OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in Spain

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Foreword

Policies for the Future of Farming and Food in Spain is part of a series of country studies that apply the OECD Agro-Food Productivity-Sustainability-Resilience Policy Framework (PSR), an evidence-based approach to assess if the policy environment is conducive to achieving sustainable agricultural productivity growth and increased resilience. To date, the PSR Framework has been applied to reviews of Australia, Brazil, Canada, the People's Republic of China, Estonia, the European Union, Japan, Korea, Latvia, the Netherlands, Norway, Spain, Sweden, Türkiye, and the United States.

Reconciling agro-food productivity, sustainability and resilience is a challenge common to all countries, while also unique to a country's specific context and objectives. Following an evidence-based analysis and the comparison of performance indicators across countries, PSR reviews offer country-specific policy recommendations that aim to improve agriculture and food systems policies.

Spain has a dynamic and productive agro-food sector that is competitive in international markets. However, higher productivity has not always reduced environmental pressures, including water stress which is an important challenge for Spain. The Spanish agricultural innovation and knowledge system has much potential to help address environmental challenges and to improve the sector's resilience, but it must be supported by improved co-ordination and an enabling policy and regulatory environment.

This review presents evidence and policy recommendations that aim to inform future actions by Spain to strengthen its agricultural innovation and knowledge system and improve productivity, as well as the sustainability and resilience of the agro-food sector. The proposed recommendations focus on the institutional and regulatory framework that guides and supports agricultural innovation to take full advantage of its potential.

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Acronyms and abbreviations

AC	Autonomous Community
AECID	Spanish Agency of International Co-operation for Development
AEI	Spanish State Research Agency
AI	Artificial Intelligence
AIS	Agricultural Insurance System
AKIS	Agricultural Knowledge and Innovation System
ARCA	Spanish National Livestock Breed Information System
ASAJA	Agricultural Association of Young Farmers
ASF	African Swine Fever
AWU	Annual Work Units
BAT	Best Available Techniques
BERD	Business Expenditure on Research and Development
CAP	Common Agricultural Policy of the European Union
CBGP	Biotechnology and Plant Genomics Centre
CDTI	Centre for the Development of Industrial Technology
CENCA	National Centre for Agricultural Training
CENTER	National Centre for Irrigation Technologies
CGAP	Code of Good Agricultural Practice
CH_4	Methane
CIDIHUB	Canary Islands Digital Innovation Hub
CIHEAM	International Center for Advanced Mediterranean Agronomic Studies
CISA	Animal Health Research Centre
CLUSAGA	Food cluster of Galicia
CO_2	Carbon dioxide
COAG	Co-ordinator of Organizations of Farmers and Stockbreeders
CPVO	EU Community Plant Variety Office
CPVR	Community Plant Variety Right
CRF	Plant Genetic Resources and Sustainable Agriculture Centre
CRIDA	Regional Centres for Agricultural Research and Development
CSIC	Spanish National Research Council
CSP	CAP Strategic Plan
DIH	Digital Innovation Hub
DNSH	"Do No Significant Harm" principle
DUS	Distinctness, uniformity, and stability of plant varieties
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
EC	European Commission
ECOGAN	Spanish General Registry of Best Available Techniques in Livestock Farms
EECTI	Spanish Strategy for Science, Technology and Innovation
EIA	Environmental Impact Assessment
EIP-AGRI	European Innovation Partnership for Agricultural Productivity and Sustainability
ELP 2050	Spanish Long Term Decarbonisation Strategy
ENISA	*Empresa Nacional de Investigación S.A.*, Spanish state-owned company
EPO	European Patent Organisation
ERDF	European Regional Development Fund

ETS	Emissions Trading System
EU	European Union
EUR	Euro
FECYT	Spanish Foundation for Science and Technology
FEGA	Spanish Agrarian Guarantee Fund
FIAB	Spanish Federation of Food and Beverages Industries
FNVA	Farm Net Value Added
FRMP	Flood Risk Management Plan
FTTH	Fibre to the Home
FTTP	Fibre to the Premises
GACSA	Global Alliance for Climate-Smart Agriculture
GAEC	Good Agricultural and Environmental Conditions
GBARD	Government budget allocation for Research and Development
GDP	Gross Domestic Product
GERD	Gross domestic expenditure on research and development
GHG	Greenhouse Gas
GII	Global Innovation Index
GPS	Global Positioning System
GRA	Global Research Alliance on Agricultural Greenhouse Gases
HIBA	Hub Iberia Agrotech project
HNVS	High Nature Value Systems
HPC	High Performance Computing
ICIFOR	Forest Science Institute
ICT	Information and Communication Technology
IEC	Innovative Enterprise Clusters
INIA	National Institute for Agricultural and Food Research and Technology
INNDIH	Valencia Region Digital Innovation Hub
INTIA	Navarrese Institute for Agro-food Technology and Infrastructure
IP	Intellectual property
IPFL	Non-Profit Private Enterprises
IPR	Intellectual Property Rights
IRIS	European Digital Innovation Hub Navarra
IRTA	Catalonian Institute for Research and Technology in Food and Agriculture
ISCO	International Standard Classification of Occupations
LIFE	EU Funding Instrument for the Environment and Climate Action
LUCAS	EU Land Use and Land Cover survey
LULUCF	Land Use, Land-Use Change and Forestry
MAPA	Ministry of Agriculture, Fisheries and Food
MEFP	Ministry of Education and Vocational Training
MCIN	Ministry of Science and Innovation
MINCOTUR	Ministry for Industry, Commerce and Tourism
MINECO	Ministry of Economic Affairs and Digital Transformation
MITERD	Ministry for the Ecological Transition and the Demographic Challenge
MNE	Multinational Enterprise
N	Nitrogen
N_2O	Nitrous oxide
NABIA	Spanish National Water Quality Database
NAPCP	National Air Pollution Control Programme
NEC	National Emission Ceilings
NECP	National Energy and Climate Plan
NGA	Next Generation Access
NGO	Non-governmental organization
NH_3	Ammonia
NOx	Nitric oxide
NRDP	National Rural Development Program
NVZ	Nitrate Vulnerable Zone
P	Phosphorus

PAF	Prioritised Action Framework for Natura 2000
PBR	Plant Breeder's Rights
PCT	Patent Co-operation Treaty
PEICTI	Spanish State Scientific, Technical and Innovation Research Plan
PERTE	Strategic projects for economic recovery and transformation
PGE	Spanish State Public Budget
PGI	Protected Geographical Indication
$PM_{2.5}$	Fine Particulate Matter
PPS	Purchasing Power Standard
RBA	River Basin Authority
RBD	River Basin District
RBMP	River Basin Management Plan
RDP	Rural Development Program
RRF	EU Recovery and Resilience Facility
RTRP	Recovery, Transformation and Resilience Plan
SCAR	Standing Committee on Agricultural Research
SDG	Sustainable Development Goals
SEA	Strategic Environmental Assessment
SEIASA	State Agricultural Infrastructure Company
SIAR	Agroclimatic Information System for Irrigation
SIEX	Spanish Farm Information System (*Sistema de Información de Explotaciones Agrícolas*)
SIIU	Integrated System of University Information
SME	Small and Medium Enterprise
SMR	Statutory Management Requirements
SO_2	Sulfur dioxide
SOC	Soil Organic Carbon Content
SOx	Sulfur Oxide
STI	Science, Technology, and Innovation
SWOT	Strengths, Weaknesses, Opportunities, and Threats
TFP	Total Factor Productivity
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UAA	Utilised Agricultural Area
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UPA	Union of Small Farmers
UPOV	International Union for the Protection of New Varieties of Plants
USD	US Dollar
USDA	United States Department of Agriculture
VAT	Value added tax
VITARTIS	Association of the Food Industry of Castile and León
VOC	Volatile Organic Compounds
WFD	EU Water Framework Directive
WTO	World Trade Organization

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Executive summary

Key messages

- Spain's dynamic agro-food sector has achieved high productivity and is successful in international markets. At the same time, growing environmental concerns, including water stress, remain a challenge to the sector's future.
- Spain has been making efforts to address these environmental challenges in recent changes to agricultural policies. Going forward, this should be kept as a high priority on the agenda. Clear incentives are needed to steer innovation towards environmental sustainability, re-orient policy efforts to mitigate negative environmental impacts and promote a transformation of the sector.
- The potential of the innovation system to contribute to Spain's policy objectives and deliver sustainability and resilience is very high, but it needs strengthened co-ordination and a propitious enabling environment.
- The government should lead in developing and implementing an ambitious agricultural innovation strategy focused on reconciling productivity with environmental sustainability. A strengthened Agriculture Knowledge and Innovation System (AKIS), including advisory services, will foster the flow of knowledge and the adoption of innovation.

Spain's agro-food sector is competitive and successful in international markets. The diverse Spanish agriculture has proven able to adapt and respond to international trends and demands in traditional export markets and in emerging new markets. Spain is among the top world exporters of many agro-food products, and its agriculture and up and down-stream industries are an important part of the local economy and a significant source of income in many regions.

However, this positive performance is not exempt from environmental sustainability concerns, particularly in the case of water. Spain has one of the highest levels of water stress amongst OECD countries, and climate change is likely to reduce average annual rainfall and increase the frequency of acute droughts in many country locations. Agriculture − being at the origin of 80% of water demand − would be one the most affected sectors. Pollution from agricultural nutrients also affects water quality and threatens important ecosystems. The set of economic, regulatory and governance incentives existing up to now needs to evolve to address the challenge and urgency of water pressures from agriculture and its capacity to adapt to climate change. Although the most recent data shows an improvement, Spain did not meet its emissions commitments for ammonia − most of which comes from livestock activities – between 2010 and 2020, and the sector's contribution to the country's greenhouse gas (GHG) emissions increased.

Spain is embarking on policy efforts to tackle these environmental challenges. New policies and regulations are supported with substantive funding from the 2023-27 Common Agricultural Policy (CAP) and the EU-wide COVID-19 recovery funds. Among other objectives, they aim to mitigate negative environmental impacts, promote a transformation of the sector, and attain ambitious sustainability and

innovation objectives. Support to farming from the EU's CAP is increasingly subject to environmental conditionalities, and Spain has been able to tailor some measures – in particular the eco-schemes – to its needs and ambitions through the CAP Strategic Plan (CSP). An innovative and promising farm information system (SIEX) has been approved and is in development to track farm practices for emission control, estimate GHG and ammonia emissions and monitor fertiliser use at the farm level for farmers and policy makers.

The Spanish innovation system has much potential to contribute to Spain's policy objectives and to ensure the sector's environmental sustainability. The country's dynamic agro-food sector must receive clearer environmental incentives, both economic and regulatory, and a stronger innovation response to balance productivity and sustainability objectives, and to respond more assertively to the challenges brought by climate change. The Agriculture Knowledge and Innovation System (AKIS) is fragmented; linkages and co-ordination among the diverse actors must be strengthened to create critical mass and foster the creation and flow of knowledge and the adoption of innovation. Spain is very good in the production of scientific knowledge and is one of the most successful participants in collaborative approaches at the EU level, but research often struggles to reach the productive sectors. Advisory services differ across Spain's Autonomous Communities (ACs); strengthening them can play an important role in the adoption of innovative and sustainable practices at the farm level.

The government could lead in developing and implementing an ambitious agricultural innovation strategy. All policy levers should converge to make innovation the cornerstone for reconciling environmental performance and productivity growth. A comprehensive innovation strategy for the agro-food sector would complement the changes promoted by the new CAP Strategic Plan and reinforce their potential to promote a transformation. This entails clearly targeting agricultural policies − in particular the implementation of the new eco-schemes in the Spanish CSP − and evaluating their impact and effectiveness, including through the collection and use of data. Increased public investment on innovation and improved incentives for private investment, supported by a clear and stable administrative and regulatory environment, will play a key role.

Recommendations for improved policy in Spain cover three main areas

- **Strengthen institutions, policies and regulations to strategically guide and support agricultural innovation.** Spain should develop an ambitious and comprehensive agricultural innovation strategy. Agricultural policies should be better targeted to specific income or environmental objectives and supported by an agricultural data strategy to improve the collection and use of data for policy design, assessment and monitoring. Administrative simplification and clear and stable rules would also help promote innovation and effectively implement the actions included in the new CSP.
- **Boost the agricultural innovation system and exploit its synergies to make it work for sustainability.** The AKIS should be strengthened to obtain maximum advantage of its diversity. This includes better co-ordination, enhanced public-private collaboration and engaging farmers in the development process. Spain should increase public investment and create incentives for private investment, ensure access for SMEs, and promote the efficient use of innovation funding. Further reducing the digital gaps will encourage the adoption of digital technologies. Farm advisory services can be harnessed to better respond to the environmental challenges and farmers' needs.
- **Tackle urgent environmental pressures via innovations that will lead to more sustainable agriculture**. Given the serious water pressures, urgent action is required to address the full extent of this problem and the responsibility of the agricultural sector. The impact of irrigation policies deserves an in-depth assessment to make sure that they tackle water stress, and insurance policies should be aligned with the need for climate adaptation. Mitigation and adaptation actions should be strengthened to better respond to climate change and ensure the sector's preparedness.

Assessment and recommendations

Assessment of performance

A productive, competitive, and dynamic agro-food sector in transition

Spain is the second-largest country in the European Union (EU), with a climatic diversity that has allowed for the development of a variety of crop and livestock activities in an agricultural area that covers more than half of its territory. The contribution of the agro-food sector to the economy – with 5.2% of total value added – is above the OECD and EU averages.

Agro-food exports represent 18.3% of total exports of goods for Spain, a share higher than for many peer countries. Spain's agriculture and food industry is productive, competitive, and successful in international markets. Farmers in export-oriented sectors are able to adapt and respond to international trends and demands, both in Spain's traditional export markets and in emerging new markets. This is evidenced by the growth of several strong export-oriented sectors, including conventional and organic fruit and vegetables, which are mostly sold in the EU market, and pig meat, which is exported mainly to Asian markets.

Agriculture is an important part of the local economy and source of income in many regions of Spain. The development of agricultural production has in many cases driven the development of supporting industries and services, such as processing, distribution and research. Examples include the clusters of supporting industries around organic agriculture and greenhouse horticulture, which are important motors of local growth and employment in some regions.

Farms are increasing in size and becoming larger commercial operations

The productivity gains and export growth in Spanish agriculture have come together with and are the result of a shift away from small family farms toward a more commercial farming model. This is evidenced by an increase in the number of large farms (with 100 hectares or more) and in their share of the total agricultural area, as well as by the decrease in the work done by farm owners and family workers, to some extent replaced by contracted labour, including more immigrant workers. Between 2009 and 2020, the number of farms of less than 100 hectares fell by almost 65 000 or 7%, while the number of larger farms grew by over 4 500 or 9%. Smaller farms tend to be managed by older farmers, and their reduction highlights the generational renewal challenge that is not exclusive of Spain.

Spain has undertaken policy initiatives to improve the gender balance in the sector, but change has proven to be challenging

Spain has shown a proactive approach to harness agricultural and rural development policy for improving the sector's gender balance, including through legal reforms and payments that target women. The 2011 Shared Ownership Law was a significant step to increase the visibility and active role of women in agriculture, giving them an equal status with their partners in family farms. Over ten years after this reform, the number of female farm managers has increased, but female managers still represent only 29% of the total. The number of farms registered under the shared ownership model represents only 0.1% of the total number of farms in Spain, well below the original expectations. This deserves a deeper examination of the causes and difficulties to comply with some of the requirements of the law.

Spain is one of only two EU Member States that include in their new Strategic Plan (CSP) for the 2023-27 Common Agricultural Policy (CAP) the objective of improving participation of women in farming, and one of five that propose specific measures supporting rural women. The main measure is an increase of 15% in the complementary direct payment for young farmers (of 40 years or less) if the beneficiary is female and owns or co-owns the farm.

Productivity is growing, but environmental sustainability remains a challenge to ensure the sector's future

Even if it has slowed down in the last decade, agricultural total factor productivity has for long been the main driver of Spain's agricultural output growth. However, the OECD Agri-Environmental indicators show that the sector's good performance from the perspective of productivity, output and exports has not been exempt from sustainability concerns.

Spain's agricultural greenhouse gas (GHG) emissions grew between 2013 and 2020, even as the emissions level of the whole economy declined. Agriculture represents 14% of total emissions in Spain, an increase from 11% in 2000. The productivity gains in recent years have allowed to reduce the average emission intensity of the sector but have not been sufficient to revert total emission growth. In its National Integrated Energy and Climate Plan 2021-30, Spain has set ambitious GHG reduction goals, including a target for the agriculture sector, which must reduce its GHG emissions by 18% with respect to 2005.

The important expansion of the pig meat sector and the strong increase in pig livestock numbers has brought about an increase in GHG and ammonia emissions, which has resulted in a consistent failure to meet Spain's ammonia emission ceilings. Fertiliser use has also increased in recent years, as have the nitrogen and phosphorus surpluses. Pollution from these nutrients is impairing the quality of Spain's ground and surface waters, increasing the already high levels of water stress, and threatening important ecosystems.

Addressing these problems has been prioritised in Spain's agri-environmental policies, including the CSP for the 2023-27 CAP and the measures promoted under the Spanish Recovery, Transformation and Resilience Plan (which uses EU funding to mitigate the impact of the coronavirus pandemic). Some of the efforts that Spain is undertaking include the development and revision of the regulatory framework for the environmental sustainability of livestock farming, a new regulation on sustainable nutrition in agricultural soils, and the development of a registry of Best Available Techniques in livestock farms (ECOGAN) and an electronic farm notebook for monitoring fertiliser application at the farm level.

Innovation can play a key role in balancing productivity gains and environmental sustainability, if supported by ambitious policy strategies

The innovation system in Spain has delivered productivity and competitiveness in world markets. However, it seems to have underdelivered in some areas of environmental performance and in adaptation to climate

change. Spain's innovation has had a moderate performance relative to other EU countries, with heterogeneity among Autonomous Communities (ACs). The Spanish Agriculture Knowledge and Innovation System (AKIS) is better in science than in developing innovation and facilitating adoption. The main obstacles to harnessing innovation are the low public and private investments, the fragmentation of the AKIS, and a low co-ordination between the national and regional administrations.

Innovation and digital technologies are strong tools to address the environmental sustainability challenges, but they require public and private investment under an ambitious strategy that includes all policy levers: from innovation funding to agricultural and environmental policy incentives. This strategy also needs to be supported by a system to collect data for monitoring and evaluation that allows self-assessment by farmers and other actors and enables policy assessment and implementation by the government.

Spain should continue reducing the urban-rural digital gap to guarantee that digital technology is an engine of innovation in agriculture

Spain has made important progress in reducing the rural-urban gap in access to digital technologies. However, differences persist between rural and urban areas in access to high quality broadband and in digital use and skills, often linked to farmers' age and farms' size. Further reducing this gap is critical to ensure that digital becomes an enabling technology that, as in other sectors, fosters innovation in all aspects of the agro-food sector.

Tackling environmental pressures should be a priority with clear incentives to foster innovation for sustainability

Water stress is a longstanding environmental concern that must be prioritized with a more comprehensive and ambitious policy approach

There is a significant risk of pluviometry reduction due to climate change in many regions in Spain, reducing the average annual rainfall and increasing the frequency of acute droughts. This trend has been affecting the Spanish agriculture for decades and is expected to continue in the future. Its impact is already visible in many locations. It is not surprising that the availability and distribution of water have long been a matter of concern in Spain, while water quality is also becoming a growing and interrelated concern. The level of water stress continues to be one of the highest in the OECD; and in October 2022, Spain registered the lowest groundwater levels for that month in a decade (MITERD, 2022[1]). The expansion of irrigated agriculture has traditionally been a response to climate dryness; however, as agriculture is the origin of 80% of water demand, it imposes much pressure on the resource. At the same time, agriculture is one of the sectors most impacted if less water is available.

Spanish water policies have evolved throughout the decades, from exclusively being concerned with managing and distributing water quantities across the territory, to giving greater emphasis to quality and environmental aspects. Spain dedicated significant public resources in the past to expand irrigation, but in the last two decades shifted the policy effort to the modernisation of irrigation infrastructure. This has resulted in an important increase in the use of localised methods (such as drip irrigation, which currently is used in over half of the irrigated area) and a decrease of 1 403 cubic hectometres in the volume of water distributed to farms between 2000 and 2018. The total public investments by national and regional authorities on irrigation modernisation and transformation were of EUR 3.8 billion between 2000 and 2021. Additional public investments of over EUR 800 million to further modernise irrigation systems are planned for the coming years in the framework of the Recovery, Transformation and Resilience Plan (RTRP) and the rural development plan for the 2023-27 CAP. These investments will be subject to environmental standards, with a prioritisation of actions that use new technologies to generate water and energy savings.

The irrigation modernisation programmes have brought benefits, such as reduced abstraction, increased production, and a more efficient use of fertilisers through the use of fertigation. At the same time, multiple international studies have noted that irrigation efficiency improvements can be associated with a higher water consumption, and the evidence suggests that technology modernisation policies should be accompanied by other policies to control water demand, cap abstractions or limit the irrigated area. In the case of Spain, the total irrigated area has constantly expanded in the last two decades, growing by 17% between 2002 and 2021. The lack of a comprehensive evaluation of the impact of this large public investment programme makes it difficult to assess its effectiveness in reducing water pressures.

The current policy focus on irrigation efficiency is not delivering enough response in terms of total water use and water quality…

The OECD Council Recommendation on Water calls for promoting water use efficiency to alleviate pressure on all surface and groundwater resources, taking into account the need for groundwater recharge and environmental flows. In Spain, the agriculture authorities in charge of irrigation policies have no influence over the volume of water supplied to farms. This is authorised by the river basin authorities, based on the availability of the resource and users' entitlements, in particular through the irrigation communities of farmers in each river basin. The efforts of the agriculture authorities in irrigation policy thus concentrate on increasing efficiency at the irrigation point. Efforts are made to co-ordinate the planning of irrigation modernisation works with the basin authorities: prior to drafting the project for an irrigation work, the basin authority is requested to report on the availability of water. Once the work is completed, the basin authority is notified so that it can act accordingly.

The recent establishment of a National Irrigation Board (*Mesa Nacional del Regadío)* is a welcome step towards a broader approach and increased co-ordination. It will promote co-operation, consultation, analysis, and information exchange among the authorities at the national and regional levels, river basin authorities, users, environmental organisations and other stakeholders.

In Spain, all small groundwater abstractions of less than 7 000 m^3/per year must be registered, but they do not require a permit, unless they are in water bodies at risk. Illegal abstractions are an additional element of pressure on the groundwater reserves; yet, the extent of the problem is not fully known due to the lack of official data. Efforts should be made to quantify and understand the dimensions of the problem, and to ensure an agile enforcement (i.e. closing of illegal wells). Illegal abstractions are a potential loophole for a coherent, comprehensive and effective water and irrigation policy.

Around 20% to 35% of ground and surface water bodies is at risk from diffuse pollution from bad agricultural practices, among other sources. High nitrate concentrations especially affect groundwater bodies. Eutrophication from excess phosphorus is also affecting the quality of water bodies, with the Mar Menor saltwater lagoon as its most visible example. In some areas, particularly in the Mediterranean, the quality of groundwater has also been affected by salinisation driven by the over-abstraction for irrigation and other uses. Policy efforts in Spain have focused on promoting a more efficient application of fertilisers and on actions targeted to most vulnerable areas such as the Mar Menor watershed.

…and must better reflect the sense of urgency: A deeper change in paradigm is needed

Water prices can be an important part of the policy mix to manage water resources, address negative externalities and improve the financial sustainability of infrastructures and services. Information on the water prices established by the basin authorities in Spain is scattered and hard to find. The lack of data makes it difficult to assess the extent to which costs are recovered and prices reflect water scarcity, as well as the prevailing pricing methods and the extent to which irrigation water is metered and priced according to volume. Since 2009, the installation of meters and volumetric pricing is required for any irrigation infrastructure that is modernised using government subsidies. Water pricing is not only a good

instrument to better allocate water according to its current scarcity, but also a good signal to induce private innovation towards the best adapted responses to climate change, be it in terms of irrigation efficiency, crop mix or others. In general, water data in Spain, including data on water pricing, and water use and consumption, is not available at a single database.

As agriculture is the most important user of water, irrigation communities play a particularly important role in water management at the river basin level. Irrigators sit with other stakeholders in the governing and management bodies of the river basin authorities, which make decisions on water management. This model of broad user participation has been in place for a long time and contributes to peer control and monitoring. However, the importance of irrigation water in some river basins may give a dominant role to irrigation communities. To ensure the representation of other users and voices such as environmental groups, civil society or the scientific community, the decisions on water entitlements are a matter of state level competence, and the number of representatives from the different users in the governing and management bodies is regulated by law.

The current situation of water scarcity and risk for water quality and ecosystems, already exacerbated by the impact of climate change, call for a paradigm change, both from the authorities at all administration levels and from the users. In August 2022, the government launched a preliminary public consultation towards a reform of the Spanish water law. This legal reform is an opportunity for Spain to broaden the discussion and the institutions to a diversity of actors, engaging the agricultural sector according to its responsibilities, in order to better align Spain with the OECD recommendations and the EU Water Framework Directive, and ultimately promote the necessary paradigm change.

Subsidies and tax advantages for agriculture in Spain could potentially increase irrigation water use or be harmful for the environment

Irrigation has been a cornerstone of the development of Spanish agriculture and of national agricultural policy programmes; the differences in yield between irrigated and rainfed production are significant. The direction of water policy has evolved to give greater consideration to environmental aspects. While irrigation works and other agricultural practices are increasingly subject to environmental requirements, irrigation and other sectors benefit from low electricity taxes, subsidies for the use of desalinated water and exemptions from water taxes and fees at the regional level. As in the case of other sectors, these measures often seek to address concerns about the economic sustainability of certain activities or respond to emergencies. For example, in March 2022, facing the most severe droughts in decades, the government implemented emergency measures to alleviate farming costs and short-term income, including tax reductions, reduced costs for desalinated water, and in some cases lower water fees (Gobierno de España, 2022[2]). While these *ex post* risk management measures are often triggered by the need to ensure the survival of certain activities, they are unlikely to contribute to incentivising a lower water use, alleviating the underlying causes of water scarcity, or promoting adaptation of the sector for the medium to long-term.

Beyond water policy, agriculture benefits from tax reductions for its use of fuel, lower VAT rates for inputs such as fertilisers, pesticides and plastics, and exemptions from numerous regional taxes on GHG emissions. OECD research has found that fuel tax rebates and low energy prices stimulate the use of fossil fuels and greenhouse gas emissions and that some agricultural subsidies can lead to the overuse of pesticides and fertilizers (OECD, 2005[3]). Already in 2015, the OECD advised Spain to identify and remove fiscal measures and subsidies that are environmentally harmful and economically inefficient, including fuel subsidies for the agricultural sector, taking account of potential social impacts (OECD, 2015[4]). The problems of pollution from agriculture and over-abstraction of water might merit a revision of these subsidies and tax exemptions in light of the growing environmental pressures. In order to foster innovations that respond to the sustainability challenges and environmental externalities, incentives are needed for finding innovative solutions. The inclusion as a priority for the selection in the European Innovation

Partnership “Agricultural Productivity and Sustainability” (EIP-AGRI) of projects that seek new sources of nutrients and improvements in the efficiency of their application is a welcome step in this regard.

As climate change impacts grow, adaptation and resilience require more determined policy action with a holistic approach

Warmer temperatures in some regions may favour certain agricultural activities and even open new market opportunities for Spain. However, the growing water scarcity and advance of desertification brought about by climate change threaten the future of the whole sector. An increase in extreme weather events, including droughts, is reflected in the annual loss rate of the Spanish Agricultural Insurance System. Adaptation to this new reality must become a main guiding objective of Spanish policy. Agricultural insurance is an important tool, but it cannot be the only one: it must be complemented by other preventive and adaptation measures and actions by farmers.

In the context of high loss rates and taking into account that agricultural insurance subsidy levels had been reduced in the previous decade, the Spanish government has taken measures to strengthen the system. For example, in 2022, it modified the reinsurance scheme, with the public reinsurer consortium taking on a greater role in protecting the system through its stabilisation reserve. In addition, the government increased support for agricultural insurance by raising the base subsidy by 10 percentage points, the same amount by which it had been reduced in 2016.

While these measures help guarantee that the system remains operational and solvent, this may not be sufficient in the long term, as severe weather events become even more frequent and serious. Spain should take this into account in its climate risk management and resilience strategy and complement the insurance system by incentivising climate change adaptation with less water-demanding production and investment on preparedness to the new climate and risk environment.

Spain has recognised in its CSP the need to adapt the insurance system to guarantee its solvency and sustainability in light of the new reality. Recognising the need to make the necessary adjustments to ensure the effectiveness of the system is a good step, but more far-reaching actions may be necessary to maintain the solvency of the system and the sustainability of production, avoiding the emergence of adverse selection and moral hazard problems. The OECD has recommended that Spain develops a broad framework for disaster risk management in agriculture, defining the role of all government policies and farmers’ strategies (Antón and Kimura, 2011[5]). Beyond insurance, policy action should promote preparedness and adaptation by farmers, enhancing their role and responsibility in managing their risks and adapting to a changing climate.

Agricultural policy is evolving, but there is room for policy choices and regulations to better reflect environmental and innovation priorities

The change in CAP delivery through national strategic plans is an opportunity for Spain to tailor policy to national needs…

As discussed, the two main nationally financed agricultural policies in Spain are irrigation and insurance. The EU Common Agricultural Policy is the most important source of funding to the sector. Spain is one of the top beneficiaries of CAP expenditures, even if they represent a lower share of gross added value than for the EU as a whole (European Parliament, 2022[6]). The CAP 2023-27 offers for the first time the opportunity to Spain – and all EU member states – to orientate CAP expenditure in the direction that better fits its national circumstances and environmental pressures. The strategic orientation, priorities and actions to be undertaken in 2023-27 have been spelled out in the new CAP Strategic Plan (CSP) which started implementation in January 2023.

An important feature of the new CSPs is that Pillar 1 measures that used to be fully designed at the EU level are now part of the national strategy. In the case of Spain, rural development measures under Pillar 2, which previously were presented separately in one national plan and 17 plans for each of the Autonomous Communities, have been consolidated into a single plan. The ACs remain responsible for implementing the specific measures according to their needs and priorities. The development of a single strategic plan required a substantial co-ordination effort between national and regional authorities. This new delivery model is an important step towards an agricultural policy that better responds to the national needs, but at the same time represents a co-ordination challenge that must balance the priorities and production structures at the regional level with the environmental, innovation and sector resilience goals at the national level. Ensuring an agile and continuous discussion among all relevant actors will be key to reach this balance.

…but continuity has prevailed in keeping income support that is not fully targeted and tends to prevent change…

Income objectives are a priority for the Spanish government, as expressed in the CSP. This includes direct payments as a safety net, redistribution of payments to medium and smaller farms and convergence of payments across regions. Ensuring a basic safety net from stable income support for farmers is a declared priority. Achieving a redistribution of these payments to small and medium-sized farms and reaching a convergence of direct payments among the 20 agricultural regions (different from the territorial delimitation of the ACs), are also important policy objectives. Focus is given to ensuring the continuity of farming by preserving farmers' income as a means to prevent the abandonment of rural land and the lack of generational renewal. Direct and complementary payments take up the largest share of payments, with no redistribution of funds towards the rural development pillar.

While in general EU policies have made progress in moving towards less market distortions and higher income transfer efficiency, the CAP direct payments are not the most suitable instrument to provide a safety net for farm households and tend to create barriers to entry, including for young farmers and women. Spain has made efforts to improve the targeting of these payments, for example by cross-checking data of CAP payment recipients with tax and social security data to examine the importance of agriculture as an income source and the extent to which farmers perform other activities (MAPA, 2020[7]), and through the use of the available tools for capping and redistribution.

The main shortcoming of CAP direct payments as designed at the EU level is the gap between the ambitious goals being set for the sector and the implementation of results. An EU-wide discussion is needed on the targeting of CAP payments and the relative weight and resources given to income, environmental or other objectives (OECD, forthcoming[8]). Direct payments tend to be proportional to land, providing more support to larger farms, and adjustments to the payments' provisions may not revert this regressivity of income support. Moreover, eligibility is based on income from agriculture only, hence not taking into account other economic activities that farmers or farm households may have. The OECD has noted that objectives related to low farm household incomes could be addressed through income and social policies that are better targeted (OECD, 2002[9]). Social safety nets can be an effective means for income support that ensures equal treatment between agricultural and non-agricultural households (OECD, 2021[10]). In any case, targeting income objectives requires measuring the full farm household income to estimate the prevalence of low income among farmers and design safety net policies addressing low-income concerns among farm households.

If income is a priority, data efforts for measuring farm household income should also be a priority. Continuing the efforts to cross-check income data started during the CSP preparation, including through strengthened collaboration between the public entities involved, is a valuable step that Spain could take in this direction. The European Union plans to convert the Farm Accountancy Data Network (FADN) into a

Farm Sustainability Data Network (FSDN) may also include the collection of information related to non-agricultural income from farms.

Spain is one of 20 EU Member States that will dedicate more than 10% of their direct payment envelope to providing income support coupled to production. With 14% of the Pillar 1 budget, the share of coupled payments in Spain's new CSP is higher than in the previous CAP period and close to the allowed ceiling. Coupled support is less efficient in transferring income to farmers (OECD, 2003[11]). Furthermore, the OECD has called for a transition towards less coupled payments to support a reduction of climate impacts and further strengthen the sustainability of production (OECD, 2022[12]).

The stated objective of these payments is to maintain types of farming that are vulnerable from a social and economic point of view, and to support their transition to more sustainable production models. Spain has made efforts to increasingly subject these payments to environmental conditionalities, for example by excluding individuals or legal entities that have been sanctioned for illegal water use or by requirements on sustainable inputs management and contracts. In addition, some coupled payments are targeted to crops that generate positive externalities (such as nut production in areas at risk of desertification due to low precipitation levels or steep slopes). While coupled payments are designed to create incentives to keep the activity, they might not create incentives for the needed transition. It might be worth considering whether this model is keeping farmers in activities that are no longer viable, affecting the entrance of young farmers, or even discouraging innovation.

… while environmental sustainability is mainly reflected on new eco-schemes that in Spain are focused on practices related to carbon agriculture and agroecology

In line with the general EU policy direction, Spain's CSP represents an effort to move the focus toward agri-environmental objectives. The CSP includes strengthened conditionality requirements for direct payments – including a new national good agricultural and environmental condition (GAEC) on sustainable nutrition of agricultural soils aiming to fight water pollution and ammonia emissions – voluntary eco-schemes and several rural development measures (such as irrigation infrastructure investments and organic farming support). It will be important that the conditionality is properly enforced, and non-compliance sanctioned at the national and regional levels, in order to ensure that requirements and conditions (such as not granting support to those previously sanctioned for illegal water use) actually realize their potential impact.

The voluntary eco-schemes cover issues related to biodiversity, low-carbon agriculture, permanent pastures, and soil conservation. Payments are granted to farmers for implementing in a given plot of their farm one out of a "menu" of seven management practices. The payment applies to only one practice per plot of land. Not all practices from the menu are applicable in every type of farm. For farmers that are able to apply several practices on the same plot, no incentive is provided for going beyond the minimum of one practice. On the other hand, there are supplements for repeating certain practices on the same area in successive years. One of the considerations for this design is that, for a given budget, an additional payment for a second practice would require a reduction of the first payment, which would disincentivise uptake of the first practice. Another consideration is that agri-environmental measures under the second pillar could potentially pay for additional practices that complement the eco-schemes.

If taken up and implemented with the planned ambition, the eco-schemes could mark the start of a shift in the sector towards the application of farming practices that contribute to reverting trends such as the observed decline in Spain's biodiversity and the increasing soil degradation. However, there is no evidence of the impact that these practices may have over the whole country. As farmers become more familiar with the practices, and their adoption increases, Spain could consider adjusting the incentives to encourage the application of more practices, gradually introducing additional or more ambitious measures, or even making them mandatory. Farmers must have the appropriate incentives to adopt and consistently apply

these practices. Outreach efforts, training and farm advisory will be essential to change farmers' mindset towards environmental sustainability, as will be an accurate follow-up and monitoring of compliance.

Implementing and monitoring good environmental practices, changing the mindsets and inducing subsequent innovation require investments on good data…

Precise and timely data are essential for strategic planning and decision making by farmers, industry and policy makers, and for implementing better policies. Together with the new CSP, Spain counts on the Recovery, Transformation and Resilience Plan (RTRP), financed by the Next Generation funds of the EU. Spain may embark in a significant public policy and investment agenda for the next years, which could help achieve a transformation of the agricultural sector and reach ambitious sustainability and innovation objectives. Significant funding from the EU and the national and regional budgets has been allocated for these plans: EUR 32.5 billion for the implementation of the CSP during the 2023-27 implementation period, and over EUR 1.8 billion for the reforms and investments of agro-food and fisheries, water management and irrigation modernisation within the RTRP up to the end of 2026. It is critical that a significant part of these funds focus on data collection and processing, including through digital technologies, and on inducing the development and adoption of innovation for sustainability.

Spain must step up its efforts to develop indicators and collect the necessary data to monitor and assess the effectiveness with which these policies are meeting their objectives. As part of this effort, policies should support farmers' investment on information systems to track and monitor the environmental performance of their farms, and advisory services that contribute to that end. The new farm information system (SIEX), with the Digital Farm Notebook and the ECOGAN registry for livestock farms, represents a significant effort to collect information that may allow to track farm practices for emission control, estimate greenhouse gas and ammonia emissions, and monitor fertiliser use at the farm level. The Agroclimatic Information System for Irrigation (SIAR) also represents an innovation to allow for a precise estimation of the water needs of crops, through the collection of agroclimatic data and calculation algorithms. Good farm-level data may allow for better monitoring the evolution in priority areas at the regional and national level and make it easier to identify potential adjustments needed in policy measures. Co-ordination and communication between the authorities at the different levels is essential to ensure the implementation of the system.

Also essential is the creation of incentives for farmers to invest in data and digital information systems on farm. National and regional budgets must contemplate appropriate funding for the implementation of these investments on information systems, in line with the ambition of the changes sought on environmental performance. This has been considered for example in one of the sectoral interventions of the new CSP, which will support producers' organisations of fruits and vegetables, with the requirement that at least 2% of the expenditure is earmarked for research and innovation.

...as well as ex post evaluation of policies, including of the eco-schemes and irrigation modernisation programmes…

The *ex ante* environmental assessment of legislation, public plans, programmes and projects is well-established in Spain, and it is widely used at the national and regional levels; one recent example is the *ex ante* assessment of the new CSP. Although *ex post* evaluation is important to assess whether laws are working as originally intended and, if not, to propose improvements, the use of this type of evaluations across OECD countries remains low. Spain is not an exception: for example, the authorities have not conducted a full *ex post* evaluation of the effectiveness of the irrigation modernisation policy, despite the long duration of the programmes and the magnitude of the public investments involved.

The 2015 *OECD Environmental Policy Review of Spain* recommended strengthening capacity for conducting *ex ante* and *ex post* economic analysis of environmental policies and regulations; establishing closer links between the administration and the research community in this regard; and systematically

conducting regulatory impact assessment for major regulatory initiatives, among other aspects (OECD, 2015[4]). Spain should ensure that sufficient financial and human resources are allocated to the management, data collection, analysis of results, monitoring and evaluation of the new policies and regulations, including the CSP. The evaluation of the impact of the eco-schemes on the environmental performance of the farms and the sector, and of the irrigation modernisation policies is of particular importance. Spain is currently developing the Evaluation Plan of the CSP, as required by the EU regulation. The recent establishment of a collaboration agreement between the Ministry of Agriculture, Fisheries and Food (MAPA) and the Spanish National Research Council (CSIC) for developing analysis and indicators to monitor and evaluate the CSP is a key step in this regard. It will be essential to guarantee its functioning beyond the initially foreseen three years of duration and ensure that the experience and capacities generated from this collaboration benefit future policy processes.

… and SMART regulatory approaches that foster innovation

Spain tends to favour a regulatory approach in its policies and has developed a large set of legal and regulatory instruments to respond to different challenges in the areas of agriculture and the environment. There is a complex set of rules in different environmental domains and at different administration levels. In this respect, the OECD has suggested that Spain develops an environmental code to consolidate the numerous acts that exist in this area (OECD, 2015[4]). There has been progress in this regard through the development of Electronic Water Codes that compile and publish online the state and regional regulations on water management.

This regulatory approach also prevails in science and innovation policy, where the OECD has recommended that Spain reduce the regulation of every aspect of the system. Instead, a progressive transition to a framework governed by general principles, codes of conduct, guidelines and good practices that are reviewable would help to effectively respond to the needs of the collaboration and knowledge transfer system's actors (OECD, 2021[13]).

Regulations are an important part of the policy toolkit available for countries to manage externalities and public goods connected with agriculture. A first rule of good policy design is having SMART (specific, measurable, achievable, relevant, time-bound) objectives. According to the OECD Recommendation on Agile Regulatory Governance to Harness Innovation, governments can design regulations that encourage innovation through more flexible, iterative and adaptive regular assessments of whether regulation remains fit for purpose and delivers its policy objectives. The opportunities provided by digital technologies could be utilised to improve the quality of evidence (Martini, 2023[14]).

The potential of the innovation system to improve sustainability and resilience is very high, but needs policy ambition and a propitious enabling environment

Spain has relatively high-performing science and research communities, as well as institutions that are well integrated in the single European Research Area. Its dynamic and competitive agro-food sector needs to be further exposed to the right environmental incentives to respond more assertively to the big challenge of adapting to dryer climate conditions and balance productivity and sustainability. The links between the different actors in the AKIS need to be strengthened, to foster the creation and flow of knowledge and the adoption of innovation that responds to these needs.

