GHG emissions per output and total GHG emissions instead of emissions per land area.

Figure 6.9. Norway achieved weak sustainable productivity growth in 2000-16

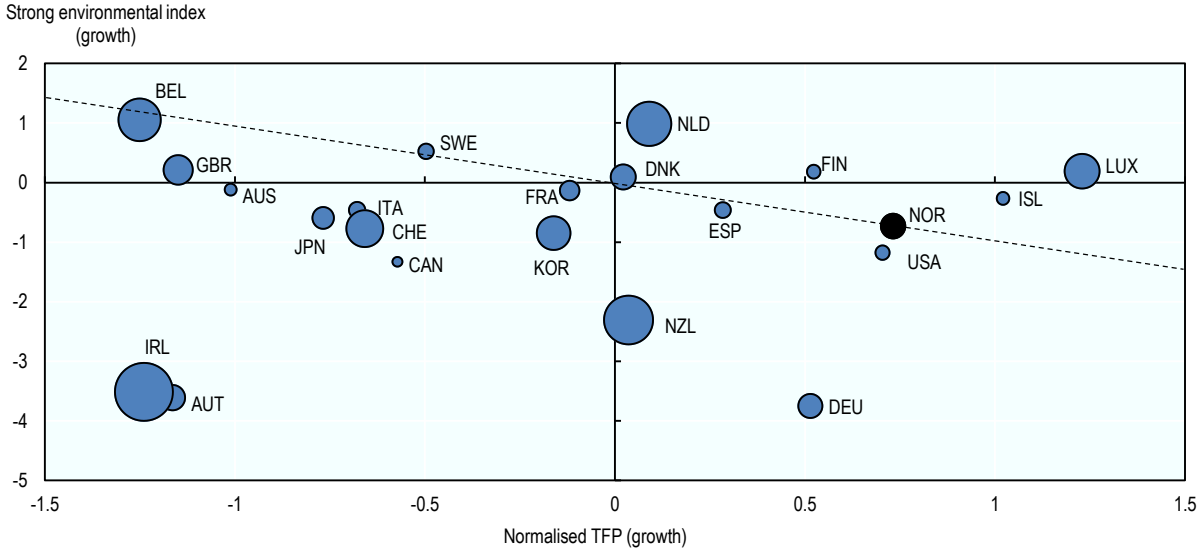


Notes: The weak environmental growth index is the *average* of the normalised values of growth rates of N surplus, P surplus, and GHG emissions intensity per hectare of agricultural land area for years 2000-16. Positive values imply better environmental growth outcomes. The dashed line indicates where the average of normalised agricultural TFP growth and the weak environmental growth index are equal to zero, thus countries above this line achieved weak sustainable productivity. Bubble size is proportional to livestock density (LU/ha). The full methodology and sample behind the graph are explained in Annex 6.B. The countries used in the normalisation include all OECD countries except Chile, Colombia, Israel, and Estonia. Only a subset of 22 countries are presented for comparison.
Source: Authors' calculations based on USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth; and OECD (2019[22]), OECD Agri-Environmental Indicators (database), for nutrient balances (measured in kilogrammes per hectare) and GHG emissions intensity.

The performance of other Nordic countries, especially Denmark, Finland, and Iceland, as well as the Netherlands suggests that much further progress can be made on average environmental performance in Norway without sacrificing substantial productivity. In Denmark, for example, policies like the banning of broadcast manure spreading in 2002 have proved to be both cost effective and beneficial to farmers. Much of Denmark's initial improvements in reducing nitrogen losses and emissions, were achieved through legislation, with a recent shift towards a geographically differentiated and voluntary framework (Dalgaard, 2014[32]). This system of regulations, combined with the broader agricultural policy environment, have the potential to encourage substantial improvements in sustainability alongside sustained productivity growth. In addition to regulation, the existing innovation system can be leveraged to improve the complementarity

between productivity and sustainability. This includes environmental incentives to adopt technologies and management practices that lead to sustainable productivity growth such as precision agriculture, reprogramming agricultural extension services to focus on how to adopt technologies that improve environmental performance in a cost effective manner, and using digital information services to improve monitoring for efficient agri-environmental payment schemes.

Figure 6.10. Norway did not achieve strong sustainable productivity growth in 2000-16



Notes: The strong environmental growth index is the *minimum* of the normalised growth rates of N surplus, P surplus, and GHG emissions intensity per hectare of agricultural land area for years 2000-16. Positive values imply better environmental growth outcomes. The dashed line indicates where the average of normalised agricultural TFP growth and the strong environmental growth index are equal to zero, thus countries above the dashed line achieved semi-strong sustainable productivity, while countries in the upper-right quadrant achieved strong sustainable productivity growth. Bubble size is proportional to livestock density (LU/ha). The full methodology and sample behind the graph are explained in Annex 6.B. The countries used in the normalisation include all OECD countries except Chile, Colombia, Israel, and Estonia. Only a subset of 22 countries are presented for comparison.
Source: Authors' calculations based on USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth; and OECD (2019[22]), OECD Agri-Environmental Indicators (database) for nutrient balances (measured in kilogrammes per hectare) and GHG emissions intensity.