The Spanish agricultural innovation system needs to avoid the costs of fragmentation, with a shared national vision of the AKIS that exploits the advantages of its diversity

The Spanish AKIS is highly fragmented. It involves many actors of different sizes and characteristics at national and regional levels, and a decentralised governance. Autonomous Communities (ACs) lead

regional AKIS systems, which include research and development (R&D), innovation, and knowledge transfer policies. The central and regional governments exercise competences in agricultural-relevant R&D and innovation policies within the EU framework.

A decentralised system allows for the development of strategies that respond better to the local needs and specificities. However, to be successful, it also requires co-ordination and joint planning to strengthen knowledge flows and to build critical mass. The co-ordination of the national AKIS has so far been weak, hindering collaboration between ACs, which is needed to face global problems. The CSP includes several references to the AKIS and a compromise of creating an AKIS co-ordination body, which is currently in development. However, there is no national strategy specifically defining common agricultural innovation priorities and each region sets up its own smart specialization strategy depending on its own production systems and priorities.

ACs are very heterogeneous in terms of resources and have not always committed enough funding to the AKIS. In several ACs, policy responsibilities linked to the development of the regional AKIS are dispersed among different institutions, which are often not able to co-operate effectively with each other, hampering co-ordination at the regional level. Spain's eighteen public agricultural research centres are very diverse. There are differences in their size, with some large institutes that address a wide range of issues and smaller ones that focus on specific regional issues. The connection and co-ordination between them could be improved in the whole AKIS system. Some regional research centres have additional problems, such as increasingly ageing staff or the impossibility to hire new researchers due to budget constraints. In some cases, these centres lack the critical mass needed to be competitive and succeed in open calls for proposals at national and international levels. Existing channels to enhance co-operation between the research centres and the agro-food sector are weak, and the collaboration tends to be sporadic, temporary, and highly dependent on personal relationships.

Although Spain has achieved very good results in scientific production, this research often struggles to reach the productive sectors, and the transfer system tends to be linear, with little involvement of farmers: the research originates in the research, development and innovation (R&D&I) centres and then it is applied in the field. As in other sectors, collaboration between scientists and the business sector is affected by several limitations, such as the absence of effective intermediaries, lack of business demand, legal and administrative barriers, lack of skills or experience, and lack of financial or other incentives (OECD, 2021[13]). In addition, there is a weak connection with farmers and other actors of the AKIS, often small-sized stakeholders, which creates difficulties to reach them and respond to their needs. Other key challenges of the system include the low private investment in innovation, in particular by farms, due to their small size and the lack of incentives for investing to improve sustainability.

Spain successfully participates in collaborative research at the EU level. A similar collaboration model could be valuable at the national level among ACs

Spain has successfully implemented 481 operational groups at the national and regional level under the European Innovation Partnership "Agricultural Productivity and Sustainability" (EIP-AGRI), which brings together different public and private actors to promote agri-food innovation that solves specific problems. This makes Spain the second country, after Italy, at the top of the ranking of operational groups. EIP-Agri has brought together more than 2 000 different actors of the Spanish AKIS, including all kinds of entities from all Spanish regions, with SMEs and regional research centres standing out. However, at the European Union level there is a lack of appropriate measuring of the results of these partnerships.

In the new CSP, funding for EIP-Agri amounts to EUR 168 million, including national, regional and EU funds and representing only 2% of total Pillar 2 Rural Development funding. The CSP also includes measures for innovation co-operation groups different from EIP-Agri with an allocation of EUR 34 million, following the European Commission recommendation to focus more support on EIP-Agri and avoid duplication.

In Spain there are relatively few examples of collaboration in public-private partnerships apart from those under the CSP. However, there are some successful programmes by the Spanish State Research Agency that combine loans and subsidies to support public-private collaboration, and partnership agreements led by the MAPA. Horizon Europe could be a model of mission-oriented co-funding to enhance co-operation across the Spanish regions and their agricultural research and innovation institutes and actors, in particular considering that Spanish entities have been successful in being beneficiaries of Horizon 2020 funds.

Data on innovation effort and performance is scarce and scattered

Data and information about the functioning of the AKIS, including funding and knowledge flows among actors, is needed to fully assess, monitor and enhance the agricultural innovation system. This is a precondition for a successful policy design and for improving the co-ordination of the AKIS. However, there are several areas with a lack of systematic and periodic data at different levels. This includes information about expenditure, research, the advisory capacities of the regional agricultural research institutes, or their priorities and programmes. This information is important for co-ordination and for the identification of challenges and opportunities of the Spanish AKIS.

Public investment in R&D&I is relatively low, and smaller companies have difficulties to access fiscal incentives

Overall investment in R&D&I as a percentage of GDP in Spain is much lower than the EU average, and the gap has widened since the economic crisis. Even if the private sector has become the main source of funding, it is also low compared to the EU average and relies on increasingly fewer firms. The Spanish government has set the goal to increase public investment on R&D&I to reach 1.25% of GDP by 2030, but closing the gap with the European Union will require increased private investment too. Despite this general context, government spending on R&D for the agro-food sector has been increasing in recent years, although it remains below the level observed before the 2008 financial crisis.

The Spanish system combines direct public grants for R&D&I projects, and tax incentives including tax deductions (up to 25%) for R&D&I in corporate tax, reductions in Social Security payments for research personnel, and reductions in income tax for revenues obtained through exploiting intangible assets (patents, utility models, etc.). However, in Spain, most agro-food companies are SMEs with low or no R&D&I activities, and do not benefit from those incentives. This may be due to a relatively high administrative burden and frequent changes of rules that difficult the access of companies to these support measures.

Low education and skills among farmers are concerning. The educational system should seek to respond to the needs of the agro-food sector

The level of education of most agricultural workers remains well below the EU average, with 40% being elementary workers – compared to the EU average of 14% − and only 22% of farm managers having a formal training. There is also evidence of skills mismatches in the sector that are larger than in other countries. In the Spanish agriculture, forestry and fishing sector, there is a total qualification mismatch of 48%, with 26% of workers being overqualified and 22% of workers being underqualified. This, together with the ageing of farmers, can exert a negative impact on the dynamism and innovation capacity of the agricultural and food sector.

The training needs of the agricultural sector are evolving and require high entrepreneurship, digital, and environmental skills to facilitate the adoption of new technologies and the commitment to enhanced environmental sustainability. Improving the formal and informal links of agricultural education (including both the schools and universities and their students) with the rest of the AKIS actors will be vital.

Advisory services have evolved towards private service providers often focused on administrative paperwork…

Spanish advisory services have evolved from traditional public agricultural extension services towards private and commercial advisors, often linked to input providers. While these advisors provide an essential service, the advice they give to farmers risks being linked to their commercial interests. Independent private advisors are key to provide independent advice. They allow to address and support the provision of public goods that otherwise would not be provided due to market weaknesses or failures, without imposing the funding and provision costs on the public system.

There are significant differences in the approaches followed by the different Autonomous Communities (ACs). Currently, there are almost no public advisory services in Spain, except in Navarra and the Canary Islands. Given the importance of the CAP as the main agricultural policy, the work of agricultural extension officers often focusses on processing CAP payment applications, rather than on inducing innovation and sustainability. The joint participation in EIP-Agri operational groups represents an interesting example of interaction between advisors and researchers, but the interrelations between advisors and research centres need further strengthening. Including farmers in these partnerships is key to effectively respond to farmers' needs while also inducing them to adopt more sustainable practices. Farmers' involvement can be achieved in different ways, including through consultation or by their indirect participation through co-operatives, sectoral associations or professional agricultural organisations.

…the government could incentivise high quality advisory services focused on innovation, digital and environmental sustainability

In the 2014-20 CAP period, Spain only marginally used the support measure to farm advisory services (M2) set within the framework of the Pillar 2 Rural Development Programmes. There is scope for more active policies in this area, which is critical to foster innovation. The government could contribute to finance the levelling up of advisory services across ACs, which nowadays have very different systems in place. Different approaches are possible. In the Netherlands, under the new CSP farmers receive vouchers to spend to access advice from independent private advisors whose knowledge and capacity on specific areas (such as the environment) is certified by a government system. In Ireland, farmers have a choice to engage with an advisor from the public, private or industry sector, while publicly funded, mixed funded, and privately funded services coexist. In Germany, advisory services are also offered by a variety of organisations from the public, private, and non-profit sectors, which are co-ordinated by some multi-level farmer-based organisations and private entrepreneurial associations, contributing to the maintenance of an overarching AKIS and its vertical connection with other actors at the state and local level.

Policy recommendations

In light of the above assessment, the following policy actions are recommended. The recommendations are structured towards three areas: 1) strengthen institutions; 2) boost innovation systems; and 3) tackle urgent environmental measures. There are eleven recommendations under these areas, each with several specific actions.

Strengthen institutions, policies and regulations to strategically guide and support agricultural innovation

1. Develop an ambitious and comprehensive long-term policy strategy to make innovation the cornerstone for reconciling environmental performance and productivity growth

- *Develop an ambitious agricultural innovation strategy* in which all policy levers converge to strengthen the agricultural knowledge innovation system and its capacity to respond to the most acute environmental pressures, in particular water management. This strategy should encompass agricultural policies under the CSP; national agricultural policies on insurance and irrigation; agri-environmental policies and regulations; water policies and institutions; agro-food research and innovation support; and rural digital infrastructure and education policies. The EU recovery funds, and the relevant elements of the Spanish Recovery, Transformation and Resilience Plan (RTRP), provide an opportunity to cover funding gaps to foster innovation and transformation. Building on existing co-ordination mechanisms, the strategy should strengthen the respective interlinkages with other Ministries that lead on policy areas with a direct impact on agricultural sustainability and innovation. The government should lead the implementation of the agricultural innovation strategy and the identified set of priorities.
- As part of the broader agricultural innovation strategy, *define a specific set of priorities and missions for innovation in the agricultural sector* at the national level, making sure that the most acute environmental pressures are well identified, in particular water stress. These priorities should guide subsequent policy decisions and R&D&I efforts and help improve the performance of the AKIS and its responsiveness to identified sector priorities. The government has a role in guiding strategic priorities and raising awareness and facilitating a change in mindsets towards a vision of productivity and sustainability as essential parts of the sector's competitiveness.
- Create an enabling environment that *prioritizes tackling the environmental pressures and accelerating the transition to a more sustainable system, while keeping productivity growth*. The government should invest in long-term policies to create awareness to allow farmers to assessment their performance, changing the mindset, and shaping the priorities of a more sustainable future in the farm and in the sector.

2. Target agricultural policies to specific objectives and make them work for innovation, sustainability and resilience

- In coherence with the government's declared income priority, *invest resources on the measurement of farm household income to estimate the prevalence of low income among Spanish farmers* and help the design and targeting of income support to those suffering from low income. Investigate the potential to design safety net policies – possibly as part of broader social programmes – that target farming households, instead of counting on less targeted decoupled CAP payments.
- In light of the growing environmental pressures, *consider reforming input subsidies and tax advantages on electricity, fuel and other variable inputs* that currently benefit the agricultural sector and particularly irrigated agriculture. Transform these tax advantages into tax incentives for on-farm investment on innovation.
- *Undertake an ex post assessment of coupled payments, building on previous assessments made in the CSP process, to evaluate their impact* on income, environmental pressures, and the adoption of changes and innovations. In future revisions of the CSP, consider reducing the share of coupled payments, given their potential distortive and environmental effects.

- *Enforce and monitor the mandatory cross-compliance of the CAP and the implementation of the voluntary eco-schemes* to ensure that farmers comply and contribute to the sector's shift to more sustainable production. Beyond the current CAP requirements, commission an independent *ex post* impact assessment of the eco schemes and the extent to which they add environmental value and reach their objectives. In order to enable this assessment, make sure that there are well-defined environmental objectives and that the appropriate methodology and data collection is designed from the beginning of their implementation.

3. Embrace administrative simplification, clarity and stability of rules and regulations

- *Simplify and create a more stable administrative and regulatory environment*, striking the right balance between accountability and a reasonable administrative burden. Consider steps to simplify or consolidate the numerous laws and regulations that exist for different environmental areas, and to improve transparency, following the example of the water management domain with the publication of the Electronic Water Codes.
- *Reduce the administrative burden and the delays in access to support policies and to funding for R&D*. Simplify the application process for national calls for proposals of R&D&I projects, such as those funded by the Spanish State Research Agency (AEI), the Centre for the Development of Industrial Technology (CDTI), or the regional governments, and reduce the time for their resolution. Simplify the administrative requirements in the provision of public support, in particular fiscal incentives for innovation. Facilitate as much as possible the management of innovation measures such as the Operational Groups, avoiding bureaucratic barriers. Simplified requirements should be designed for farmers or small and medium-sized agro-food firms that currently have difficulties to benefit from these provisions.
- *Continue embracing digital technologies in the government, for the design, monitoring, implementation and assessment of policies.* Facilitate full interconnectivity among digital tools and information for different policies and include the possibility of using a share of public support for digital investment by the beneficiaries. Use satellite and other digital technologies for policy monitoring.

4. Develop an agricultural data strategy as part of the innovation strategy, and improve the collection and use of data for policy design, assessment and monitoring

- *Define ex ante quantifiable policy objectives and strategies to measure them and invest in monitoring*. Establish indicators and data collection mechanisms to monitor and evaluate the effectiveness of the CSP and other agricultural, agri-environmental and innovation policies at the national and regional levels. Ensure that sufficient human and financial resources go to the monitoring and evaluation of these policies and build upon the recent MAPA-CSIC agreement to monitor the CSP. This will help determine if policies are meeting their objectives, provide a basis for adjustments if needed, and generate knowledge for future policy design.
- *Ensure that sufficient funds go to the new farm information system SIEX with well-identified earmarked budget lines*. Important investments from RTRP funds have been made for the establishment of this system for data collection, follow-up and benchmarking. Continued funding will be essential to guarantee that it remains operative in the longer term and ensure a comprehensive and timely implementation to monitor farmers and assess policy performance.
- *Explore innovative avenues to generate and collect data* for evaluating and monitoring the performance of the regional and national innovation policies, to take best advantage of the synergies and avoid duplication in innovation efforts. The use and development of open data should be prioritised in the data strategy.

Boost the agricultural innovation system and exploit its synergies to make it work for sustainability

5. Strengthen the AKIS and get the maximum advantage of its diversity through better co-ordination, public-private collaboration, and engaging farmers in co-creation processes

- *Improve co-ordination and knowledge flows between the national and regional levels to enhance the implementation of the agricultural innovation strategy.* Encourage the investment in AKIS by the ACs, in particular those with weaker innovation structures. Establish a governance structure at the national level, including agencies from the ACs, for improved co-ordination of the AKIS between the national and regional governments. Improve co-operation and knowledge flows at all levels, avoid the duplication of efforts, create critical mass to tackle shared problems, and share best practices.
- *Promote co-operation among the ACs, including their regional agro-food research centres*. Ensure cross-region knowledge gains and enough critical mass to get the maximum advantage of the regional AKIS diversity. Accelerate the creation of the announced "AKIS Co-ordination Body" initiative and ensure funding to incentivise joint projects and partnerships across regions. EU tools such as Horizon Europe could be an example to design similar national incentives to work across ACs.
- *Improve the interrelations among institutions and the competitiveness of research groups* by creating joint research centres with other regional centres, the CSIC, and universities, through the collaboration of public and/or private entities.
- *Use the new AKIS co-ordination body to establish a mutual evaluation and monitoring system to follow up the measures implemented by the regions*. Map the set of actors, capacities, projects and available resources, and the existing interrelations and incentives to collaborate. Design a process and a methodology of mutual reporting and evaluation of AKIS systems and initiatives in the different ACs. A better co-ordination of the AKIS also implies improving the communication channels and generating and sharing relevant information.
- *Foster the involvement and active participation of the private sector through public-private multi-stakeholder partnerships*, involving public institutions at different levels. Maintain and encourage participation in the EIP-AGRI operational groups and provide incentives to induce new types of public-private partnerships to address environmental problems using all the policy space allowed by the CAP and possibly national funding. Ensure that innovation results reach more farmers, promoting a higher involvement of farmers in R&D&I projects to ensure that their needs are being considered. Develop a mission-oriented co-funding to enhance co-operation across the Spanish regions and their agricultural research and innovation institutes and actors, taking successful EU tools as models.
- *Encourage the development of new co-operation mechanisms based in co-creation processes*. This could be fostered through, for example, living labs, promotion of entrepreneurship, collaborative platforms, formal and informal networks for knowledge transfer, public procurement of innovation, and promotion of peer-to-peer learning. Based on the experience of operational groups under the EIP-AGRI, regional exchange groups could be created to profit from sharing and exchanging the knowledge generated, search for shared concerns, and work together to find practical solutions.

6. Increase public investment, create incentives for private investment, and promote a more efficient use of the funding

- *Increase investment in R&D&I in the national and the regional AKIS*. Increase funding for the implementation of the elements of the CSP Rural Development plan linked to the AKIS. Consider transferring financial resources from CAP Pillar 1 to strengthen the innovation-related components of the programmes in Pillar 2. Promote the establishment of programmes to stimulate demand for innovation services among agro-food companies (especially SMEs).
- *Assess and monitor the participation of farms and agro-food firms in R&D&I funding and innovation tax incentive programmes and use the information to induce innovation to address environmental sustainability needs*. For instance, explore the possibility of strengthening the current use in some ACs of public procurement processes to boost private R&D&I by increasing demand of problem-solving technologies. Monitor and assess the use of the tax advantages by the agro-food sector, including farmers, and identify barriers that reduce the take up in the sector.
- *Promote the ex post evaluation of R&D grants and loans and take these evaluations into account for the renewal of grants*. This includes evaluating the performance and results of the operational groups, creating a methodology to track their activities and performance in order to identify the main drivers of success.
- *Adapt support policies and financing to target SMEs and help them become more innovative and sustainable*. In particular, improve outreach and simplify administrative requirements for those seeking to create start-ups. Strengthen the capacity of technology centres to effectively conduct R&D through partnerships between firms – especially SMEs – and research institutes.

7. Reduce the remaining gaps in access to digital technologies by farmers and in rural areas and encourage the adoption of digital technologies at the farm level

- *Speed up the deployment of connectivity* and 5G in the agro-food sector and rural areas. Make digital infrastructure a key catalyser to attract and facilitate innovation in agro-food, as it is in other sectors. Improve and facilitate the access of SMEs and agricultural holdings to digital technologies, considering barriers and providing elements to overcome them. Use these facilities to encourage the development of services in rural areas and the connection between farms and other actors in the food chain and in the local service economy. Fully roll out the National Plan for Digitalisation of Public Administration.
- *Encourage the co-ordination between the actions of the Digital Innovation Hub*s, including the hub to be created by the MAPA and those that already exist in the regions.

8. Encourage independent advisory services with the capacity to respond to the environmental challenges and farmers' needs

- *Implement a broad and ambitious strategy to improve the quality and quantity of agricultural advisory services*, considering the specificities of the different regions and the diversity of the current models. Strengthen support policies and regional structures and attract new professional profiles better suited to farmers' needs and environmental performance. Encourage independent private advisors that provide impartial advice focused on entrepreneurial solutions to environmental constraints.
- *Strengthen the announced platform for agro-food advisors* by offering and promoting the use of online advisory services and of powerful digital technologies. Use the platform to boost knowledge transfer and interactions among AKIS stakeholders. Consider the implementation of successful measures to improve independent advisory services and their use by farmers, such as the voucher system of the Netherlands.

- *Improve the education and training levels of independent advisors, in particular to enhance sustainable innovation and adoption.* Encourage them to obtain the Certificate for European Consultants in Rural Areas (CECRA). Use the AKIS co-ordination body to share experiences on how ACs invest in their advisory services and encourage mutual learning between different institutional arrangements. In particular, strengthen knowledge and awareness of environmental pressures and sustainability practices: specific advisory services could be proposed to farmers about the practices required by the eco-schemes. Policies could also be targeted to farmers of different ages, with low training level, or to small farms. More tailored measures could be needed for groups of farmers that lack the necessary skills to take advantage of advisory services and digital technologies.

Tackle the urgent environmental pressures and induce innovation towards a more sustainable agriculture

9. Act on the serious water pressures by addressing the full extent of the problem and the responsibility of the agricultural sector

- *Quantify and understand the extent of the illegal extraction problem*.
- *Take firm action to reduce illegal water extractions. Consider extending the permit requirement to all small water abstractions*, regardless of the quantitative status of the water body, for an exhaustive control of extractions. Create awareness among farmers about the real risk of the aquifers from which they extract irrigation water. Develop guidelines or a policy mandate to ensure an agile enforcement (i.e. closing of illegal wells) at the national and regional level.
- *Meter all water used for irrigation.* Enforce compulsory metering and tracking of water use by irrigators, using a hotspot approach to prioritise water bodies at risk. Commission an independent evaluation to examine the balance of power of the communities of irrigators in the decision making of river basin authorities. Review their level of influence in RBA decisions and make sure that other actors (such as the civil society or environmental organisations) are heard, to reach the right balance between agricultural users' priorities, other water users and environmental concerns.
- *Take advantage of the foreseen reform of the Water Law to promote a comprehensive approach* that considers the full water cycle at the basin level and addresses the full extent of the water problems. Consider this opportunity to fully align with the OECD Council recommendations.
- *Improve the transparency on water policies and facilitate their assessment by establishing a repository of data* related to water management and water pricing for all river basin districts.

10. Strengthen climate change mitigation and adaptation and foster the preparedness of the agro-food sector

- *Develop additional instruments to encourage sector adaptation and preparedness*, which complement the agricultural insurance system to better manage climate risks through a holistic approach. This could encompass reforming or reorienting support that could potentially exacerbate climate change, applying appropriate mitigation incentives, and investing in innovation and knowledge transfer. It should take account of wider implications for food systems, exploit synergies with other social and environmental objectives and be balanced in each context with potential adverse impacts.
- *Use the strengthened advisory services to create awareness among farms about the main risks of climate change* in their farms and their specific needs of adaptation.

11. Align irrigation and insurance policies with the urgency to tackle water stress and adaptation to the new climate

- *Commission an in-depth assessment of the successive irrigation modernisation plans*. In particular, assess their impact on total irrigated area and total water consumption, and identify the potential loopholes in the design of the irrigation plans that may reduce their effectiveness in promoting long-term adaptation strategies.
- *Strengthen the focus of irrigation plans on supporting investments that reduce water consumption beyond just increasing efficiency*. Given the increasing water stress accentuated by climate change, modernisation of irrigation systems needs to translate into reductions in water consumption and improvements in water availability. Improve controls to ensure that efficiency improvements are reflected in real savings in the water consumed.
- *Strengthen the climate risk management and resilience strategy, complementing ex post compensation from insurance* with measures for incentivising climate change adaptation with less water-intensive productions and investment on preparedness to the new climate and risk environment.

The future of food and farming in Spain requires balancing growing competitiveness with using less inputs and natural resources. Spain has developed a highly productive and competitive agro-food sector; at the same time, the sector's growth has not been exempted from environmental sustainability concerns. The country is taking steps to mitigate the environmental impacts of farming activities and incorporate innovation as a catalyst of change, including through its CAP Strategic Plan. Reaping the benefits of these policy efforts and promoting a transformation towards a sustainable path of agricultural productivity growth requires determined action: an enabling policy environment, further targeting policies to their income and environmental objectives, and using data and analysis to evaluate their impact and effectiveness. Spain must decisively address water stress and generate the incentives necessary to foster innovation for sustainability. For this, it must take full advantage of the potential and the diversity of its agricultural knowledge and innovation system (AKIS) improving its co-ordination. An ambitious and comprehensive innovation strategy is needed to make knowledge the agent of change for the future.

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1 Context, drivers and outcomes

Agriculture occupies half of Spain's land area and its contribution to value added is above the OECD average. Agro-food production has experienced important growth in recent decades and exports have quadrupled since 2000. This chapter examines trends in agro-food production, consumption, and trade, as well as the policies that most affect this sector. The main drivers and outcomes are presented, with a focus on the evolutions in productivity, input use, and emissions. The challenges facing this sector at present include the significant pressure on Spain's water resources and on the country's rich biodiversity in a context of increasing climate vulnerability, as well as social issues such as the ageing of farmers and the relatively low participation of women.

Key messages

- Agriculture occupies half of Spain's land area. The sector's contribution to value added is above the OECD average, and its share of employment has remained constant in the last decade.
- Agro-food exports have more than quadrupled since 2000, widening the trade surplus. Spain is the largest producer and exporter of fruits and vegetables in the European Union (EU).
- In the last decade, pig meat emerged as the leading export product, surpassing more traditional export products such as wine and olive oil, and making Spain the world's top exporter of pig meat. This production boom has made Spain's pig herd the largest in the European Union.
- The sector's evolution has contributed to structural changes in the last decade. The total number of farms and the agricultural workforce declined. For profitability reasons, many smaller farms disappeared, while the number of larger farms and the average farm size increased.
- Spain has taken a proactive approach to improve the gender balance of agriculture and is one of few EU Member States that included measures supporting women in the new strategic plan for the 2023-27 Common Agricultural Policy. Female participation has increased in the last decade, but the sector remains predominantly male.
- Productivity growth has been the main driver of Spain's agricultural output growth in the last five decades. However, after 2010 the total factor productivity growth decelerated, and the use of labour and variable inputs picked up pace as contributors to growth. Agricultural greenhouse gas (GHG) emissions also began rising. Spain is very vulnerable to climate change, which will have an uneven impact on different agricultural activities and regions.
- The average use of water and energy in agriculture fell in the last decade, but the OECD Agri-Environmental Indicators database shows worrying trends in some indicators associated to input use and agricultural emissions, particularly in the most recent years.
- Spain has a highly decentralised government system with competences that are sometimes shared between the levels. The Autonomous Communities have competences on agriculture and are very diverse in terms of their economic indicators and the importance of the sector.
- The CAP Strategic Plan for 2023-27 (CSP) emphasises preserving basic income support as a safety net for farmers, with measures to redistribute funds from larger to smaller and medium-sized farms.
- The CSP incorporates specific environmental aspects through mandatory conditions for direct payments, rural development measures applied at the national and Autonomous Community level, and voluntary eco-schemes, which Spain has defined as the implementation in a given plot of a farm of at least one of a "menu" of seven soil conservation or biodiversity practices.

1.1. The Spanish agro-food sector

With a land area of 504 745 km^2 and 47.4 million inhabitants (2020), Spain is the second largest country in the European Union, and the fourth in terms of population. Along with the mainland in the Iberian Peninsula, its territory includes the Canary Islands in the Atlantic Ocean, the Balearic Islands in the Mediterranean, and the cities of Ceuta and Melilla in North Africa. The country is organised in 17 self-governing autonomous communities, two autonomous cities, 50 provinces and 8 131 municipalities. Eighty-four per cent of Spain's territory is classified as rural,[1] and 16% of its population live in rural areas (MAPA, 2022[1]). The population density of 94 persons per square kilometre (2019) is relatively low in comparison with European peers such as Germany, France, Italy, and Portugal (Eurostat, 2021[2]).

Due to its geographical position, extension and orography, Spain has a large climatic diversity, with sharp contrasts in average temperatures and precipitation levels: while in the north and northwest areas, known as the "humid Spain", annual precipitation can reach up to 2 000 mm, the southeast area is semi-arid and has precipitation levels below 300 mm (Gobierno de España, n.d.[3]). Spain is also one of the world's biodiversity hotspots and one of the most biodiverse countries in the European Union (Convention on Biological Diversity, n.d.[4]).

Before the onset of the COVID-19 pandemic, the Spanish economy had been experiencing a robust recovery after the global financial crisis. However, the pandemic caused an unprecedented GDP contraction of 11% and accentuated the country's structural vulnerabilities (OECD, 2021[5]). While growth recovered in 2021, it is set to slow down again in 2022 and 2023, due to heightened uncertainty, high inflation, and slower external demand (OECD, 2022[6]).

1.1.1. The role of the agro-food sector in the Spanish economy

Half of Spain's territory is agricultural land; the sector's contribution to value added is above the OECD average and has remained constant in the last decade

More than half of Spain's total land area is used for agriculture, in line with countries such as France, Germany and Australia, and considerably above the OECD average (Table 1.1). Agriculture, forestry and fishing activities contributed almost 3% of Spain's total value added in 2020, above the average share of the European Union and OECD. Within the primary agricultural sector, crop and animal production are the most important activities, while fishing, aquaculture and forestry play a relatively minor role in aggregate. The contribution of the food and beverage industry to value added was only slightly lower than that of primary agricultural activities. Together, primary and manufacturing activities add up to 5.1%. A larger share (almost 7%) of the Spanish workforce was working in the agro-food sector (including primary and manufacturing activities) in 2020, in line with the EU average but above some European peers. The sector also represented 18% of Spain's goods exports and 10% of its total goods imports; the agro-food share in Spanish exports is twice the EU average and higher than in most peer economies. The weight of agriculture and agro-food activities in Spain's value added and employment has remained relatively unchanged between 2010 and 2020.

Table 1.1. The share of the agro-food sector in Spain's value added is above the OECD average

Share of the sector in the economy (%), 2020[1]

	Agricultural land area[2]	Gross value added[3]					Employment[4]					Agri food exports[5]	Agri 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, beverages		
Spain	52.33	2.86	2.66	0.09	0.11	2.30	3.94	3.59	0.22	0.14	2.73	18.33	10.35
France	52.15	1.86	1.67	0.15	0.04	2.06	2.25	2.06	0.07	0.12	2.39	14.25	10.03
Germany	47.50	0.86	0.78	0.08	0.00	1.52	1.14	1.02	0.00	0.11	1.72	6.12	8.50
Italy	43.96	2.13	1.95	0.13	0.05	1.88	3.79	3.50	0.08	0.22	2.23	11.03	10.35
Portugal	42.28	2.41	1.74	0.48	0.20	2.32	3.23	2.78	0.17	0.27	2.44	12.31	13.26
Australia	46.25	2.43	…	…	…	…	3.08	2.24	0.05	0.11	2.05	12.25	7.35
Canada	6.44	1.82	1.32	0.39	0.11	1.65	1.94	1.55	0.29	0.10	…	14.19	9.25
Colombia	43.48	8.12	7.55	0.26	0.30	3.58	17.10	…	…	…	…	24.78	15.04
EU27[6]	41.03	1.78	1.54	0.20	0.05	2.00	4.03	3.70	0.07	0.26	2.31	9.39	7.08
OECD[7]	33.52	2.77	…	….	…	…	4.77	…	…	…	…	13.34	10.34

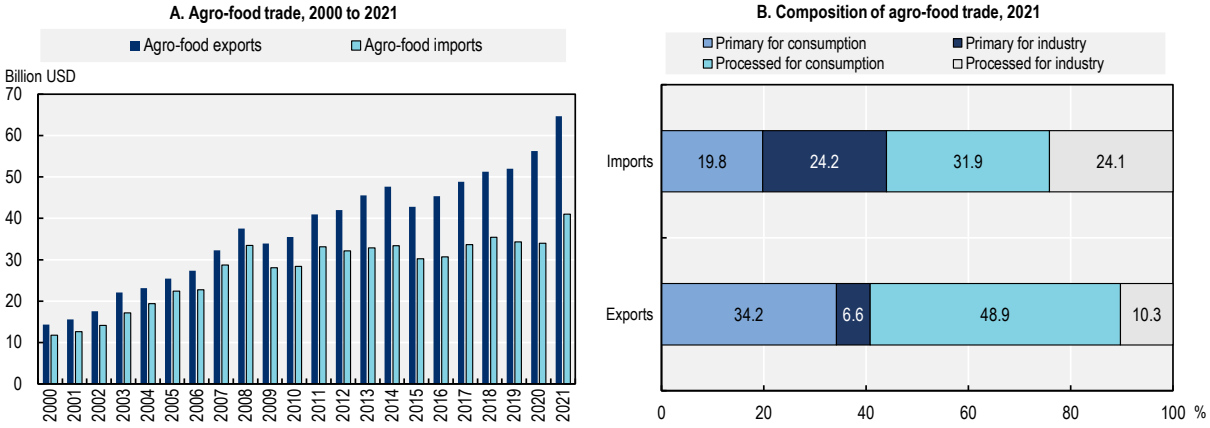
Notes: ...: not available.
1. Or latest available year.
2. Share of total land area.
3. Share of total gross value added.
4. Share of employed persons, aged 15 years and over, in total NACE activities. Except for Australia: ANZSIC Classification: 01 to crop and animal production and hunting, 03 to forestry and logging, and 02 and 04 to fishing and aquaculture (It also includes employment in hunting and is therefore misallocated); Canada: NAICS Classification: Agriculture [111-112, 1100, 1151-1152], Forestry and logging and support activities for forestry [113, 1153], Fishing, hunting and trapping [114] ; Colombia: ISIC 4 Classification [A].
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 EU27, imports and exports include only extra-EU trade.
7. For OECD, imports and exports include both intra- and extra-OECD trade.
Source: Authors' calculations based on OECD (2022), System of National Accounts and Annual Labour Force Statistics (databases), http://stats.oecd.org/; UN (2022), UN Comtrade database, https://comtrade.un.org/; Eurostat (2021), [nama10_a10], [lfsa_egan22b], http://ec.europa.eu/eurostat/data; FAO (2022), FAOSTAT, Land use (database), http://www.fao.org/faostat/en/; Australian Bureau of Statistics (2022), https://https://www.abs.gov.au/statistics/labour/labour-accounts/labour-account-australia [Industry Summary table]; Statistics Canada (2022), https://www150.statcan.gc.ca [Labour force characteristics by industry]; DANE (2022), https://www.dane.gov.co/index.php/estadisticas-por-tema/mercado-laboral/mercado-laboral-por-departamentos [Mercado laboral-Anexo].

1.1.2. Evolution of Spain's agro-food trade

In the last two decades, Spain has grown into an agricultural export powerhouse

Spain is a net exporter of agro-food products, and its exports have grown significantly over time. Between 2000 and 2021, agro-food exports more than quadrupled, reaching USD 64.6 billion (Figure 1.1, Panel A), with an average yearly growth rate of 7%. The Spanish agro-food trade balance has been positive since the late 1990s, and the trade surplus has widened from about USD 2 billion to over USD 20 billion in the same period. Processed products for consumption and industry represent almost 60% of exports and 56% of imports (Figure 1.1, Panel B).

Figure 1.1. Spain's exports of agro-food products have more than quadrupled since 2000



Note: 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.
Source: Authors' calculations based on UN Comtrade (database), http://comtrade.un.org/ [accessed July 2022].

Spain's top export products include pig meat, olive oil, wine, citrus fruits, and fresh fruits and vegetables such as peppers, strawberries, and stone fruits (Table 1.2). While citrus fruits, wine and olive oil have headed Spanish exports for decades, pig meat only appeared among the top 10 export products after 2010, and the sector has expanded considerably since then (Box 1.1).

Spain's trade in fruits and vegetables has increased steadily over the last two decades. Between 2000 and 2021, exports and imports of fresh fruit and vegetables[2] more than tripled, with a trade balance that was consistently positive and expanded considerably. While exports increased in absolute terms, the share of fruits and vegetables in total agro-food exports declined from 41% to 33% (UN Comtrade, 2022[7]).

High sectoral growth rates have underpinned Spain's position as the largest producer and exporter of fruits and vegetables in the European Union. Spain accounted for 21% of the value produced by the European Union in 2020. Citrus fruits, peppers, tomatoes, and berries are among the most important export products, with 81% of total fruit and vegetable exports going to other EU countries. In 2016, over 200 000 jobs were associated with the production of fruits and vegetables, or 25% of total agricultural employment. Another 100 000 jobs in handling and conditioning centres were indirectly associated with the sector (MAPA, 2021[8]).

Greenhouse agriculture is an important part of Spain's fruit and vegetable production. Some of the top export fruits and vegetables have a high share of cultivation area under cover, including strawberries, cucumbers, zucchini squash, eggplants, peppers, tomatoes, and watermelons. In the farming year 2021/22, vegetable production under cover accounted for 60% of the value of vegetable exports (MAPA, 2022[9]). Over 80% of greenhouse vegetable exports go to other EU Member States.

The greenhouse UAA in 2020 was of 64 925 hectares (0.3% of Spain's UAA). Seventy-two per cent of this area is in Andalusia, followed by the Canary Islands and Murcia (10% and 9%). Based on the five main crops for which statistics are available,[3] Spain has the largest area under cover in the European Union (Eurostat, 2022[10]).

The most important agro-food import products of Spain are maize and soya beans for animal feed (which together represented 10% of agro-food imports in 2021), followed by vegetable oil cakes and residues, cigarettes, and spelt wheat (UN Comtrade, 2022[7]).

Table 1.2. Spain is a net exporter of most of its top export products

Agro-food imports and exports, 2021

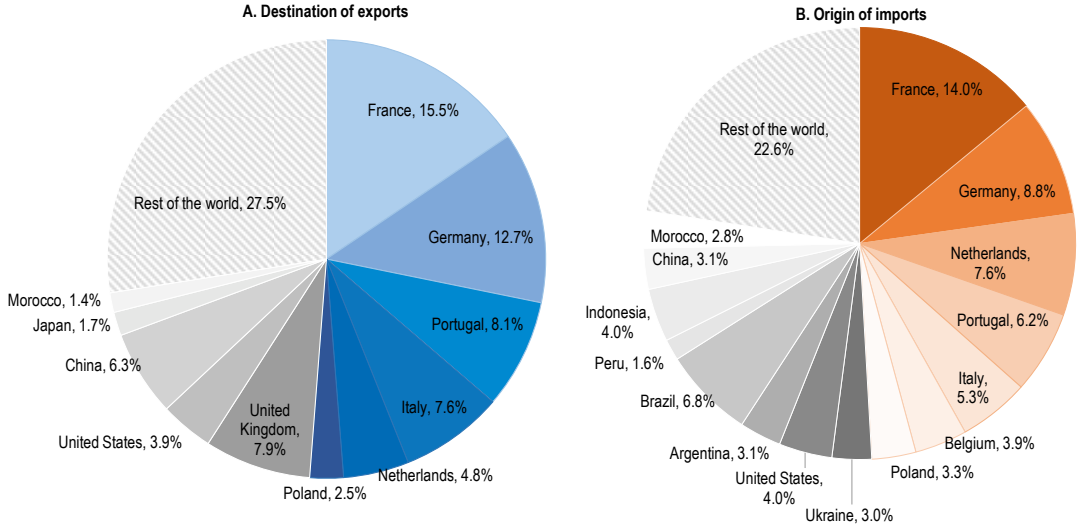
Code	Product description	Exports	Share in agro-food exports	Imports	Share in agro-food imports	Trade balance	Total trade (X+M)
HS-4	Commodity groups	USD million	%	USD million	%	USD million	USD million
0203	Meat of swine, fresh, chilled or frozen	6 507	10.1%	241	0.6%	6 266	6 748
0805	Citrus fruit, fresh or dried	4 232	6.5%	246	0.6%	3 985	4 478
1509	Olive oil and its fractions, obtained from the fruit of the olive tree	3 558	5.5%	559	1.4%	3 000	4 117
2204	Wine of fresh grapes, incl. fortified wines	3 479	5.4%	284	0.7%	3 195	3 763
0709	Other vegetables, fresh or chilled	2 921	4.5%	237	0.6%	2 684	3 158
0810	Strawberries, raspberries, blackberries, black, white or red currants, fresh	2 450	3.8%	807	2.0%	1 643	3 257
0809	Apricots, cherries peaches incl. nectarines, plums and sloes, fresh	1 630	2.5%	34	0.1%	1 596	1 663
1905	Bread, pastry, cakes, biscuits and other bakers' wares	1 550	2.4%	927	2.3%	624	2 477
2005	Other vegetables, prepared or preserved otherwise	1 250	1.9%	381	0.9%	869	1 631
2309	Preparations of a kind used in animal feeding	1 201	1.9%	990	2.4%	211	2 191
0702	Tomatoes, fresh or chilled	1 154	1.8%	185	0.5%	969	1 339
0705	Lettuce and chicory, fresh or chilled	1 052	1.6%	40	0.1%	1 012	1 092
0206	Edible offal of bovine animals, swine, sheep, goats and others	1 013	1.6%	45	0.1%	968	1 058
2009	Fruit juices, incl.. grape must, and vegetable juices	967	1.5%	270	0.7%	697	1 237
2208	Undenatured ethyl alcohol of an alcoholic strength of < 80%	961	1.5%	842	2.1%	118	1 803
0807	Melons incl. watermelons and papaws (papayas), fresh	942	1.5%	179	0.4%	763	1 121
0802	Other nuts fresh or dried, whether or not shelled or peeled	898	1.4%	941	2.3%	-43	1 839
2106	Food preparations, n.e.s.	859	1.3%	1 078	2.6%	-219	1 937
0707	Cucumbers and gherkins, fresh or chilled	855	1.3%	8	0.0%	847	862
0201	Meat of bovine animals, fresh or chilled	796	1.2%	577	1.4%	219	1 372
Total agro-food trade		64 642	100.0%	41 013	100.0%	23 629	105 656

Note: 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.
Source: Authors' calculations based on UN Comtrade (database), http://comtrade.un.org/ [accessed July 2022].

The European Union is Spain's main agro-food trading partner. In 2021, it was the destination of 62% of Spain's agro-food exports and the source of 57% of its imports. For decades, Germany and France have been the main EU trading partners of Spain, both as destinations of its exports and as sources of its imports (Figure 1.2). Outside of the European Union, the main export destinations in 2021 were the United Kingdom, the People's Republic of China (hereafter "China") and the United States, while the top non-EU import sources were Brazil, Indonesia and the United States. In recent years, China has grown in importance as a destination market for Spanish agro-food products, in particular pig meat (Box 1.1).

Figure 1.2. Most of Spain's agro-food trade is with other EU countries

Main trading partners for agricultural and food products, 2021



Note: 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.
Source: Authors' calculations based on UN Comtrade (database), http://comtrade.un.org/ [accessed July 2022].

Box 1.1. Evolution of the Spanish pork sector

The sector has experienced a considerable expansion and is associated with environmental concerns

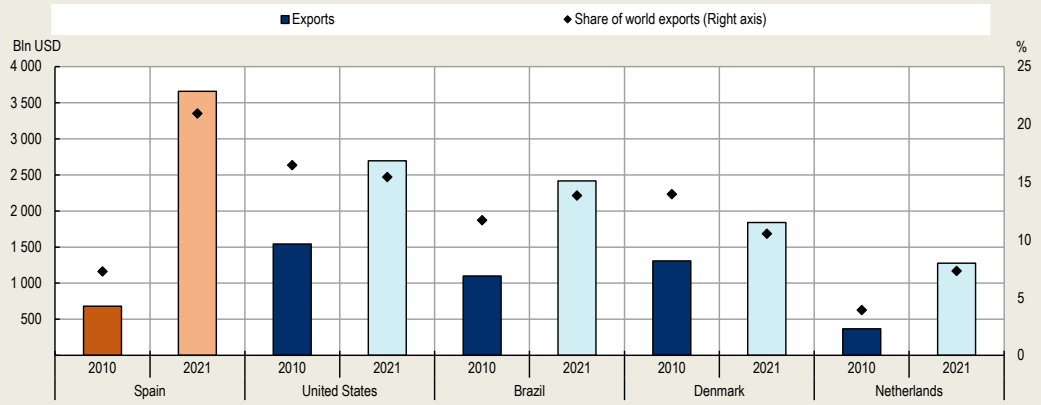
The growth experienced by the Spanish pork sector in recent years has been largely export-driven (Giménez García et al., 2021[11]; Álvarez Ondina, 2021[12]). The eradication of African Swine Fever in 1995 allowed Spanish pork to access foreign markets and opened the door for the development of a competitive pork industry, capable of taking advantage of new market opportunities. Technological developments and a vertical integration model that allows for better planning and sharing of operational risks, have contributed to the sector growth.

Since 2020, Spain has positioned itself as the top world exporter of pig meat, and the second most important exporter of edible pig offal. The sector's international trade profile has changed radically: up to 1995, exports of pig meat were practically inexistent, and the trade balance was negative. After 2000, exports have grown at an average yearly rate of 14% (UN Comtrade, 2022[7]).

The top export product is frozen meat, which in 2021 accounted for 50% of the sector's exports, followed by fresh and chilled meat (22%), frozen edible offal (11%) and frozen hams (9%). 2021 frozen meat exports were over five times higher than in 2010 and almost 30 times than in 2000 (Figure 1.3). Before 2010, most exports of this product went to other European countries, but more recently Asia has gained importance as a destination market. In 2021, 45% of exports went to China and 17% to Japan.

Spanish supply to the Chinese market – the world's largest for pig meat (Frezal, Gay and Nenert, 2021[13]) – became particularly important after 2018, with the outbreak of African swine fever (ASF) and the subsequent decimation of Chinese domestic production. Between 2019 and 2021, Spain was the main supplier of China's pig meat imports and one of the two most important suppliers of frozen offal (UN Comtrade, 2022[7]).

Figure 1.3. Spain's exports of frozen pig meat grew by 436% between 2010 and 2021

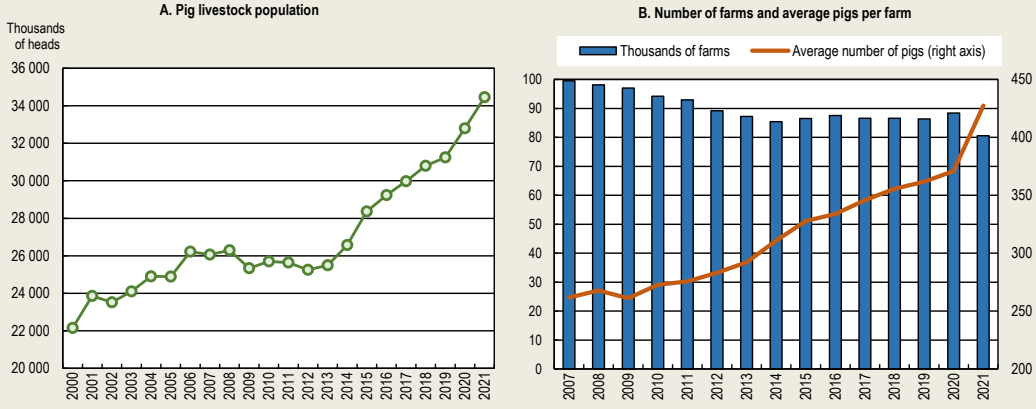


Note: "Frozen pig meat" refers to the HS code 020329.
Source: Authors' calculations based on UN Comtrade (database), http://comtrade.un.org/ (accessed July 2022).

With over 34 million animals (2021), Spain has the largest pig population in the European Union, having surpassed Germany in 2015 (Eurostat, 2022[14]). Spain and Germany are the two largest EU pig producers. While the herd size and meat production in Germany have declined, the opposite has happened in Spain (Eurostat, 2021[15]). Domestic consumption is also decreasing, with declines of 11.8% in consumption of fresh pig meat, and of 6.5% in processed pig meat in 2021 with respect to 2020, and a general downward trend (MAPA, 2021[16]).

Between 2010 and 2021, the pig population grew by 8 million heads or 34%, while the number of farms decreased by 14%, resulting in an increase of 1.5 times in the average pigs per farm (Figure 1.4). The strongest reductions have occurred in smaller-sized farms; the number of larger farms actually increased between 2013 and 2021 (MAPA, 2021[16]).

Figure 1.4. While the number of pig farms declined, the pig population had a sustained increase



Source: Eurostat (2022), Pig population [APRO_MT_LSPIG]; MAPA (2021), Pig sector indicators.

Already in 2003, an OECD study noted a larger risk of negative environmental effects – particularly water and air pollution – in regions with a high concentration of pig production, and an increasing risk in Spain (OECD, 2003[17]). The Spanish pork sector has made efforts to reduce its carbon footprint, and its share in the total GHG emissions is around 2.6% (Financial Food, 2022[18]). However, pig production can be associated with ammonia (NH_3) emissions to the atmosphere (Philippe, Cabaraux and Nicks, 2011[19]), and the sector is a major contributor to total ammonia emissions in Spain (Section 2.4.1).

1.1.3. Evolution of the organic farming sector

Spain is a key producer and exporter of organic products at the EU and global level. Its domestic market, while growing, is still relatively small

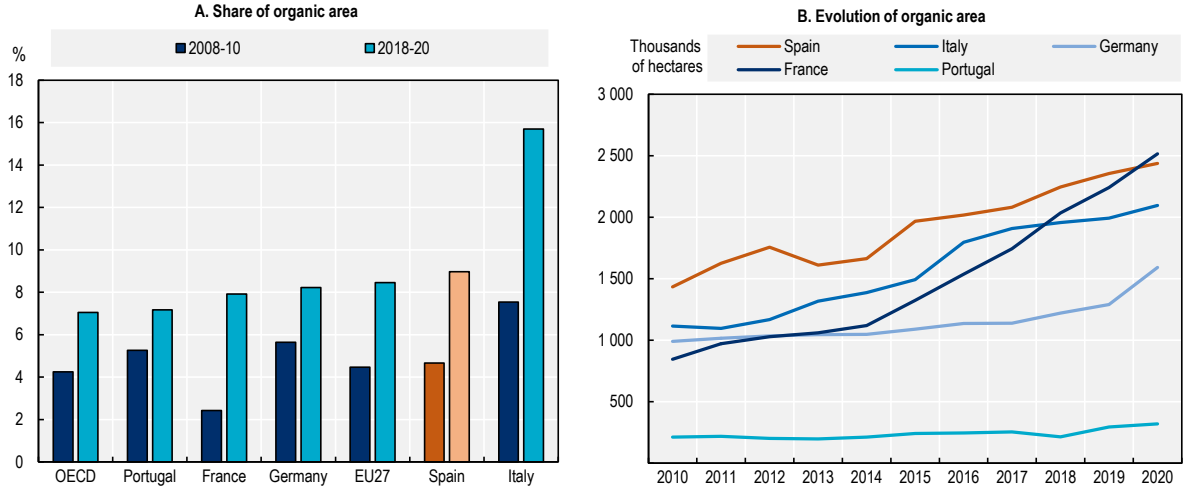
Organic agriculture in Spain has grown and diversified significantly, in line with the worldwide expansion of this market and the increase in consumer demand for organic foods (Willer et al., 2022[20]).[4] In 1991, there were only 346 organic farms covering 4 235 hectares (De Marcos Sanz, n.d.[21]). By 2020, the agricultural census recorded 42 312 farms, more than twice the number found in 2009 (Instituto Nacional de Estadística, 2022[22]). Spain's organic area expanded by almost 1 million hectares and grew at an average yearly rate of 5% between 2010 and 2021. The utilised agricultural area (UAA) dedicated to organic crops reached 2.6 million hectares in 2021.

As of 2020, Spain is sixth in the world in terms of total organic area, and second in Europe after France (Willer et al., 2022[20]). The organic share in the total agricultural area experienced important growth, surpassing the OECD and EU shares and those of most peer countries (Figure 1.5). Andalusia alone concentrates almost 50% of Spain's organic land, followed by Castile-La Mancha (15%) and Catalonia (10%) (MAPA, 2022[23]).

During the process of preparation of the CSP, Spain highlighted the role of the CAP in promoting organic production, particularly through Pillar 2, because this allows each AC to tailor support to its characteristics, sectors, and operators. The EU Farm to Fork strategy set a target of 25% of agricultural land under organic farming by 2030. As the organic UAA in Spain is currently approaching 11%, the Spanish authorities have indicated that achieving the target will require an extraordinary effort and support (MAPA (Ed.), 2021[24]). A Roadmap for promoting organic production and consumption is in preparation (MAPA, 2022[25]).

Figure 1.5. Spain is a leader in organic farming

Evolution of the organic share in the total agricultural area and of the total organic area



Note: "Organic area" refers to the agriculture area under organic agriculture.
Source: FAO (2022) [Land use indicators].

While the production of organic crops is well established in Spain, organic livestock lags behind. The share of organic farms per type of livestock is low: 3% for cattle, around 2% for sheep and goats, 1% for poultry and 0.5% for pigs (Instituto Nacional de Estadística, 2022[22]). Growth in the number of organic livestock farms has also been modest, with 0.5% between 2015 and 2020, although the number of organic farms

that mix crop and livestock activities grew by 6% in the same period (MAPA (Ed.), 2021[24]). Nevertheless, animal products represented 22% of the value of Spain's organic production in 2020.

Spain's organic production and exports have grown robustly. Between 2012 and 2020, the volume of organic production more than doubled (from 1.3 to 3 million tonnes), while the value of production grew by 97%, from EUR 1.4 million to EUR 2.7 million. The most important organic products of plant origin are fresh vegetables and potatoes, citrus fruits and wine grapes. Milk is the most important organic product of animal origin. The fact that both the volume and the value of production increased by respectively 17% and 16% in 2020 despite the COVID-19 pandemic is an indicator of the sector's resilience (MAPA (Ed.), 2021[24]). A network of processors and distributors of organic products has developed rapidly (Box 1.2).

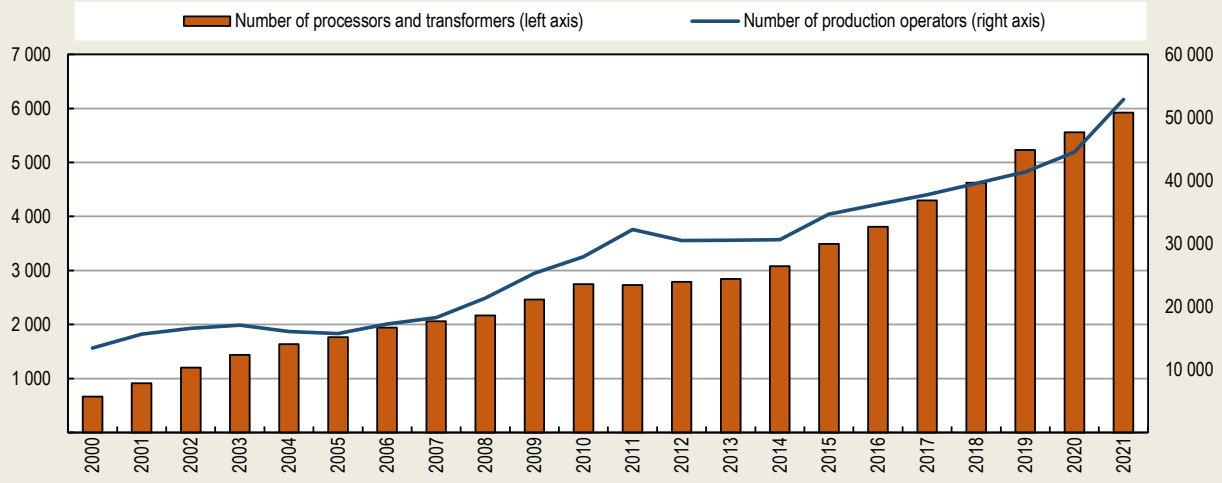
Box 1.2. Development of the organic value chain in Spain

Manufacturers, processors and distributors have grown along with the organic primary production

The rapid expansion of the organic primary sector in Spain paved the road for the development of an organic value chain encompassing manufacturers, wholesalers, retailers and distributors. In 2021 there were 9 291 operators[1] accounting for 15% of agents in the organic value chain. Five ACs concentrate two-thirds of Spain's organic operators other than producers: Catalonia (26%), Andalusia (15%), Valencia (13%), Castile-La Mancha (7%), and Murcia (6%) (MAPA, 2022[23]). Employment in organic-related activities had a share of 7% in total agro-food employment in Spain (MAPA (Ed.), 2021[24]).

Figure 1.6. The number of organic processors and transformers more than doubled since 2010

Evolution of the number of organic producers, processors and transformers, 2000-2021



Source: MAPA (2022), Producción ecológica estadísticas 2021.

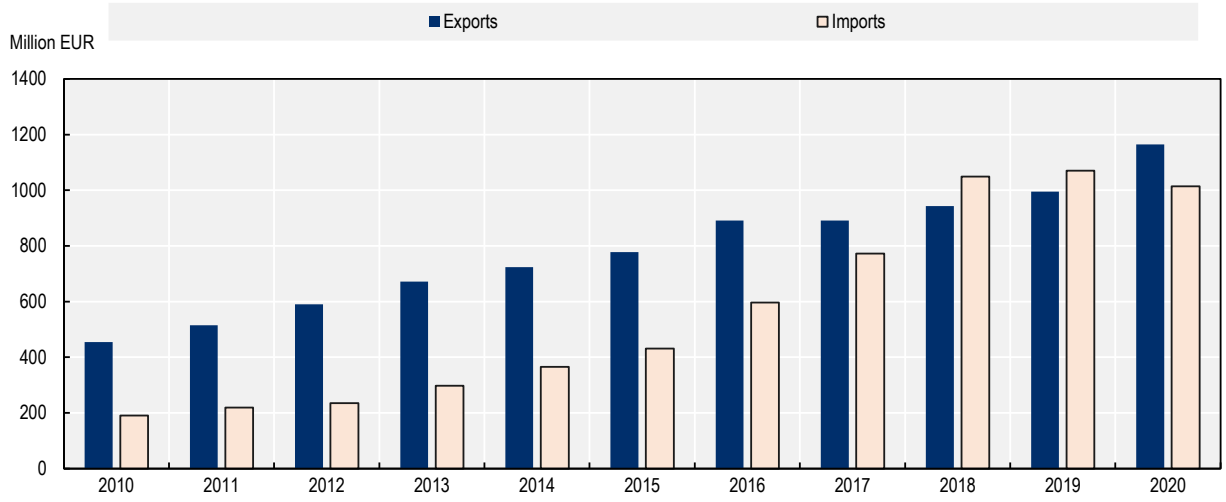
The value chain development has also responded to policy initiatives at the regional or local level. An example is the city of Barcelona, which has become an important promoter of organic products as part of its 2030 Sustainable Food Strategy.[2] In 2020, it opened one of the largest organic wholesale markets in Europe (Barcelona BIOMARKET). The city has also launched programmes such as *Comerç Verd* (Green Commerce), to promote the local supply of organic products (Ajuntament de Barcelona, n.d.[26]).

Notes: 1. This includes agents other than producers, dedicated to the processing, distribution and sale of organic products, including manufacturers, transformers, importers, exporters, wholesalers and retailers.
2. This strategy is a roadmap for food policy that aims to connect all the stakeholders involved in the transformation of the city's food system.

As of 2020, Spain became once again a net exporter of organic products, after two years of negative trade balances (Figure 1.7). While this reflects the general growth trend of Spanish agro-food trade, organic exports grew even more rapidly than conventional exports (17% versus 5%). 44% of the Spanish organic production was exported in 2020, down from 60% ten years before. While imports of organic products decreased by 5% between 2019 and 2020 (in line with total agro-food imports), before 2019 they had been growing strongly, accounting for a large part of the increase in organic consumption in Spain (MAPA (Ed.), 2021[24]).

Figure 1.7. In 2020, Spain became a net exporter of organic products again

Organic exports and imports, 2010-2020



Note: Data compiled from national sources (statistical offices, governments, private sector), certifiers, and Eurostat.
Source: Research Institute of Organic Agriculture FiBL (2022), [Data table organic markets and trade], statistics.fibl.org.

Organic retail sales in the Spanish market reached EUR 2.5 million in 2020, continuing a trend of sustained growth and almost tripling since 2010. Per capita consumption has also increased significantly, from EUR 19.5 in 2010 to EUR 53.4. Despite this, the Spanish market is still relatively small and per capita consumption is only about a third that of France and Germany (Willer et al., 2022[20]).

1.1.4. Food consumption and trends

Spanish household expenditure in food is close to the EU average, although the COVID-19 pandemic drove an increase in food purchases

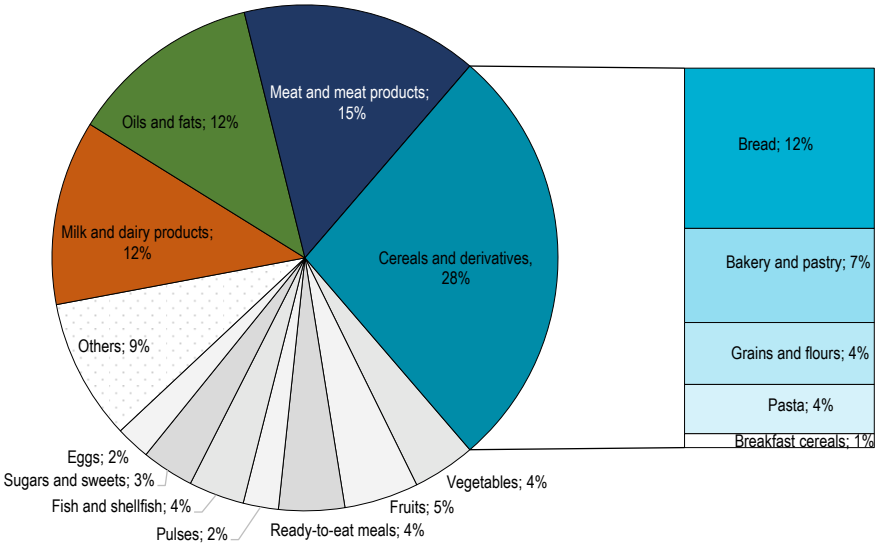
In 2020, Spanish households dedicated 16% of their expenditure to food and non-alcoholic beverages, slightly above the EU-27 average of 15%. However, this share was lower in 2019 and in the years before, when it remained around 12-13% and closer to the EU average (Eurostat, 2022[27]). In fact, per capita food expenditure increased by 14% in 2020 with respect to 2019, thanks to a sharp increase in purchases for consumption at home, given that food consumption outside of the home decreased because of the COVID-19 pandemic (MAPA, 2021[28]).

Cereals and their derivatives are the largest sources of energy in the Spanish diet (Figure 1.8). The Spanish Nutrition Institute considers that the energy intake profile is unbalanced in terms of the types of fats consumed, and that protein intake is above the recommended limits (FEN ANIBES, n.d.[29]). In general, Spanish dietary patterns are moving away from the traditional Mediterranean diet (Ruiz et al., 2015[30];

Partearroyo et al., 2019[31]; Serra-Majem, Castro-Quezada and Ruano-Rodríguez, 2014[32]), with a higher intake of foods of animal origin and a lower consumption of legumes, nuts, fruits and vegetables.[5]

Figure 1.8. Cereals and meats are the main food groups in the Spanish diet

Dietary sources of energy (%) from food groups in Spain



Notes: Food intakes in terms of energy (calories). The category "Others" includes appetizers, sauces and condiments, and alcoholic and non-alcoholic beverages.
Source: ANIBES study, Spanish Nutrition Institute (FEN), 2016.

1.2. Policy setting of the agro-food sector

1.2.1. Spain's decentralised system of government

According to the Spanish Constitution, regions have considerable autonomy, but competences are often shared between administrations

The Spanish Constitution of 1978 marked the start of a process through which Spain evolved from a centralised to a highly decentralised system with three levels of government: national, regional (Autonomous Communities) and local (provinces and municipalities). Since 1983, the country is organised in 17 Autonomous Communities (AC).[6] The Constitution establishes the framework for the distribution of competences; some are exclusive to the central government, but most are shared between the central and regional governments (Box 1.3).

The OECD conducted a survey to collect information at the AC level from the regional authorities. The survey covered aspects related to environmental sustainability and innovation in agriculture, including regional policy priorities, challenges, strategies, policies, and regulations. Results and regional examples are presented in specific sections of Chapters 2 and 3. The questions are included in Annex 1.A.

Box 1.3. Spain's Autonomous Communities (ACs) and their competences

The ACs are very diverse. They differ in terms of GDP, population, and employment (Table 1.3) and in the predominance of rural areas: while in four communities (Castile and León, Aragón, Castile-La Mancha and Navarra) over 90% of the land is rural, this share is below 50% in the Balearic Islands, Madrid and Murcia. The percentage of the total population living in rural areas also shows large differences, ranging from 2% in Madrid to 49% in Extremadura (MAPA, 2022[1]).

Table 1.3. Population, unemployment, and GDP by autonomous community

	Population (1 000, January 2021)	GDP per capita (EUR, 2020)	Unemployment rate (%, 2022 Q2)
Andalusia	8 472	17 747	18.7
Aragón	1 326	26 512	9.0
Asturias	1 012	21 149	11.4
Balearic Islands	1 173	22 048	9.3
Canary Islands	2 173	17 448	17.8
Cantabria	585	22 096	8.2
Castile and León	2 383	23 167	10.2
Castile – La Mancha	2 050	19 369	14.1
Catalonia	7 763	27 812	9.3
Valencia	5 058	20 792	12.8
Extremadura	1 060	18 301	16.7
Galicia	2 696	21 903	11.2
Madrid	6 751	32 048	10.2
Murcia	1 518	19 838	12.2
Navarra	662	29 314	8.8
Basque Country	2 214	30 401	8.8
La Rioja	320	25 714	10.2
Ceuta	84	19 559	22.8
Melilla	86	17 900	24.7
Total	47 385	23 693	12.5

Note: Unemployment data for Ceuta and Melilla may be affected by sampling errors.
Source: INE (2022), "Monthly statistical bulletin", July 2022 and "Spanish Regional Accounts", INEbase (database).

The Spanish system distinguishes between exclusive competences of the State or the ACs (*competencias exclusivas*), shared competences (*competencias compartidas* with different faculties for the State and the ACs) and concurrent competences (*competencias concurrentes* on which both the State and the ACs can concur). The Constitution explicitly (albeit generically) lists the exclusive competences of the state. The exclusive competences of each AC are listed in their Statutes of Autonomy.

In the case of agriculture and livestock, according to the Constitution, ACs may assume competences "in accordance with the general organization of the economy". All ACs have included competences in this area in their Statutes of Autonomy. As agriculture is one of the common policies of the European Union, with the bulk of policy design and funding decided at the EU level, the State administration represents Spain and co-ordinates the Spanish position in these discussions (MAPA, n.d.[33]).

In general, ACs provide major public services in such areas as education, health and environment (OECD, 2015[34]). As of 2020, decentralised expenditure at the level of regional and local government in Spain represented almost 42% of the general government expenditure (OECD, n.d.[35]).

1.2.2. Spain's new CAP Strategic Plan

New elements of the 2023-27 CAP Strategic Plan include the consolidation of the rural development pillar in a single national plan and the definition of seven agricultural practices as voluntary eco-schemes

The European Union's Common Agricultural Policy (CAP) is the main agricultural policy instrument in Spain. After France, Spain is the second beneficiary of CAP expenditure; the sum of its Pillar 1 (direct payments and market measures) and Pillar 2 (rural development) expenditures in 2019 represented EUR 6.8 billion or 12.4% of the EU total (European Parliament, 2022[36]). The rules of the 2014-20 CAP remained in force until 31 December 2022 as a transitional period for the post-2020 CAP reform.

Under the 2014-20 CAP, EU Member States had flexibility to choose among several alternatives for implementing the rules at the national level. The choices included whether to transfer funds between the two pillars, the use of a redistributive payment for the first hectares of the farm, the share of funds dedicated to a payment for young farmers, and the use of payments coupled to production, among others. Spain dedicated 56% of its funding allocation to the basic payment and chose to use 12% of its funding allocation for coupled payments. It also allocated the maximum possible (2%) for the payment to young farmers, but chose not to grant the redistributive payment. Spain did not make use of the flexibility to transfer funds between pillars. The second pillar was implemented through 18 rural development plans: one at the national level and one for each Autonomous Community.

In the context of the 2023-27 CAP, EU Member States have more space to adjust the common policy to the national needs, for which they must submit a national CAP Strategic Plan (CSP) indicating their specific needs and the interventions. This is based on an analysis of the strengths, weaknesses, opportunities, and threats (SWOT) of their agro-food sector. The rest of this section focusses on Spain's new plan, which was approved by the European Commission at the end of August 2022.

Spain's total CAP budget for 2021-27 is EUR 47.7 billion. Of this, EUR 32.5 billion is destined to the measures envisaged in the CSP, and the remainder corresponds to funding for the transitional period of the previous CAP 2021-22 (EUR 13.7 billion) and to specific programmes not covered by the CSP (among others, programmes for the distribution of dairy products, fruits and vegetables in schools).

A significant change in the new Spanish CSP is the consolidation of the AC rural development plans for Pillar 2 into a single national plan for both pillars for the period 2023-27. The formulation of a single plan required an intensive process of co-ordination and consultation with the ACs (MAPA, 2021[37]), which remain responsible for establishing and implementing the rural development measures for their territories according to their needs and priorities, within the framework of the national plan.

In August 2022, the Spanish Government launched the process of public consultations for a draft Royal Decree establishing the new governance of the CSP and the management of funds from the European agricultural guarantee fund (EAGF) and the European agricultural fund for rural development (EAFRD) (MAPA, 2022[38]). The Ministry of Agriculture, Fisheries and Food (MAPA) will be the authority responsible for the management of the CSP and for ensuring an adequate co-ordination with the Regional Management Authorities to be designated by each AC. The decree also establishes several co-ordination structures involving the national and regional governments and other stakeholders.

Table 1.4. Direct payments make up over two-thirds of Spain's 2023-27 CSP budget

Structure and budget of Spain's CAP Strategic Plan

Component	Measure	Description	Budget (EUR million/year)[1]
Direct payments	Basic income support	Direct support to active farmers, subject to enhanced conditionality (environmental/climate and from 2024 social/labour).	2 460.0
	Redistributive payment	Complementary direct payment based on farm size (hectares) subject to thresholds; aims to benefit middle-sized farms.	483.0
	Young farmers' payment	Complementary payments for farmers under 40 years of age and with a minimum training level; payment increases by 15% if beneficiary is female.	96.5
	Eco-schemes	Payments based on implementation of one out of seven conservation practices per plot of the farm. Farmers may implement more practices, but the payment covers only one.	1 107.0
	Coupled support	Payments for the production of a specific crop or for the maintenance of a specific type of livestock. Approximately 80% of this component's budget is for livestock activities.	677.0
Sectoral programmes	Continuation of sectoral interventions already in place for fruits and vegetables (payments to producers' organisations), wine and apiculture.		582.0
Rural development programmes[2]	Integrates the rural development measures of the ACs and the supra-autonomous measures, which were previously included in 17 regional programmes and one national programme.		1 762.0

1. Approximate figures.
2. The amount for rural development programmes includes EUR 1 080 million from the European Agricultural Fund for Rural Development (EAFRD), as well as funds from the national and autonomous communities' budgets.
Source: MAPA (2022), *El plan estratégico de la PAC de España 2023-2027*, https://www.mapa.gob.es/es/pac/post-2020/resumen-pac-es_tcm30-627662.pdf.

An objective of Spain's CSP is to redistribute funds from larger to small and medium-sized farms. One of the ways through which it intends to achieve this is through a new definition of "active farmers" who may benefit from direct payments. Active farmers must be affiliated to the Social Security system as self-employed people in the agricultural sector or make at least 25% of their overall income from agricultural activities (5% in the Canary Islands). These requirements do not apply to farmers who receive direct payments for an amount of EUR 5 000 or less. In 2021, 68% of beneficiaries of direct payments were below the EUR 5 000 threshold, receiving just 14% of payments (MAPA, 2022[25]). Spain opted to include two additional redistributive measures: capping and degressivity.[7] Payments may not exceed EUR 200 000 per beneficiary; and, starting from EUR 60 000, direct payments will be subject to a reduction of 25%, with higher amounts to be reduced at a higher rate.

The CSP aims to maintain, at the national level, the direct payment envelopes received by each region in previous CAP periods, as these payments are considered a basic safety net. Agricultural regions for CAP implementation purposes do not correspond to the territory delimitation of the ACs; rather, they are defined according to agronomic and socioeconomic criteria. The basic income support and the complementary redistributive payment – which is additional to the direct payment and focused on medium and small-sized farms – will be based on 20 new agricultural regions,[8] defined as follows (MAPA, 2021[39]):

- Rainfed croplands (five regions): Highly affected by annual climatic conditions and with very different labour needs due to their productive characteristics.
- Irrigated croplands (five regions): Characterised by the availability of water and by crops that are more productive, dynamic and have more alternatives.
- Permanent crops (four regions): Fewer crop alternatives, less flexibility and higher labour needs.

- Permanent pastures (five regions): As defined in the EU regulation 2021/2115.
- Balearic region: Characterised by socioeconomic conditions resulting from its insularity, which entails higher costs.

Direct payments will be subject to a process of convergence to reduce the differences within the same agricultural region that were created by past entitlements based on historic production or activities. Thus, entitlements above the agricultural region average will be reduced and entitlements below it will be increased. The objective is that all entitlements reach at least 85% of the regional average by 2026, and full convergence by 2029.

In Pillar 1 of the new CAP, sustainability aspects are incorporated chiefly through enhanced conditionality for direct payments and through the voluntary eco-schemes. Enhanced conditionality requires beneficiaries of direct payments and some rural development payments to fulfil environmental and animal welfare regulations and good practices (Statutory Management Requirements – SMR and Good Agricultural and Environmental Conditions – GAEC). The eco-schemes are payments per hectare to farmers that, on a voluntary basis, implement in a given plot of their farm some determined management practices. In the case of Spain, at least one of a "menu" of seven agricultural practices must be implemented to receive the payment. The practices selected (Table 1.5) are deemed beneficial for climate and the environment, and should have a higher level of environmental ambition than the one arising from the enhanced conditionality (which constitutes the baseline), such that the payment rewards the additional effort. The payment is granted for the implementation of one practice per plot of land, even though farmers can choose to apply more than one practice on the same plot.

Table 1.5. Practices included in the Spanish eco-schemes

Eco-scheme	Main objective	Practices	Crops allowed
Low-carbon agriculture	To improve soil structure, reducing erosion and desertification, increasing the carbon amount and reducing emissions.	P1: Extensive grazing	Permanent pastures and permanent grasslands
		P4: Conservation agriculture: direct sowing (with a sustainable management of irrigation inputs)	Arable land
		P6: Spontaneous vegetation cover or sowed with woody crops	Permanent crops
		P7: Inert vegetation cover in woody crops	Permanent crops
Agro-ecology	To favour biodiversity associated to agricultural areas, landscapes, and the conservation and quality of the natural resources, water, and soil.	P2: Sustainable mowing and biodiversity isles on the pasture areas	Permanent pastures and permanent grasslands
		P3: Crop rotation on land with improving species (with a sustainable management of irrigation inputs)	Arable land
		P5: Biodiversity areas on arable land and permanent crops (with a sustainable management of irrigation inputs): Non-productive areas and landscape features.	Arable land and permanent crops. Specific conditions for crops growing under water.

Source: MAPA (2022), *El plan estratégico de la PAC de España 2023-2027*, https://www.mapa.gob.es/es/pac/post-2020/resumen-pac-es_tcm30-627662.pdf.

In the rural development pillar, several policy interventions address sustainability considerations, including agri-environmental measures, investments with environmental contributions (Section 2.1.2) and support to organic farming. These interventions are co-financed, with over 67% of the funds coming from the EAFRD and the rest from Spain. The agri-environmental interventions target a variety of environmental and climate-related goals through practices that, among others, seek to improve soils and biodiversity, with a total public budget of EUR 763 million for 2023-27. The budget for the investment interventions with environmental contributions is of EUR 1.6 billion, including EUR 317 million for irrigation infrastructure investments.[9] In the case of organic agriculture, the total funding envelope is EUR 819 million; payments will be granted for the conversion and maintenance of organic farming areas.

Spain has not included CAP interventions for climate risk management. The main tool for climate risk management is the agricultural insurance system (Box 1.4), which is financed with national funds. The Spanish authorities consider that this system is providing a satisfactory response to the weather variability affecting agriculture, even in the context of climate change (MAPA, 2022[25]).

Box 1.4. Insurance of agricultural risks in Spain

Climate change is a major challenge for the agricultural insurance system

The Agricultural Insurance System has its roots in a period in which new democratic institutions were emerging in Spain. It was one of the pillars of a 1977 pact signed by the main democratic parties and trade unions, which included the commitment to prepare an Agricultural Insurance Law to "protect farmers from the consequences of catastrophic events". The first law enacted under the 1978 democratic Constitution, it has remained in place through Spain's EU accession and successive CAP reforms and has been defended by all Spanish governments and main political parties.

Each year the government approves a new Agricultural Insurance Plan with the list of insurance lines available, specifying the opening dates and the level of subsidies to be granted. Initially the insurance was applicable only to certain crops (mainly cereals) and risks (hail and fire), but it has expanded to cover 45 different insurance lines for crops, livestock, forestry and aquaculture.

Agricultural insurance is voluntary for farmers. The subsidised policies cover losses caused by natural factors, including adverse climatic events, animal diseases, removal and destruction of fallen stock, and damage caused by protected animals. Private insurance companies operate within a pool that shares the risk in a co-insurance regime. They offer the same products, guarantees and premium rates, but compete in the management costs charged and customer service provided. Insurers cannot deny coverage to producers who fulfil the minimum system requirements.

The subsidies by the central administration are applicable in the whole territory; each AC establishes the rules for its own subsidies. For most insurance lines, there is a basic subsidy (applicable to all farmers) and additional subsidies (e.g. for young farmers). Subsidies are applied as direct deductions from the insurance premium, up to 65% of its cost. AC subsidies may complement those paid by the central government, but the aggregate must not exceed the 65% threshold. In 2022, the national budget for agricultural insurance subsidies was EUR 276 million and the system covered an insured capital of EUR 16.3 billion with about 390 000 insurance policies. Claims amounted to EUR 769 million. There are no supplemental disaster relief payments from the national budget for losses caused by risks that are insurable.

Climate change is the main challenge facing the agricultural sector, and therefore agricultural insurance programmes. Although the system already covers the risks associated to climate change, it is now facing increased uncertainty and a higher frequency and intensity of damage. The system is seeing a growing number of claims for losses by farmers: the five years with the highest loss ratio were all during the period 2012-22. In response, the Spanish government has taken measures to avoid increases in the cost of insurance for farmers while recovering the subsidy levels, which had suffered severe cuts as a consequence of the economic crisis. The public insurance subsidy budget approved for September 2022 represents an increase of EUR 60 million or 23% with respect to the previous year and is over 50% higher than the budgets approved for each year between 2013 and 2020.

These challenges mean that the insurance programme and the farmers will have to adapt in the context of climate change to guarantee the insurance system's solvency and contribute to the sustainability of the sector. In its CSP, Spain acknowledged the need to adjust the system's coverage, guaranteed risks and thresholds, actuarial calculations, and formulas for reinsurance to this new reality. Seeking the

technical-actuarial balance for each insurance line, adjusting premiums and other corrective measures are currently given priority attention in Spanish insurance.

Studies have found that insurance – and particularly subsidised programmes that do not accurately reflect the farmers' risk profile – can be counterproductive for resilience purposes. These programmes can crowd out on-farm risk management strategies and private insurance options, drive the emergence of problems of adverse selection and moral hazard, incentivise maladaptive outcomes (allowing producers to remain viable even if avoiding long-term risk management practices), or disincentive additional risk reduction. For this reason, the premiums should reflect the actual risk faced, so that actors have an incentive to take other risk-reducing measures. In general, insurance can be useful to enhance resilience, but only if it is treated as a tool in a wider overall resilience strategy rather than as an alternative to adaptation.

Source: Based on Antón and Kimura (2011[40]), MAPA (2022[25]), (2022[41]), (2022[42]), Glauber et al. (2021[43]) and OECD (2020[44]).

Data and digital technologies will be essential to monitor the implementation of the enhanced conditionality, the eco-schemes and other CAP measures. In the case of Spain, many of the necessary data collection and monitoring tools are at their early stages of implementation or are not yet in force. As a result, the availability of data is still limited.

As of mid-2022, several national regulations aiming to improve data collection and monitoring were in process of approval or starting implementation. They include decrees on sustainable soil fertilisation, use of phytosanitary products and use of antibiotics in livestock farming. A farm information system (*Sistema de Información de Explotaciones Agrícolas y Ganaderas y de la Producción Agraria* – SIEX) will also be implemented. SIEX will integrate all agricultural information that farmers must provide to the competent authorities. It will include a new Digital Farm Notebook (*Cuaderno Digital de Explotación Agrícola*) for crops and a General Registry of Best Available Techniques in Livestock Farms (ECOGAN). The Digital Notebook will collect and provide quantitative farm-level information on the use of phytosanitary products, fertilisers and antibiotics (MAPA, n.d.[45]). ECOGAN represents the consolidation and digitalisation of the existing livestock registries, which were initially established for sanitary reasons but are increasingly being used for environmental monitoring. ECOGAN will record the Best Available Techniques (BAT) applied and estimate pollutant and greenhouse gas emissions at the farm level. Its implementation in the pig farming sector has been prioritised in order to address the ammonia emission problems associated with this activity.

In November 2022, the MAPA signed a collaboration agreement with the Spanish National Research Council (CSIC) for monitoring and evaluating the economic, social and environmental dimensions of the CSP based on science and indicators. The agreement will be implemented through an interdisciplinary platform (AGRIAMBIO), with the participation of different research centres and collaborations with universities and NGOs. Among other activities, CSIC will design indicators to determine the status of soil organic matter content, birds linked to agricultural habitats, pollinators, and other indicators of biodiversity and ecosystem services. The collaboration has an initial duration of three years, but an extension beyond this time limit to cover the full CAP implementation period is foreseen. The budget until end-2025 is of EUR 1.8 million, to be financed in equal parts by each of the institutions.

1.3. Drivers and outcomes of the agro-food sector performance

This section presents the essential drivers and outcomes of the performance of the Spanish agro-food sector, according to the OECD Food and Agriculture Productivity-Sustainability-Resilience (PSR) Framework. The PSR framework follows the main objectives of the 2016 Declaration of the OECD Meeting of Agriculture Ministers and seeks to advise countries on the policy mix that can best contribute to enhancing the productivity, sustainability and resilience of their food and agriculture sector.

1.3.1. Productivity changes

Agricultural output in Spain experienced remarkable growth in the last five decades. Growth was driven by total factor productivity increases, as the use of inputs declined. In the last decade, input use has picked up pace

Agricultural output in Spain has experienced sustained growth since 1960, with a particularly high growth rate in the first four decades. While output growth decelerated between 2001 and 2010, after 2011 it recovered and surpassed the EU average (2.15% vs 0.60% in 2011-19).

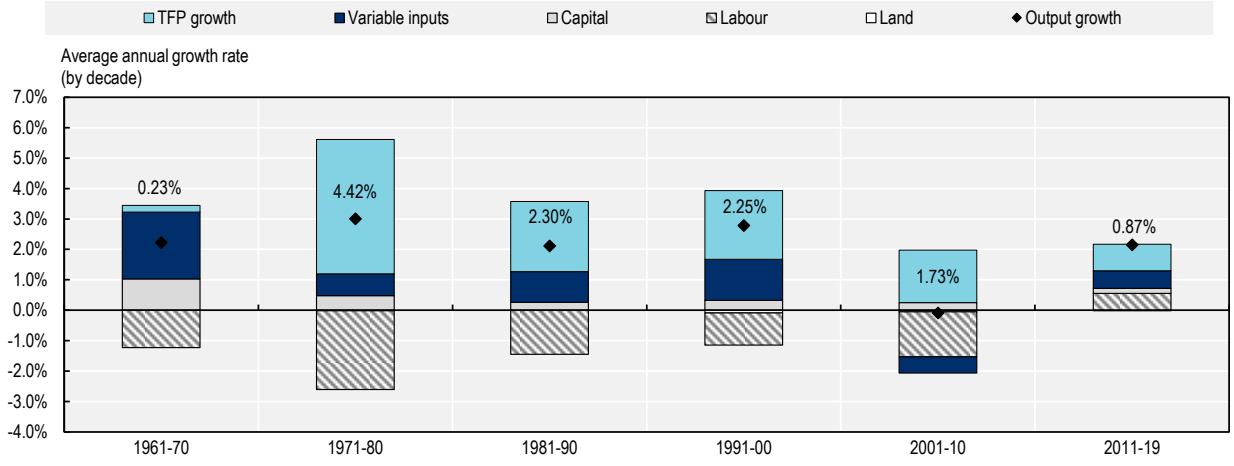
Growth in agricultural total factor productivity (TFP) reflects the ability of the sector to use inputs and land more efficiently, thus achieving a higher output per unit of inputs or per hectare of land. Since the 1970s and until 2010, productivity was the primary driver of Spanish output growth: TFP experienced increases above the EU average, which drove production up despite significant reductions in labour (Figure 1.9). TFP and overall output growth have slowed in the last two decades; between 2011 and 2019 TFP grew at an average rate of 0.87%, falling for the first time slightly below the EU average of 0.96%.