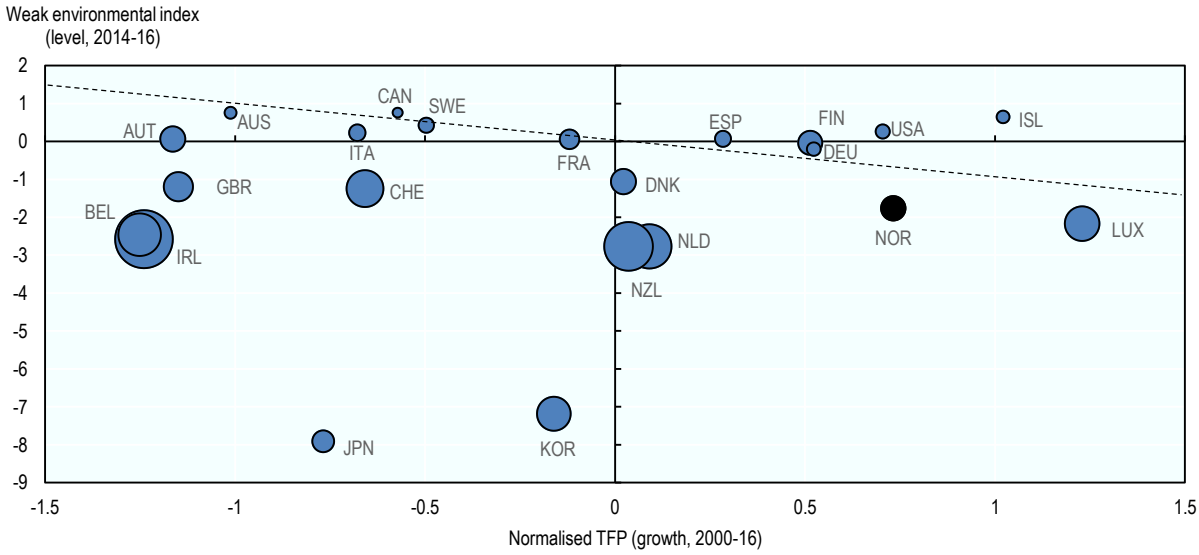
Rather than considering just the average of environmental performance and productivity, Figure 6.10 plots productivity growth along with the *strong* environmental growth index to measure *semi-strong* and strong *sustainable productivity* (semi-SSP and SSP) growth. Instead of the average of standardised growth rates across the indicators, the *strong* environmental growth index measures the relative growth of each country's worst performing environmental indicator. Countries located above the dashed line achieved semi-strong sustainable productivity growth between 2000 and 2016, meaning that they improved both productivity and the performance of their worst environmental indicator relative to other countries. In Norway, the worst performing environmental outcome, GHG emissions per hectare, had a negative score that exactly counterbalance the TFP growth, and therefore Norway barely achieved *semi-SSP* growth. Because of the below median performance in GHG emissions reductions per hectare, Norway's overall environmental performance was not sufficient to achieve strong sustainability productivity growth (*SSP*), which captures the worst performing indicator (including TFP). Only those countries in the upper-right quadrant achieved strong sustainability growth including Luxembourg, Finland, and the Netherlands. The strong sustainable productivity performance achieved by these countries with similar production structures to Norway suggests that TFP growth can be achieved without having to trade off environmental

performance, even where there are high marginal costs of abatement. Rather, there may be complementarities in production techniques that improve all environmental outcomes, such as advancements in precision agriculture, or policies that target abatement of environmental damages directly (OECD, 2013[33]). Similar analyses were conducted using total GHG emissions and GHG emissions per output instead of GHG emissions per agricultural land area. In both cases, Norway achieves semi-strong sustainable productivity growth but does not achieve strong sustainable productivity growth.

6.2.3. Norway's environmental score in levels is below the threshold of weak sustainable productivity growth

Figure 6.11 shows the relationship between the levels – rather than changes – of environmental sustainability and TFP growth. The weak environmental scores in levels are plotted across OECD countries between 2014 and 2016 relative to standardised TFP growth since 2000. This figure provides a benchmarking of where Norway stands in terms of sustainability following a period of relatively high productivity growth (2000-16). Amongst the top ten countries in terms of productivity growth,[16] only Norway and Luxembourg have an environmental score that is significantly negative (lower right quadrant), meaning that they have below median environmental outcomes despite fast TFP growth. Countries in the upper right quadrant achieved both positive TFP growth and have positive environmental scores compared to the OECD median, including Iceland and the United States. Countries above the dashed line have productivity growth that is high enough to compensate for negative environmental outcomes, thereby achieving weak sustainability productivity growth (SPW). Norway falls in the lower right quadrant and below the dash line, which means that it has not achieved weak sustainability and productivity growth. This is not surprising given that Norway has made little progress in reducing nitrogen balances and GHG emissions intensities in the past two decades. The performance of other Nordic countries, suggests that the nature of production may be a constraining factor in achieving sustainable productivity levels given current technological constraints, natural capital, and policy environments. Further, countries with high livestock densities,[17] such as New Zealand, Ireland, and Luxembourg, and to a lesser extent Norway, tend to have relatively low environmental performance using these indices due to high nitrogen and phosphorus manure intensity as well as high GHG emissions. Sweden had negative scores on TFP but positive scores on weak environmental performance, while Switzerland had negative scores in both productivity and the environment.