In the last decade, the use of agricultural inputs in Spain picked up again. In particular, labour use had a slight increase for the first time in five decades, after having experienced a fast and consistent decline, at rates above those observed at the EU level. The growth in variable input use remained consistently positive and large until 2001-10 when it declined. As production recovered in the most recent decade, use of variable inputs such as fertilisers increased again.

Even if the Spanish TFP average growth was below the EU rate between 2011 and 2019, the sector still performed better than in other European peers such as Italy, France and Germany (Figure 1.10).

Figure 1.9. Productivity improvements have driven Spain's agricultural output growth

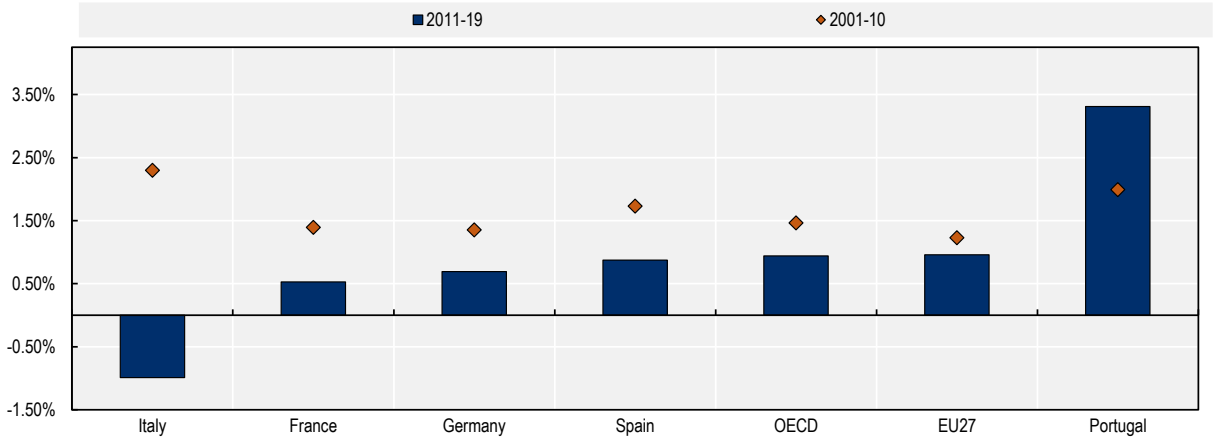
Decomposition of Spanish output growth by decade



Note: TFP growth is calculated as a residual, equal to growth in outputs minus growth in inputs.
Source: Authors' calculations based on USDA (2021), International Agricultural Productivity (database).

Figure 1.10. Despite having slowed down, Spain's TFP grew at higher rates than in selected peer countries

Agricultural TFP growth in Spain and selected countries



Note: TFP growth is calculated as a residual, equal to growth in outputs minus growth in inputs.
Source: Authors' calculations based on USDA (2021), International Agricultural Productivity (database).

1.3.2. Natural resources and climate change

Spain's agricultural area grew slightly between 2009 and 2020. The area under greenhouse cover – concentrated in the Mediterranean coast and the Canary Islands – had the strongest increase

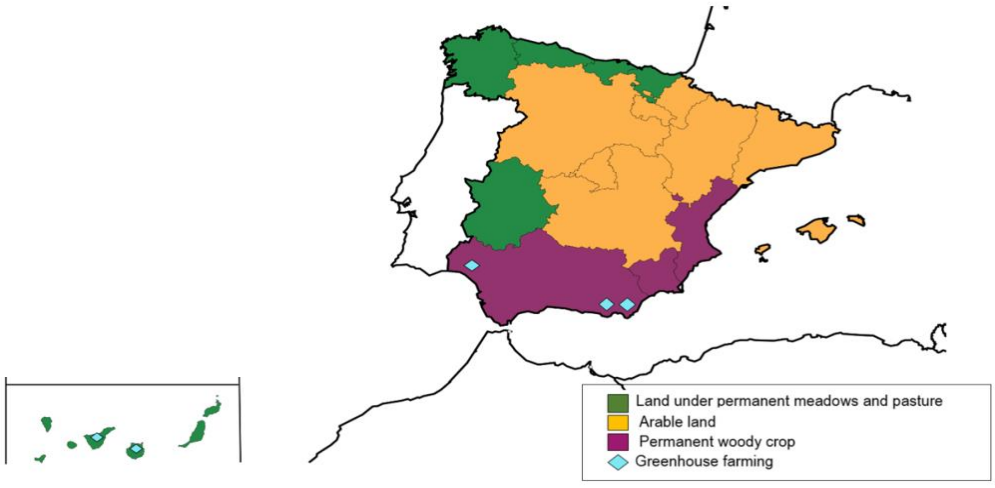
Agriculture is present in most of Spain's territory (Figure 1.11). According to the latest Agricultural Census (Instituto Nacional de Estadística, 2022[46]), the total Utilized Agricultural Area (UAA) in 2020 was of 23.9 million hectares, 0.7% larger than in the previous census (2009). Spain's large size, geographical position and climatic variability allow for a great diversity of agricultural activities. Arable land constituted almost half of the total UAA (49%), followed by permanent pastures (31.5%) and woody crops (19.5%). The remaining 0.3% corresponds to the area of greenhouse cultivation, which is mostly present in the Canary Islands and the mainland ACs of Murcia and Andalusia.

There was an expansion of the area with woody crops, including fruit trees (20%) and olives (14%). Arable land increased by 4%, while permanent pastures decreased by 10%. Spain's total area under organic certification expanded from 2% to 8%.

As of 2020, 45% of Spain's UAA was managed by high-input intensity farms, while low and medium-input farms had a share of 27.5% each. In 2015, these shares were 41%, 33% and 26% for high, medium and low-intensity farms. When the 2020 shares of high-intensity farms are compared across EU Member States, Spain is near the middle, below Portugal but slightly above Germany, France, Italy and the European Union as a whole. At the regional level, in 2019 the Balearic Islands, Madrid and Murcia had the highest UAA shares managed by low-input farms, while the Canary Islands, the Basque Country, Navarra and La Rioja all had over 70% of their UAA managed by high-input farms (Eurostat, 2021[47]).

Figure 1.11. Arable land represents half of Spain's agricultural area

Predominant crop in Spanish Autonomous Communities



Note: "Predominant crop" is the one with the largest share of the UAA for each AC.
Source: Authors, based on Instituto Nacional de Estadística (2022), Censo Agrario 2020.

Spain's agricultural output and productivity have grown in the last decade, but there are worrying trends in some input use indicators

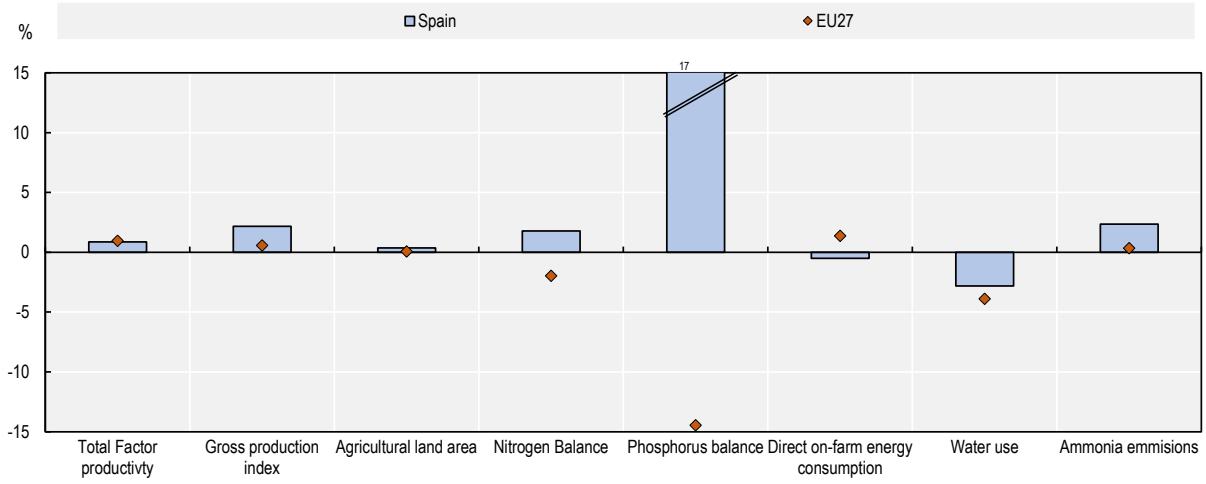
The OECD Agri-Environmental Indicators database shows that the increase in Spain's productivity between 2011 and 2019 was accompanied by decreases in the use of water and energy, while the farming land area expanded slightly. On the other hand, the balances of nitrogen (N) and phosphorus (P) grew above the EU averages (Figure 1.12). While they are essential inputs in agriculture, very high N or P surpluses can have adverse effects on the environment (OECD, 2019[48]): nutrient leaching that causes drinking water pollution and eutrophication, or releases of emissions that contribute to atmospheric pollution, soil acidification and water eutrophication. The management and storage of animal manures also generates ammonia emissions, which increased more than the EU average. The agricultural sector was responsible for nearly 97% of ammonia emissions in Spain in 2018 (European Comission, 2020[49]). Recent advanced data point to a decrease in ammonia emissions between 2020 and 2021 (MITERD, 2023[50]).

The volume of agricultural freshwater abstractions experienced a decrease, which was slightly lower than the decline observed in the European Union as a whole. Yet, Spain's water resources remain under significant pressure: the share of abstractions as a percentage of renewable resources is one of the highest in the OECD. Agriculture – and in particular irrigation – is the largest water user; the sector accounts for over 80% of water demand.

Improving the efficiency of irrigation systems is an important policy objective for Spain. For over twenty years, the Ministry of Agriculture, Fisheries and Food has led substantial efforts to modernise irrigation infrastructure with the aim of using water more efficiently (Box 1.6). Spain is currently starting a new irrigation modernisation plan, with public investments of over EUR 800 million, including initiatives in the framework of the Spanish Recovery, Transformation and Resilience Plan[10] and CAP Pillar 2 payments for investments for the modernisation of irrigation infrastructure which are acceptable under the condition that they do not lead to an increase in irrigated area (Section 2.3.3).

Figure 1.12. Spain's agricultural production is growing, as is its use of some inputs

Average annual percentage change in selected agri-environmental indicators, 2011-2019 or nearest available period



Source: Authors' calculations based on OECD (2022), Agri-environmental Indicators (database) and USDA (2021), International Agricultural Productivity (database).

Habitat deterioration, pressures on water resources and agricultural pollution threaten Spain's rich biodiversity. Soil degradation poses a risk for the future of agricultural activities

Spain has one of the highest biodiversity levels in the European Union. At 28%, its total share of protected terrestrial areas is well above the Aichi target of 17%. Natura 2000 terrestrial sites cover over 138 000 km^2 and correspond to 17% of the total Natura 2000 land area in the European Union. About one-quarter of Spain's Natura 2000 area is agricultural, such as natural grasslands and pastures. However, this rich biodiversity is under pressure: the conservation status of agricultural habitats has worsened in recent years, and the common farmland bird population has decreased, in line with the decline observed in the European Union. Forty-two per cent of the known species of freshwater fish are threatened, with water abstraction, droughts and agricultural pollution among the factors associated with their decline.

Spanish agriculture is also threatened by soil deterioration, while at the same time contributing to it. Ten per cent of the UAA is at risk of severe erosion, which particularly affects arable and permanent crops. The depletion of soil organic matter is also an important concern, as is the increasing salinisation. Three-quarters of Spain's tillable land was subject to conventional tilling practices as of 2016, in line with the EU average. Land degradation processes are associated with desertification,[11] which will also be aggravated by climate change.

Agricultural energy consumption has decreased after its 2004 peak, but the sector could still optimise its energy use

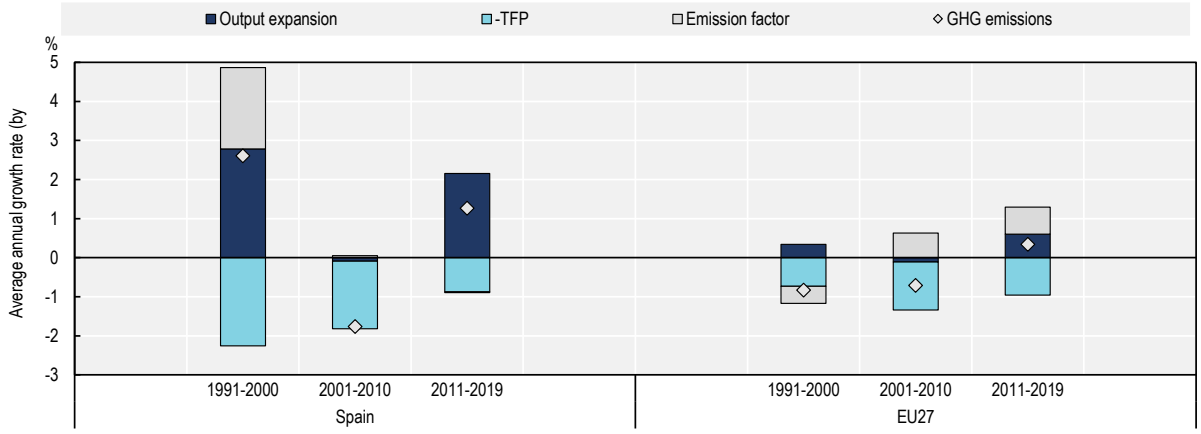
The direct energy consumption of Spanish agriculture in 2019 was of 2.6 million tonnes of oil equivalent (toe). The sector's average energy consumption decreased between 2011 and 2019 and it is below its peak of 3.3 million toe in 2004, but the most recent trend is of an increase. The analysis made for the CSP notes the sector's high dependency on fossil fuels, a low implementation of renewable energies, and the existence of numerous facilities not optimised for energy savings. The highest energy consumption in 2016 was for agricultural machinery, followed by consumption by farms and consumption for irrigation (MAPA, 2021[51]).

GHG emissions are on the rise again after declining in the previous decade

Emissions of greenhouse gases (GHG) from agriculture in Spain began rising again in 2011-19 after decreasing in 2001-10. This growth in emissions was mainly driven by agricultural output growth. Until 2010, Spain's robust TFP growth partially mitigated the growth in total emissions. However, in 2011-19, agricultural output grew at annual rates of 2% while TFP growth decelerated to 0.9%, so that productivity gains were unable to offset output growth, leading to an increase in emissions (Figure 1.13). The emission intensity per output unit has been decreasing in the last two decades more rapidly than the OECD average, but the pace of reduction has recently fallen. This underlines the importance of efforts to mitigate agricultural GHG emissions.

Figure 1.13. Productivity gains have helped mitigate GHG emission growth

Decomposition of changes in GHG emissions in Spain and the EU, 1991 – 2019



Note: Growth in output (blue) and in the emission factor of input use (emissions per unit of inputs) (grey) contribute positively to the growth in GHG emissions (the diamond marker). Productivity (TFP) improvements (light blue) contribute negatively; thus, they are shown as negative values.
Source: Authors' calculations based on USDA (2021), International Agricultural Productivity (database).

The impacts of climate change on Spanish agriculture will be numerous and uneven

Spain is already experiencing the impact of climate change. In the last 50 years, the average temperature has risen by 1.5°C (above the global and European averages). The overall volume of precipitation is changing, as is its annual distribution. The average flow of most Spanish rivers has decreased, and the frequency and intensity of extreme events such as heat waves and droughts are increasing (MITERD, 2020[52]). Between 1980 and 2020, the Spanish economy incurred losses amounting to EUR 60 billion as a result of weather and climate-related extreme events, the fourth highest amount among the 32 members of the European Environmental Agency (European Environmental Agency, 2022[53]). The OECD has identified Spain as the EU Member State facing the highest proportion of severe future water risks, and the sixth among OECD members (OECD, 2017[54]).

The specific impact on the agricultural sector is expected to vary depending on the geographical location and the activity. In general, production will be altered by the temperature increase, the reduced availability of water resources, and by extreme weather events. This effect will be uneven: the higher temperatures and frost reduction may increase production of some crops or turn some Mediterranean areas into optimal land for growing tropical fruits, but other areas (especially in the southeast) may be unable to continue growing crops as they have done so far due to the increase in temperatures, salinisation, or lack of water. The northern area would see positive changes in yields across the board but may experience a decrease

in the production of native crops such as vineyards. Lastly, the decrease in rainfall for pastures could result in a change in land use from permanent towards herbaceous crops. In some areas, a loss of pasture productivity could have a negative impact on livestock.[12]

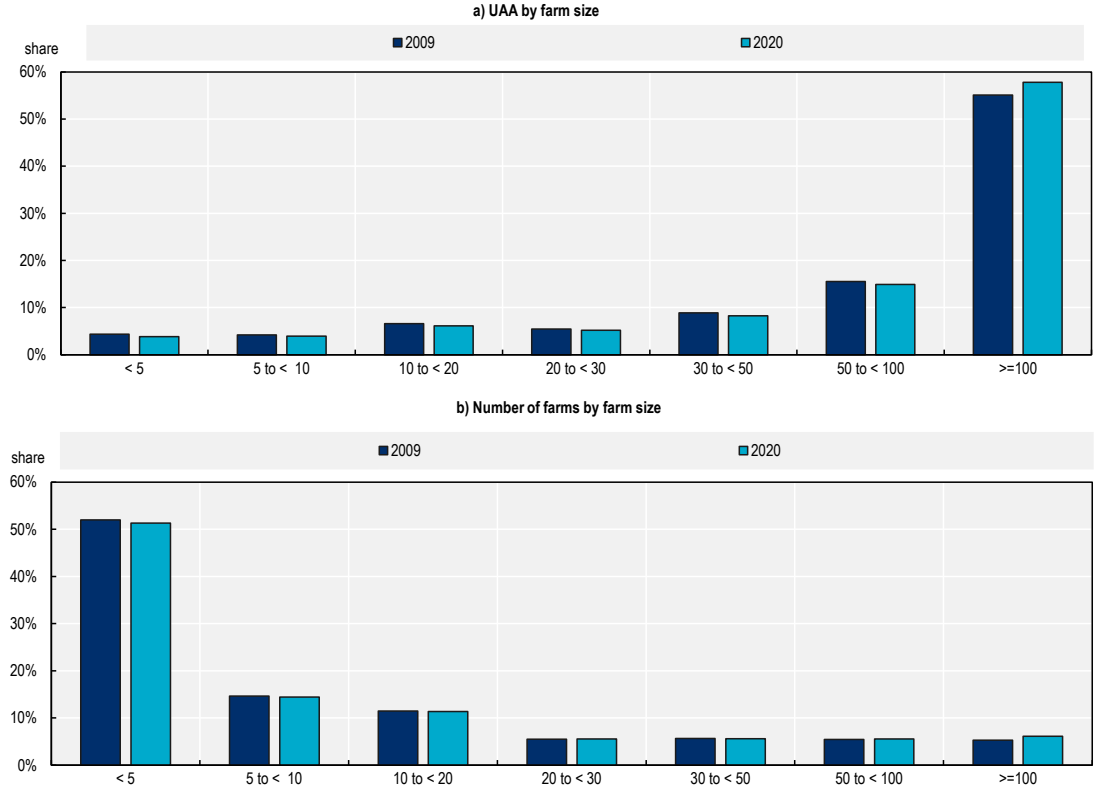
1.3.3. Structural changes

The Spanish agricultural sector is experiencing a transformation toward fewer farms of a larger average size

As of 2020, there were over 914 000 farms in Spain. More than half of them were small or very small (5 hectares or less), mainly run as family businesses; only 6% had an area of 100 hectares or more. The total number of farms has been on a downward trend: between the agricultural censuses of 2009 and 2020, it decreased by 75 000, a relative decline of 8%.[13] This affected farms of all sizes with the exception of the largest ones (of 100 hectares or more), which increased by 9% (Figure 1.14). This evidences a shift away from traditional small family farms towards larger commercial enterprises (PWC and Aepla, 2019[55]).

Figure 1.14. Larger farms are growing in area and number

Distribution of Spain's UAA and number of farms by farm size (ha), 2009 and 2020



Source: Instituto Nacional de Estadística (2022), Agricultural Census 2020.

In parallel with the decline in the number of farms, the share of the UAA held by larger farms rose from 55% in 2009 to 58% in 2020. This means that the largest 6% of farms take up more than half of the agricultural area. This situation is not unique to Spain: in the European Union the largest farms (3% of the total) cover over half of the UAA (Eurostat, 2022[56]). In line with the decrease in their numbers, smaller

farms' share of the UAA also became smaller. This resulted in an increase in the average farm size from 24.6 hectares to 26.4 hectares between 2009 and 2020.

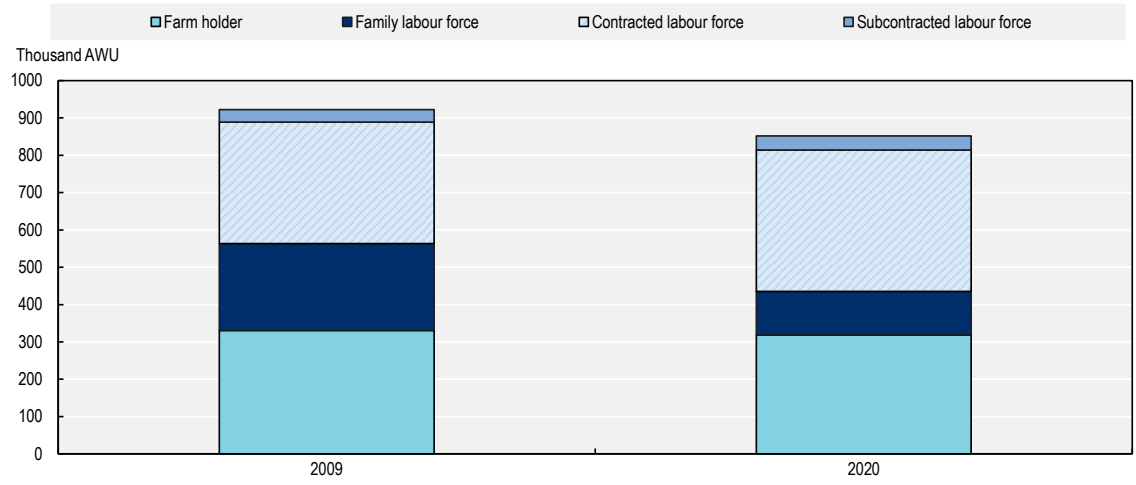
Several reasons explain this structural trend. They include the low profitability of farming and the general perception of poor persectives for the sector, which makes farming less atractive compared to other activities. In addition, increased productivity and mechanisation – which often requires a larger scale to be efficient – also play a role in the reduction of the total agricultural workforce (Garrido and Chuliá, 2020[57]), (European Commission, 2022[58]).

The number of farmers is declining, and their average age is increasing

Another characteristic of the structural transformation of the sector is a continuous decrease in the working population. In 2009, the sector's total workforce amounted to 922 026 Annual Work Units (AWU);[14] by 2020 it had declined by 8%, to 851 405. Particularly remarkable was the loss of family workers, which fell by 50%, while farm owners' work decreased by 4%. Conversely, contracted and subcontracted labour increased by 16% and 14% (Figure 1.15); their share in the farm workforce increased to 49% in 2020 compared to 39% in 2009 (Instituto Nacional de Estadística, 2022[46]). This development also evidences a shift away from family farms toward commercial operations, which rely more on contracted workers. In this context, it is also important to highlight the role of foreign agricultural workers: with a share of 26% in agricultural employment – compared with 18% in the overall Spanish workforce – they constitute the backbone of the Spanish farming sector (Garrido and Chuliá, 2020[57]).

Figure 1.15. Contracted labour is gaining importance in farming

Labour force composition among agricultural workers, 2009 and 2020

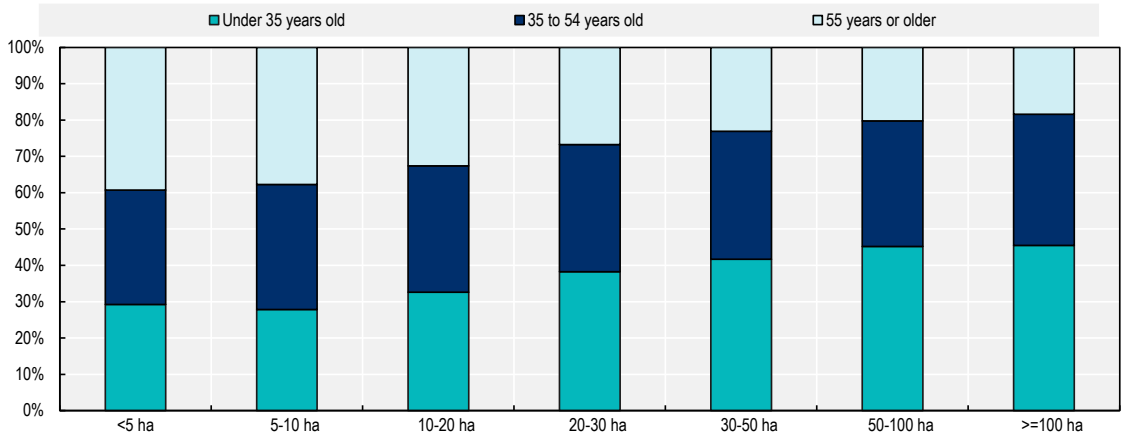


Source: Instituto Nacional de Estadística (2022), Agricultural Census 2020.

The rural population in Spain is ageing. Over two-thirds of farm managers were 55 or older in 2020, while only 4% was under the age of 35. Older farmers tend to concentrate on smaller farms: the larger the farm, the larger the share of younger managers (Figure 1.16).

Figure 1.16. Younger farm managers tend to work in larger farms

Age of farm managers by farm size, 2020



Source: Instituto Nacional de Estadística (2022), Agricultural Census 2020.

Box 1.5. Women in Spanish agriculture

While the number of female farm managers has increased, there is still a long way to go to make agriculture attractive to young women and improve the gender balance

Against the backdrop of the continuously diminishing labour force and the problem of generational renewal in the Spanish agricultural sector, the role of women is increasingly in focus. The sector, however, is traditionally dominated by men. In 2016, women accounted for only 30% of the total agricultural workforce. Official statistics tend to underestimate the participation of women, as female work often remains invisible. Compared to men, women carry out the majority of unpaid and informal activities, such as taking care of the household and the family; they also often support male farm holders as unregistered family labour. In addition, many women have temporary or part-time contracts that might understate their roles and responsibilities.

The presence of women in agriculture has become more visible in recent years. While the total number of farm managers in Spain decreased by 8% since 2009, the number of female managers actually rose by 22% (in contrast to male managers, which decreased by 16%). Nevertheless, only 29% of all farm managers were female in 2020. In addition, farms managed by women have less land at their disposal and account for lower economic outputs.

Ensuring accessibility and opportunity for women in the agricultural sector is indispensable to counter the demographic imbalances and assure a viable future for the sector. However, the data show that few young women have a recognised role in farms: only 3% of female farm managers were younger than 35, compared with 5% of men. This can indicate that agricultural careers are not attractive for women.

Spain has taken steps to acknowledge women's work in agriculture, including through Law 35/2011 on Shared Ownership of Agricultural Enterprises. The law aims to give legal and economic recognition to female work, and to remedy the gender imbalance between holders of farms' property titles. It allows couples to manage a farm jointly, sharing the work but also the farm's profits and entitlements (such as the CAP payments). However, a 2015 assessment showed that very few farms had registered as jointly owned. Some factors explaining this low uptake include lack of knowledge of the law, unequal implementation at the regional level, and difficulties to comply with the requirement for both co-owners

to pay into the social security system (although at a reduced rate under certain conditions). To remedy this, the Spanish authorities carried out information and awareness-raising actions and, since 2021 grant specific direct payments to shared-ownership farms.

Currently, 1 031 farms operate under shared ownership, 44% of them in Castile and León. While progress has been made, this still represents a very small proportion of Spanish farms. As of 2020, 70% of the Spanish farm managers that also own their farms were male, similar to when the law was enacted. This shows that work still needs to be done to improve the gender balance in agriculture.

Spain is one of only two EU Member States that address in their new CAP Strategic Plan the objective of improving participation of women in farming (the other one is Ireland). The Spanish CSP increases by 15% the complementary direct payment for young farmers (of 40 years or less) if the beneficiary is female and owns or co-owns the farm. Together with other four EU Member States, Spain also proposes measures supporting rural women in the new CSP. Rural development interventions include in some cases positive discrimination measures in favour of women. For example, women are prioritised in grants for investments in the processing, commercialisation, and development of agricultural products. Furthermore, farms owned by women or under shared ownership are prioritised in support programmes such as the 2019-2023 National Support Program for vineyard restructuring and reconversion.

Source: Based on Boletín Oficial del Estado (2011[59]), European Commission (2022[58]), European Institute for Gender Equality (2016[60]), (Gimeno Pérez, 2018[61]), Giner, Hobeika and Fischetti (2022[62]), Instituto Nacional de Estadística (2022[46]), and MAPA (2022[63]), (2021[64]).

Facing these social and structural challenges is an important policy priority in Spain. Agricultural and rural development policies seek to make the activity more profitable and sustainable, revitalise rural areas and fight against their abandonment, improve female participation, and make farming more attractive to young people. Relevant policy interventions include the CAP income support and complementary payments, as well as investments to support farm infrastructure improvement, such as irrigation modernisation programmes (Box 1.6).

Box 1.6. Socio-economic effects of irrigation modernisation

Following a period of intense droughts, Spain embarked in a process of modernisation of irrigation infrastructure that is considered to be one of the largest in the world in recent decades (Berbel et al., 2019[65]). The first and second modernisation plans, implemented between 2002 and 2015, improved about 1.8 million hectares of irrigated land. Between 2000 and 2021, the total investments by the MAPA and the AC administrations for transforming irrigation systems amounted to EUR 3.8 billion (MAPA, 2022[66]). As a result of these efforts, over half of Spain's irrigated surface now uses localised methods such as drip irrigation. More recently, an important amount of funding has been destined for new modernisation programmes subject to environmental requirements (Section 2.3.3).

Beyond the objective of achieving a more efficient use of water resources (covered in Section 2.3), the irrigation modernisation policy also aims at improving the socio-economic situation of farmers: by enhancing the competitiveness of agriculture, it seeks to promote development and employment in rural areas and improve the quality of life of farmers, thus helping combat the problem of rural abandonment (Gutiérrez-Martín and Montilla-López, 2018[67]).

Irrigation policies have contributed to dynamise agricultural production and raise productivity, but their social effects have been less studied at the country level. The evidence available comes from case studies or surveys for specific communities. The State Agricultural Infrastructure Company (SEIASA) compared the situation before and after modernisation for individual irrigation communities (associations of users) and crops. It found that beneficiaries produced more per cubic metre of water

used, used less fertilisers, and faced lower fertiliser costs due to the use of fertigation. The higher production and income result in improved quality of life and working conditions for farmers (SEIASA, 2017[68]). Another effect identified in case studies is the use of more high-skilled labour due to the implementation of more innovative technologies (del Campo García, 2017[69]). A 2014 survey (Castillo, Borrego-Marín and Berbel, 2017[70]) found that the crop changes driven by the modernisation process are positively correlated with the younger and more entrepreneurial farmers in the sample, and that the automation and remote control of irrigation have improved the quality of life of agricultural workers. The authors of the survey called for the development of socio-economic analyses of the impact of modernisation to complement the work done in the agronomic and hydrological fields.

Farm income has increased, but there are large differences depending on the farm output and activities

Between 2007 and 2020, the annual average farm income in Spain – expressed as average farm net value added (FNVA) per AWU[15] – increased by 34%, to EUR 31 913. While this clearly surpasses the EU average of EUR 23 649 for 2020 (FADN, 2022[71]), wide discrepancies in farm income exist depending on the level of standard output and the type of farm. Income generally rises with farm output, leading to differences of more than EUR 40 000 between low and high output farms. There are also divergences depending on the activity of the farm: for example, granivore livestock farms (pigs and poultry) earned over twice the average, while wine farms had a particularly low income (FADN, 2022[71]).

Income from agricultural activities only provides a partial picture of the situation of rural households in Spain: many farmers do not dedicate their working time exclusively to farming, but have additional gainful activities (PWC and Aepla, 2019[55]). Unfortunately, neither the EU farm accountancy data network (FADN) database nor Spanish national statistics collect information about off-farm income to analyse the income situation of farm households. The 2020 census reported that 7% of all farms that were managed by their owner had lucrative activities unrelated to the farm (Instituto Nacional de Estadística, 2022[46]).

1.4. Conclusions

Spain has developed an agriculture that is competitive and successful in international markets. The sector is productive, and farmers in export-oriented sectors have been able to adapt and respond to the trends in external demand, both in Spain's traditional export markets and beyond. This is evidenced by the important growth of conventional and organic fruit and vegetables, which are mostly sold to other European Union Member States, and by the expansion of pig meat exports that go mainly to Asian markets. The development of agricultural production has in many cases driven support industries and services that are important motors of growth and employment in the regions where they are active.

At the same time, the sector is moving toward a more commercial farming model. While the number of large farms and their share of the agricultural area are increasing, the number of farms of less than 100 hectares – which are more often managed by older farmers – fell by 65 000 between 2009 and 2020. The participation of women has increased: the number of female managers grew by 22% in the same period. Yet, they represent less than one-third of farm managers. The share of farms that operate under the model promoted through the 2011 shared ownership law is still small.

Following a deceleration between 2001 and 2010, agro-food production picked up again after 2011, surpassing the average output growth of the European Union and returning to the trend of sustained growth observed between 1960 and 2000. While productivity has historically been the main driver of output growth, agricultural total factor productivity (TFP) has slowed down in recent years.

Between 2011 and 2019 the farming area grew slightly, and the use of water and energy by the sector decreased. At the same time, the balances of nitrogen (N) and phosphorus (P) and ammonia emissions grew above the EU average. While agricultural freshwater abstractions declined, Spain's share of abstractions remains one of the highest in the OECD, and agriculture represents over 80% of water demand. Agricultural GHG emissions also began rising again after experiencing a decrease, and Spain faces climate change threats that include water scarcity and more extreme weather events

Spain has destined substantial public investments to the modernisation of irrigation infrastructure. Through the irrigation policy, the Spanish administration seeks to simultaneously address environmental and socio-economic objectives. Thus, the policy aims to save water and increase the efficiency in its use (the effects on water resources are discussed in Chapter 2), and also to promote agricultural productivity and improve the income of rural populations.

Spain's autonomous communities are very diverse in size, in their share of rural areas and predominant agro-food activities. The State and AC administrations have competences in agriculture, which at the same time is a common policy area at the EU level. This makes co-ordination and dialogue between State and regional authorities essential. The effort made for developing a single national plan for the 2023-27 CAP is a remarkable example.

Spain's new CAP plan emphasises the importance of income support to ensure a safety net to farmers, and on redistributing these payments to small and medium-sized farms. Focus is given to ensuring the continuity of farming and to the role of income support in addressing challenges such as the abandonment of rural land and the lack of generational renewal. Coupled payments represent around 14% of the Pillar 1 budget. Preserving this support is considered vital for certain activities and regions that are economically and socially vulnerable, and efforts have been made to increasingly subject these payments to environmental conditions.

The new CAP seeks to give an increasingly central role to agri-environmental objectives, with strengthened conditionality requirements for the direct payments and voluntary eco-schemes as the main instruments. In the Spanish eco-schemes, farmers receive a payment for implementing in a given land plot at least one of seven agricultural practices. The payment aims to reward additional efforts done beyond the minimum CAP conditionality requirements.

In order to monitor the implementation and effectiveness of the new CAP environmental requirements and the voluntary eco-schemes, Spain has embarked in the development of a new regulatory framework and a farm information system (SIEX) to collect and provide quantitative information on the use of phytosanitary products, fertilisers and antibiotics and the application of Best Available Techniques at the farm level. A recent agreement between the Ministry of Agriculture, Fisheries and Food and the Spanish National Research Council provides the basis for developing indicators and research to evaluate the implementation of the CSP from the economic, social and environmental perspective.

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Notes

[1] Law 45/2007 defines a rural area as the geographic space formed by the aggregation of municipalities or smaller local entities with a population of less than 30 000 inhabitants and a density of less than 100 inhabitants per km^2.

[2] Trade data for “Fresh fruits and vegetables” cover chapters 06, 07 and 08 of the Harmonised System.

[3] Data on harvested areas under glass or high accessible cover are available for lettuces, tomatoes, cucumbers, peppers (capsicum), and strawberries.

[4] Spanish official publications and data refer to “ecological production” used as a synonym of “organic” or “biologic”. This report uses the term “organic”, understood as a system that produces food using natural substances and processes and aims to have a limited environmental impact, and as covered by the relevant EU rules and regulation. For a discussion of approaches and practices to produce food in an environmentally friendly way, including organic agriculture, see Box 1.2 of OECD (forthcoming[73]).

[5] The Mediterranean diet – inscribed since 2013 in the Representative List of the Intangible Cultural Heritage of Humanity – is characterised by a nutritional model consisting mainly of olive oil, cereals, fresh or dried fruit and vegetables, a moderate amount of fish, dairy and meat, and many condiments and spices, all accompanied by wine or infusions. This concept expands beyond food consumption to include a set of skills, knowledge, practices and traditions associated with the preparation and consumption of food (UNESCO, 2010[72]).

[6] This was completed in 1995 with the approval of the Statutes of Autonomy of the cities of Ceuta and Melilla. The Statutes of Autonomy establish the basic institutional rules of each AC, including their institutions of self-government and the competences that they have assumed within the constitutional framework.

[7] “Degressivity” refers to the reduction of payments above a certain level with the objective of improving the distribution of support.

[8] This represents a simplification from the previous CAP period, when there were 50 agricultural regions.

[9] These investments are subject to a number of conditions, including the existence of a river basin district management plan for the area in which the investment is made and the installation of a water meter. Investments that improve the irrigation installation or infrastructure shall be subject to a technical assessment in advance to ensure that they will result in potential water savings. Investments affecting bodies of surface or groundwater in less than good quantitative status must guarantee an effective reduction of water consumption of at least 50% of the potential water savings.

[10] The Spanish Recovery, Transformation and Resilience Plan (RTRP) is financed by the EU Recovery and Resilience Facility, the key funding instrument of the Next Generation EU plan to mitigate the social and economic impact of the coronavirus pandemic. The Spanish RTRP has eleven strategic projects (known by their Spanish acronym as PERTEs). Of them, the PERTE Agroalimentario is specifically dedicated to the development of the agro-food chain, including through digitalisation, knowledge and innovation. Another PERTE is dedicated to the digitalisation of the water cycle, including irrigation.

[11] Desertification refers to the degradation of land in arid, semi-arid and dry sub-humid areas. It is a complex process with multiple causes, including climatic variations and human activities.

[12] Information provided by MAPA in response to an OECD questionnaire.

[13] When comparing the figures of both censuses, it should be noted that the minimum surface thresholds in the 2020 census were lower than those of the 2009 census.

[14] AWU is the measure used to describe the work carried out by one person who is working full-time in a farm. It is equivalent to the total hours worked divided by the average hours worked in full-time jobs in the country.

[15] Average farm net value added (FNVA) per AWU is equal to gross farm income minus the depreciation costs. It takes into account agricultural support and income taxes. Measuring farm income per AWU allows to account for the different farm scales and provides a better measurement of agricultural labour productivity.

Annex 1.A. Survey for the Autonomous Communities

The following questions were used by the OECD to gather information from the Autonomous Communities in preparation of this report. The survey was distributed in July 2022. As of October 2022, responses from eight ACs had been received: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, Madrid.

Support from the MAPA and the Spanish Delegation to the OECD to distribute the survey to the regional authorities is gratefully acknowledged.

Part I: Innovation

1. Innovation: Institutions and long-term strategies

Q1. What are the main **agency/agencies** implementing agro-food innovation initiatives in your Community? *(Please select one answer)*

a) Private sector/Industry
b) Regional research institute
c) An agricultural research consortium
d) Other (please provide the name and web site) [ ]

Q2. Please provide the following information about the **agro-food research institution** from your Community that is part of the INIA system.

Number of employees Annual budget

Q3. What are the **main activities** of your Community's **agro-food research institution**? (*Please select up to 2 options*)

a) Generate knowledge through academic research
b) Develop innovative products and services
c) Provide advisory services and technical assistance
d) Provide training and capacity-building
e) Other (specify) [ ]

Q4. Please indicate the three **main products or thematic areas of focus** of the work of your Community's **agro-food research institution**:

1
2
3

Q5. Is there a long-term **strategy** for agro-food innovation in your Community?

a) Yes (please attach the document or provide a web link
b) No (if so, skip Q6)

Q6. What are the **key priorities** of the agro-food innovation **strategy** in your Community? *(Please select up to 3 answers)*

a) Adaptation to climate change
b) Animal health and welfare, and plant health
c) Collaboration along the agriculture and food supply chain
d) Digital technologies in farming and along the supply chain
e) (for example, use of precision agriculture tools on farm; digital technologies for traceability purposes; use of digital tech. and big data for monitoring and tracking of environmental parameters; etc.)
f) Increased value added from the agriculture and food sectors
g) Modernisation of rural areas and restructuring of farms and agro-food firms
h) Resilience of the sector
i) Sustainable natural resources management in the sector (for example improving soil health, and water quality; boosting clean energy; closing nutrient cycles; reducing food waste; reducing emissions and pollutants; preserving and restoring biodiversity and ecosystems; sustainable value chains; etc.)

Q7. Are there specific **policies for agro-food innovation** in your Community?

a) Yes
b) No (*if so, skip Q8*)

Q8. What are the **main focus areas** of the agro-food innovation **policy** in your Community? *(Please select up to 3 answers)*

a) Digital technologies
b) Bioeconomy
c) Circular economy
d) Food systems
e) Organic farming
f) Education and skills
g) Other (*What?*) [ ]

2. Investment in agro-food R&D&I (research, development and innovation)

Q9. What public **policy incentives for private investment** in agro-food research and innovation exist in your Community? *(Please select up to 3 answers)*

a) Public funding opportunities (such as Horizon Europe or AEI funds)
b) Financial incentives, such as grants, loans, loan guarantees
c) Fiscal incentives, such as tax credits, tax holidays, reduced tax rates (general)
d) Fiscal incentives, such as tax credits, tax holidays, reduced tax rates (specific to agriculture)
e) Public-private partnerships (for example EIP-Agri)
f) Regulatory concessions
g) Sharing the outcomes of public research (spill-overs)
h) Other *(What?)* [ ]
i) There are no incentives

Q10. Is the **effectiveness** of these research funding mechanisms evaluated? *(Please select one answer)*

a) Yes, regularly (*please attach the most recent evaluation document or provide web links*)
b) Yes, *ad hoc* (*please attach the most recent evaluation document or provide web links*)
c) No

Q11. Which **alternative sources of funding** for agro-food research and innovation exist in your Community? *(Please select up to 2 answers)*

a) Farmers' contributions via producer levies
b) Revenues from royalties or patents
c) Venture capital and Foreign direct investment (FDI)
d) Other *(What?)* [ ]
e) There are no alternative sources of funding

3. Farm advisory services

Q12. Which of the following types of **farm advisory services** are present in your Community and what is their importance? Please note that there might be two dominating types of farm advisory services, when two types coexist almost equally. *(Please select one answer for each row)*

	Dominating type	Existing type of lower importance	Non-existing type
Public (public organisations at the Community level; wholly financed from public sector)	□	□	□
Public-private service (increasingly provided by private consultant firms; farmers partly/wholly pay for services; centralized and decentralized)	□	□	□
Farmer's organisations (provided by farmer's organisations; financed through membership fees and payments by farmers)	□	□	□
Commercial (provided by commercial firms or private individuals; payment through project implementation or grants)	□	□	□

Q13. What are the **main subjects** covered by the farm advisory services offered in your Community? *(Please select up to 3 answers)*

a) Commodity-specific advice
b) Compliance with regulations or policy requirements
c) Digital skills (including knowledge and services about digital technologies
d) Entrepreneurial skills
e) Farm management
f) Financial/legal advice
g) Marketing of products
h) Sustainable technologies and practices to strengthen environmental performance
i) Technological innovation to increase productivity and competitiveness
j) Other (What?) [ ]

Q14. Is the **performance of public farm advisory services** evaluated? *(Please select one answer)*

a) Yes, regularly (*please attach the most recent evaluation document or provide web links*)
b) Yes, *ad hoc* (*please attach the most recent evaluation document or provide web links*)
c) No

4. Digital: Information and communications technology (ICT)

Q15. Are there any **policies** promoting access to and adoption of **digital technologies** and tools in general/for rural areas/for agriculture/for sustainable agriculture in your Community? *(Please select one answer in each row)*

	Yes	No
In general	□	□
For rural areas	□	□
For agriculture sector	□	□
For sustainable agriculture	□	□

Q16. How do you evaluate the availability and performance of the **digital infrastructure** (broadband) in general / for agriculture in your Community? *(Please rate on the scale from 1 to 5)*

	1 (Very poor)	2	3	4	5 (Very good)
In general	□	□	□	□	□
For agriculture	□	□	□	□	□

5. Education and skills

Q17. Are there any programmes/initiatives promoting **education in agriculture** in your Community?

a) Yes *(please attach relevant documents or provide web links)*
b) No

Q18. What long**-term skills / knowledge gaps** have been identified in the food and agriculture sector in your Community? *(Please select up to 3 answers)*

a) Accounting
b) Digital technologies
c) Environmental management
d) Entrepreneurship
e) Farm management
f) Marketing
g) Other *(What?)* [ ]

Q19. What is the approximate annual share of farmers *(Please provide approximate figures)*

Using extension and advisory services	[ ] %
Undertaking training	[ ] %
Information not available	

Q20. How do you evaluate the current average status of digital skills among farmers in your Community? (Please rate on the scale from 1 to 5)

□ 1 (Very poor for most famers)
□ 2
□ 3
□ 4
□ (Very good for most farmers)
□ Information not available

Q21. Are there any **policies supporting digital skills** among farmers in your Community?

a) Yes (*please attach relevant documents or provide a web link)*
b) No

6. Statistics on agricultural R&D&I

Q22. Does **your** Community collect **data on agricultural/agro-food R&D&I**? *(Please select one answer)*

a) Yes, data are collected and made available online (please attach the most recent report or provide a web link)
b) Yes, data are collected, but not officially published
c) No

Part II: Environmental aspects

7. Environmental challenges and regulations

Q23. Which are the main **environmental challenges** related to agricultural activities in your Community? *(Please select the main 3 options)*

a) Greenhouse gas (GHG) emissions
b) Nutrient pollution in water bodies
c) Pesticide contamination in water or air
d) Biodiversity loss
e) Deforestation
f) Soil degradation
g) Water scarcity
h) Other (What?) [ ]

Q24. Has your Community developed any **strategies** to deal with these challenges?

a) Yes (please attach relevant documents or provide a web link)
b) No

Q25. Is there an **agency** in the Community specialised in designing best practices or monitoring agri-environmental performance?

a) Yes (please provide a link to the agency's web site)
b) No

Q26. Please name and rank the five most important **environmental regulations related to agriculture** that are currently in force in your Community (beyond regulations by the European Union or the Government of Spain)

Name	Objective	Comment (*please include a web link to more information, if available*)
1.		
2.		
3.		
4.		
5.		

8. Environmental policies

Q27. Please indicate if your Community has implemented specific **policies or programmes** in the following areas (specific for this Autonomous Community):

Objectives	Yes	No
Support farming activities and/or practices (for example traditional practices or organic agriculture)	□	□
Water quality improvement (for example nutrient management, sediment runoff reduction)	□	□
Air quality improvement (for example reduction of GHG or ammonia emissions)	□	□
Natural resources protection (for example water quantity protection, preservation of the soil fertility/quality, carbon sequestration)	□	□
Protection of biodiversity (for example protection of ecosystems, pollinators, wild, native or at risk species)	□	□
Adaptation and resilience to natural hazards and/or climate change	□	□
Protection of genetic resources (for example crops, livestock, forest)	□	□
Other [What?]	□	□

Q28. Is the effectiveness **of these policies** evaluated? *(Please select one answer)*

a) Yes, regularly (*please attach the most recent evaluation document or provide web links*)
b) Yes, *ad hoc* (*please attach the most recent evaluation document or provide web links*)
c) No

9. Final remarks

Thank you very much for your co-operation in filling out the survey. If you have any additional remarks or comments, please use this space. If possible, please provide the contact details of a person or persons responsible for the areas covered by the survey, who might provide additional information or clarifications if required: [ ]

2 Environmental sustainability

This chapter presents Spain's policy priorities on agriculture and the environment and outlines the main agri-environmental policies and regulations at national and regional levels. It examines trends and assesses the current situation in greenhouse gas (GHG) emissions, water, nutrient balances and ammonia emissions, biodiversity, and soils. Water management is one of the main environmental challenges for Spain, with the agro-food sector accounting for over 80% of water use. Water pressures are aggravated by over-extraction in some regions, illegal groundwater pumping, and reduced availability due to droughts. This chapter examines the evolution of policies related to water and agriculture, and of their alignment with the OECD Council Recommendation on Water. Recent policy initiatives are discussed, including measures that aim to tackle GHG and ammonia emissions from farms, to prevent water pollution by nitrates and phosphates, and to modernise irrigation systems.

Key messages

- The right to an adequate environment and the obligation to preserve it are enshrined in the Spanish Constitution. Spain's EU accession and its process of decentralisation have also shaped the evolution of agricultural and environmental policies and regulations.
- Spain's climate plan requires that agricultural greenhouse gas (GHG) emissions are cut by 18% by 2030 with respect to 2005 levels. However, increases in livestock numbers and fertiliser use have resulted in a rise of GHG emissions since 2013. Ammonia emissions − 97% of which originate from agriculture − also began growing in the last decade, contributing to Spain's incapacity to meet its national ammonia reduction targets. New policies and regulations, including the Strategic Plan (CSP) for the 2023-27 Common Agricultural Policy (CAP) and the Spanish Recovery, Transformation and Resilience Plan (RTRP) aim to tackle the problems and help achieve the emission targets.
- Water management is one of the main environmental challenges. Water use – of which over 80% is by agriculture – is one of the highest in the OECD. Over-extraction of water by irrigators in some regions – aggravated by illegal groundwater pumping – and recurrent reduced water availability, in part due to climate change, affect farmers, other water users and ecosystems. Diffuse pollution from agricultural activities, salinisation, flooding and droughts also affect the water resources.
- Large investments to modernise and digitalise irrigation systems and monitor water use are in the pipeline. Previous irrigation plans have resulted in an increase in localised irrigation and a decrease in water use in 2000-18. At the same time, the irrigated area has expanded by 12% since 2011 (reaching almost 3.9 million hectares in 2021), water stress has not been reverted and there are questions on the effect of irrigation policies on water consumption.
- Spain is one of the world's biodiversity hotspots and has the highest agricultural biodiversity in Europe. Yet, changes in agricultural habitats and water bodies threaten the diversity of birds and freshwater fish species and put pollinators and indigenous livestock breeds under pressure. In addition, Spanish soils are threatened by erosion, loss of organic matter and salinisation, which are associated with desertification and aggravated by agricultural practices such as conventional tillage and groundwater pumping. The voluntary eco-schemes included in the CSP seek to incentivise farmers to go beyond the CAP mandatory conditionality requirements by providing a payment for the implementation of practices that seek to improve agricultural biodiversity and soils.

2.1. The Spanish policy perspective on agriculture and the environment

The right to an adequate environment, and the obligation to preserve it, are enshrined in Article 45 of the 1978 Spanish Constitution. The Constitution also gives public authorities the duty to safeguard the rational use of all natural resources to protect and improve quality of life and preserve and restore the environment, and states that violations of this clause shall be subject to sanctions and to the obligation to repair the damage caused. Spain's subsequent adoption and implementation of the EU environmental acquis and the transfer of environmental competences to the Autonomous Communities (ACs) have led to the development and consolidation of a significant body of legislation and jurisprudence in this area (García Giralda, 2011[1]). Competences in the environmental area are distributed among the different levels of administration according to Spain's decentralised structure (Table 2.1).

Table 2.1. ACs may develop their own laws, which must respect a minimum level of protection

Main environmental competences of each level of administration

Level of administration	Competences
European Union	The EU and its Member States may legislate and adopt legally binding law (shared competence).
National	Elaborating basic State legislation and transposing EU law. Ensuring compliance with international agreements. Defining national plans and strategies.
Regional (Autonomous Communities)	Implementing national legislation. May develop their own laws, so long as they do not reduce the level of environmental protection established by national law. Defining priorities for environmental action within their jurisdiction. Applying specific policy instruments, carrying out investment programmes, monitoring environmental performance and responding to non-compliance.
Local (municipal)	No legislative competences but may regulate through municipal ordinances in areas such as waste management, water supply and treatment, land use and public health protection. Larger municipalities (with more than 50 000 inhabitants) are responsible for local environmental protection, subject to prescriptions set out by national or regional authorities.

Source: Authors, with information from Ministerio de Trabajo y Asuntos Sociales (2002[2]).

2.1.1. General environmental policies and regulations

There is a complex set of rules and strategies for different environmental domains

Spain does not have a single national environmental law or strategy; there are numerous legislative instruments, plans and strategies related to specific environmental domains. This results in a complex set of rules at various levels of the administration. In 2015, the OECD noted that while EU policies have provided a unifying guidance for a multitude of strategies and programmes, transposition of EU directives has often been late or there has been a gap between transposition and implementation. The OECD suggested developing an Environmental Code to consolidate the numerous acts regulating separate areas (OECD, 2015[3]). The following sections of this chapter will cover the specific policies and regulations in the most relevant agri-environmental areas.

Spain was an early adopter of the concept of strategic environmental assessment

In Spain, strategic environmental assessment (SEA) of plans and programmes has been carried out since the 1990s. SEA procedures became obligatory after Spain transposed the EU SEA Directive (2001/42/EC) in 2006. The relevant national legislation (Law 21/2013) was last updated in 2018 to strengthen the role of SEA in the protection of Natura 2000 sites (Arce-Ruiz, Soria-Lara and González-Del-Campo, 2019[4]).

Public plans and programmes are subject to the SEA, while projects (either public or private) are subject to an environmental impact assessment (EIA). SEA is required for plans or programmes that, among other things, establish the framework for the future authorisation of projects legally subject to an EIA, or affect Natura 2000 sites. This includes plans and programmes in agriculture, farming and forestry.

The SEA can be carried out either at the national or at the regional level by the respective environmental authorities and according to the specific legal framework. All ACs have their own environmental assessment laws and procedures. For this reason, the implementation and effectiveness of environmental assessments differs across the regions, as does the number of assessment processes carried out. At the national level, Spain initiated 32 domestic SEA procedures between 2019 and 2021, including two in agriculture. One of them was for the new Strategic Plan (CSP) for the 2023-27 Common Agricultural Policy (Box 2.1). Four additional transboundary SEAs were initiated for the hydrological plans of the watersheds that Spain shares with Portugal, pursuant to the bilateral Albufeira Convention (UNECE, 2022[5]).

According to OECD recommendations and analysis, both *ex ante* impact assessment and *ex post* evaluation are key parts of evidence-based decision making. *Ex post* evaluation should be an integral and permanent part of the regulatory cycle. It helps to assess if laws are working as originally intended and, if not, to propose improvements. It is also an important check to ensure that laws are still justified and in the public interest; left unchecked, the stock of laws will continue to grow, creating unnecessary red tape for citizens and businesses (OECD, 2021[6]). Despite their importance, *ex post* reviews tend to be the "forgotten child" of regulatory policy (OECD, 2020[7]), and their use across OECD countries remains low.

Box 2.1. Assessing the environmental implications of the CSP

Stakeholder inputs received in the SEA process helped shape the final version of the plan

The strategic environmental assessment of Spain's CAP Strategic Plan (CSP) started in February 2020. The main authorities involved are the Ministry of Agriculture, Fisheries and Food (MAPA) as the promoter and substantive authority, and the Ministry for the Ecological Transition and the Demographic Challenge (MITERD) as the competent environmental body.

Key steps of the process include: consultations by the MITERD with concerned authorities (national and regional administrations) and other stakeholders (such as environmental NGOs) based on the initial CSP draft; the preparation by the MAPA of a strategic environmental study; and a public information process, through which the initial plan and the environmental study were made available to the public for comments. Following the consultation and information processes, the MAPA modified the strategic environmental study and prepared the final CSP proposal. These documents were sent to the MITERD, which examined the file and in December 2022 formulated a final strategic environmental declaration which includes, among others, a list of indicators to monitor the contribution of the plan's measures (such as the eco-schemes) to achieve the CAP's environmental objectives and Spain's main environmental and climate policies.

One hundred and eighty observations were received in the consultations. Fifty-four were presented in the direct consultation process, mainly by ACs and national administrative bodies, and 126 were received in the public information process. Of these, 80 came from the private sector (farmers' organisations and companies) and the rest from NGOs, research associations and the public. The largest number of observations (56) concerned the eco-schemes, followed by the rural development interventions (31). The main concerns expressed included: avoiding that farms that have been sanctioned for illegal water use receive CAP payments; guaranteeing that irrigation modernisation interventions effectively result in water savings; ensuring a sustainable use of agricultural inputs to avoid water pollution; improving carbon sequestration in agricultural soils and improving biodiversity. Numerous requests for training and advice to farmers in environmental and climate protection were also received.

The consultations and the environmental study helped shape the contents of the final CSP. For example, provisions were included in the eco-schemes, the coupled payments and some sectoral interventions to ensure that individuals or legal entities that have been sanctioned for illegal water use do not receive these payments. The irrigation modernisation interventions were also refined to include technical criteria for defining minimum potential water savings. Other changes include a revision of the indicators used for monitoring and evaluation, and adjustments to the financial plan.

Source: Information provided by the Ministry of Agriculture, Fisheries and Food (MAPA); Resolution of 7 December 2022 with the strategic environmental declaration of the CSP (BOE-A-2022-23029).

Autonomous communities apply their own environmental policies and regulations; many of them regularly evaluate the policies' effectiveness

There is a large number of agri-environmental policies and programmes at the regional level. All the ACs that responded to the OECD survey[1] indicated that policies and programmes are in place for the protection of biodiversity and genetic resources. Most ACs also have policies for supporting certain farming activities (such as traditional practices or organic agriculture), improving water and air quality, protecting natural resources, and adapting to natural hazards and climate change. All indicated that the effectiveness of these policies is evaluated. In four of the ACs this is done regularly; for example, in Castile and León as part of the regular evaluation of its rural development programme. In other cases, policies are evaluated on an *ad hoc* basis; for example, Cantabria performed an evaluation of its Strategic Plan for the Prevention and Control of Forest Fires in 2018. Five ACs indicated that they have an agency specialised in designing best practices or monitoring agri-environmental performance.

Many ACs have enacted agri-environmental regulations in addition to those at the national and European levels. They range from broader environmental protection laws to specific agri-environmental regulations, including those related to the regional rural development plans. Examples include the Environmental Protection Law (7/2006) of Aragón, the Draft Environmental Quality Law of Asturias (in development as of October 2022) and the Forestry and Nature Protection Law (16/1995) of Madrid.

2.1.2. Agri-environmental policy priorities

Recent agricultural policies and initiatives have prioritised actions in climate change and GHG emissions, water, nutrients management and biodiversity

The formulation of the new CAP Strategic Plan (CSP) involved an in-depth assessment of the agro-food sector's situation to identify and prioritise its needs in the areas covered by the CAP's ten key objectives. In the environmental domain, this focussed on "climate change action", "fostering sustainable development and efficient natural resource management" and "preserving landscapes and biodiversity" (Table 2.2). The highest priority was given to GHG and ammonia emissions, carbon sequestration, water status and biodiversity. Soil protection and controlling erosion and desertification, on the other hand, were given the second-highest prioritisation, even if they are an important component of the new CAP eco-schemes.

Table 2.2. Spain has given highest priority to climate change, water, ammonia emissions and biodiversity

Environmental sustainability needs in the CAP Strategic Plan

	Key CAP policy objective		
	Climate change action	Natural resource management	Landscapes and biodiversity
Prioritisation level: +++	Minimise GHG emissions Increase carbon sequestration Reduce climate change impact	Achieve good water status Reduce agricultural water pollution Reduce ammonia (NH3) emissions	Maintain agroforestry biodiversity Mitigate or reverse the decline of agricultural birds Habitat maintenance and recovery Promote the allocation of European funds in Natura 2000 Network areas Promote sustainable production systems
Prioritisation level: ++	Promote climate change adaptation Increase renewable energies Energy efficiency Reduction and optimisation of inputs	Forest land conservation and management Reduce erosion and desertification Protect agricultural soil	Maintain and enhance landscapes and connectivity Minimise the negative effects of phytosanitary products

	Key CAP policy objective		
	Climate change action	Natural resource management	Landscapes and biodiversity
Prioritisation level: +	R&D&I in climate change mitigation and adaptation Knowledge transfer in mitigation and adaptation Minimise risks of extreme climate events[1]	Reduce fine particulate matter (PM2.5) emissions Improve soil quality management and preservation Prevent PM2.5 emissions from forest fires	Preserve High Nature Value Systems (HNVS) Reduce use and improve management of plastics Improve coexistence with large carnivores Transfer and improvement of knowledge in biodiversity

1. This need will only be partially addressed by the CAP, as Spain intends to continue to use its national agricultural insurance system as the main tool for climate risk management.
Source: Spain's CAP Strategic Plan (July 2022), https://www.mapa.gob.es/es/pac/post-2020/pepac-sfc2021-v12_tcm30-623871.pdf;

In the context of the Next Generation EU plan to mitigate the impact of the coronavirus pandemic, the Spanish Recovery, Transformation and Resilience Plan (RTRP) will provide up to EUR 140 billion in transfers and loans for the period 2021-26. Within the plan, EUR 1 billion has been allocated for investments and reforms for the digital and environmental transformation of agro-food and fisheries. The specific RTRP reforms aimed at improving the environmental sustainability of the agro-food sector are:

- Developing and revising the regulatory framework for the environmental sustainability of livestock farming, including developing a general registry of Best Available Techniques (ECOGAN) and revising the livestock management regulations.
- Developing a new regulation on sustainable nutrition in agricultural soils, which aims to regulate fertiliser use practices to address water pollution and improve air quality (among others), and an electronic farm notebook for monitoring fertiliser application at the farm level (Section 2.4).
- Establishing a governance mechanism for irrigation systems at the national level, accompanied by investments in irrigation modernisation (Section 2.3).

Many of the policy interventions to address the needs identified in the CSP and implement the RTRP priorities take the form of new or reformed regulations. This prevalence of the use of a regulatory approach over other types of measures (such as economic incentives) may be attributed to the need to allocate a limited budget to address numerous needs and priorities.

Regions face diverse environmental challenges. The CAP rural development plan provides flexibility to implement agri-environmental interventions at the AC level

Given Spain's extension and regional diversity, the ACs face different types of environmental challenges. Biodiversity loss, soil degradation and GHG emissions were the most mentioned in the responses to the OECD survey, followed by nutrient pollution of water bodies and pesticide contamination of water and air. Specific ACs indicated that they face challenges related to ammonia emissions, deforestation, forest fires, the coexistence of livestock farming with large carnivores, and land use changes. All of the responding ACs have developed strategies to deal with these challenges; specific examples will be cited in the following sections.

The rural development pillar of the CSP includes eight types of agri-environmental measures that target a variety of environmental and climate-related goals in agricultural land. ACs choose which of the eight interventions they will apply and establish the specific conditions for the implementation within their territory. In some cases, the ACs opted out of certain agri-environmental measures due to potential overlaps with the eco-schemes or the measures to promote organic farming. The total 2023-27 expenditure forecast for these measures is EUR 763 million, of which EUR 508 million will come from the European Agricultural Fund for Rural Development (EAFRD) and the remainder from the national and AC budgets.

Table 2.3. Agri-environmental measures are characterised by a regional design

Agri-environmental commitments in agricultural land included in Spain's new rural development plan

	Total 2023-27 budget EAFRD funding (EUR million)	Improving water quality	Reducing water pollution	Reducing NH3 emissions	Addressing farmland bird decline	Maintaining & recovering habitats	Natura 2000 network	Sustainable production systems	Minimising GHG emissions	Increasing carbon capture	Reducing climate change impact
Measure *ACs applying the measure*		High priority goals (+++)									
Integrated production[1] *Basque Country, Extremadura, Balearic Islands, Canary Islands*	**87.1** 65.6	✓	✓	✓	✓	✓	✓	✓			
Sustainable farming commitments *Galicia, Basque Country, Navarra, La Rioja, Castile and León, Castile - La Mancha, Catalonia, Balearic Islands, Andalusia, Canary Islands*	**201.5** 143.3	✓	✓	✓	✓	✓	✓	✓			
Promotion and sustainable management of pastures *Galicia, Cantabria, Basque Country, Navarra, Castile and León, Catalonia, Andalusia, Canary Islands*	**130.7** 93.7				✓	✓	✓	✓	✓	✓	✓
Beekeeping for biodiversity *Galicia, Cantabria, Basque Country, Navarra, La Rioja, Aragón, Madrid, Castile-La Mancha, Castile and León, Extremadura, Catalonia, Valencia, Andalusia, Murcia, Canary Islands*	**124.4** 87.6				✓	✓	✓	✓			
Protection of bird fauna *Navarra, Aragón, Madrid, Castile-La Mancha, Castile and León, Extremadura, Catalonia, Valencia, Andalusia, Murcia*	**62.8** 39.0				✓	✓	✓	✓			
Maintaining or improving habitats and traditional agricultural activities that preserve biodiversity *Asturias, Cantabria, Navarra, La Rioja, Aragón, Madrid, Castile-La Mancha, Castile and León, Catalonia, Valencia, Murcia*	**88.8** 45.9	✓	✓	✓	✓	✓	✓	✓			
Alternatives to chemical pest control *La Rioja, Aragón, Catalonia, Balearic Islands*	**33.8** 15.4				✓	✓	✓	✓			
Soil improvement practices and fight against erosion *Navarra, Aragón, Castile and León, Canary Islands*	**34.6** 17.9	✓	✓	✓						✓	✓

1. "Integrated production" is defined as agricultural systems for vegetable production that make maximum use of natural resources and production mechanisms and ensure long-term sustainable agriculture and natural resource protection.
Source: Spain's CAP Strategic Plan (July 2022), https://www.mapa.gob.es/es/pac/post-2020/pepac-sfc2021-v12_tcm30-623871.pdf.

2.2. Climate change and GHG emissions

2.2.1. Assessment of status and trends

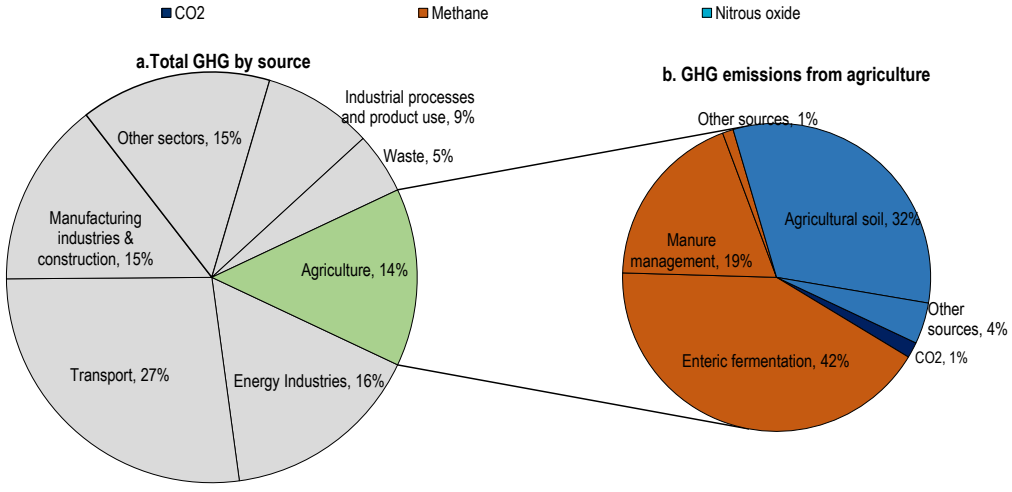
Agricultural GHG emissions in Spain are on the rise again after a period of decline. The most important GHG emitted is methane from livestock activities

Agriculture accounted for 14% of Spain's total GHG emissions in 2020, above the sector's share in 2000 (11%). Spain is the third largest emitter of agricultural GHG in the European Union, with 38.5 million tonnes of CO_2 equivalent ($MtCO_2eq$), after France (70.6 million $MtCO_2eq$) and Germany (56.1 million $MtCO_2eq$), and accounting for 10% of EU agricultural emissions (OECD, 2022[8]).[2] The sector is also a major contributor to national emissions of methane (CH_4) and nitrous oxide (N_20): in 2020, 63% and 77% (respectively) of the emissions of these gases came from agriculture.

Methane from enteric fermentation and manure management constitutes the bulk of agricultural GHG emissions (Figure 2.1). The second largest are nitrous oxide emissions, mostly from agricultural soil fertilisation. Only 2% of agricultural emissions are of carbon dioxide (CO_2), stemming mainly from urea application and liming of soils. Methane is a precursor of ozone; it is estimated that about 1 800 premature deaths in Spain in 2019 were due to ozone exposure (European Environment Agency, 2021[9]).

Figure 2.1. Methane from livestock is the major agricultural GHG in Spain

Agricultural GHG emissions by gas and source, 2020



Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

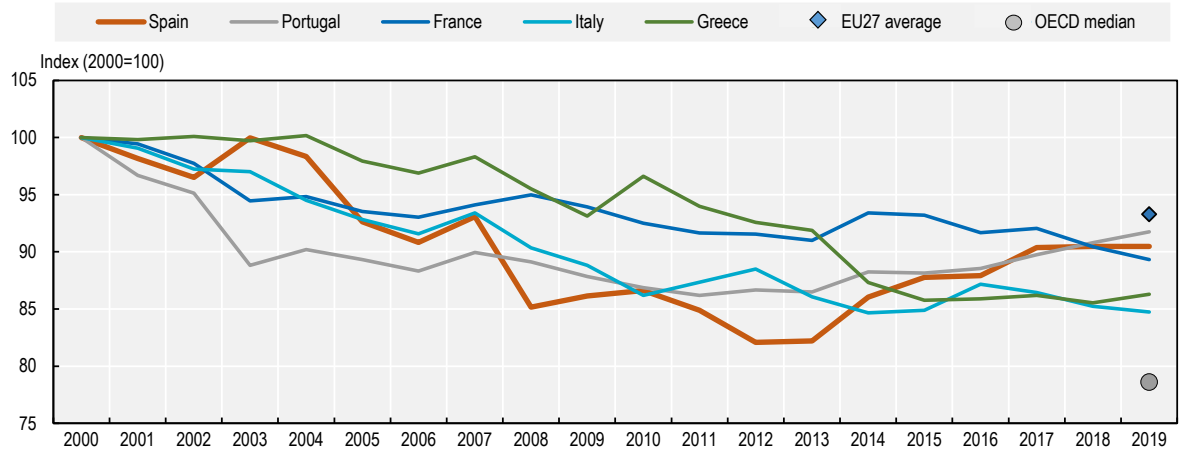
Land use, land-use change and forestry (LULUCF) is a net carbon sink: its net emissions were of -35.5 million $MtCO_2$ eq in 2020, with CO_2 removals coming mainly from forests. Spain is a major contributor to EU LULUCF removals, together with other large Member States (such as Sweden, Italy, France, Poland, and Romania) that as a group were responsible for approximately two-thirds of the EU LULUCF carbon sink (European Environment Agency, 2021[10]).

Agriculture GHG emissions decreased between 2000 and 2013, more sharply than in peer countries. However, they grew by 12% between 2013 and 2020, while the GHG emissions level of the whole economy was decreasing. While Spain remains below the EU average, overall progress is now below that of most peer countries (Figure 2.2). The decline in the early 2000s was due to the introduction of emission control

techniques in fertiliser application and improvements in animal feeding and manure management techniques. These changes brought 2012 emissions below their 1990 levels. The reversal of the trend after 2013 is associated with an increase in livestock numbers (such as the increase in the pig herd discussed in Box 1.1) and an upturn in the use of organic (manure) and inorganic fertilisers (MITERD, 2022[11]).[3]

Figure 2.2. Spain's recent agricultural GHG emissions are following an upward trend

Changes in agricultural GHG emissions, 2000 – 2019 (baseline year = 2000)



Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

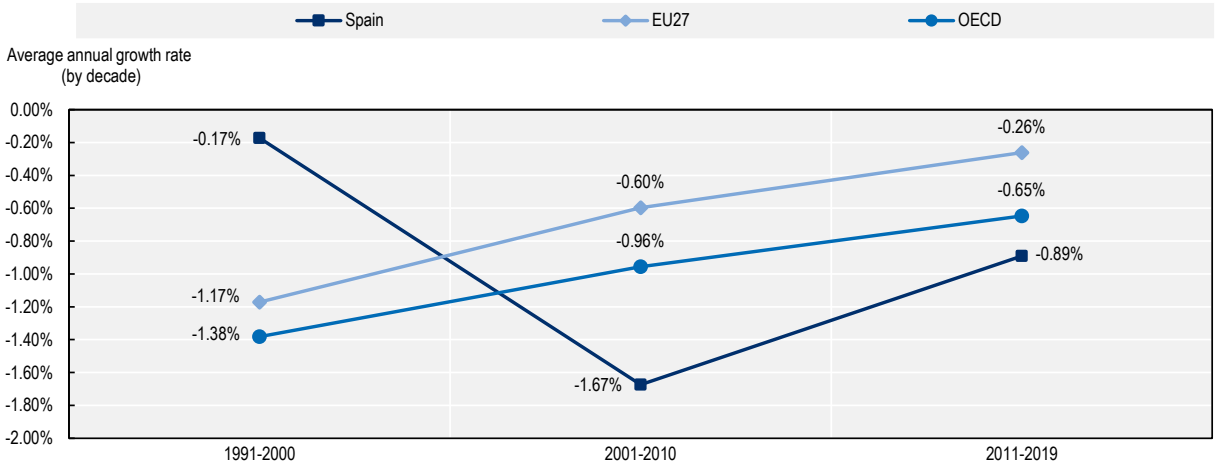
Agricultural GHG emissions have grown at a slower rate than agricultural output, and Spain has achieved relative decoupling of output from emissions

While overall agricultural emissions have increased in recent years, the emission intensity[4] of Spanish agriculture has decreased in the last three decades as emissions from agriculture have grown at a slower rate than the sector output. Between 1991 and 2000, Spain performed worse than the EU and OECD averages in terms of emissions intensity reductions but outperformed them in more recent decades (Figure 2.3). The rate of emissions reduction, however, decelerated in the last decade.

Spain succeeded in achieving relative decoupling[5] in 2011-19, as it experienced both an expansion of output that was larger than the expansion of emissions, and GHG emission intensity decreased. An absolute decoupling, however, was not achieved in any of the three most recent decades: in 2001-10, the only one in which GHG emissions decreased, output growth was also negative.

Figure 2.3. The emission intensity of agricultural production has fallen in the last three decades

Evolution of changes in emission intensity in Spain, the European Union and OECD, 1991–2019



Note: Emission intensity measures the amount of greenhouse gases emitted per unit of output. Lower numbers show greater improvement.
Source: Authors' calculations based on OECD (2022), Agri-environmental Indicators (database) and USDA (2021), International Agricultural Productivity (database).

2.2.2. Policies and regulations

Spain has set ambitious GHG reduction targets and aims to become carbon neutral by 2050

Under the EU 2030 Climate and Energy Framework, Member States must develop National Energy and Climate Plans (NECP) for 2021-30, in which they outline how they will address GHG reduction and improve energy efficiency. Spain's NECP[6] sets an economy-wide target for reducing GHG emissions by 23% with respect to 1990 levels, as set out in the Climate Change and Energy Transition Law (7/2021). In order to reach the national target, sectors not covered by the EU Emissions Trading System (non-ETS or "diffuse" sectors, which include agriculture) have to contribute with a reduction of 39% as of 2030, compared with their 2005 levels. This is in line with the new proposal for the EU Effort Sharing Regulation (which would amend the existing regulation (EU) 2018/842), part of the "Fit for 55" package of legislative proposals adopted by the European Commission in July 2021.

In the National Integrated Energy and Climate Plan 2021-2030, the agricultural sector as a whole must reduce its GHG emissions by 18% with respect to 2005 levels, as a sectoral target. A larger contribution (25%) is expected from the livestock sector (MAPA, 2022[12]). These are the reductions necessary to achieve the economy-wide target. Other EU Member States, among them Germany, France and Portugal, have specific GHG targets for agriculture (OECD, 2022[13]). The NECP acknowledges the CAP's role to address climate and environmental challenges, including through cross-compliance requirements that promote practices such as efficient fertilisation (Gobierno de España, 2020[14]).

The national energy and climate plan specifies measures to reduce GHG emissions from agriculture and livestock activities, including:

- promoting crop rotation on unirrigated land, adjusting nitrogen application to the needs of the crop
- frequently emptying slurry from pig housing
- covering slurry ponds
- separating the solid and liquid parts of slurry to use the liquids for irrigation and the solids for composting.

The plan also sets out measures to promote renewable energies, including doubling the installed capacity of electricity from biomass between 2015 and 2030. For the LULUCF sector, measures include regenerating silvo-pastoral systems, promoting poplar trees as replacements for agricultural crops in flood-prone areas, creating forest areas, preventing forest fires, integrating planned grazing into fire prevention efforts, promoting conservation agriculture, maintaining plant cover and incorporating pruning residues into the soil for woody crops, among others.

According to Spanish authorities' projections, a scenario with the adoption of all the measures proposed in the NECP would reduce total agricultural GHG emissions by 14% between 2020 and 2030, compared with only 3% in a "business as usual" scenario. The strongest impact would be in the emissions from manure management, which would decline by 43% compared with 0.3% in the baseline scenario. Removals from LULUCF are set to decrease in both scenarios, as grasslands and wetlands have switched to become slight emitters in recent years (IEEP, 2021[15]). However, the NECP measures would help mitigate this by increasing the carbon sink capacity of agricultural land (MITERD, 2021[16]).

The Spanish Long Term Decarbonization Strategy (ELP 2050) commits to reducing Spain's total GHG emissions by 90% with respect to their 1990 levels and achieving carbon neutrality by 2050. However, even though emissions from the primary sector are forecast to decrease by 53%, the sector's characteristics make mitigation difficult, so that by 2050 more than half of the emissions remaining will come from primary activities (MITERD, 2020[17]).

The National Climate Adaptation Plan 2021-2030 was approved in September 2020, following the declaration of a climate and environmental emergency in January. It established 81 lines of action for the different sectors of the Spanish economy. The lines of action that directly concern agriculture, livestock and food include improving the current knowledge on the climate impacts, risks and adaptation measures for the main agricultural and livestock production activities and the Spanish food system, strengthening adaptation in the new CAP, and integrating climate change in the sectoral regulations and strategies and in irrigation planning.

Most ACs have developed or are developing regional climate change strategies or plans, as well as autonomous climate change laws (Fundación Biodiversidad, n.d.[18]). For example, the Basque Country's draft Energy Transition and Climate Change Law aims to tax actions that increase GHG emissions and incentivise those that reduce emissions, including through the promotion of sustainable agriculture and forestry management.

The CSP will play a central role in promoting interventions to reduce agricultural GHG emissions. Spain is also developing new regulations addressing specific problems

Spain included a number of specific interventions in its CSP to meet the CAP climate change objective and ensure coherence with the NECP, both for reducing GHG emissions and for improving carbon sinks. They include the enhanced conditionality (minimum requirements for benefitting from direct payments and some rural development payments); the practices to be incentivised by voluntary eco-schemes; investments and other sectoral interventions for fruits and vegetables, apiculture and wine; and rural development interventions such as agri-environmental commitments and support to organic agriculture. Other interventions for climate action include the revision of the livestock planning regulation – with the establishment of the ECOGAN livestock registry – the new regulation on sustainable nutrition in agricultural soils, and the investments for irrigation modernisation contemplated in the Recovery, Transformation and Resilience Plan and the CSP rural development plan.

Climate risks to agriculture in Spain are mainly managed through the agricultural insurance system (Box 1.4). The system consists of subsidised policies that cover losses resulting from adverse climatic events and other natural causes. The subsidies are granted by the central administration and may be

supplemented by subsidies granted by the AC administrations, up to 65% of the premium cost. No additional disaster relief payments are granted for losses caused by insurable risks.

There are a number of taxes on GHG emissions at the national and regional level, but agriculture is often subject to reductions or exemptions

Spain applies some national taxes on energy use and for GHG reduction. While the existing electricity and hydrocarbons taxes are applicable to both agricultural and non-agricultural activities, agriculture is often subject to reduced rates. For example, electricity used for agricultural irrigation receives an 85% reduction of the taxable base of the Special Tax on Electricity. This partial exemption, which already benefitted other industrial sectors, was extended to irrigated agriculture in 2014 to compensate farmers for an increase in electricity tariffs (MAPA, n.d.[19]). In addition, the fuel used in tractors and agricultural machinery is charged a reduced tax, and farmers using agricultural diesel are entitled to a tax refund. Like other EU Member States, Spain applies a reduced VAT rate of 10% (as opposed to the general rate of 21%) for agricultural inputs such as fertilisers, herbicides, pesticides and plastics for crops (Agencia Española de Administración Tributaria, 2022[20]).

Spain also charges an indirect tax on the use of fluorinated GHGs, which impacts the agro-food industry through the food storage and distribution chain, since these gases are used in the operation of refrigeration systems (OECD, 2020[21]).

All the ACs except Madrid apply their own taxes, and some tax fossil fuel use and GHG emissions. For example, Catalonia taxes GHG emissions from industry and CO_2 emissions from vehicles, while Aragón, Castile-La Mancha, Galicia and Valencia tax some GHG emissions. In some cases agricultural activities are subject to exemptions or reductions. For instance, Murcia taxes emissions of sulphur dioxide (SO_2), nitrogen oxides (NOx), volatile organic compounds (VOC) and ammonia (NH_3), and Andalusia taxes CO_2, NOx and sulphur oxide (SOx) emissions, but both regions exempt facilities for intensive poultry and pig breeding from their taxes. Andalusia also levies a tax on single use plastic bags but exempts those used for food products. In the Canary Islands, farmers get a refund of the fuel tax for the use of agricultural diesel (Ministerio de Hacienda y Función Pública, 2022[22]).