Figure 6.11. Norway's environmental outcomes in levels are relatively poor despite fast TFP growth



Notes: Weak environmental index in levels is the *average* of the normalised values of N surplus, P surplus, and GHG emissions intensity per agricultural land area for years 2000-16. Positive values imply better environmental impacts. The dashed line indicates where the average of normalised agricultural TFP growth and the weak environmental growth index in levels are equal to zero, thus countries to the right of the dashed line achieved weak sustainable productivity. Bubble size is proportional to livestock density (LU/ha). The full methodology and sample behind the graph are explained in Annex 6.B.The countries used in the normalisation include all OECD countries except Chile, Colombia, Israel, and Estonia. Only a subset of 22 countries are presented for comparison.
Source: Authors' calculations based on USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth; and OECD (2019[22]), OECD Agri-Environmental Indicators (database), for nutrient balances (measured in kilogrammes per hectare) and GHG emissions intensity.

6.3. Norway is delivering unevenly its four agricultural policy objectives

There are four broad objectives for agricultural policies in Norway (Ministry of Agriculture and Food, 2016[2]): food security and preparedness, maintaining agriculture across the entire country, increasing value added, and sustainable agriculture with lower GHG emissions (Figure 6.1). The analysis in this and other chapters in this review reveals that the agricultural policy achievements are unbalanced in favour of some policy objectives in detriment of others, primarily in pursuing resilient food security and focusing on increased production and landscape spread across the country at the expense of the environment and the innovation and value creation in the value chain. Norway's food system has achieved high food security standards and is able to produce some food even in the most remote areas of the country. However, TFP growth was not driven by innovation that reduced the use of inputs, but by movements of labour out of the sector and structural change towards high capital intensity and labour saving technologies. Despite high rates of growth in TFP, there has been little progress in terms of reducing negative environmental impacts due to sustained applications of nitrogen fertiliser and livestock production.

Due to the current policy environment, the analysis in this chapter demonstrates that Norway's sustainable productivity performance is mixed relative to other OECD countries. Using either of the GHG emissions indicators (total, per hectare or per output), Norway has not achieved strong sustainable productivity growth over the past two decades. The performance of other livestock producing countries suggests that there are potential opportunities to improve in environmental performance without sacrificing productivity. Further, due to the structure of production, Norway does not achieve even weak agri-environmental performance in levels. The recent rapid TFP growth is not driven by the efficient allocation of

environmentally damaging inputs or technological innovation. The policy emphasis on aggregate *production* rather than environmental outcomes is particularly concerning because their current levels of nitrogen and phosphorus surpluses, for example, are amongst some of the highest in the OECD. Agricultural policy in Norway continues to maintain the *status quo* of high levels of distortionary support and coupled policies, and a low share of agri-environmental payments and incentives for farmers to improve environmental outcomes.

Annex 6.A. Regression of environmental outcomes on TFP growth

This annex provides further details on the empirical analysis of agricultural productivity, GHG emissions intensities and nutrient balance. The methodology of the analysis is similar to Chapter 2 in (OECD, 2019[22]). Table 6.A.1 shows descriptive statistics of the data used for the period 1990-2015.

Annex Table 6.A.1. Summary statistics

Variable	Observations	Mean	Std. Dev.	Minimum	Maximum
Nitrogen balance	809	-0.011	0.173	0.693	-0.938
Phosphorus balance	676	-0.039	0.403	3.312	-2.996
Growth in GHG emissions intensity (kg of CO2e/USD)	871	0.000	0.052	0.524	-0.375
Growth in Agricultural TFP	874	0.013	0.055	0.200	-0.200

Notes: The summary statistics reported are annual growth rates calculated at the country level over the period 1990 through 2016 for OECD countries when the data are available. Notably, nutrient balance data is not available for Israel and Chile for the whole period, and only available partially in Hungary, Estonia, the United Kingdom, Lithuania, and Luxembourg.
Sources: USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP growth; and OECD (2019[22]), OECD Agri-Environmental Indicators (database), for nutrient balances and GHG emissions.

Figure 6.7 and Figure 6.8 were estimated using non-parametric local polynomial regressions. Local polynomial regressions are suitable for this analysis because they do not assume a particular shape of the relationship between the outcome and the covariates (Ordas Criado, 2008[34]). The method consists of running a number of local regressions at different values of the covariates with an optimal bandwidth. The density of the outcome is estimated by using the Epanechnikov Kernel function. A rule-of-thumb estimator selects the optimal bandwidth. Each graph includes only the two variables specified – growth in agricultural TFP and one of N balance growth, P balance growth, or emissions intensity growth – to create the graphs. The sample includes each country-year pair over OECD countries between 1990-2016 when data is available. All variables are in annual growth rates. A parametric model is also estimated as follows:

$$Y_{it} = \alpha + \beta X_{it} + \eta_t + u_{it},$$

Where Y_{it} is one of three dependent variables: growth rate of nitrogen balance, growth rate of phosphorus balance, and growth rate of GHG emissions intensity. These variables are regressed on agricultural TFP growth (X_{it}) and a set of yearly time dummies (t). Standard errors are clustered at the country level.