2.3. Water

2.3.1. Assessment of status and trends

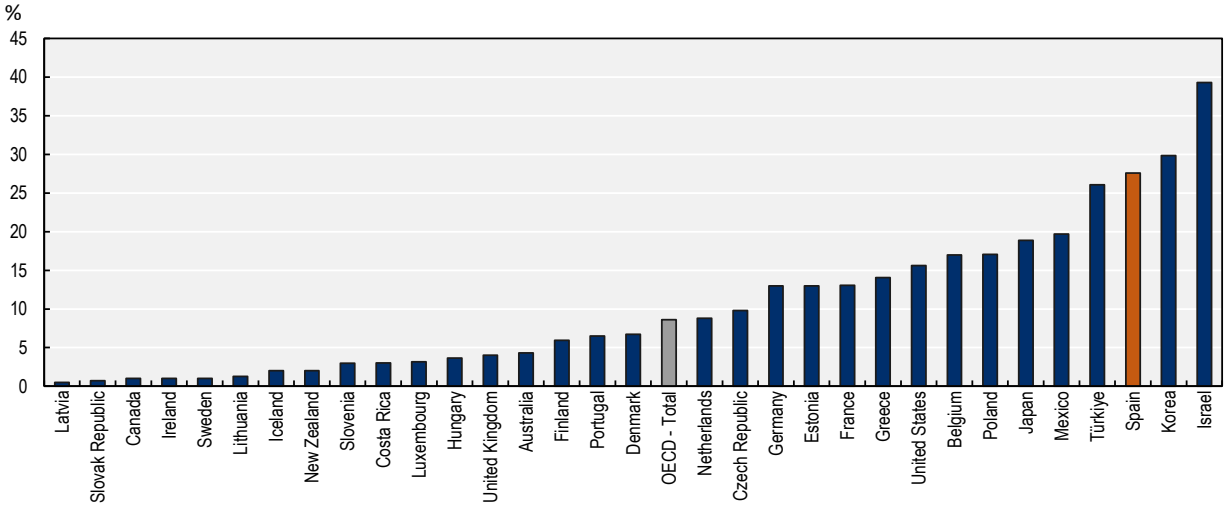
The climate and physical characteristics of Spain – including a large share of territory with a semi-arid climate and a strong variability of rainfall – present substantial water management challenges, including the need to secure water supply, manage demand for competing water uses, and recover over-exploited resources (OECD, 2020[23]). The major issue relates to water scarcity due to water abstraction pressures. Adding to this are agricultural pollution and water-related risks such as flooding – a recurrent problem in several regions of Spain – and frequent droughts affecting areas with a semi-arid climate. These problems are aggravated by climate change and pose significant challenges for agriculture (OECD, 2019[24]).

Spain's water resources are under enormous pressure, and agriculture is a major water user. The situation is worsened by illegal extractions and climate change

Spain has one of the highest intensities of water use in the OECD; already in 2015 it was considered to be medium-high water-stressed, or abstracting around 30% of its total available renewable freshwater (OECD, 2015[3]). Despite a slight decline in the last decade, the share of abstractions remains one of the highest in the OECD (Figure 2.4).

Figure 2.4. Spain's water stress level is among the highest in OECD countries

Gross abstractions, % of total renewable resources, 2018 or latest year available



Note: The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.
Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

Pursuant to the requirements of the EU Water Framework Directive (2000/60/EC), Spain reported 762 groundwater bodies covering 360 812 km^2. Nineteen per cent of this groundwater surface (68 573 km^2) was in a poor quantitative status[7] as of 2018. Particularly affected are four of Spain's river basin districts,[8] where over 70% of the area failed to achieve a good quantitative status: Melilla; Tinto, Odiel and Piedras; Guadiana (shared with Portugal); and the Andalusia Mediterranean Basins (European Environment Agency, 2018[25]).

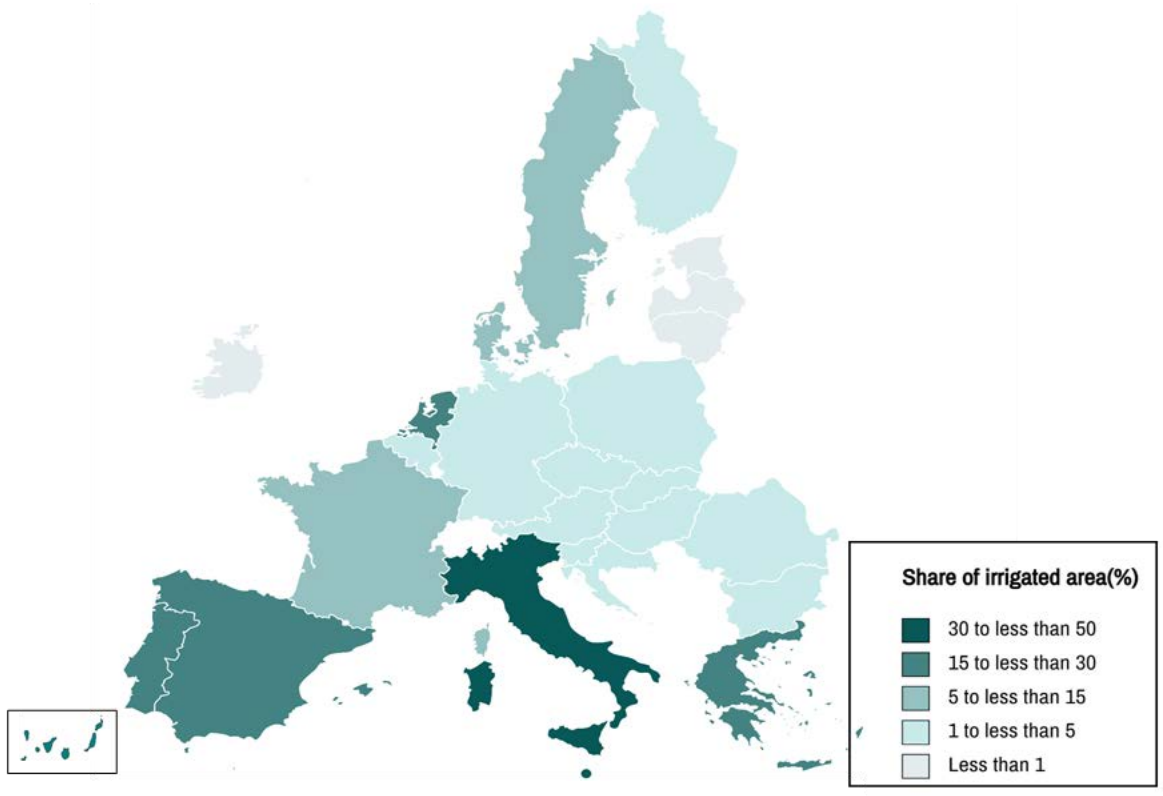
Agriculture is the largest consumer of water in Spain and the most significant pressure on its surface and groundwater bodies. Over 80% of water demand in Spain is for agricultural uses, mostly for irrigation. Around 65% of crop production and 20% of the utilised agricultural area (UAA) depend on irrigation (MAPA, 2021[26]). Spain is among the EU Member States with the largest shares of irrigation in agricultural areas, which are predominantly in the Mediterranean regions (Figure 2.5).

Spain has made important efforts to modernise its irrigation systems. This has led to a decrease in the use of surface (gravity) irrigation and an increase in localised methods (such as drip irrigation). Between 2011 and 2021, the area irrigated by gravity shrank by 16% while the area using localised systems increased by 28% from 1.6 to 2.1 million hectares, thus accounting for 55% of Spain's irrigated surface (MAPA, 2022[27]).

Between 2000 and 2018, the total volume of water distributed to farms for irrigation decreased from 16 897 to 15 495 cubic hectometers (hm^3), although a slight increase took place between 2015 and 2018 (Table 2.4). Drip irrigation systems accounted for 40% of the 2018 abstraction,[9] a significant increase from 2000, when they had a share of 9%. Gravity irrigation, on the other hand, declined from 73% to 33% in the same period (Instituto Nacional de Estadística, 2020[28]). At the same time, the total irrigated area reached almost 3.9 million hectares in 2021, having increased by 12% with respect to 2011 (17% with respect to 2002) and grown at an average yearly rate of 1% in the decade (MAPA, 2022[27]). While water use has reduced overall, it is not sure whether it has translated to lower agricultural water consumption (Section 2.3.2).

Figure 2.5. Agricultural irrigation is particularly high in the Mediterranean

Share of irrigated area, % of total utilised agricultural area (UAA), 2016



Source: Authors, based on Eurostat (2021), Agri-environmental indicators: Irrigation (database).

Almost three-quarters of the water distributed for irrigation in 2018 was surface water, while 24% was groundwater and 2% was desalinated or regenerated water (e.g. from the sea or from wastewater treatment plants) (Instituto Nacional de Estadística, 2020[29]).

Table 2.4. Drip irrigation systems have gained importance in the last two decades

Distribution of water to farms by irrigation method

	2000		2005		2010		2015		2018		2000-18	
	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Volume	Share	Variation volume	Interannual variation (%)
Total	**16 897**	**100%**	**16 505**	**100%**	**16 118**	**100%**	**14 945**	**100%**	**15 495**	**100%**	**-1 402**	**-0.87**
Sprinkler	3 058	18%	3 872	23%	3 895	24%	4 001	27%	4 121	27%	1 062	2.28
Drip	1 440	9%	4 859	29%	5 299	33%	5 739	38%	6 267	40%	4 826	8.36
Gravity	12 398	73%	7 774	47%	6 924	43%	5 204	35%	5 107	33%	-7 291	-5.65

Note: Volumes in cubic hectometres (hm^3).
Source: INE (2020), Survey on water use in agriculture, series 2000-2018.

Water pressures in Spain are aggravated by illegal or unregulated extractions (Box 2.2). The lack of official data makes it difficult to assess the extent of the problem. There is a 2005 estimate of 510 000 illegal wells in Spain (OECD, 2015[30]). The EU Court of Auditors reports that recent efforts to collect information from two regional authorities on how they detect and sanction illegal water use went unanswered (European Court of Auditors, 2021[31]).

Water availability problems will only be worsened by climate change. According to the National Adaptation Plan, average temperature increases of 1ºC and average precipitation decreases of 5% would lead to decreases of 5% to 14% in natural water inputs by 2030 (MITERD, n.d.[32]). A simulation under a 2°C warming scenario including climate change, land use change and water demand changes for 2026-55 estimated that Spain would have the highest decrease in groundwater recharge (-3 272 million m^3/year) and the most dramatic water scarcity situation in the European Union (Bisselink et al., 2018[33]). The water availability reduction will come together with an increase in evapotranspiration, a decrease in average annual precipitation and an increase in the frequency, intensity and duration of droughts (MAPA, 2021[26]).

Box 2.2. Depletion of groundwater bodies in the Doñana protected area

Illegal water abstractions are putting habitats at risk

In 2019, the European Commission (EC) referred Spain to the EU Court of Justice over its failure to take adequate measures to protect the groundwater bodies feeding the wetlands in the Doñana protected area (in Andalusia), as required by the Water Framework Directive (WFD). The Commission alleged that intensive irrigation and demand from tourism had overexploited the aquifers (European Commission, 2019[34]). In June 2021, the Court ruled that Spain failed to fulfil its obligations by not taking into account the pressures of illegal abstraction in its estimations of the pressures and impacts of water abstraction on the Doñana groundwater bodies. It also did not take the appropriate steps to avoid disturbing protected habitats (Court of Justice of the European Union, n.d.[35]).

A 2022 assessment by the Guadalquivir River Basin Authority found that maintaining the current degree and mode of exploitation of underground resources in areas of the aquifer would compromise its good condition and that of the dependent terrestrial ecosystems. It found that three out of five groundwater masses did not have a good quantitative condition. The report also recommended actions with a view to reverting this situation by 2027. They include strengthening water governance through a strict application of the law, preventing any increases in the area eligible for concession, and closing illegal abstractions (MITERD, 2022[36]).

As of July 2022, the EC considers that the measures put in place by Spain are insufficient to end the infringement, and sent a letter of formal notice to Spain. If Spain's response is not deemed satisfactory, the EC may refer the case again to the Court and ask for financial penalties to be imposed (European Commission, 2022[37]).

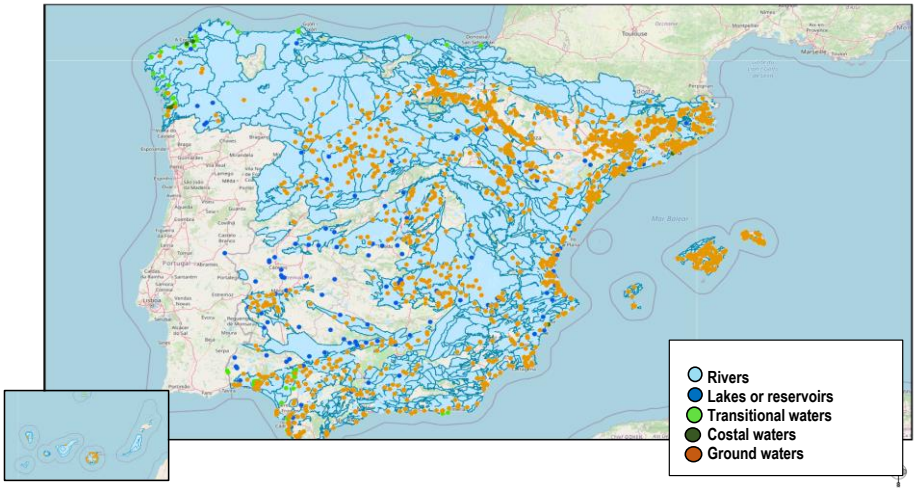
Nutrients from agriculture are the most important source of pollution in Spanish waters. Salinisation also affects water quality and impacts agricultural activities

Diffuse pollution from agricultural activities is one of the most significant risks for the quality of ground and surface waters in Spain (European Commission, 2020[38]). The most common contaminants are nitrates that reach water by filtration or runoff or through the oxidation of ammonia from animal waste. While agriculture's share of nitrogen discharges to the aquatic environment in Spain decreased from 93% to 89% between the reporting periods 2012-15 and 2016-19 of the EU Nitrates Directive (91/676/EEC), it was still the sixth highest among the Member States that provided data (European Commission, 2021[39]).

In Spain, nitrate concentrations are higher in ground waters than in surface waters, and are at concerning levels in a significant number of groundwater bodies (Figure 2.6). As of 2020, 33% of the sampled groundwater stations had nitrate concentrations above 37.5 mg per litre (mg/l), and 24% had concentrations above 50 mg/l[10] (MITERD, n.d.[40]).

Figure 2.6. Nitrate pollution particularly affects ground waters

Map of waters affected by nitrate pollution



Notes: The map shows the points where the maximum nitrate concentration in 2016-19 exceeded the thresholds established for surface water and groundwater, as well as reservoirs, natural lakes, ponds, estuaries and transitional and coastal waters that are in eutrophic state. Transitional waters are surface water bodies near river mouths, which are partly saline due to their proximity to coastal waters.
Source: © Ministerio para la Transición Ecológica y el Reto Demográfico.

In December 2021, the EC referred Spain to the EU Court of Justice for failing to take sufficient action on nitrate pollution. The Commission considers that Spain must take additional measures to prevent eutrophication in its whole territory – as previous efforts are deemed insufficient – and that it must designate additional Nitrate Vulnerable Zones, among other allegations (European Commission, 2021[39]).

Other sources of water pollution from agriculture are excess phosphorus (which can cause eutrophication and harmful algal growth), as well as pesticides reaching the aquatic environment through runoff, seepage or leaching. While it is difficult to identify a clear trend for the phosphorus values in superficial waters due to variations in the stations monitored (MITERD, n.d.[40]), the overall phosphorus balance in Spain is above the OECD average and continues to increase (Section 2.4). Phosphorus from agriculture has also been identified as one of the contributors to eutrophication in water bodies such as the Mar Menor (Box 2.3). A 2017 report estimated the annual national cost of nitrate and phosphate pollution for Spain to be EUR 150 million (OECD, 2017[41]).

The number of stations surpassing pesticide thresholds increased between 2018 and 2020, both in surface and in ground waters. This could partly be explained by an increase in the number of samples examined (MITERD, n.d.[40]). At the EU level, the monitoring of pesticides in water bodies is still at an early stage, covering a limited number of substances and based on voluntary reporting. Changes in the approval of substances also makes it difficult to identify trends. For 2013-19, Spain's exceedance rates (percentage of sites over the established thresholds) were 13% for surface waters and 9% for groundwater, below the rates reported by peer countries such as France and Italy (European Environment Agency, 2021[42]).

Box 2.3. The Mar Menor: Eutrophication due to nutrient pollution

Agricultural pollution has caused the deterioration of Spain's largest saltwater lagoon

The Mar Menor is a saltwater lagoon located in the autonomous community of Murcia, in the southeast of the Iberian Peninsula. It is one of the largest saltwater lagoons in Europe; several areas on its coastline have a protected status. The lagoon itself was designated in 1994 as a Ramsar site (a wetland of international importance).

The delicate ecosystem of the Mar Menor has been subject to substantial pressures, and it is currently affected by severe eutrophication. The situation has deteriorated in recent years, as agriculture and livestock activities, as well as tourism and urban development have expanded and intensified. There have been several episodes of advanced eutrophication, and in 2019 and 2021 events of mass mortality of marine fauna occurred. The input of nutrients provoked an excess of phytoplankton, which limited the entry of light and affected photosynthesis and oxygen availability. The resulting lack of oxygen killed thousands of fish and crustaceans along the shores.

For decades, the Mar Menor has received a large amount of organic matter and nutrients, in particular point and diffuse pollutant flows (mainly of nitrates but also phosphates and ammonia) from agricultural and livestock activities in the nearby Campo de Cartagena. Contamination is associated with the expansion of irrigated agriculture, which has increased water and fertiliser use. It is estimated that each hectare of lagoon is influenced by four hectares of intensive irrigation. Nitrates and phosphates end up in the lagoon by various routes and cause eutrophication. Other activities in and around the Mar Menor – including the urbanisation of its coasts, dredging and contamination from motor boats – contribute to aggravate the ecological and chemical state of its waters.

The Spanish Government has announced investments of EUR 484 million until 2026 to restore the Mar Menor. The Ministry for the Ecological Transition and the Demographic Challenge developed a plan of actions that includes measures to limit agricultural activities along the shores, tackle unauthorised irrigation, review discharge authorisations, and monitor livestock farms and their impact.

Source: Based on MITERD (2021[43]), Fernández López and Heezen (2022[44]), and (Ruiz et al., 2020[45]).

Another water quality problem associated with agriculture in Spain is the salinisation of groundwater. Over-abstraction of groundwater for irrigation can drive the intrusion of saline water in aquifers near the coast. Salinisation can be disastrous for agricultural activities: salt is left in the root zone of plants, which makes soils less permeable to water. Saline water can also filter into wetlands and affect their ecosystems (OECD, 2015[30]). The problem of groundwater salinisation is especially acute in Mediterranean areas such as the Segura river basin and the Balearic Islands (MITERD, n.d.[40]).

2.3.2. Policies and regulations

The decentralisation process, EU regulation and the increased pressure on water resources have driven changes in Spain's water policy, its focus areas and actors

Water policy in Spain has evolved significantly. The first River Basin Authorities (RBA) were established in 1926. The twentieth century saw an emergence of large infrastructure projects, including large dam reservoirs and, later, infrastructure for transfer between basins. These projects were often devised top-down, as part of national economic development strategies (Hernández Mora et al., 2010[46]). The return to democracy, the decentralised system and Spain's EU accession in 1986 influenced governance and management and changed the policy focus areas and the roles of actors (Table 2.5).

Table 2.5. Policy focus has shifted over time to consider water quality and environmental aspects

Phase	Policy focus	Relevant actors (level of involvement)	Key legal instruments and plans
Distribution of authority (1978-1987)	Water quantity	Central government (higher) River Basin Authorities (lower)	1978 Constitution 1985 Water Law
Distribution of water resources (1987-2004)	Water quantity and quality	Central government (higher) River Basin Authorities (higher) Autonomous communities (lower, higher at the end of the period) Parliament (lower) Courts (lower) Civil society (higher, but only in later years)	1987 Decree redefining river basin boundaries 1998 River Basin Management Plans (RBMP) 2000 EU Water Framework Directive (WFD) 2001 National Hydrological Plan 2001 Consolidation of reforms to Water Law into a new law (1/2001) 2003 Transposition of WFD into national law
Redefining roles and policy goals (2004-present)	Water quantity, quality and water ecosystems	Central government (higher) River Basin Authorities (higher) Autonomous communities (higher) Parliament (higher; lower in later years) Courts (higher) Civil society (higher)	2005 New National Hydrological Plan 2009-2015 First RBMPs under the WFD 2016-2021 Second RBMPs 2022-2027 Third RBMPs

Source: Based on De Stefano and Hernández-Mora (2018[47]), with information from MITERD (n.d.[48]) and European Commission (n.d.[49]).

The years following the 1978 Constitution were characterised by new legislation and the decentralisation process. Managing water quantity remained the main policy focus. This included infrastructure to increase availability. In 1979, the Tagus-Segura transfer – the first large interbasin transfer, to move water for agricultural irrigation to the southeast of the peninsula – started operating.

In 1987, the river basin boundaries were redefined, and regional governments became part of the management boards of the RBAs within their territory. The construction of large infrastructure continued. Severe droughts in the first half of the 1990s led to water use restrictions, later incorporated into a 2001 consolidated text of the Water Law (Hernández Mora et al., 2010[46]).

In the early 2000s, regional governments assumed full authority over the basins that are entirely located in their territory and created new RBAs. The WFD, with its broader approach to water policy, was incorporated into Spanish law in 2003. While Spain was a pioneer in the approach based on river basins, the new EU framework brought about new goals and actors.

This new context, with more attention to environmental concerns, influenced the approach of the 2001 Hydrological Plan, and led to the abandonment of its main project, a 914 km-long water transfer from the Ebro River in the northeast to the Mediterranean coast. The next hydrological plan shifted emphasis towards managing demand, wastewater recycling and reuse, and strengthened governance. It also emphasised the role of desalination to increase supply (OECD, 2015[3]), with important public investments in desalination infrastructure. Today, Spain has over 900 desalination plants with an installed capacity of over 4.5 hm^3/day (MITERD, n.d.[50]). It is one of the countries with the highest capacity in the world, accounting for over half of the total desalination in Western Europe (Jones et al., 2018[51]). This evolution, together with further drought episodes and increased pressure on resources, also influenced Spanish irrigation policy and drove actions to improve irrigation efficiency and modernise infrastructure.

Since 2002, Spain has conducted extensive programmes for modernising irrigation infrastructure with the objective of saving water and increasing efficiency in its use

The droughts experienced in the late 1990s motivated an ambitious National Irrigation Plan (*Horizonte 2008*) that aimed to modernise the infrastructure of over 1 million irrigated hectares between 2002 and 2008. Following further drought episodes, an additional plan was launched in 2006 (Shock Plan). Interventions under these plans subsidised around 60% of capital expenses to improve the infrastructure

in 1.8 million hectares of irrigated land. The objectives of this policy are to improve and modernise irrigation infrastructure in order to save water, promote rural development through a more competitive agriculture (see also Box 1.6); improve water quality and reduce diffuse pollution, and adapt to climate change (Berbel et al., 2019[52]).

Along with carrying out infrastructure works, the irrigation policy invests in innovation through the development of the Agroclimatic Information System for Irrigation (SIAR) network and in the training of technicians and irrigators. The SIAR network collects and publishes data from 468 stations distributed throughout the Spanish territory (361 belonging to the MAPA and 107 to the ACs). The agroclimatic data collected allows for a more precise estimation of the water requirements of irrigated crops. This information is available to irrigators through the web and a mobile app.

Given the major role of irrigation modernisation in Spanish agriculture and water policy, evaluating its impact and effectiveness is of crucial importance. The State Agricultural Infrastructure Company (SEIASA) has compared the situation of water use and other social and economic variables in specific irrigation communities and crops before and after the modernisation works. Several authors have also conducted surveys (Castillo, Borrego-Marín and Berbel, 2017[53]) or examined case studies of specific projects to identify changes after the modernisation (López-Gunn, Mayor and Dumont, 2012[54]) and (Gutiérrez-Martín and Montilla-López, 2018[55])). However, a comprehensive ex-post evaluation of the modernisation programmes at the country level is not available. Such a study would help have a better picture of the impact of this major public policy.

In addition to the decrease in the volume of water distributed to farms observed between 2000 and 2018 (Table 2.4), a 2019 synthesis study found that the objective of increasing irrigation efficiency (minimising losses) was achieved at a basin scale, and confirmed an average reduction of irrigation water use in Spain based on case studies comparing abstractions before and after the modernisation works (Berbel et al., 2019[52]). Other authors have also found a more efficient application of fertilisers through the use of fertigation (López-Gunn, Mayor and Dumont, 2012[54]). The case studies examined by SEIASA also noted less fertiliser use and lower associated costs for the farmers in some communities where modernisation works took place.

Multiple studies, including reports published by the OECD (OECD, 2016, pp. 41-42[56]), the World Bank (Scheierling and Tréguer, 2018, pp. 29-33[57]), the FAO (Perry, Steduto and Karajeh, 2017[58]),and the International Water Management Institute (IWMI) (Giordano et al., 2017, p. 30[59]), have noted that irrigation efficiency improvements can be associated with higher water consumption.[11] This is due to two phenomena observed in different international contexts. First, higher efficiency without production constraints can encourage farmers to switch to more water intensive crops and/or to expand their irrigation area, an effect called the Jevons paradox or rebound effect (observed in the energy sector). This results in increased water consumption and limited water saving, or even an increase in water use. For instance, a recent randomised control trial in India found that the adoption of drip irrigation by farmers led to a shift to more profitable irrigated crops, which resulted in increased revenue but led to no groundwater savings (Fishman, Gine and Jacoby, 2021[60]). Second, irrigation efficiency, even without changes in crop or area, ensures that all withdrawn water goes to the plants, thereby limiting losses, including in many contexts return flows to the environment. This can mean that groundwater recharge is diminished and so are returns to rivers, which means that water sources can be depleted even if applications are more efficient with observed water use reduction, an effect called the irrigation efficiency paradox (Grafton et al., 2018[61]).

In Spain, (Berbel et al., 2019[52]) found evidence of water consumption increases deriving from an expansion of the irrigated area in some cases and under certain conditions. (Sampedro-Sánchez, 2022[62]) found that the higher efficiency of the irrigation systems in three irrigation communities in the Guadalquivir basin led to an increase in the irrigated area, the introduction of more water-intensive crops, and the production of two harvests per year, increasing pressure on water resources.

This research, and the broader body of evidence, suggests that irrigation technology modernisation alone does not result in a decrease of water consumption. To avoid the rebound effect, these policies should be accompanied by others such as volumetric counters and control measures, reducing abstraction entitlements, capping water withdrawals or limiting the irrigated area. Addressing this issue is the reason the new CAP included a conditionality for any new irrigation efficiency investment to only be conducted in ways that do not impede on the water basin WFD quantitative status.[12] Even before its implementation, several Spanish river basin authorities facing urgent situations imposed measures to restrict water demand. This is the case of the Guadalquivir basin, which in the revision of its water management plan for the third cycle of the WFD (2022-2027) imposed a moratorium in the irrigated area (MITERD - Confederación Hidrográfica del Guadalquivir, 2022[63]).

Progress in the implementation of the EU Water Framework Directive has continued, and the river basin management plans for the third cycle are in preparation

Spain also progressed in implementing the WFD and in the requirement to submit river basin management plans (RBMP) every six years. There are 25 river basin management districts, six of which are shared with either France or Portugal. For the second planning cycle (2015-21), all 25 RBMPs have been adopted (MITERD, n.d.[64]); consultations are ongoing for the third cycle. Several ACs adopted regional water laws or adapted their legislation to comply with the WFD. They include Catalonia (2003), Basque Country (2006), Andalusia (2010), Galicia (2010 and 2015) and Aragon (2014) (Marcos Fernández, 2017[65]).

Users have an important role in water distribution and participate in the decision-making process of the River Basin Authorities

Water governance in Spain involves the interaction of numerous actors (Table 2.6). While the national and regional governments and the RBAs have a predominant role, local governments also have some competences. Users sharing a common entitlement or water outlet are required by law to constitute an association or users' community (and can be obliged to do so if they are using water from an overexploited aquifer). These associations are represented in the governing and management bodies of the RBAs and participate in the management of the basin's water resources. Given that agricultural irrigation is the main use of water in Spain, irrigation communities have a particularly important role (Box 2.4). According to the river basins regulation, the decision on water entitlements (allocation per user) is a state-level competence (of river basin authorities or, in certain cases, of ministerial authorities in charge of water management). In addition, the number of representatives from the different users in the governing and management bodies is regulated by law.

Table 2.6. Water governance and management in Spain involve multiple actors at different levels

Actor	Role and responsibilities
National government	Setting policy priorities in line with EU legislation. Exclusive competence regarding legislation, co-ordination and licensing of resources and hydrological uses for water that runs through more than one AC. Oversight over intra-regional RBAs.
Autonomous Community governments	Regional policies on natural resources, agriculture, land-use planning, in line with EU legislation and central government guidelines. Competences on projects, construction and utilisation of hydrological exploitations, channels and irrigation systems of interest for the AC and mineral and thermal waters. Oversight over RBAs within their borders.
River Basin Authorities	Elaboration, implementation and revision of RBMPs, administration and control of the public water domain; granting water use rights through licences; development, construction and use of the hydraulic works developed with the RBA's own funds, and those provided by the State.
Local governments	Collection and treatment of wastewater and supply of drinking water.
Users' associations (such as irrigation communities)	Establishment of norms for distribution and control, regulating the use and maintenance of shared hydraulic systems, organising shared payments and resolving problems among members. They are members of the key decision-making units in the RBAs.

Source: Based on Fuentes (2011[66]) and OECD (2015[67]).

Box 2.4. The role of irrigation communities

Associations of users are in charge of the distribution of water for irrigation

Irrigation communities (*Comunidades de regantes*) have long been part of water management in Spain. While the participation of organised groups of irrigators in management and distribution decisions dates back to centuries earlier, they were first recognised in the 1866 Water Law (del Campo García, 2018[68]).

Today, irrigation communities are public law corporations attached to the RBAs. They group the landowners in irrigated areas sharing a water entitlement or outlet. The entitlement is granted to the community and not to the property owner. Thus, they constitute an exception to the linkage between water rights and property rights prevailing in Spain (OECD, 2015[67]). The communities have autonomy for their management and define their own ordinances and regulations, which must comply with the provisions in the law and be approved by the RBA. Their main function is to distribute and manage their water entitlement. They set rules for water distribution and penalties for non-compliance and regulate the fees and charges for the use of water and the maintenance of the hydraulic systems. They also have irrigation juries in charge of resolving conflicts between users and imposing sanctions.

The communities are part of the governing and management bodies of the RBAs, where they seek to defend their interests in matters such as the volume of their water entitlement, the use of public funds for irrigation works and the equitable establishment of the levies to cover these costs. They are very numerous and diverse, comprising historic groups that were in existence even before 1866, communities formed by the public administration to manage large irrigation networks, and groups of private farmers that organise on their own initiative (Varela-Ortega and Hernández-Mora, 2010[69]).

Other policies include the establishment of a national monitoring and information system to monitor quality indicators such as the presence of nitrates and pesticides

While addressing the poor quality of surface and groundwater related to agricultural activities is a significant challenge in achieving the WFD's objectives, it has received less attention in policy than water quantity risks (OECD, 2020[23]). Nevertheless, Spain has established criteria for the monitoring and assessment of the qualitative status of surface waters and set out environmental quality standards (Royal Decree 817/2015). The domestic regulation transposing the EU Nitrates Directive was recently replaced by a new Royal Decree (47/2022) to protect surface and groundwater from diffuse agricultural pollution. The new regulation mandates the establishment of action plans in nitrate vulnerable zones, as well as codes of agricultural good practices related to fertiliser use and manure management (Boletín Oficial del Estado, 2022[70]). Recent implementing regulations are discussed in Section 2.4.2.

Spain has a national water quality database (NABIA information system), which collects data from the monitoring programmes of the river basin districts (RBD). It monitors, among other indicators, nitrates of agricultural origin and pesticides in surface and groundwater, ammonium and phosphates in rivers, and the degree of marine intrusion in groundwater (MITERD, 2021[71]). Management of the individual RBD monitoring networks is done by the national administration or the ACs, according to their competences.

Droughts and flood risks are managed at the RBD level; drought risk management plans are required by Spanish law since 2001

Drought management was incorporated in the 2001 National Hydrological Plan, with the objective of viewing drought response actions as elements of a planned risk management strategy instead of as emergency response measures (MITERD, n.d.[72]). Inter-regional RBDs must adopt drought management plans; these plans were approved in 2007 and revised in 2018. The latest revision incorporates climate

change and differentiates between drought (caused by reduced precipitation) and water scarcity (related to water demand). Among other aspects, the plans aim to guarantee water availability, avoid or minimise the effects of drought on the ecological status of water bodies and minimise the negative effects on economic activities. The legal obligation to establish a plan applies only to inter-regional basins, but intra-regional basins – which are under the authority of the ACs – may also prepare drought management plans (MITERD, 2020[73]).

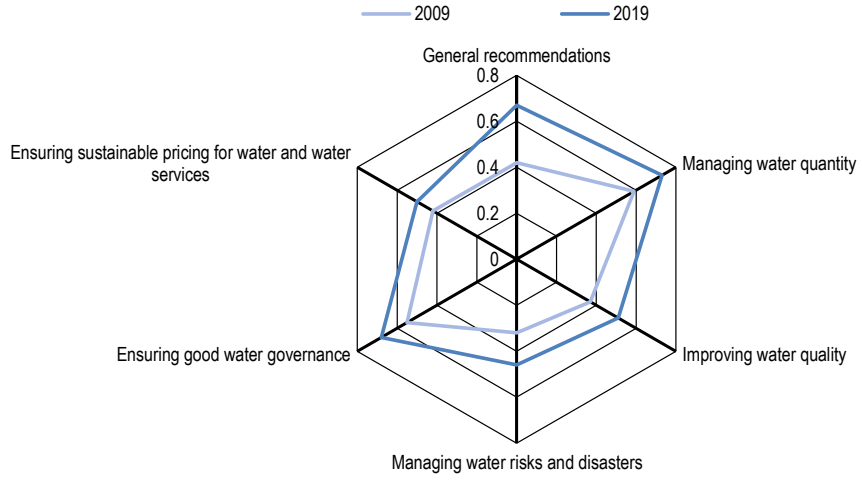
Spain transposed the EU Floods Directive (2007/60/EC) in 2010. The Directive requires Member States to establish flood risk management plans (FRMP) at the RBD level. The FRMPs for the Directive's first cycle (2010-15) had to be submitted by March 2016, and the FRMPs for the second cycle (2016-21) by December 2021. Most of Spain's first cycle plans (which are currently in force) were approved in 2016, and the second cycle plans are in preparation. A delay in the submission of the FRMPs for the basins of the Canary Islands led the EC to refer Spain to the EU Court of Justice in 2019 (European Comission, 2019[74]). A positive effect of the joint work required by the process of drawing up the Spanish FRMPs was an improvement of co-ordination among authorities at different levels, which facilitates implementation efforts (Sánchez Martínez, 2015[75]).

In general, water polices have become more in line with OECD recommendations, but more progress could be done in certain areas

Between 2009 and 2019, Spain's water and agriculture policies became more aligned with the OECD Council Recommendation on Water (Figure 2.7). Water quantity management is the area where Spain's policies are most in line with the Recommendation. The most progress in the decade was made with respect to the general policy recommendations, which refer to aspects such as water policies that are based on long-term water management plans and are adjusted to local conditions. There is room for improvement particularly in the management of water risks and in water pricing, given that often only the transport and infrastructure costs are charged.

Figure 2.7. Spain has made progress to align its agriculture and water policies with OECD recommendations, but pricing and risk management could still improve

Alignment of agriculture and water policies with the OECD Council Recommendation on Water, 2009 and 2019



Notes: Indices range from 0 to 1, higher values indicate a higher alignment.
Source: Gruère, Shigemitsu and Crawford (2020), Agriculture and water policy changes: Stocktaking and alignment with OECD and G20 recommendations, https://dx.doi.org/10.1787/f35e64af-en.

All river basin districts have a system of permits and a registry for groundwater abstractions. Smaller abstractions in water bodies not at risk do not need a permit (but must be registered), and some wells remain unregistered

The 1985 Water Law declared all waters to be in the public domain. This included groundwater, which until then could be privately owned. Water extractions established after 1985 require a licence, but owners of pre-existing wells could retain the private property right if they registered them with the RBA. However, the incomplete registration of those wells and the difficulties associated with monitoring contributed to aggravate the problems of overexploitation and illegal extractions (Fuentes, 2011[66]).

The EC's 2021 examination of the WFD implementation notes that Spain has made progress on measures to address water abstraction. All 25 river basin districts (RBD) have established a permit regime and a registry for both surface and groundwater (European Commission, 2021[76]). Small abstractions do not need a permit, but must be registered in RBDs, with an obligation to report the amount of water extracted every year. However, a 2012 legal reform that modified some provisions of the Water Law to achieve a more adequate use of water (Law 11/2012 of Urgent Environmental Measures) clarified that the exemption does not apply to bodies of water at risk of not reaching good quantitative or chemical status. This means that small extractions in bodies of water at risk also require a permit.

The need to establish a system for monitoring water use was incorporated in the 2001 Water Law. For inter-regional river basins, the responsibility falls under the national authorities (Ministry for the Ecological Transition and the Demographic Challenge), while regional governments are responsible for the river basins within their ACs. A 2009 ministerial order (ARM/1312/2009) regulates the system for monitoring the volumes of water used from and returned to the public hydraulic domain. It requires holders of water entitlements to install and maintain a meter, and to communicate their water use data. In the case of water for irrigation, the obligation applies to irrigation communities.

At the regional and local levels, abstraction controls and restrictions have been applied in groundwater bodies overexploited and at risk, and they are incorporated in River Basin Management Plans (OECD, 2015[3]). Technology is increasingly employed to monitor and meter water use (Box 2.5).

Box 2.5. Monitoring water use in the Mancha Oriental aquifer

A user-led initiative to use satellite technology for monitoring groundwater extractions in the face of overexploitation

Remote sensing technologies are increasingly being used by Spanish RBAs and users to monitor irrigated areas, estimate water consumption and verify if it corresponds to the water entitlement. The use of satellite technology was introduced in 1998 for monitoring water abstractions from the La Mancha Oriental aquifer – part of the Júcar River Basin – in a user-driven initiative that today is showcased as a success story of users' co-ordination for self-regulation over the use of water resources.

The aquifer, covering a surface of about 10 000 km^2, supports more than 120 000 hectares of irrigated crops. In the 1980s and early 1990s, large areas of rainfed crops were converted to groundwater irrigation. This led to increased extraction which, combined with the severe drought experienced in 1995 and 1996, caused several stretches of the Júcar river to dry up (Castaño Fernández, 1999[77]).

The users' community of this aquifer is the Central Irrigation Board of La Mancha Oriental, which was established in 1994 and currently groups over 2 000 users. In 1997, in light of the overexploitation of the aquifer, the irrigation board entered into a public-private partnership (the ERMOT project) with the regional administration of Castile-La Mancha, the RBA and the University of Castile-La Mancha, for the latter to develop annual maps of irrigated areas using remote sensing techniques. In 2009, the public

enterprise TRAGSATEC joined the project. The irrigation community also used satellite images provided by the EU project SIRIUS-GMES to map and estimate the irrigation water needs of cultivated plots according to precipitations, atmospheric demand and irrigation methods.

The system has operated since 1998, and the irrigation board has developed the capacity to use the images in its monitoring and decision-making and for its annual planning. Satellite monitoring is combined with flow meters on the ground. This has resulted in a substantial decrease in abstractions and the stabilisation of the aquifer level. If an infringement is detected, it is sanctioned by the irrigation jury and the RBA, a system that also resulted in a significant drop in the number of sanctions (Fundación Botín, 2020[78]). The irrigation board reports that the combination of remote sensing and other techniques has resulted in almost full compliance with their annual plans, and in the restitution of 100% of the volume exceeded in cases of non-compliance (Junta Central Regantes Mancha Oriental, n.d.[79]).

Trading water rights is possible, but rare. While Spain has made progress in pricing and cost recovery, groundwater abstraction is not subject to any charges

A 1999 legal reform introduced market-based mechanisms for trading water rights, through water permit exchange centres managed by the RBAs, which can use public funds to buy water rights from users, either permanently or for a certain amount of time. This has been used to address overexploitation in some river basins (Hernández Mora et al., 2010[46]). It is also possible for holders of water rights to enter into contracts (*contratos de cesión*) to temporarily cede their entitlements to other users in the same basin, provided that they respect the order of priority allocation of the RBMP. However, formal trading occurs only sporadically (Lopez Gunn and Vargas Amelin, 2020[80]). A 2015 evaluation found that water markets in Spain have only been functional during drought periods, and accounted for less than 5% of water use even during such conditions of scarcity (Palomo-Hierro, Gómez-Limón and Riesgo, 2015[81]). In agriculture, informal trading is more common, based on trust among farmers and typically limited to farmers within an irrigation community (Fuentes, 2011[66]).

In Spain there are no charges for the abstraction of groundwater *per se*. The pricing instruments applied to the use of surface or groundwater account for the costs associated with building, operating, and maintaining public water regulation infrastructure (Regulation Fee), and public investments on specific hydraulic infrastructure (Water Utilisation Tariff) (OECD, 2015[67]). The OECD Council Recommendation on Water calls to consider establishing pricing instruments where appropriate and applicable, in combination with other instruments, to manage water resources, phase out negative externalities and improve the financial sustainability of infrastructures and services. Charges for water supplied to agriculture should reflect at least full supply costs (OECD, 2020[82]).

Spain has reported to the EC a proportion of cost recovery for irrigation of 78% (a share higher than in Italy but lower than in Portugal and France) and large variations in water tariffs: the tariff per cubic meter ranged between EUR 0.06 and EUR 0.9 depending on the RBD. In general, data on irrigation water pricing for EU Member States are scattered and incomplete. Often, there are differences within the same country on tariffs, cost-recovery levels or the basis for charging (volumes or irrigated area), which makes analysis and comparisons difficult (European Comission, 2021[83]).

In order to create incentives to use water economically in the irrigation sector, it is essential to use metering and volume-related charges. In Spain, volumetric pricing is mandatory for irrigation communities that receive subsidies for irrigation infrastructure (Expósito, Montilla-López and Berbel, 2019[84]). The most recent initiatives for irrigation modernisation, including the CSP irrigation infrastructure subsidies, require the installation of meters (Section 2.3.3).

In general, Spain has made progress regarding the introduction of water pricing policies and cost recovery in agriculture, with a positive trend and narrowing gaps in this area's indicators (European Commission,

2021[76]). As some gaps still persist, it is necessary to advance towards developing a water pricing policy that encourages savings, efficiency, and helps reduce pressures on the water environment and manage water scarcity (MITERD, 2020[85]).

Agriculture is often exempted from water taxes, particularly at the regional level. Water use by the sector also benefits from subsidies and tax rebates

The different administration levels in Spain (national, regional or municipal) can charge taxes on water use or pollution, according to their areas of competence. At the national level, wastewater discharges into surface and groundwater masses are subject to a tax (*canon de control de vertidos*) payable to the RBA. The tax is levied on authorised or unauthorised discharges into the public water domain and is calculated by multiplying the volume of the discharge by a unit price, currently set at EUR 0.04377/m^3 for industrial wastewater (with agriculture among the industrial activities covered).

All ACs except Madrid have established their own taxes over different parts of the water cycle. Most regional taxes focus on sanitation and effluent control (García Valiñas and Arbués Gracia, 2020[86]). Four ACs (Catalonia, Castile-La Mancha, Galicia and the Basque Country) charge an environmental tax on water use and consumption (*canon del agua*). However, Catalonia and Galicia exempt agricultural uses in most cases, while Castile-La Mancha exempts agricultural uses that do not take public water or discharge into the public network (Ministerio de Hacienda y Función Pública, 2022[22]). The Basque Country reformed its water tax in late 2021; it now applies to water withdrawals instead of consumption. While all sectors including agriculture are covered, farmers benefit from a tax rebate of 90% provided that they comply with the regional agricultural code of good practices or a similar environmental certification (Gobierno Vasco, 2022[87]). Most regional taxes on water pollution, wastewater production and wastewater sanitation also have exceptions for agricultural and livestock activities (Table 2.7).

Table 2.7. Agricultural activities are often exempted from regional taxes on water

Taxes or levies on water use, wastewater generation or sanitation applied by the Autonomous Communities

Autonomous Community	Name of the tax	Special conditions for agriculture/livestock sector
Andalusia	Tax on coastal wastewater discharges	Not indicated.
Asturias	Tax on the environmental effects of water use	Irrigation and water used in livestock farming exempted.
Aragón	Environmental tax on wastewater generation	Agricultural uses exempted if they do not take water from an urban supply network.
Balearic Islands	Water treatment levy	Agricultural irrigation exempted.
Basque Country	Water tax	Rebate of 90% subject to compliance with code of good practice.
Basque Country	Tax on land wastewater discharges into sea	Not indicated.
Canary Islands	Tax on wastewater discharges	Not indicated.
Cantabria	Tax on wastewater generation	Agriculture, forestry and livestock exempted, except in case of pollution from fertilizers, pesticides or organic matter and if there are discharges into public sewage systems or water bodies.
Castile-La Mancha	WFD environmental tax	Agriculture, forestry and livestock exempted if not taking water from the public network nor discharging into public sewage
Catalonia	Water tax	Agricultural uses exempted unless pollution from fertilizers, pesticides or organic matter has been detected.
Extremadura	Water treatment levy	Agriculture and forestry exempted, except in case of pollution from fertilizers, pesticides or organic matter. Livestock farming exempted if not generating discharges to the sewage system.
Galicia	Water tax	Agriculture, forestry and livestock not subject, unless there is pollution or discharges into public sewage.
La Rioja	Water treatment levy	Water for irrigation exempted.
Murcia	Tax on coastal wastewater discharges	Discharges from desalination plants producing water for agriculture, irrigation, industry or human consumption exempted.

Autonomous Community	Name of the tax	Special conditions for agriculture/livestock sector
Murcia	Water treatment levy	Not indicated.
Navarra	Tax on waste water treatment	Not indicated.
Valencia	Water treatment levy	Water used by livestock farms exempted.

Sources: Ministerio de Hacienda y Función Pública (2022[22]); García Valiñas and Arbués Gracia (2020[86]); Gobierno de Navarra (1988[88]); Gobierno Vasco (2022[87]); OECD (n.d.[89]).

Agricultural irrigation benefits from two tax reductions, adopted in late 2014 as part of a package of measures to offset the effect of electricity price increases on farms using irrigation. Thus, consumption of electricity for irrigation receives an 85% reduction of the taxable base for the national tax on electricity. Irrigators may also apply a reduction coefficient for the personal income tax. It reduces by 20% the net yield from crops grown on irrigated land that use electricity (MAPA, n.d.[19]). In recent years, irrigated agriculture faced higher costs due to the elimination of double pricing, which allowed for prices to be differentiated between the irrigation season and the rest of the year.

Spain subsidises desalinated water to make it affordable for farmers. In the first quarter of 2022, the national administration approved a package of urgent measures to help farmers in light of the prolonged drought situation threatening agricultural production. It included maximum tariffs for desalinated water and a reduction of the water regulation fees and water use tariffs in the Guadalquivir and Guadiana basins (Gobierno de España, 2022[90]).

Even when water is not directly subsidised, support to agriculture can influence farmers' decisions in ways that result in higher water use. The EU Court of Auditors identified a lack of alignment between European agricultural and water policies: it found that CAP income support does not promote an efficient use of water, and that few payment schemes are linked to strong sustainable water use requirements. Payments coupled to production were found to support production of water-intensive crops in water-stressed areas of six Member States, including Spain (European Court of Auditors, 2021[31]). Another study found that coupled subsidies incentivised growth in irrigated vineyards in the La Mancha area between 1999 and 2007, leading to an increase in groundwater consumption (Closas, Molle and Hernández-Mora, 2017[91]). Coupled payments have decreased throughout the years in line with the successive CAP reforms. While they still represent approximately 14% of Spain's Pillar 1 budget for the new CAP, only 20% of the coupled payment budget will support crop production.

Improving access to data would be a positive step for water management and policy evaluation

Data related to water (such as water pricing and water use) are scattered, which hinders the evaluation and analysis of water policies at the country level. A multi-stakeholder process conducted in 2019 found that information and knowledge about water in Spain − particularly about groundwater − are fragmented and distributed among the actors involved in research and management: basin authorities, universities, research centres, public entities and users' associations, among others. It is unclear who is responsible for the management of hydrogeological information and knowledge (MITERD, 2020[85]). (Berbel et al., 2019[52]) also pointed out that there are significant limitations on data collection and reporting on water use and consumption at the basin scale, which impairs the quality of the resulting figures.

2.3.3. Planned water and irrigation policy interventions

The coming years will see the implementation of significant public investments in irrigation modernisation and digitalisation

Irrigated agriculture will benefit from funding from the Spanish Recovery, Transformation and Resilience Plan: in 2021, an investment plan for sustainable irrigation systems was launched as part of the key actions. Significant funding has been earmarked for investments to modernise the irrigation systems, covering approximately 100 000 hectares (OECD, 2022[13]).

The irrigation plan foresees an investment of over EUR 700 million, of which EUR 563 million will come from public funds; the remaining amount will be financed by the private sector, including irrigation communities. The projects included in this initiative must follow the principle of Do No Significant Harm (DNSH)[13] to the environment. Priority will be given to interventions that replace the use of ground or surface water by treated wastewater and desalinised water, that do not use electricity or use renewable energy, or that that apply innovative technologies, among others. Concrete measures include increasing the surfaces irrigated by drip and sprinkler systems, installing meters and using binomial tariffs (comprising a fixed and a volumetric charge), installing sensors to detect soil moisture and nutrient contents, and measures to protect fauna from drowning.

The CSP rural development plan foresees further EUR 316 million (55% financed by the EAFRD) for investments in irrigation infrastructure with environmental objectives. This measure will be implemented at the national level and has been programmed by eleven ACs. The infrastructure modernisation must not lead to an increase of the irrigated surface. The conditions for payment include: the existence of a river basin district management plan in the area where the investment is done; the installation of meters and the existence of a minimum potential water saving of 7% according to the technical parameters of the existing infrastructure. In the case of investments affecting bodies of surface or groundwater in less than good quantitative status, there must be an effective reduction of water consumption of at least 50% of the potential water savings (MAPA, 2022[92]). Following the CAP public consultation and environmental assessment process, provisions were included to ensure that farms or producers' organisations that have been sanctioned by the competent authorities for illegal water use do not receive payments.

Irrigation policies focus on how to use the water available in the most efficient way, but do not modify in any way the volume of water supplied, as this is determined by users' entitlements and rights. The authorities in charge of the management and planning of irrigation have no influence over the quantity of water provided through the systems, and conflicts can arise when users feel that their water entitlements are under threat.

In line with the distribution of competences in Spain, the Ministry of Agriculture, Fisheries and Food (MAPA) is in charge of the infrastructure for water distribution in irrigated zones. The Autonomous Community administrations also carry out irrigation works within their territory. Water management and hydrological planning are in the hands of the Ministry for the Environmental Transition and the Demographic Challenge and the autonomous governments. This makes co-ordination amongst central and regional authorities essential.

As part of the implementation of the RTRP irrigation plan, the establishment of a National Irrigation Board (*Mesa Nacional del Regadío*) was formalised in October 2022 (Royal Decree 854/2022). This body is in charge of promoting co-operation, consultation, analysis, and information exchange between national and regional administrations, the RBAs, irrigation communities, farmer organisations, environmental organisations and other stakeholders. The same decree created an Irrigation Sustainability Observatory, an online platform to publish information and report on the evolution of indicators related to the economic, social and environmental sustainability of irrigated agriculture in Spain.

The RTRP also includes a programme for the transformation and modernisation of water management, known by its Spanish acronym as PERTE for Water Cycle Digitalization. It aims to mobilise public and private investments for up to EUR 3 billion between 2022 and 2026, of which EUR 200 million are earmarked for irrigation. These funds will be used to provide subsidies to support irrigation communities and other users in the digitalisation of irrigation management, including through the installation of meters at water intakes and on plots of land, and the automatisation of irrigation systems (MITERD, 2022[93]).

Spain is working on a comprehensive reform to its Water Law; a draft document indicating the priority areas was presented for public consultations in August 2022. This reform is also part of Spain's commitments in the framework of the RTRP. Among the modifications foreseen are changes in the wastewater discharge taxes in line with the "polluter pays" principle, and in the cost recovery system for water infrastructure (MITERD, 2022[94]).

2.4. Nutrients and manure management

2.4.1. Assessment of status and trends

Fertiliser use is on the rise, as are the balances of nitrogen and phosphorus

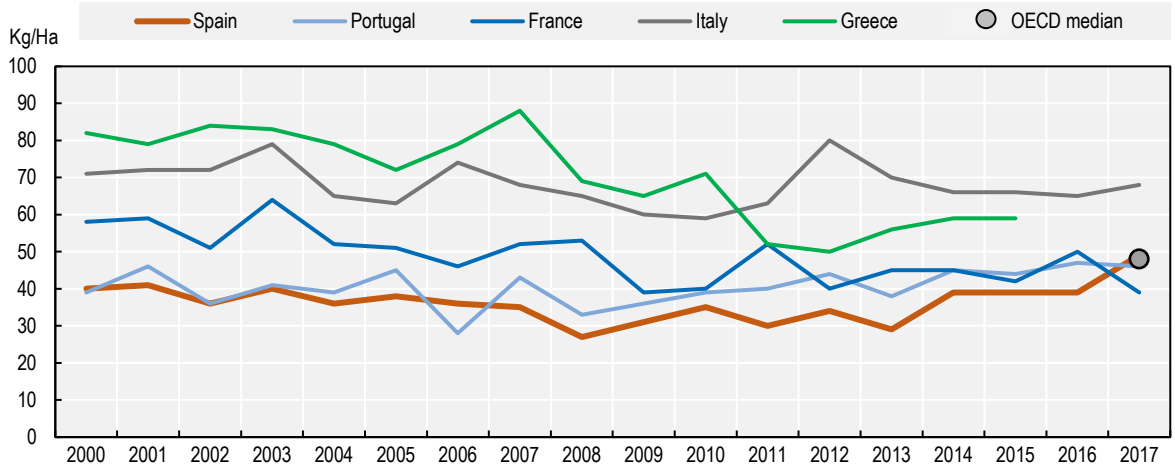
Nitrogen (N) and phosphorus (P) are essential inputs, fundamental for agricultural productivity. Their excessive use, however, can result in water and air pollution. N is added in inorganic fertilisers and manure. It is estimated that 40% to 60% of N fertiliser is absorbed by crops and the remainder can follow two paths in the environment: some stays in the soil and some volatilises in the form of ammonia (NH_3) and nitrous oxide (N_2O). Nitrogen can reach groundwater by leaching or surface water via runoff. Phosphorus, on the other hand, comes from mineral sources and has a lower uptake rate by plants (of about 10% to 15%), with the remainder staying in the soil, especially in calcareous conditions, or ending up in water bodies. Phosphorus surpluses can lead to surface water contamination, which favours the growth of cyanobacteria and algae in bodies of water. Livestock density and composition are also key drivers of nutrient balances (OECD, 2019[95]).

The use of fertilisers in Spain has increased in recent years. Phosphate fertilisers had the strongest increase: their consumption (domestic sales and imports) grew by 21% between 2015 and 2019, while nitrogen fertilisers increased by 4.5%. Three ACs (Andalusia, Aragón and Castile and León), which cover more than half of the Spanish crop area, concentrate over half of the consumption of both types of fertilisers (MAPA, 2022[12]). As noted in Chapter 1, the size of the pig herd has also expanded considerably.

The Spanish N balance has shown an increasing trend after 2013. As of 2017, it was of 49 kg/ha, on par with the OECD median (Figure 2.8). During the same period, the efficiency in N use (ratio of nutrient outputs to inputs) has remained stable but below the OECD median (OECD, 2021[96]). Nitrate Vulnerable Zones (NVZ) represent 16% of Spain's territory and 35% of its agricultural area (European Commission, 2020[38]).

Figure 2.8. Spanish nitrogen surpluses are comparatively low but show a rising trend

N balances, kg/ha

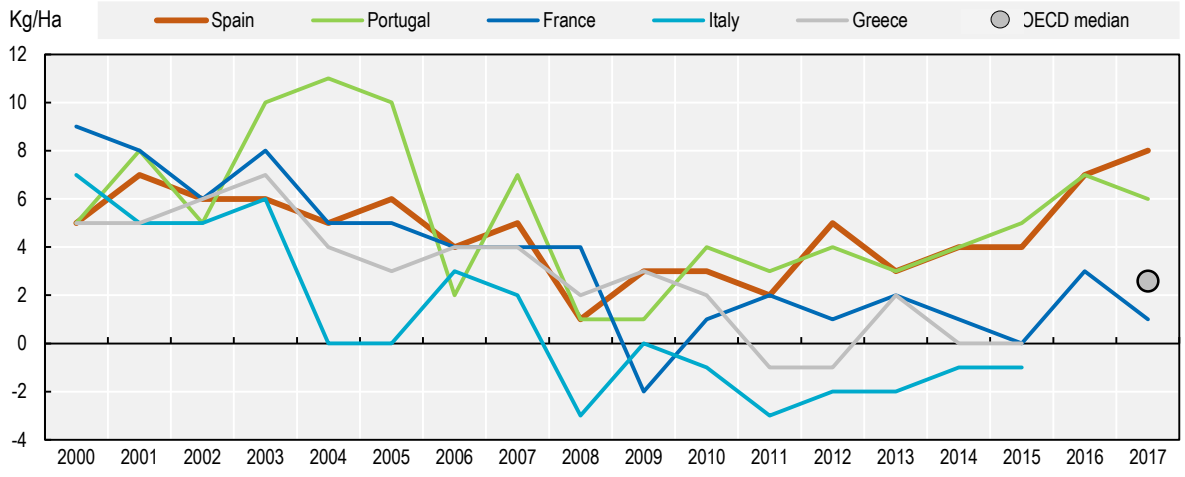


Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

The annual P balance also increased from 5 kg/ha to 8 kg/ha between 2000 and 2017; the rise has been particularly strong in the most recent years. Since 2012, the balance is equal to or surpasses the OECD median and lies above those of peer countries. Efficiency in the use of phosphorus approached the OECD median in 2013 but has been decreasing since (OECD, 2021[96]).

Figure 2.9. Phosphorus surpluses are high and continue to increase

P balances, kg/ha



Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

Ammonia emissions – almost exclusively from agriculture – are well above EU and OECD averages. Spain has failed to meet its national reduction targets

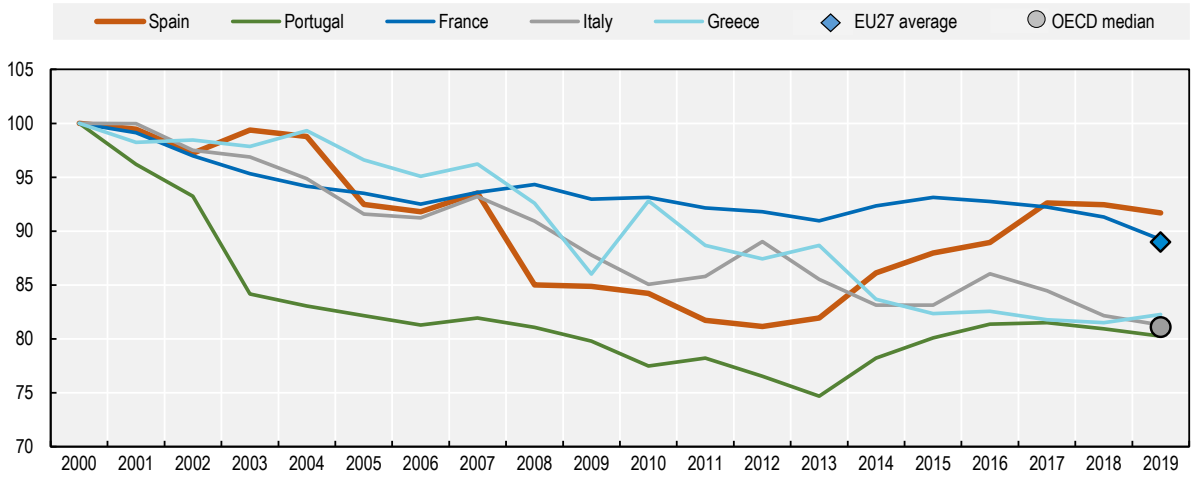
Agriculture is the most important source of ammonia (NH_3) emissions in Spain: in 2020, the sector generated 97% of all NH_3 emissions, most of which came from livestock. The activities with the highest NH_3 emissions are manure management (particularly from pig farming) – which contributed to 43% of the emissions in the 2020 Spanish Inventory – the animal manure applied to soils (28%), the use of synthetic N fertilisers (17%) and urine and dung deposited by grazing animals (8%) (MITERD, 2022[97]).

NH_3 emissions are associated with the acidification of soil and water and with increased N levels that can lead to eutrophication. They can also affect air quality and human health: in high concentrations, NH_3 can affect the respiratory track and lung function. NH_3 is also a precursor of secondary particulate matter (PM), a harmful air pollutant (OECD, 2019[95]).

Between 2000 and 2020, Spain reported an overall decline of 7% in agricultural ammonia emissions. They reached their lowest level in 2012 but picked up again in 2013. Spain had outperformed most peer countries until 2013, but is now lagging behind, as well as with respect to the OECD median and the EU average (Figure 2.10). The national inventory registered a further increase of 2.7% in NH_3 emissions between 2019 and 2020, and an increase of 4% between 1990 and 2020 (MITERD, 2022[11]).

Figure 2.10. Agricultural ammonia emissions exceed the OECD and EU averages

Changes in agricultural NH_3 emissions, 2000 – 2019 (Index, 2000 = 100)



Source: OECD (2022), Agri-environmental indicators (database), http://stats.oecd.org/.

The emissions reduction observed until 2012 was due to improvements in fertiliser application, animal feed and manure management techniques. However, increasing livestock numbers (in particular pigs) and rising fertiliser use have pushed them back to higher levels (MITERD, 2021[16]).

Ammonia is the only air pollutant for which Spain has failed to meet its emissions ceilings and reduction targets. Spain was one of two EU Member States that failed to meet national NH_3 ceilings in all years between 2010 and 2019 (European Environment Agency, 2021[98]). The EU directive on national emission reduction commitments for key air pollutants (NEC Directive 2016/2284/EU), which also transposes Member States' Gothenburg Protocol commitments, set national reduction commitments with respect to 2005 levels for any year between 2020-29 and from 2030 onwards. Spain's commitment is to reduce NH_3 emissions by 3% for any year between 2020 and 2029, and by 16% for any year starting in 2030. As of

2020, this target was not met: NH_3 emissions increased by 0.7% compared to 2005 (MITERD, 2022[11]). However, more recent data point to a decrease of 5.9% in 2021, putting the reduction for the first time in line with the commitment (MITERD, 2023[99]).

According to national projections, a "business as usual" scenario would result in NH_3 emissions remaining practically constant. The measures contemplated in the National Energy and Climate Plan (NECP) and in the National Air Pollution Control Programme (NAPCP), which include manure management and fertiliser use actions, would allow for an average yearly decrease of 2.2% between 2020 and 2030. This would result in NH_3 emissions by 2030 being 25% lower when compared with their 2005 levels (MITERD, 2021[16]).

2.4.2. Policies and regulations

The EC considers that Spain's implementation of the EU Nitrates Directive has been insufficient. Recent regulatory reforms and new digital tools intend to better address agricultural pollution and tackle ammonia emissions

Spain's initial transposition of the EU Nitrates Directive dates from 1996. However, the European Commission referred Spain to the EU Court of Justice in late 2021, as it believes that Spain's measures have not been sufficient to achieve the objectives of the Directive. According to the EC, Spain must take additional measures to prevent eutrophication and designate further nitrate vulnerable zones, among other actions (European Commission, 2021[39]).

A new regulation transposing the Nitrates Directive (Royal Decree 47/2022) was recently enacted. It aims to establish measures to reduce water pollution and to achieve alignment with the EU Farm to Fork and Biodiversity Strategies. The First National Air Pollution Control Programme, approved in 2019, also includes horizontal and sectoral measures in line with the NECP, including commitments for reductions of 62% in NOx emissions and of 16% in NH_3 emissions by 2030.

The reforms applicable to livestock farming include new regulations for the management of farming sectors and the development of ECOGAN, a registry of Best Available Techniques (BAT). Farm notebooks and registries for the livestock sector in Spain have been in use for years, but the current reforms intend to strengthen the inclusion of environmental aspects and the use of digital technologies.

The sectoral regulations include new requirements on location, distance, size, sanitary conditions and biosecurity, as well as environmental and animal welfare infrastructure on farms. Priority was given to pig farming, as it is the main source of NH_3; the decree for this sector was approved in 2020, followed by the decree for poultry, approved in mid-2021. In the case of bovine farms, the decree is in process.

ECOGAN will verify the implementation of BATs and support the calculation, monitoring and reporting of emissions at the farm level (MAPA, 2022[100]). Farmers must use an online system to answer questions about farm practices, which the system uses to calculate the farm emissions at different stages based on standard values. Farmers will also be informed about their carbon footprint. ECOGAN represents an improvement of monitoring, which will get closer to Tier 3 (higher level of precision), as previous standard values were based on the national agricultural census and only updated every five years.

The system advises farmers about which BAT should be applied for emission control. In the case of pig farming, two BATs are mandatory: providing multiphase feeding (which adjusts the nutrient content of the diet to the requirements and growth phases of the animals) and emptying slurry pits at least once a month; other BATs are elective. Using ECOGAN is only mandatory for intensive pig farms; extensive farming is exempted, while farms for self-consumption and smaller farms (with up to 5 breeding sows and up to 25 pigs for fattening) are exempted from several of the requirements.

Implementation of ECOGAN in intensive poultry farms (broilers and laying hens) will follow the pig sector. The bovine sector will be the last to implement ECOGAN, after the development of the sectoral management regulation is completed. Use of the registry is foreseen for dairy farms and feedlots, but not for extensive cattle farming; the latter is not subject to emissions reduction practices.

Large-scale cattle farming will also be brought within the scope of the revised EU Industrial Emissions Directive, which foresees the establishment of activity thresholds so that BATs are applicable to a larger number of installations. The EU plans to adopt the new Directive by the end of 2023.

Given the distribution of competences between the national and regional administrations, ECOGAN does not have a single national point to collect information; rather, farmers enter the data through the portals established by their ACs. Catalonia has opted not to join ECOGAN, so the monitoring of BATs will be done through the tools made available by the regional authorities. All the data notified by farmers to AC authorities will be notified to the BAT General Register, managed by the MAPA.

In the case of crops, a new regulation on sustainable nutrition in agricultural soils has been published. It aims to manage crop nutrition in a sustainable way, to increase food production by promoting a coherent approach to the sources of nutrient inputs to the soil, maintain or increase soil organic matter, reduce GHG and NH_3 emissions, and prevent water pollution by nitrates and phosphates. Farmers must establish a fertilisation plan (based on a nutrient balance) and use accredited advisory services to comply with the legal requirements and rationalise fertilisation. Rainfed farms of less than 10 hectares are exempted from the requirement of elaborating a fertilisation plan. Good practice guidelines will also be developed.

The new regulation is accompanied by a Digital Farm Notebook, which will be implemented by July 2024 (or ten months earlier for larger or irrigated farms). The digital notebook will register fertilisation practices in the farm. Its use will begin with irrigated crops and larger farms, and later be extended to rainfed agriculture. Among the measures to minimise nitrate leaching or NH_3 emissions are the prohibition of broadcast application of slurry and the establishment of periods in which N application is prohibited.

Sustainable fertilisation is also a new national good agricultural and environmental condition (GAEC) for the enhanced conditionality in the CSP: recipients of payments must record all operations aimed at providing nutrients or organic matter to the soil in the farm notebook, and establish a fertilisation plan where applicable. Also required are the localised application of slurry and burying of solid manure.

Some ACs have developed regulations on manure management and soil fertilisation. For example, Aragón enacted a decree (53/2019) regulating the management of manure, followed by a regional plan for the inspection and control of manure production and management activities for 2022-26, applicable to intensive livestock farming, manure management centres, and farms where manure is applied.

2.5. Biodiversity

2.5.1. Assessment of status and trends

Spain has a very rich biodiversity and a high share of protected areas. However, the conservation status of some agricultural habitats is worsening

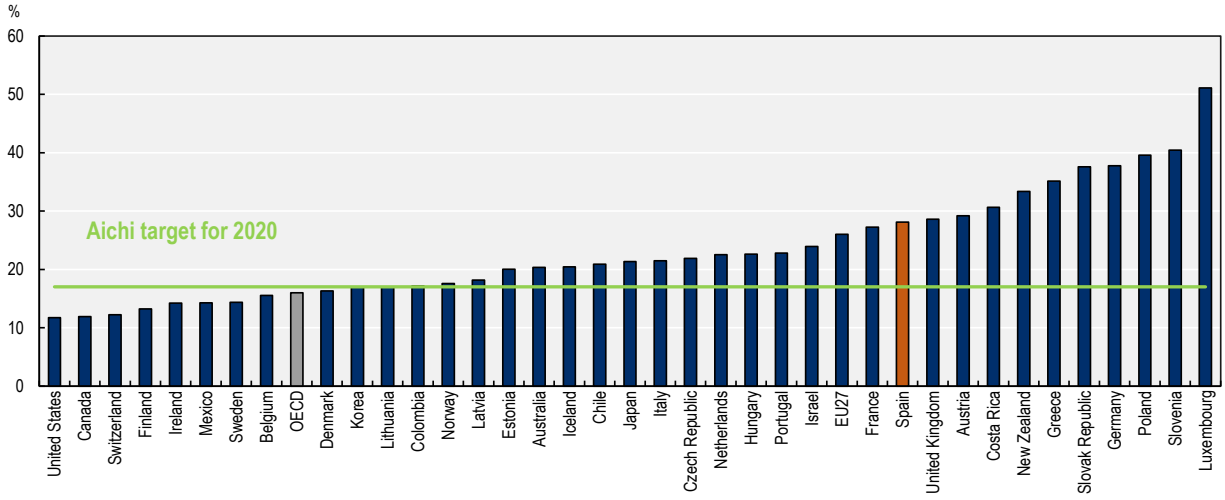
Spain is one of the world's 25 biodiversity hotspots, and one of the countries with the highest level of biodiversity in the European Union (Convention on Biological Diversity, n.d.[101]). Over 85% of the vascular plant species and about half of the animal species identified in Europe are present in the country, which is also home to 120 of the 197 natural habitat types of community interest identified in Annex I of the EU Habitats Directive (92/43/EEC) (MAGRAMA, 2016[102]).

Spain has a high level of biodiversity in its agricultural environment. Forty per cent of the species and 48% of the habitats protected under the EU Birds (2009/147/EC) and Habitats directives and present in the country are associated with agricultural landscapes. There is also an important diversity of autochthonous livestock breeds: the national catalogue kept by the Ministry of Agriculture, Fisheries and Food lists over 150 breeds that are indigenous to Spain, including 42 varieties of sheep and 40 varieties of cattle (MAPA, 2022[103]).

Having designated 28% of its terrestrial area protected, Spain meets the Aichi target of protecting at least 17% of terrestrial area by 2020 and is well above the OECD and EU shares and those of most European peers.

Figure 2.11. Spain has one of the highest shares of protected land areas in the European Union

Share of terrestrial protected areas in total land area, 2021 or last year available



Source: OECD (2022), Protected areas (indicator), https://doi.org/10.1787/112995ca-en.

As of 2020, forests (including wooded, bush and scrub vegetation) covered 40% of Spain's land area, followed by cropland (including arable crops, woody crops and fallow land) with 33% and pastures (12%). Between 2010 and 2020, forest areas increased from 18.6 to 20.1 million hectares, or 8%, while pasture area increased by 15% and that for woody crops grew by 7%. On the other hand, the surface of natural meadows and fallow land decreased (MAPA, 2022[12]).

Spain also has the largest land area under Natura 2000 in the European Union, 138 083 km^2 in 2020, and accounting for 17% of the total EU Natura 2000 area (IEEP, 2021[15]). About one-quarter of the Natura 2000 network in Spain corresponds to agricultural area, including pastures and natural grasslands (MAPA, 2021[104]). However, data on the conservation of agricultural habitats for 2013-18 shows that only 9% of grassland habitats were in a favourable status while 63% were considered inadequate and 16% in a bad conservation status. This represents a worsening from the previous reporting period, and the trend remains negative (European Commission, 2020[38]).

Changes in agricultural habitats and water bodies threaten the diversity of birds and freshwater fish. Pollinators and indigenous livestock breeds are also under pressure

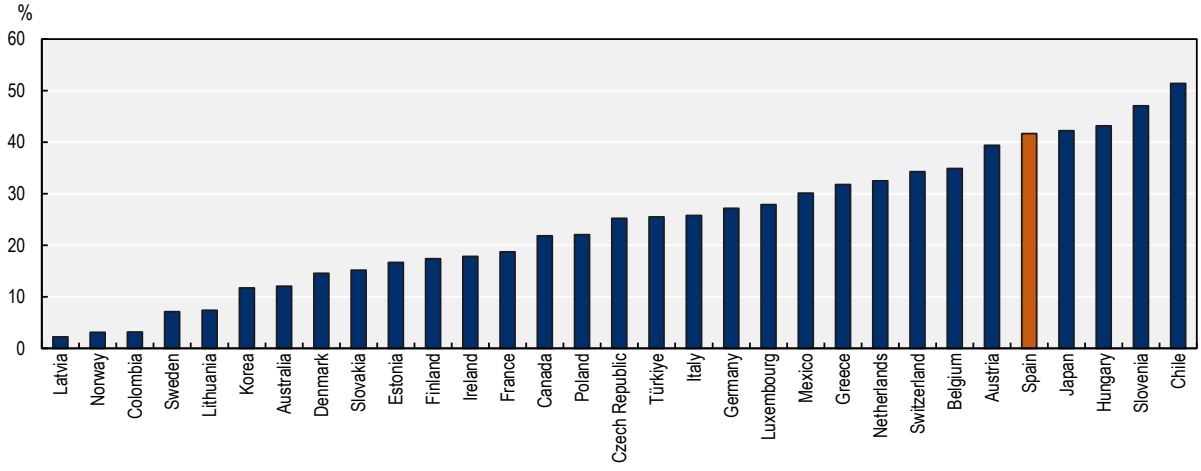
As is the case for the European Union as a whole, the common farmland bird population in Spain has experienced a strong decrease. The farmland bird index – often used as a proxy indicator of the status of agricultural biodiversity – shrank by 33% between 2000 and 2017, around the EU-27 average (European

Commission, 2020[38]). The reduction in the farmland bird population is associated with the intensification of agriculture and an increased use of pesticides, as well as with the decrease in fallow land (Traba and Morales, 2019[105]). Dry cereal farmland is the most important habitat for farmland birds in Spain, yet this type of land has been subject to an intensification in input use. The increase in irrigated woody crops and in fertiliser use, together with a decrease in extensive grazing and an abandonment of dry cereal land also threaten farmland birds (IEEP, 2021[15]). Twenty-one per cent of the Nitrate Vulnerable Zones identified in Spain for 2016-19 correspond to protected areas, and over half of them are Special Protection Areas for birds.[14]

While several types of species in Spain are threatened to some extent, including amphibians (23% of known species), reptiles (18%), mammals (15%), vascular plants (12%) and birds (10%), the situation of freshwater fish is particularly alarming: 42% of the species known are threatened, the fifth highest share in the OECD (Figure 2.12). The major threats to European freshwater fish include dams and water management, water abstraction, droughts, invasive species and pollution, in particular from agricultural and forestry effluents. Seventy-three per cent of the fish species in Spain are estimated to be endemic to the Iberian Peninsula and have a restricted distribution range (Costa et al., 2021[106]). This adds an additional factor of vulnerability, putting endemic fish more at risk than those with a wider distribution.

Figure 2.12. Spain has one of the highest shares of threatened freshwater fish in the OECD

Threatened species of freshwater fish as % of known species, latest year available



Note: Excludes OECD countries for which data was not available.
Source: OECD (2022), OECD Environment Statistics, https://doi.org/10.1787/env-data-en.

The population of pollinators is also under pressure from habitat loss and the use of pesticides (MAPA, 2021[104]), as well as from pathogens and illnesses, invasive species and climate change. An estimated 2.6% of Spanish bee species are threatened according to the European Red List of Bees; this share could be even higher, as the status of more than half of bee species is unknown (MITERD, 2020[107]).

Changes in the agricultural landscape, the abandonment of rural land and the shift to more intensive production systems have affected the genetic diversity of Spain's livestock. As of 2020, 82% of the indigenous breeds were classified as threatened. The most vulnerable were poultry, horses and donkeys, with 90% of breeds classified as endangered (MAPA, 2021[104]). Native livestock breeds are adapted to a specific region, help maintain the diversity of animal genetic resources and provide agroecosystem services (Velado-Alonso, Morales-Castilla and Gómez-Sal, 2020[108]). As these breeds have historically adapted well to the Spanish natural systems, their conservation could be key for the adaptation of the Spanish livestock sector to climate change (Rubio and Roig, 2017[109]).

2.5.2. Policies and regulations

Spain has developed several programmes to protect species and promote the genetic diversity of plants and animals related to agriculture. Three practices included in the new CAP eco-schemes aim to improve biodiversity

The EU Birds and Habitats Directives were incorporated into Spanish legislation through Law 42/2007 of Natural Heritage and Biodiversity, which establishes the basic legal framework for the preservation and sustainable use of biodiversity and regulates the management of the Natura 2000 network. The Law for the Sustainable Development of Rural Areas (Law 45/2007), gives special prioritisation to rural areas that are part of the Natura 2000 network. Biodiversity considerations have also been included in Spain's Climate Change and Energy Transition Law.

Spain's Prioritised Action Framework for Natura 2000 (PAF) provides an overview of the funding needs to implement the Natura 2000 network and the associated "green infrastructure" measures to connect nature sites. For the 2021-27 period, the cost of maintaining the Natura 2000 terrestrial area was estimated at EUR 1.4 billion.

Recent developments related to biodiversity include the approval of several national strategies:

- Spanish National Strategy for Pollinator Conservation (September 2020), which includes measures for promoting favourable habitats; reducing risks from pests, pathogens and invasive species; reducing risks from pesticide use; and research.
- National Strategy for Green Infrastructure and Ecological Connectivity and Restoration (July 2021), to foster the creation of a network of natural and semi-natural areas designed and managed for the conservation of ecosystems and the maintenance of their services.
- Strategy for the Conservation of Threatened Birds Linked to Agricultural Steppe Environments (June 2022), focussed on the conservation of seven bird species through measures to manage habitats such as improving fallow land management or adjusting the timing of agricultural tillage and harvesting to avoid the nesting and brooding season, among others.
- National Strategy for the Conservation and Use of Wild Relatives of Crops and Wild Plants for Food Use (July 2022). Wild relatives are genetically related to crops and an important source of genetic diversity to protect the latter from threats. The strategy establishes an inventory and prioritisation of these plants and proposes actions for their conservation.

In 2008, Spain established a national programme for the conservation, improvement and promotion of indigenous livestock breeds. As part of the actions in this area, subsidies are granted to support the work of officially recognised breeders' associations. They are regulated by Royal Decree 794/2021 and financed by funds from the national budget. In 2021, funding amounted to EUR 4.9 million (MAPA, 2022[110]); similar amounts are foreseen for 2022 and 2023. Other measures of the programme include the development of a voluntary "native breed" logo to help consumers distinguish the products from these breeds and the places where they can be bought or consumed, and the establishment of an online system (ARCA) with information about the breeds and their regulation (see also Section 3.7).

The management and protection of plant genetic resources is regulated by Law 30/2006. A National Programme for the Conservation and Sustainable Use of Plant Genetic Resources for Agriculture and Food was established in 2017. Its work includes actions for conservation, research, information, awareness-raising and training. The National Plant Genetic Resources Centre (CRF) develops and maintains the National Inventory.

Measures related to biodiversity have been incorporated in the CSP enhanced conditionality requirements, the eco-schemes and the rural development plan. The eco-scheme practices aiming to improve the biodiversity associated to agricultural areas and the conservation of natural resources and water are:

- Biodiversity islands or sustainable mowing in permanent pastures and grasslands (eco-scheme practice P2): Farmers have a choice between either of the two options. In the biodiversity island option, at least 7% of the farm's pasture area is left unmowed until 31 August, after which it can be subject to practices (extensive grazing, mowing, weeding, tillage, sowing, etc.) to ensure that it is in good agricultural and environmental conditions. The use of herbicides is prohibited. The "island" area should rotate every year. Sustainable mowing requires a lower number of cuts per year and a period of at least 60 days in which mowing cannot take place. The practices must be recorded in the farm notebook.
- Annual rotation with soil-improving species in arable land (eco-scheme practice P3): At least half of the surface must be planted with a crop different from the previous crop. At least 10% of the surface should have soil-improving species, and half of the latter surface should correspond to legumes. Some exceptions and flexibilities apply, for example for farms of 10 hectares or smaller.
- Biodiversity areas in arable land and permanent crops, with sustainable management of irrigation inputs (eco-scheme practice P5): Part of the surface is left as non-productive areas and landscape features. It should be at least 7% in rainfed areas or 4% in irrigated areas and permanent crops. In the case of underwater cropland (rice), a choice can be made between keeping at least 3% of the area uncultivated or managing the water table sustainably. No fertilisers or phytosanitary products are allowed on the biodiversity areas.

An example of a regional regulation for the protection of biodiversity is Cantabria's Nature Conservation Law (4/2006), which among other aspects establishes a regional network of protected areas and a catalogue of threatened species. As the coexistence of large carnivores and livestock farming is a particular challenge for this AC (OECD, 2022[111]), it approved a regional Wolf Management Plan in 2019, according to which the regional administration shall compensate farmers for damages caused by the species. Extensive livestock farms that contribute to biodiversity conservation in areas where wolves are present are entitled to a yearly payment for environmental services. The payment amounts to EUR 20 per head for sheep or goats, EUR 15 for horses and EUR 10 for cattle, and is financed from the regional budget. For 2022, a total of EUR 1 million was granted to 955 farmers (Gobierno de Cantabria, 2022[112]).

2.6. Soil conservation

2.6.1. Assessment of status and trends

Spanish soils are threatened by erosion, loss of organic matter and salinisation. Practices such as conventional tillage and groundwater pumping worsen the problems

Soils in Spain are at a high risk of erosion by water. While the rate of soil erosion in Spanish agricultural areas decreased between 2000 and 2016, it is still higher than the EU average (Figure 2.13). Erosion by water processes is a widespread form of soil degradation in Europe, occurring more often in agricultural land and natural grassland. The consequences of erosion include the loss of fertile land and the degradation of the soil surface, with a negative impact on agriculture. At the same time, agricultural practices can aggravate erosion; a better agricultural management can prevent and mitigate it.