Annex Table 6.A.2. Regression of environmental growth rates on TFP growth

	Nitrogen balance	Phosphorus balance	GHG emissions intensity
Agricultural TFP	-0.84***	-1.36***	0.21***
	(-0.2)	(-0.48)	(-0.051)
Observations	775	656	860
Number of countries	35	35	35

	Nitrogen balance	Phosphorus balance	GHG emissions intensity
Adjusted R-squared	0.113	0.102	0.082
Mean dep. var	-0.0086	-0.036	-0.036

Notes: Coefficients were estimated using an OLS model with robust standard errors reported in parentheses. *, ** and *** represent statistically significant coefficients at the 1%, 5% and 10% levels, respectively. Year dummies are included.
Sources: USDA, Economic Research Service (2019[15]), International Agricultural Productivity (database), for agricultural TFP; and OECD (2019[22]), OECD Agri-Environmental Indicators (database), for environmental indicators.

Annex 6.B. Benchmarking weak and strong sustainable productivity growth

This analysis benchmarks Norway's sustainable productivity performance using three thresholds: "sustainable productivity weak" (SPW) with perfect substitution between all environmental and productivity outcomes; "sustainable productivity semi-strong" (SPSS) with limited substitutability between environmental outcomes and productivity, but not among the environmental outcomes; and "sustainable productivity strong" (SPS) with no substitutability (OECD, 2019[31]; Lankoski and Thiem, 2020[35]).

The environmental indicators used in the analysis are Nitrogen surplus (NS), Phosphorus surplus (PS), and greenhouse gas (GHG) emissions intensity. The analysis includes three measures of GHG emissions intensity: per hectare of agricultural land, per value of total output, and total emissions. First, each environmental indicator (growth rates or levels) and agricultural total factor productivity (TFP) growth are standardised using modified z-scores to allow for comparisons across measures. The standardisation includes converting the indicators such that higher values, either in growth or levels, indicate better performance. The analysis can be done separately for either the levels of the indicators and the growth rates of indicators. The z-score converts all indicators to a common scale with an average of zero and a standard deviation of one. A modified z-score is used based on the median rather than the mean.

The modified z-score for each country *c* and indicator *i* is calculated according to the following equation:

$$Z_c = \frac{x_c - \tilde{x}}{1.486 * MAD_N}$$

where x_c is the value of the indicator for country $c \in N$, $\tilde{x}$ is the median of the indicator across the sample of N countries, MAD_N= median($|x_c - \tilde{x}|$) is the median absolute deviation. The MAD is multiplied by a constant 1.486 to approximate the standard deviation.[18] The modified z-score tends to be more robust than the standard z-score. The countries used in the normalisation include all OECD countries except Chile, Colombia, Israel, and Estonia due to the availability of data for all of the measures and all of the years in the analysis.

Second, after the indicators (in levels and growth) are standardised, and two environmental scores are calculated using the z-scores of the environmental measures. The *weak environmental score* is calculated by taking an unweighted average of the z-scores of the environmental indicators (GHG intensity, NS, PS). The average provides an index that assigns equal weight to each indicator and allows for substitution in performance across different indicators. The *strong environmental score* is calculated by taking the minimum of the z-scores of the environmental indicators and captures the performance of the country's worst environmental indicator or growth in this indicator.

Finally, the environmental scores and the normalised productivity growth are combined to construct three measures of sustainable productivity:

- The first is a measure of *weak sustainable productivity (SPW)*, which allows for substitution both across environmental outcomes and between productivity and environmental outcomes. The *weak sustainable productivity score* is calculated by taking an unweighted average of the *weak environmental score* and normalised productivity growth.
- The second is a measure of *semi-strong sustainable productivity (Semi-SSP)*. The measure is the average of the strong environmental score and the normalised TFP measure. This measure does

not allow for substitution across environmental measures but reflects changes in the worst performing environmental damages, and allows for substitution with TFP performance.

- The third outcome is a measure of *strong sustainable productivity (SSP)*. The measure is calculated taking the minimum of the strong environmental score and the normalised TFP measure. By taking the minimum rather than average of the environmental indicators and TFP, this measure does not allow for substitution across any environmental measures or productivity.

Annex Table 6.B.1. Construction of sustainable productivity scores

Sustainable productivity	Operator	Environmental index	Productivity	Operator
Weak SP	AVG	Weak environmental score (AVG(NS,PS,GHG))	Standardised TFP growth	AVG
Semi-strong SP	AVG	Strong environmental score (MIN(NS,PS,GHG)	Standardised TFP growth	AVG
Strong SP	MIN	Strong environmental score (MIN(NS,PS,GHG))	Standardised TFP growth	MIN

Note: Environmental indices can be expressed either in levels or in growth rates.

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Notes

[1] These indicators are not meant to represent fully the levels of sustainability. Other indicators which are indicative of the environmental impacts of agricultural production but for which data is not comprehensive enough for cross country comparisons include water quality, landscape, and soil erosion.

[2] For instance, Scenario 5 defines a failure of grain supply as: a supply shortage of cereals due to national and international crop failure, with a bad monsoon season in India and The People's Republic of China, and drought in North America and Europe; in this scenario national production covers only 10% of domestic demand for food cereals, while the Russian Federation and Ukraine issue an export embargo.

[3] The Jordmod model is a recursive-dynamic multi-commodity model for Norwegian agriculture used to analyse impacts of market and policy changes on the agricultural sector and farm structural change in Norway (Britz and Bonn, 2018[36]).

[4] Johnsen and Vik (2013[37]) argue that the development of the welfare state and opportunities in other industries, including in the oil industry, were strong pull factors causing people to leave the fishing industry, for example.

[5] Total nitrogen fertilisers includes both organic and inorganic fertilisers. In Norway, the use of urea based fertilisers remains low, though changes in the relative prices of fertilisers may lead to increased usage in the future.

[6] Livestock is measured as 1 000 head of cattle-equivalents by size (Hayami-Ruttan weights).

[7] It is estimated that between 40% and 60% of nitrogen fertiliser is absorbed by crops while the rest is lost to the environment. Excess nitrogen either remains in the soil or volatilises after fertiliser application leading to ammonia and nitric oxide emissions. Because it is highly mobile, nitrogen can reach groundwater reserves due to leaching and reach surface water via runoff. Excess nitrogen leads to plant and algal growth in surface water, producing eutrophication that damages biodiversity. Further, nitrate concentrations in groundwater pose health risks to both livestock and humans. Nitrogen volatilisation contributes to higher concentrations of nitrous oxide which can lead to soil and water acidification which can lower crop yields and biodiversity.

[8] Phosphorus surpluses are associated with environmental risks as excess P can lead to surface water contamination due to runoff and soil erosions. While phosphorus concentrations in water do not pose a direct risk to human health, they do favour the growth of cyanobacteria and algal blooms in water bodies.

[9] Calculating emissions intensity per hectare captures changes in total emissions relative to agricultural land, which is a stable input in most OECD countries. This measure allows for comparisons of trends in overall GHG emissions scaled to national land usage. In general, the environmental effects in terms of greenhouse gas emissions tend to be primarily driven by extensive margin decisions (shifting between different types of agricultural land uses) as well as input usage intensity (primarily fertilisers and intensification of livestock) (OECD, 2019[31]).

[10] One difficulty in using emissions intensity per unit of output is that the measure of output is calculated using the sum of the value of production across 189 crop and livestock commodities and represents the market value of food and agricultural products within each country. The use of domestic prices potentially over-estimates the real market value of production in countries where prices and quantities are distorted by market price supports.

[11] There is a lack of empirical research on the trade-offs and synergies between TFP growth and sustainability. Coomes et al. (2019[29]) argue that this is due to how TFP is measured and a lack of sufficiently downscaled data that allow for the empirical depth need to "examine the dynamic interplay of sustainability and resilience outcomes with TFP changes in agriculture."

[12] The data used to estimate the figures taken from all OECD countries with available data over the period 1990-2016 (OECD, 2019[22]). The full methodology and sample behind the graphs in Figure 6.7 and Figure 6.8 are explained in Annex 6.A.

[13] This negative correlation exists also in the United States and Denmark, for example, but the relationship is positive in Iceland and Sweden. Country specific slopes are estimated by regressing growth in nitrogen balance on agricultural TFP growth at the country level with time fixed effects included.

[14] The dashed line indicates where the average of normalised TFP growth and the *weak* environmental growth score are equal to zero.

[15]Agricultural policy contributes to sustainable productivity where there is low levels of production-related agricultural support, though countries like Denmark and the Netherlands have achieved these results in part due to a lack of production-related support and payments linked to environmental outcomes (Henderson and Lankoski, 2020[38]).

[16] A subset of countries used in the analysis are shown in the figure.

[17] Bubble size represents the country's average livestock density per hectare.

[18] The consistency constant is used to ensure that for large samples the median absolute deviation (MAD) becomes a consistent estimator of the population standard deviation. The value of 1.486 is used as a consistency constant under the assumption that the underlying distribution is normally distributed.

Annex A. Brief description of the PEM-Norway model

General structure of PEM

The OECD Policy Evaluation Model (PEM) is an equilibrium displacement model that contains explicit product and factor markets (see (OECD, 2005[1]; OECD, 2015[2]) for further details on the general structure of the model). These markets, which *inter alia* include land, chemicals and fertiliser use, provide a direct connection between economic policy, farm activities and their environmental consequences, in particular as regards to water pollution and climate change.

PEM Norway distinguishes four outputs and 13 inputs. The outputs are wheat, coarse grains (barley and oats), milk and beef. Milk is processed further into fluid milk (e.g. drinking milk, yoghurt, cream) sold on the domestic market only and industrial milk (e.g. cheese, milk powder, butter) with is sold on both the domestic market and the international market.

No factor is assumed to be completely fixed in production, but land and other farm-owned factors are assumed to be relatively more fixed (have lower price elasticities of supply) than the purchased factors. There are three farm-owned factors: land, cows, and a residual "other farm owned factors". The representation of the land market allows simulating payments based on area, payments based on non-current area (historical entitlements), and farm income. The set of purchased factors cover fertiliser, chemical use, interest, irrigation, feed, machinery and many others.

The PEM model for Norway follows the regionalisation used in the Norwegian Farm Accountancy Register and divides Norway into five regions. It is a stand-alone version of the model that takes world market prices as given and assumes that domestic market prices are fixed via negotiations with producer groups. Domestic consumer prices only adjust when needed to clear markets to avoid additional subsidised exports. The model is calibrated to the situation in Norway in 2017.

Indicators for the four policy objectives

Norwegian agriculture has four major objectives: Food security, agriculture all over the country, value creation, and sustainability with lower greenhouse gas (GHG) emissions. For each objective, multiple indicators are produced using the model results.

Food security

Indicators for food security include self-sufficiency (on a calorie basis), farm land per 1 000 capita and cows per 1 000 capita. The energy content of food used in the calculations is 2 920 kcal per kg wheat, 703.5 kcal per kg milk and 1 697 kcal per kg beef. The numbers are taken from the agricultural sector model Jordmod (Mittenzwei, 2018[3]). The population in 2017 was 5.258 million inhabitants (SSB, 2020[4]).

Table A A.1. Indicators associated with Agricultural Policy Area I "Food security

Indicator	Measure	Baseline value (2017)
Self-sufficiency	Calories produced as share of total consumed	46.5
Farm land per capita	Total farmland hectares per 1 000 population	154.8
Cows per capita	Dairy and beef cows per 1 000 population	169.1

Source: OECD PEM model for Norway

Agriculture all over the country

The objective agriculture all over the country is reflected in 13 indicators. Seven measure the share of various variables in central regions: overall land use, land use to wheat, land use to grains, land use to milk, land use to beef, milk production, and beef production. Eastern lowlands and Jæren are considered central regions with the best natural and climatic conditions for agriculture. Land use at the regional level make up five additional indicators, while the last indicator measures overall land use compared to the baseline. This indicator is meant to cover whether land use in a region changes overall.

Table A A.2. Indicators related to "Agriculture across the country"

Indicator	Measure	Baseline value (2017)
Total land use	Hectares in production in central regions as share of total	45 %
Wheat land	Hectares of wheat land in production in central regions as share of total	94 %
Grain land	Hectares of barley and oats in production in central regions as share of total	76 %
Fodder for milk	Hectares of pasture land used for milk in central regions as share of total	22 %
Fodder for beef	Hectares of pasture land used for beef in central regions as share of total	26 %
Milk production	Production in central regions as share of total	31 %
Beef production	Production in central regions as share of total	35 %
Land use		
Eastern lowlands	1 000 ha	0.261
Jæren	1 000 ha	0.037
Central lowlands	1 000 ha	0.069
Southern valleys	1 000 ha	0.376
Northern Norway	1 000 ha	0.071

Source: OECD PEM model for Norway.

Value creation

Value creation is measured via farm incomes and productivity. Fifteen productivity indicators are included, which differ with respect to the measurement of outputs and inputs. In general, productivity measures output in relation to input. The following formula has been used:

$$\left(\frac{Output_1}{Output_0} - 1\right) - \left(\frac{Input_1}{Input_0} - 1\right)$$

where superscripts 1 and 0 indicate the scenario and the baseline, respectively. Inputs and outputs are valued at base year prices both in the scenarios and in the baseline.

Total factor productivity measures productivity growth of all outputs and all inputs. Productivity indicators are presented for each of the four outputs (wheat, coarse grains, milk, and beef) for all inputs, purchased inputs and farm-owned inputs.

Sustainability with reduced greenhouse gas (GHG) emissions

The fourth policy objective, sustainability with reduced greenhouse gas emissions, is reflected in indictors on GHG emissions, nutrient balances, and selected aspects of cultural landscapes. The parameters to calculate gaseous emission and nutrient balances are adapted from data for Switzerland (OECD, 2015[2]). These parameters are specific to plains, hilly, and mountainous areas. The parameters for plains regions are applied to the eastern lowlands and Jæren. The central lowlands and the southern valleys are associated with hilly areas, while the parameters for mountainous areas are used for northern Norway.

Nitrogen balances and phosphorus balances measure inputs and outputs of the two nutrients from all sources and are calculated on a regional basis. The data used to construct the environmental indicators come from the OECD AEI database along with additional calculations to disaggregate the environmental indicators to match each commodity covered by PEM. The N and P balance indicators were constructed following OECD and EUROSTAT guidelines (Eurostat, 2013[5]; OECD, 2013[6]).

Greenhouse gas emissions in CO_2-equivalents are produced using a conversion factor of 25 for methane and 298 for nitrous oxide following the AR4-report of the IPCC (GWP100). The GHG emission calculations were based on the national GHG inventory methods outlined in IPCC (2006), with the Tier 1 approach used to calculate N_2O emissions from crops, and the Tier 2 approach used to calculate all other GHG emission sources.

Two environmental indicators shed light on aspects of cultural landscapes: the livestock density defined as the number of animals per unit of land devoted to milk and beef production, and grassland as a share of total land use. Both indicators are calculated at the regional level.

Table A A.3. Indicators associated with Agricultural Policy Area IV "Sustainability"

Indicator	Baseline levels (2017)
Emissions	
GHG emissions (mill t CO2e)	4.648
GHG emissions, wheat (mill t CO2e)	0.131
GHG emissions, coarse grains (mill t CO2e)	0.356
GHG emissions, milk (mill t CO2e)	1.540
GHG emissions, beef (mill t CO2e)	2.621
GHG emission intensity wheat (t/ha)	1.566
GHG emission intensity coarse grains (t/ha)	1.770
GHG emission intensity milk (t/dairy cow)	7.004
GHG emission intensity beef (t/beef cattle)	2.948
Methane emissions (1000 t)	114.00
Nitrous oxide emissions (1000 t)	6.03
Nitrogen balance (1000 t)	
Eastern Lowlands	24.82
Jæren	22.16
Central Lowlands	12.10
Southern valleys	19.69
Northern Norway	8.11
Phosphorus balance (1000 t)	
Eastern Lowlands	3.50
Jæren	4.79
Central Lowlands	2.24
Southern valleys	-1.28
Northern Norway	1.80
Livestock density (animals/ha)	

Indicator	Baseline levels (2017)
Eastern Lowlands	1.60
Jæren	2.37
Central Lowlands	1.93
Southern valleys	1.32
Northern Norway	1.02
Grassland share **(%)**	
Eastern Lowlands	25.91
Jæren	93.43
Central Lowlands	47.94
Southern valleys	85.92
Northern Norway	99.67

Source: OECD PEM model for Norway.

Regional structure and data

The data for the Norwegian version of the PEM model have been taken from many different sources. The OECD PSE-database, the OECD Aglink model, the Norwegian *driftsgranskinger* (i.e. counterpart to the EU Farm Data Network FADN) (Kristiansen, 2018[7]), the direct payment register of the Norwegian Agriculture Agency (2020) and a tool to calculate payments at the individual farm level (Mittenzwei, 2018[3]) have been most important.

The PEM model distinguishes five regions as presented in Chapter 1: eastern lowlands; Jæren; central lowlands; southern valleys; and northern Norway. The five regions are chosen to capture regional policy and geographic differences in order to provide a coherent analysis of the regional impact of policy reforms. Each region is relatively homogenous with respect to climatic and natural conditions for agriculture. Regions coincide with the regionalisation of the Norwegian *driftsgranskinger* and allow a straightforward calculation of factor shares for the major types of agricultural production. The regions also largely match the zones that exist for regionally differentiated payments in Norwegian agriculture.

Representation of commodities

Regional production volumes come from the price subsidy register of the Norwegian Agricultural Agency that collects data from dairies, slaughterhouses, and mills for the administration of regionalised output payments. Production volumes for processed products are taken from Norwegian Agriculture Agency that collects data on processed raw milk into different dairy products in connection with the administration of the milk price equalisation scheme. Domestic and international prices stem from the PSE database. Regional differences in output prices are insignificant and administrative prices are negotiated between the farmers' organisations and the government.

Land use for wheat and coarse grains stems from the direct payments register. That register also contains data for fodder on arable land, surface-cultivated land and fenced pastures. It is assumed that 80% of that land is devoted to milk and beef. That factor is taken from the base year of the Norwegian agricultural sector model Jordmod (Mittenzwei, 2018[3]). It is further assumed that milk and beef occupy the same amount of grassland per animal unit. In sum, PEM covers about 80% of the utilised agricultural area in Norway.

The inputs are farm-owned capital, cows, land, concentrated feed, machinery and equipment, hired labour, chemicals, energy, fertiliser, insurance, irrigation, other purchased inputs and interests. The zero-profit condition in PEM facilitates that factor shares are sufficient to calibrate the model to the base year.

Factor shares are calibrated from the *driftsgranskinger* using the economic size unit of a farm as a selection criterion to identify a sufficiently large sample of representative farms for the four productions in the five regions. For grains and milk, farms with more than 99% and 80% of their total ESU from grains and milk, respectively, were selected. Beef production in Norway takes place either in combination with dairy cows or separate (i.e. suckler cows). Dairy farms with a share of more than 150% of their economic value from beef relative to milk and suckler cow farms with more 66% of their total economic value from beef are defined as beef farms. More detailed information on this data source can be found in (Mittenzwei, 2020[8]).

There is no distinction between factor shares for wheat and coarse grains. The shares for each production in each region are calculated based on the unweighted average of the inputs of the farms (Mittenzwei, 2020[8]). The costs for feed concentrates, chemicals, energy, fertiliser, hired labour, insurance, machinery and equipment, irrigation and interests are taken directly from the farm accounts. The cost for land is calculated as the sum of own land and rented land multiplied by the price of rented land. The cost for cows is half the value of cows in the balance and multiplied by the stipulated interest rate for debt. The cost of farm-owned input is calculated as a residual using the zero-profit condition. Farm-owned input is defined as the sum of market revenue and payments minus all other input costs.

Representation of payments

There are many different budgetary payments in Norway. PEM covers the most important of these, as well as milk quota. Certain legal and regulatory constraints are also built into the model structure. Most importantly, the Soil Act requires all arable land, surface-cultivated agricultural land, and fenced pastures to be kept in food production. The aim of the Act is to produce food, maintain the soil's production capacity and to keep up the agricultural landscape. Less than 1% of the utilised agricultural area is denoted "out of production" in the direct payment register (Norwegian Agriculture Agency, 2020[9]).

The standard procedure in PEM is to take payment information directly from the PSE-database. This is not adequate in the case of Norway. In addition to the regionalised nature of payments, there is also a farm structural component in the payment system. This means that payment rates are higher for the first animals than for later animals. In other words, per unit payment rates are negatively correlated with farm size. The rationale is to incentivise farmers not to fully exploit economies of scale. The payment rates in the Norwegian version of PEM are therefore based on a detailed calculation of the most important payments into six payment groups for all active farms in Norway (Mittenzwei, 2018[3]).

The payments within each of the six Norwegian payment groups are linked to single types of support in the PSE database (Table A A.4.). Output payments coincide with output payments in the PSE database. Income support to dairy farms is a scheme where only the first five dairy cows and the first 40 suckler cows of a farm receive support. This payment is categorised as a payment based on non-current animal number with production required, because virtually all dairy farms in Norway have more than five dairy cows. Acreage payments are split between payments based on current area and payments based on non-current area. The latter cultural landscape payment is provided with a uniform payment rate for all crops in all regions. Animal payments and welfare payments belong to the category of payments based on current animal numbers where production is required. Finally, "other payments" contain all payments that cannot be linked directly to the most prominent land uses or animal numbers. Investment support, organic payments, income tax deduction, and fuel concession are examples of those payments.

The payment amounts in Table A A.4. show the payments for Norwegian agriculture. As the PEM model includes only wheat, coarse grains, milk and beef, payment amounts need to be adjusted to account for that selection. The PEM model covers about 78% of the total payment amount or NOK 10 807 million. Income support for dairy farmers is slightly higher than reported in the PSE database; the reason may lie in additional payment regulations that are not covered in the calculations for the individual farms.

The four productions included in PEM account for about half of all output payments. They allocate also almost all acreage payments and two-thirds of the animal payments. Half of the welfare payments can be traced to milk and beef, while nearly all other payments are related to the four productions.

The regional profile of the payment system is clearly visible with lowest payment rates in Jæren and highest payment rates in northern Norway for most payment categories. Regional differences in payment rates are smaller for crop products (Mittenzwei, 2020[8]).

Table A A.4. PSE categories and Norwegian payment groups in 2017

Million NOK

PSE-category / Norwegian payment group	Output payments	Income support to dairy farms	Acreage payments	Animal payments	Welfare payments	Other payments	Sum
Payments based on output	2 347	-	-	-	-	-	2 347
Payments based on variable input use	-	-	-	-	-	751	751
Payments based on fixed capital formation	13	-	-	-	-	547	560
Payments based on on-farm services	-	-	-	-	-	83	83
Payments based on current area, animal number, revenue or income, production required	-	-	1 562	3 037	1 325	1 304	7 227
Payments based on non-current area, animal number, revenue or income, production required	-	1 373	1 464	-	-	-	2 838
Payments based on non-current area, animal number, revenue or income, production not required	-	-	-	-	-	-	-
Payments based on a specific non-commodity output	-	-	-	-	-	66	66
Payments based on other non-commodity criteria	-	-	-	-	-	-	-
SUM	2 360	1 373	3 026	3 037	1 325	2 751	13 872

Source: PSE-database and own compilation.

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OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in Norway

Norway is performing unevenly across its four agricultural policy objectives. While Norway enjoys a high level of food security and is meeting its aim of maintaining agricultural production across the country, both environmental performance and the efficient creation of value added along the food chain are compromised by support policies linked to production levels. Support to producers relative to gross farm receipts is the highest among OECD countries, with 59% of farmers' revenues coming from government support. Only 3% of total support to agriculture is dedicated to research and innovation. Moreover, while Norway has strong public research institutions and well-designed tax deductions, the private sector lacks the right policy incentives to innovate.

This review proposes a new policy approach, centred around innovations that would enable Norway to achieve its objectives and improve the productivity, sustainability and resilience of its agro-food sector. Specific recommendations include increasing the responsiveness of the sector to markets, giving farmers greater flexibility in making production decisions, placing greater emphasis on agri-environmental outcomes, and increasing the role of the private sector in research and innovation.

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