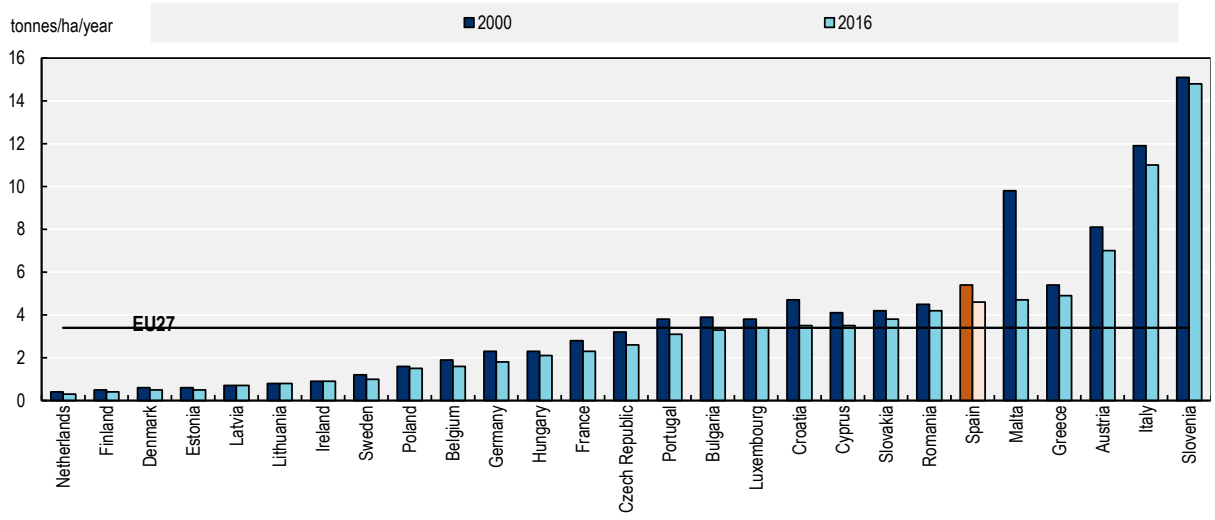
About 10% of Spain's UAA is at risk of severe erosion, above the EU average of 7%. Almost all of the area at risk is dedicated to arable and permanent crops (European Commission, 2020[38]). The maintenance of bare soil in woody crops (such as olive trees) is a particularly significant erosion driver in Spain. This practice can contribute to reaching soil losses of up to 47 tonne/ha/year (MAPA, 2021[26]).

Rainfed crops – in particular woody crops – in areas of moderate or high slopes and surface irrigated areas on steep slopes are especially vulnerable to erosion, particularly if they are not subject to soil conservation

practices. Half of the farms that applied to CAP support in Spain are estimated to be at risk of severe erosion, as some of their areas have over 25 tonne/ha/year of soil loss (MITERD, 2022[113]).

Figure 2.13. Soil erosion in agricultural areas is above the EU average

Mean rate of erosion by water, tonnes/hectare/year



Note: Includes agricultural areas and natural grassland.
Note by Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the Island. There is no single authority representing both Turkish and Greek Cypriot people on the Island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".
Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.
Source: Eurostat (2020), Agri-environmental indicator - soil erosion (AEI_PR_SOILER).

Erosion also depletes soil organic matter. As of 2015, Spain had a soil organic carbon content (SOC) in arable land of about 15 g/Kg. This value was the lowest in the European Union, but close to those reported by Greece, Portugal and Malta. The lower values in southern countries are associated with faster organic carbon mineralisation (European Commission, 2020[38]). The SOC is distributed unevenly across Spain's territory, with higher levels in the northeast and lower levels in the Ebro river basin and the areas with semi-arid climate in the south and centre (Andalusia, Castile-Leon and Murcia). The highest SOC concentrations are found in forests, and the lowest in agricultural soils (IEEP, 2021[15]).

Soils in Spain are increasingly affected by salinisation. While soil salinity can have natural sources, the problem in Europe is generally due to improper agricultural practices, including irrigation with poor quality waters, excessive pumping of groundwater and poor drainage conditions (FAO and ITPS, 2015[114]). High salinity limits the capacity of plants to absorb water and can cause nutritional imbalances or toxicity in the soil, leading to crop yield reduction (EIP-AGRI, 2020[115]). A technical report based on the EU Land Use and Land Cover (LUCAS) survey found a hotspot in the Ebro Valley, where measures of soil electrical conductivity point to a strong salinity (Fernandez-Ugalde et al., 2022[116]). It is estimated that 3% of Spain's irrigated land is severely affected, and another 15% is at serious risk (FAO and ITPS, 2015[114]). Soil erosion, salinisation and loss of organic matter are among the land degradation processes that are associated with desertification, another important environmental concern for Spain (Box 2.6).

Agricultural practices such as conventional tillage[15] can reduce soil quality and cause erosion and loss of organic matter. As of 2016, Spain was in line with the EU average, with 75% of tillable land subject to

conventional practices. The remaining tillable area either was subject to conservation tillage (18%) or not tilled (7%) (Eurostat, 2021[117]).

Box 2.6. The problem of desertification

Agricultural and irrigation practices are among the contributors to desertification in Spain

The Spanish authorities have estimated that 74% of the country's surface is at risk of desertification, with almost 18% at a "very high" or "high" risk (MAGRAMA, 2016[118]). Spain is one of thirteen EU Member States that have declared themselves as affected under the United Nations Convention to Combat Desertification (UNCCD).

Desertification is a complex and multi-causal phenomenon, for which no unique international indicators exist. The UNCCD defines it as the degradation of land in arid, semi-arid, and dry sub-humid areas (as opposed to the natural expansion of existing deserts). It is a gradual process caused by human activities and climatic variations.

In the case of Spain, a number of specific conditions – some of them related to agricultural and irrigation practices – have been identified as direct and indirect drivers of desertification processes. They include: increasing aridity, caused by higher temperatures and evapotranspiration and less precipitations; more frequent and intense drought episodes; an evolution of agricultural land characterised by the abandonment of marginal land (such as pastures and fallow land) and an increase in the irrigated surface (with the subsequent pressure on water resources); the moderate impact of the irrigation modernisation efforts on reducing pressure on water resources and the higher vulnerability to water stress, particularly in the Mediterranean; the significant growth of the livestock population (in particular the expansion and intensification of the pig sector); an increase in the share of the UAA that is intensely managed by farms; more abandoned agricultural and forest land; depopulation and population aging in rural areas; a higher risk of forest fires and more large fires; and an increase in the area of sealed soil (MITERD, 2022[113]).

2.6.2. Policies and regulations

Spain's recently updated desertification strategy and the new CAP eco-schemes include actions to promote soil conservation

In 2022, a National Strategy to Combat Desertification was approved, substituting the previous national plan of 2008. It puts the problem of desertification in the context of the international and European agenda of environmental protection and sustainable development, and in light of the advance in knowledge on the phenomenon of desertification and the role of climate change. The strategy identifies five main scenarios affected by desertification in Spain: crops affected by erosion; irrigated areas affected by desertification; landscapes associated with an unsustainable intensification of livestock farming; abandoned agricultural land; and forests with insufficient management.

The actions and measures proposed to combat desertification by 2030 include developing a plan to restore land affected by desertification; preparing a national soil inventory and an atlas of desertification; implementing good practices for sustainable land management; and drafting a national law on soil conservation and sustainable use in line with the EU Soil Strategy for 2030.

Several of the new CSP interventions aim to contribute to improving soil conditions and preventing or combatting desertification. Beyond the mandatory GAEC requirements under the enhanced conditionality, four practices of the voluntary eco-schemes aim to improve soil structure, reduce erosion and desertification, increase soil carbon and reduce GHG and ammonia emissions:

- Extensive grazing in permanent pastures and grasslands (eco-scheme practice P1): Grazing done by the farm's own animals in extensive livestock farming, for at least 120 days (continuous or not) per year (90 in some cases); the livestock load allowed in the eligible surface must respect a minimum and maximum level.
- Direct sowing (with a sustainable management of irrigation inputs) in arable land (eco-scheme practice P4): No tillage and maintaining stubble on the ground for at least 40% of the land. Crop rotation under conservation agriculture. Fertiliser application according to a plan prepared by a technical advisor and subject to the sustainable crop nutrition regulation. To be eligible, the farm must not have been sanctioned for illegal water use. Farms located in nitrate vulnerable zones can be subject to additional requirements.
- Spontaneous or sown vegetative cover in woody crops (eco-scheme practice P6): A vegetative cover, live or withered, is left on the ground for the whole year. The cover must remain alive for at least four months between 1 October and 31 March. No phytosanitary products may be applied on the cover.
- Inert vegetation cover in woody crops (eco-scheme practice P7): The pruning debris is shred and left on the ground. No phytosanitary products may be applied on the debris.

A specific Pillar 1 payment per hectare has been destined for producers of nuts (almond, hazel and carob) in rainfed areas that are at risk of desertification due to low precipitation levels or steep slopes. This sector faces limited profitability, a lack of viable alternatives, low investment levels and a higher risk of land abandonment. The income support is expected to improve the activity's profitability and competitiveness, thus preventing land abandonment and reducing desertification risks. The 2023-27 budget for this measure is EUR 70 million.

An example of policies at the regional level is Galicia's Law 6/2021 on waste and contaminated soils. Among other aspects, it establishes the principles of its soil policy, including soil conservation, quality management and the recovery of polluted soils (Xunta de Galicia, 2021[119]).

2.7. Conclusions

Spain was a pioneer in giving recognition to environmental protection at the constitutional level in 1978. Since then, it has developed a large body of regulation in different environmental domains, which has also evolved following the development of EU regulation. The performance of *ex ante* Strategic Environmental Assessment of plans and programmes has been in place for decades and is done at the regional and national levels. *Ex post* assessment, on the other hand, is less used. This type of assessment of policies and regulations would be of value to assess their impact, determine if regulations are serving their purposes and identify areas for potential simplification.

The recent formulation of the national CAP Strategic Plan for 2023-27 (CSP) entailed an extensive process of consultation and co-ordination through which Spain identified and prioritised its needs in the agri-environmental domain. Accordingly, funds and interventions under the CSP and the Spanish Recovery, Transformation and Resilience Plan (RTRP) aim to promote a transformation of the agro-food sector and improve its environmental sustainability. Given the diversity of Spain's Autonomous Communities and the different environmental challenges they face, there is flexibility, particularly in the rural development pillar of the CSP, for the ACs to apply policy interventions in ways that address the regional needs and priorities.

Agriculture accounts for a relatively small share of total GHG emissions, but this share and the emissions level have been growing in the last decade. Spain aims to reduce its agricultural GHG emissions by 18% as of 2030 and committed to achieve carbon neutrality by 2050. At the regional level, most ACs have also developed climate change strategies or plans. The role of agricultural policy to address climate and environmental challenges has been recognised in the Spanish National Energy and Climate Plan, and

numerous elements of the CSP aim to address these objectives. Taxes on energy use and GHG emissions are applied at the national and regional level, with some exemptions on agricultural activities.

Agriculture is the main user of water and a source of pressure on the quantity and quality of water resources. The modernisation of irrigation infrastructure has been a main focus of policies related to agricultural water management. In the course of the last two decades, there have been substantial public investments to improve irrigation infrastructure and incorporate technology. Additional investments to further modernise irrigation are planned for the coming years and will be subject to environmental conditions to follow the Do No Significant Harm (DNSH) principle.

As a result of the irrigation modernisation policy, the share of Spain's area irrigated by localised systems has increased to over half of the irrigated surface, and the volume of abstractions decreased between 2000 and 2018. At the same time, the total irrigated area has continuously expanded. A comprehensive evaluation of the modernisation programmes at the country level would help have a better picture of the impact of this major public policy and the achievement of its environmental and socio-economic objectives.

In general, water policy has evolved substantially throughout the decades, influenced by the development and implementation of EU regulation among other factors. Alignment with OECD recommendations has increased, with room for further improvement in some areas. The availability and transparency of water data could be strengthened to facilitate the analysis and assessment of policies.

Along with water management, there are other areas with environmental challenges linked to agriculture, including increasing nutrient balances and growing ammonia emissions, as well as threats to Spain's rich biodiversity and soils. Recent policy developments, including the new CSP and the measures promoted by the RTRP put a strong emphasis on addressing these problems, and in general on improving the environmental sustainability of agriculture and contributing to the climate objectives. Monitoring the implementation of these policies and verifying their impact on the environmental objectives will be key, and the development of the new farm information system (with the Digital Farm Notebook and the ECOGAN registry for livestock farms) is a valuable step in this direction.

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Notes

[1] Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, Madrid.

[2] The GHG emissions data compiled in the OECD Agri-Environmental Indicators Database for Spain and the other EU Member States come from the UNFCCC Greenhouse Gas Inventory Database. The agricultural emissions data exclude land use, land-use change and forestry (LULUCF).

[3] See also the discussion of emissions and total factor productivity in Section 1.3.

[4] "Emission intensity" measures the amount of greenhouse gases emitted (E) per unit of output (Y). It is calculated as the ratio between total GHG emissions generated in agriculture and the value of total agricultural output: EI = E / Y. The growth rate in emission intensity is, therefore, the difference between the growth rates of total emissions and of production. Whenever total GHG emissions grow at a slower rate than output, the emission intensity of output decreases, i.e. its growth rate is negative.

[5] Relative decoupling of production from GHG emissions occurs when output grows at a faster rate than the related emissions. It reveals progress in emission intensity but not in total emissions. The negative growth rate of emission intensity can be interpreted as a measure of relative decoupling of production from GHG emissions (provided that the growth rate of output is also positive).

[6] Known in Spanish as PNIEC, *Plan Nacional Integrado de Energía y Clima*.

[7] According to the EU Water Framework Directive, "quantitative status" expresses the degree to which a body of groundwater is affected by direct and indirect abstractions, and "good" quantitative status is such that the available groundwater resource is not exceeded by the long-term annual average rate of abstraction.

[8] In the EU Water Framework Directive, a "river basin district" is the main unit for the management of river basins. It is defined as the area of land and sea, made up of one or more neighbouring river basins together with their associated ground waters and coastal waters.

[9] Water use or water abstraction for irrigation is different from actual water consumption. Only a fraction of the water abstracted will be consumed by the crops, while the rest comes back to the environment through evaporation or return flows to aquifers or surface water, depending on the type of irrigation system. For this reason, a decrease in water use does not necessarily imply a reduction in water consumption.

[10] The threshold is 50 mg/l; anything above which waters are considered polluted or at risk of pollution under the Nitrates Directive. Areas where this threshold is surpassed are defined as "Nitrate Vulnerable Zones" (NVZs).

[11] The cited reports by IWMI and the World Bank concluded that the concept irrigation efficiency is not suitable to measure the performance of irrigation, and discussed methods to assess water productivity instead, due in part to the disconnect between water withdrawals, water applied and water consumption.

[12] See article 74 of the Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 (https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32021R2115&from=EN).

[13] The DNSH principle has been included in the EU regulation establishing the Recovery and Resilience Facility (RRF). It requires that the reforms or investments included in Member States' recovery plans do not lead to significant harm to any of the six environmental objectives contemplated in Article 17 of the EU Taxonomy Regulation ((EU) 2020/852): climate change mitigation; climate change adaptation; sustainable use and protection of water and marine resources; circular economy; pollution prevention and control; protection and restoration of biodiversity and ecosystems.

[14] Figures provided by MAPA in response to an OECD questionnaire.

[15] Conventional tillage typically includes a sequence of soil tillage, such as ploughing and harrowing, to produce a fine seedbed and remove most of the plant residue from the previous crop. It is associated with a high degree of soil disturbance. Conservation tillage creates a suitable soil environment for growing a crop that conserves soil, water and energy resources mainly through the reduction in the intensity of tillage, and retention of plant residues. No-tillage (or zero tillage) is a minimum tillage practice in which the crop is sown directly into soil not tilled since the harvest of the previous crop. Weed control is achieved by the use of herbicides and stubble is retained for erosion control.

3 Innovation for sustainability

Spain's scientific research capacity is widely respected, and directing this capacity at developing agricultural innovations and facilitating their adoption could further increase its value. The research and innovation performance of the different Autonomous Communities is heterogeneous. This chapter examines the Spanish agricultural knowledge and innovation system (AKIS), presenting its main actors, institutions and governance, the sources and flows of its funding, and the interactions between the national and regional levels. It outlines Spain's policies to facilitate innovation in the agro-food sector, in areas such as promoting public and private investment in research and development, improving digitisation and connectivity, and protecting intellectual property rights, and compares indicators of innovation performance and adoption. The chapter also assesses the evolution of farm advisory services and the level of skills of Spanish agricultural workers. In the final section, examples of Spanish initiatives to promote innovation for environmental sustainability are presented.

Key messages

- Spain has a moderate performance in innovation relative to other EU countries, and there is regional heterogeneity. The country is better in agricultural science than in developing agricultural innovation and facilitating adoption. Low public and private investments, the fragmentation of the agricultural knowledge and innovation system (AKIS), and regional heterogeneity in approaches are the main obstacles to harnessing innovation for a sustainable and resilient agriculture.
- The Spanish AKIS involves many actors at the national and regional levels, that would benefit from improved co-ordination. Autonomous communities lead the regional AKIS, which includes research and development (R&D), innovation, and knowledge transfer policies. Central and regional governments exercise competences in relevant R&D and innovation policies within the EU framework.
- Spain's eighteen public agro-food research centres are heterogeneous and relatively small. Some of them have entered into partnerships with other actors for successful R&D projects. The centres are not necessarily well connected and co-ordinated in the whole AKIS system.
- Government spending on R&D for the agro-food sector has been increasing in recent years, although it remains below the level observed before the 2008 financial crisis. The private sector has become the main source of agro-food R&D funding, though it relies on increasingly fewer innovative firms.
- The level of education of most agricultural workers remains well below the EU average. Only 22% of farm managers have a formal training. There is evidence of skills mismatches, which can exert a negative impact on the dynamism and innovation capacity of the sector.
- The training needs of the agricultural sector are evolving and need a stronger connection between knowledge transfer systems and the new forms of business and innovation, which require high entrepreneurship, digital and environmental skills to facilitate the adoption of new technologies.
- Spain has reduced the rural-urban gap in access to digital technologies. Differences persist between rural and urban areas in access to high quality broadband and in digital use skills.
- Spanish advisory services have been transformed in the last three decades. The traditional public agricultural extension services have been partly replaced by private advisors, advisory entities and commercial advisors linked to input providers.

3.1. General innovation profile

3.1.1. Spain is a moderate innovator with regional heterogeneity

The European Innovation Scoreboard considers Spain as a "moderate innovator". In 2022, Spain had a performance at 88.8% of the European Union average, below the average of the moderate innovators (89.7%) (European Commission, 2022[1]). This score positions Spain below peers such as Germany, France, and Italy. Spain performs particularly well (above the European Union average) in digitalisation, human capital, and environmental sustainability. The Global Innovation Index (GII) ranks world economies according to their innovation capabilities. In 2022, Spain ranked 29th among the 132 economies featured and 18th among the 39 economies in Europe, improving one position with respect to 2021 (WIPO, 2021[2]; WIPO, 2022[3]).

There are disparities in the level of innovation of Spain's Autonomous Communities (ACs). According to the Regional Innovation Scoreboard, the Basque Country and the Madrid Community are strong innovators, while Andalusia, the Canary Islands, Castile-La Mancha, Ceuta, Extremadura, the Balearic Islands and Melilla are emerging innovators. The remaining ACs are classified as moderate innovators (European Commission, 2022[1]).

3.1.2. Policy approach and framework: National strategies and regions

Agro-food R&D, innovation, and knowledge transfer are highly decentralised

The governance of Spain's public system of research is to a large extent the by-product of historical factors that have resulted in a system with intertwined policy responsibilities for the central government and the autonomous regions (OECD, 2021[4]). This has led to an Agricultural Knowledge and Innovation System (AKIS) with a multiplicity of actors that is more disperse and fragmented than in other EU countries where the AKIS is integrated, such as Ireland, Denmark, and France (Knierim, 2015[5]).

According to Knierim (2015[5]), a fragmented AKIS is characterised by several independent knowledge networks that operate in parallel, which are typically not well co-ordinated, rarely co-operate and might even compete. Conversely, an integrated AKIS features a co-ordinating structure, often a public body, and the system is supported by national policies on AKIS and advisory services that frame the interactions of AKIS actors. The fragmentation of the Spanish AKIS is partially explained by the distribution of powers established in the Spanish Constitution in which the ACs assume responsibility for agriculture and livestock, in accordance with the general organisation of the economy and for the promotion of research, while the central government has exclusive competence for the promotion and general co-ordination of scientific and technical research (MAPA, 2021[6]; MAPA, 2021[7]). The level of development of the AKIS and, therefore, the performance of these systems also differs among the ACs.

The government has recognised the need to improve co-ordination to ensure that the high level of fragmentation does not result in overlaps or gaps. As planned in the 2023-27 CAP Strategic Plan (CSP), the Ministry of Agriculture, Fisheries and Food (MAPA) is working on the creation of the "AKIS Co-ordination Body", a collegiate body of a mixed nature that will ensure the co-operation, participation, and co-ordination of the AKIS system with the main actors on a national scale and in the ACs. Likewise, the MAPA is working on the development of a platform that will gather information on advisory services, courses, and training.

Spain does not have a specific strategy for agro-food innovation. The general framework, provided by the Spanish Science, Technology, and Innovation Strategy (EECTI) 2021-2027, is a strategic cross-sectoral plan to organise research and innovation, which is defined by the central government. Concrete measures of this strategy are outlined in the State Scientific, Technical and Innovation Research Plan (PEICTI) for 2021-2023 – currently under implementation. The PEICTI 2021-2023 has six thematic priorities. One of them focuses on food, bioeconomy, natural resources, and environment. Regional governments can define and carry out regional research priorities within the national framework.

Having a diversity of science, technology, and innovation policy experiences at the regional level offers lessons for policy making at the national level and can help promote innovation initiatives that are more targeted to regional needs. However, a recent expert assessment noted that the lack of adequate integration through governance mechanisms and knowledge flows, adapted to the reality of AKIS structures in Spain, has indeed affected the system's efficiency (MAPA, 2021[7]). Specifically for the agricultural sector, several analyses identify a low co-ordination between the different agents and levels of the AKIS (i2Connect, 2020[8]; MAPA, 2021[6]). This low level of communication can make it difficult to align regional and national strategic priorities and to develop critical mass and synergies.

There are also limitations in the availability of information: the absence of an integrated information and follow-up system at the national level, as well as the lack of specific and detailed information at the regional level on innovation in agro-food are weaknesses of the sector and might be indicators of the low co-ordination (MAPA, 2021[6]).

3.2. Actors, institutions, and governance of the Agricultural Knowledge and Innovation System (AKIS)

3.2.1. Main actors of the Spanish AKIS and their role in agricultural innovation

The Spanish AKIS is a network of actors that shape and stimulate research, development and innovation (R&D&I). It is very diverse, involving numerous actors at national and regional level, with different degrees of co-ordination between them. The wide network of actors in the Spanish AKIS generate, disseminate, and apply knowledge and innovation for the agro-food sector.

In a schematic way, the Spanish AKIS can be divided in five main groups of actors, consisting in central and regional governments, public and private research centres, education and training, technology centres, and the private sector. They play different roles in the generation, adaptation and adoption of new technologies and the promotion of innovation for sustainability in the agro-food sector. Despite having different roles and contributing in varying ways to the AKIS, they are expected to focus on generating knowledge that is useful for farmers to meet consumer and societal demands.

Several drivers, such as new demands for public goods and services, climate change, circular bioeconomy, emerging technologies, changes in food consumption, sustainability, agricultural digitisation, and a redefinition of public and private relationships, have led to the emergence of multiple sources and flows of knowledge, also accelerating the processes of generating knowledge and innovation (Cruz, Sayadi and Albisu, 2021[9]).

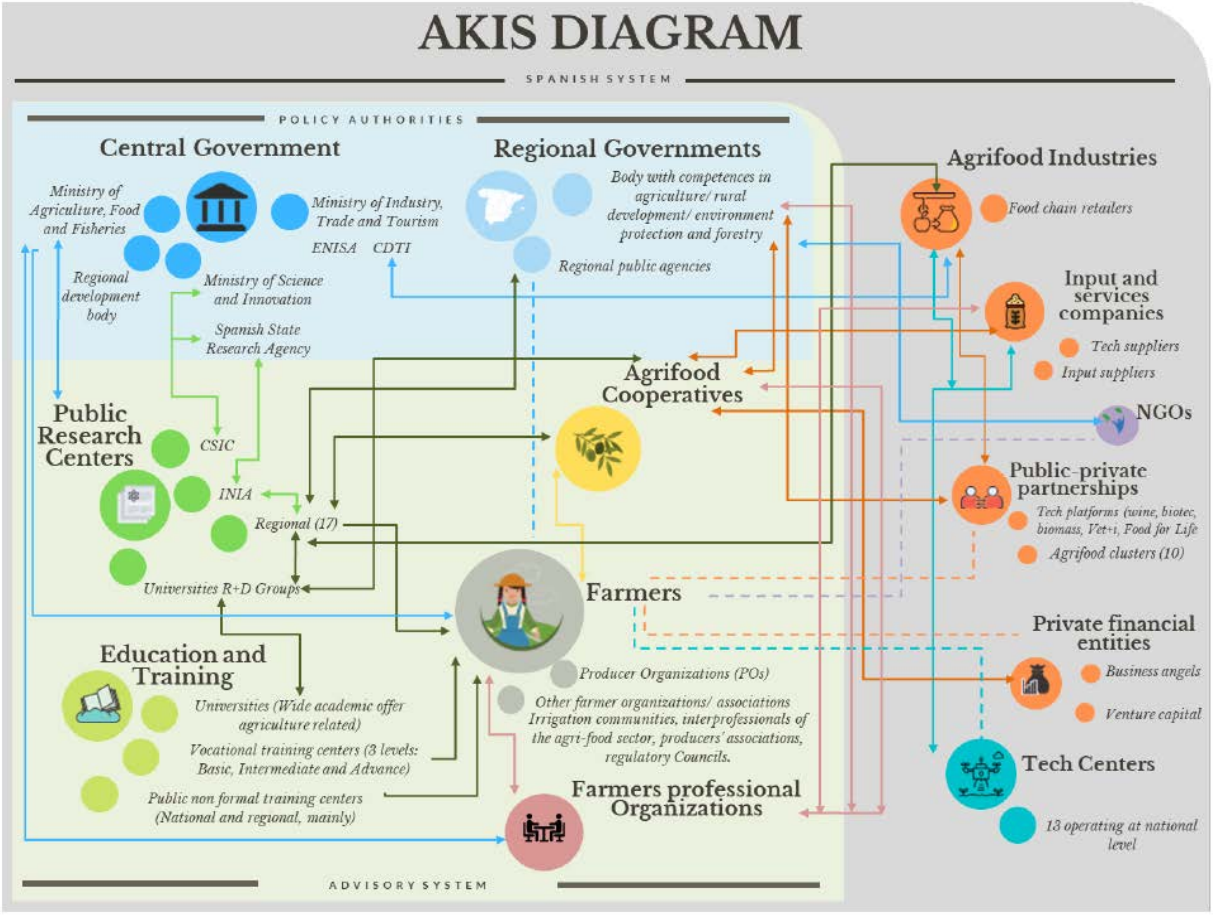
Figure 3.1 shows a representation of the Spanish AKIS. Given that the system is composed by a varied set of actors with complex interrelations between them, it is not uncommon to find overlaps between the actors and in the limits of their roles and functions with respect to knowledge. Knowledge flows can be more complex than those depicted by the figure.

Farmers (and their organisations) should be at the core of the AKIS. Managing agricultural production and its links with land and natural resources, they take decisions based on the knowledge they can generate and receive and, thus, are one of the main actors generating and using innovations for sustainability.

The central government defines the basic national objectives and provides guidelines of the general research policy, including agricultural-related research, and is in charge of the overall co-ordination of the agricultural-related projects. Also, the central government sets the overall legislative framework, co-finance initiatives, and can influence the strategy and activity of shared institutions through co-governance mechanisms (OECD, 2021[4]).

Figure 3.1. Innovation for agriculture involves a complex system with multiple actors and knowledge flows

The Spanish Agricultural Knowledge and Innovation System (AKIS)



Notes: Actors' categories are represented in circles. Under one category, there are several actors (e.g., education and training). Impartial agricultural advisory system includes some of the relevant AKIS actor's categories (green box). The lines represent the linkages between AKIS actors (dashed lines for weak linkages, and solid lines for strong linkages).
Source: i2Connect (2020[8]).

Regional governments can define and carry out regional research priorities within the national framework, based on their own regional innovation strategies (regional research and innovation strategies for smart specialisation (RIS3 strategies)). RIS3 strategies, as the national research and innovation strategy, are economy-wide; yet – in most regions – they include specific priorities for the agricultural sector and the bioeconomy. In the decentralised system of Spain, regional bodies play an important role in linking farmers' needs with public authorities. Furthermore, as in any complex system, for it to be efficient and effective there is an important need of co-ordination between regions and the central government (i2Connect, 2020[8]).

Public research centres and universities are relevant players in generating knowledge that can lead to innovation for sustainability. Similarly, there are also examples of private and public-private research centres. Universities also provide training together with public non-formal training centres at the national and regional level. In general, the education and training sector is composed by universities at the regional and national levels, vocational training schools at the regional level, and some private institutions providing

education for agriculture. These actors generate knowledge that helps improve the functioning of the AKIS and helps create and acquire agricultural skills for farmers.

Spain has a wide diversity of advisory providers from the public and private sector. Advisory services play a fundamental role in linking farmers with the knowledge generated by research centres, universities, or government authorities. Often, they also act as a channel for farmers to transfer their knowledge and innovation to other actors and institutions of the AKIS. Advisory services have gone through important transformations and many roles of the traditional public advisory service are now performed by the private sector.

The private sector is composed by a wide variety of heterogeneous actors such as farmers, small and medium enterprises (SMEs), multinational enterprises (MNEs), input and services companies, self-employed workers, co-operatives, firms from agro-food industries, and agro-food industry associations. They can also act in partnership with the public sector, and they are increasingly active in performing R&D&I activities.

Other actors, such as farmers' professional organisations, public-private partnerships and non-governmental organisations (NGOs), complete the landscape and play different roles in generating knowledge in the Spanish AKIS.

3.2.2. Funding, funding bodies, and main national and regional authorities within Spain's AKIS

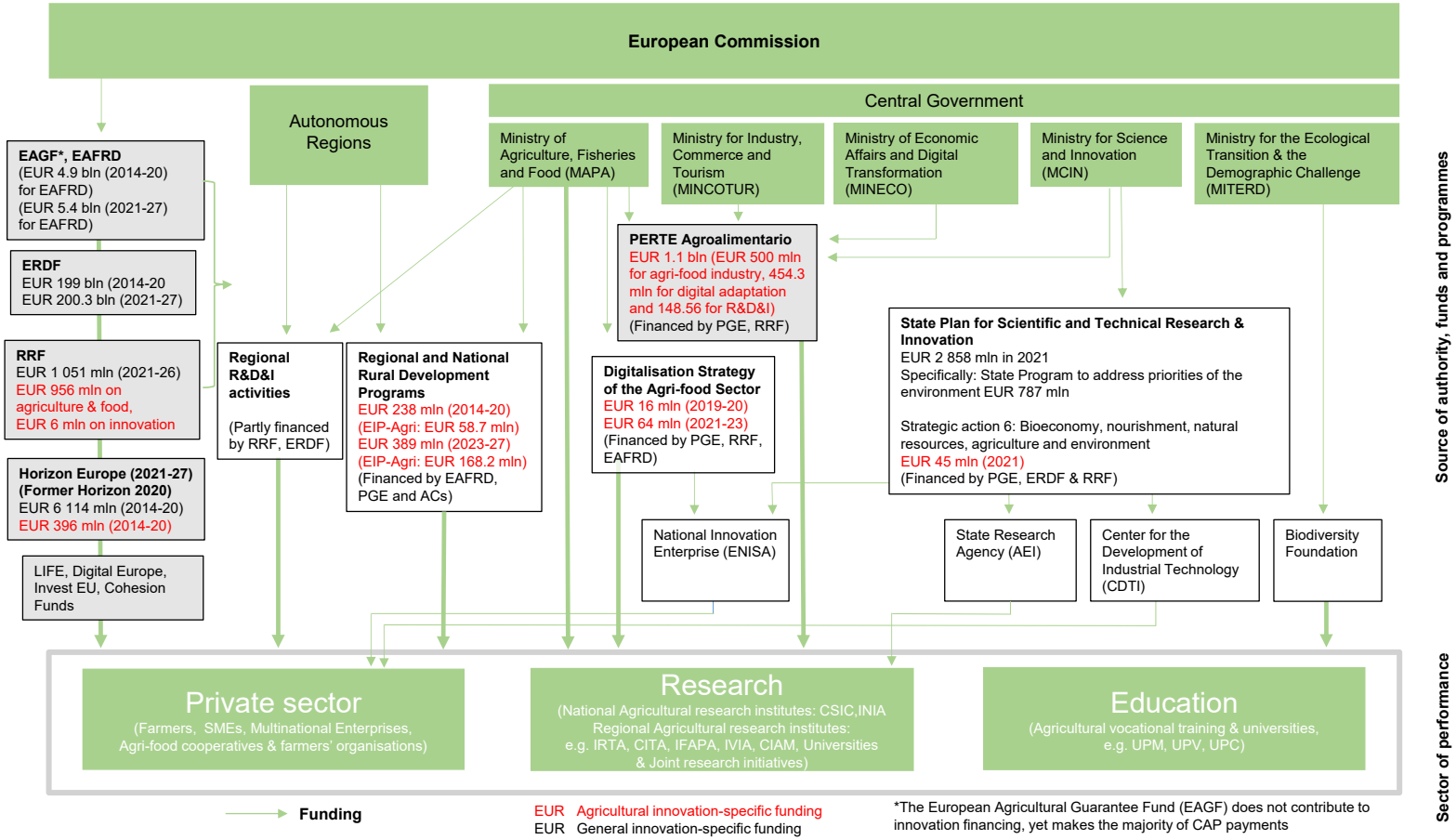
Spain has a complex governance system in which central and regional governments exercise competences in R&D&I policies relevant for agriculture, within the EU framework

The Spanish AKIS is characterised by the combination of the features of national with those of regional governance systems based on the country's decentralised political landscape, while entailing the additional attributes resulting from the EU membership. The result is a complex governance system in which central and regional governments exercise competences in R&D&I policies relevant to agriculture within the EU framework.

The central government has the exclusive responsibility for the promotion and general co-ordination of scientific and technical research. At a national scale, the Ministry for Science and Innovation (MCIN) together with the Ministry of Agriculture, Fisheries and Food (MAPA) lead the definition of the general national strategic research priorities and execute and fund most R&D&I policies for agriculture. Most often, they delegate their tasks to different implementing agencies that co-ordinate the defined policy programmes and earmark the corresponding funds. The regional governments perform and implement R&D&I tasks based on their own regional plans and budgets, within the national framework and in co-ordination with ministries and implementing agencies. Public funding is provided by the European Union, the national government, and the regional governments. The main sectors of performance of R&D that use the funding are the private, the research, and the education sectors.

Figure 3.2 provides an overview of the funding ecosystem of the Spanish AKIS, depicting the main authorities and implementing agencies, the most important funds, funding streams, and relevant R&D&I performing actors, which include private and public actors, such as partnerships, research centres, and universities.[1]

Figure 3.2. Funding of the Spanish System of Agricultural Research and Innovation



Note: This is a stylised and non-comprehensive infographic. PGE is the Spanish abbreviation for General State Budget. Bolded arrows indicate funding for the three sectors of performance, i.e. the private sector, research, and education.
Source: Authors, based on official sources and informal information from meetings.

European Union funding

Spain, with its eligible entities, received the largest share of Horizon 2020 funding under societal challenge 2, which covers agro-food

The European Union contributes to different national and regional programmes with several types of funds from different programmes. Some of them are directly linked to agriculture and to agricultural R&D&I while most are not sector-specific and do not fund these activities separately.

The European Union contributes with directly managed funds (except in the case of partnerships that have co-financing) through its main innovation programme Horizon 2020 (2014-20) and its successor Horizon Europe (2021-27). Spanish entities obtained over EUR 6.1 billion in funds from the Horizon 2020 programme, making Spain the fourth beneficiary of this programme, with 10.4% of the total EU-28 funding. Moreover, Spanish entities received the largest share of the available Horizon 2020 funding under its societal challenge 2 – which covers the agro-food sector – in 2014-20, with the total grants amounting to EUR 396.3 million (12.4% of the EU-28) (CDTI, 2021[10]; MAPA, 2022[11]). Spanish entities have been involved in 454 funded activities and 107 of these have been co-ordinated by Spanish organisations (CDTI, 2021[10]).

Under the new Framework Program for Research and Innovation 2021-27, Horizon Europe, most funding for the agro-food sector will be provided under Cluster 6 "Food, Bioeconomy, Natural Resources, Agriculture and Environment''. In this context, the European Union aims at fostering knowledge, building capacities and developing novel solutions to promote sustainable land use and a more sustainable, resilient and inclusive agricultural sector, for example through activities such as partnerships, research networks and initiatives. Also, Interreg, LIFE, Digital Europe, Invest EU, Cohesion Funds, and other European programmes have been a source of funding for the entities of the Spanish AKIS.

The Common Agricultural Policy (CAP) of the European Union is another key tool to fund R&D&I activities in the agricultural sector. The CAP's Pillar 2 fund, the European Agricultural Fund for Rural Development (EAFRD) has part of its funds directed to R&D&I activities in the sector, as it channels the European Union's rural development policy. Specific measures to fund R&D&I in agriculture under Pillar 2 of the CAP include knowledge transfer, advice and innovation through co-operation. Particularly, the European Innovation Partnership for Agricultural Productivity and Sustainability (EIP-AGRI) cooperation-innovation measure of the rural development programmes for the period 2014-22 and the co-operation intervention within the CAP Strategic Plan serve this purpose. It is co-financed by the European EAFRD and country funds (national and regional) and managed by the country. In Spain, the EIP-AGRI innovation was programmed at the supra-autonomous level within the National Rural Development Program (NRDP) 2014-22 – managed by MAPA and funded with EAFRD and funds from the State Public Budget (PGE) – and at the regional level in 15 ACs, with funds from the EAFRD, PGE, and ACs.

The European Union provides additional R&D&I funding through the European Regional Development Fund (ERDF), which can contribute to innovation for a sustainable agro-food sector through smart specialisation strategies. These strategies help to identify research and innovation priorities in strategic sectors in specific regions of the country, including agriculture and food, to channel knowledge-based investments and co-operation. In this context, the European Union supports, for example, health and safe food in Andalusia through innovation in the agro-food industry targeting consumers' food habits and food traceability, among others (European Commission, 2022[12]).

The Recovery and Resilience Facility (RRF), the European Union's recovery instrument in response to the COVID-19 crisis, is implemented through a series of aids managed by the General State Administration through various ministries, with different tools and funds, some of which are direct transfers to the ACs. One stream is dedicated to agriculture and supports, for example the Spanish rural development

programmes (RDPs) and the Digitalisation Strategy of the Agro-food and Forestry Sector of the PERTE Agroalimentario (Section 3.3.2).

National bodies, funding, and programmes

PERTE Agroalimentario is one of several strategic projects of the Spanish Recovery, Transformation and Resilience Plan (RTRP) and which receives funding from the RRF and the central administration (2022-25). The PERTE includes a set of measures that seek to strengthen the agro-food chain with tools to confront the environmental, digital, social and economic challenges of the next decade. It has a budget of around EUR 1 800 million, which is divided in three parts. The first has a budget of EUR 500 million (initially EUR 400 million), is implemented by the Ministry of Industry, Trade and Tourism (MINCOTUR) and seeks to strengthen the agro-food industry; the second has a budget of EUR 454.4 million and is implemented by MAPA and the Ministry of Economic Affairs and Digital Transition (MINECO); finally, the third part, with a budget of EUR 148.6 million, focuses on research, innovation and technology transfer, and is implemented by MCIN and MAPA with the support of CDTI and complementary plans between regions and MCIN.[2]

The PERTE Agroalimentario includes programmes and measures such as the Digitalisation Strategy of the Agro-food and Forestry, the establishment of the AKIS advisory and knowledge exchange digital platform, as well as the creation of a Digitalisation Observatory for the agro-food sector which was recently kick-started with the signature of a collaboration agreement with the financial institution CAJAMAR (Gobierno de España, 2022[13]). It also includes the establishment of a Digital Innovation Hub, which aims to promote the implementation of digital technologies. Also linked to this strategy are the actions under AgroInnpulso, a financing line established between MAPA and the state-owned company Empresa Nacional de Investigación S.A. (ENISA) to provide credit to agro-food SMEs to implement digital and innovative technology-based projects (MAPA, 2021[14]).

The Ministry of Science and Innovation (MCIN) holds the main responsibilities for research, technological development, and innovation policies across sectors and is in charge of the EECTI and PEICTI. It is the main R&D&I funding body and encourages R&D&I, co-ordinating with the ACs and overseeing the public research organisations. Among the latter, the most relevant is the Spanish National Research Council (CSIC). The role of the CSIC has become increasingly important for agro-food since 2021, when the National Institute for Agricultural and Food Research and Technology (INIA) was integrated under its umbrella (Section 3.2.5).

The Spanish State Research Agency (AEI) – created in 2015 and attached to the MCIN – plays a significant role as it is the agency responsible for the management of the PEICTI. Its programmes, measures, and corresponding funds are financed from the General State Budget and co-financed with EU funds.

Other relevant institutions that depend on the MCIN are the Spanish Foundation for Science and Technology (FECYT), a public foundation that seeks to strengthen the link between science and society, and the Centre for the Development of Industrial Technology (CDTI), which is a public business entity that promotes innovation and the technological development of Spanish companies. It channels the requests for aid and support for R&D&I projects from Spanish companies, both nationally and internationally. The CDTI supports projects by granting economic aid to companies and facilitating access to funding from third parties (such as the EU Framework Programme, the European Space Agency funds, or international multilateral initiatives for technological co-operation such as Eureka and Iberoeka).[3] In 2020, the CDTI provided funding of EUR 819 million for 1 601 R&D&I projects involving companies. The sectors that benefitted the most from the CDTI's contributions were industry (36% of the total), ICT (20%) and food, agriculture, and fisheries (18%) in 2020. The allocation of funding shows a strong territorial imbalance, indicative of the uneven development of the industrial sector in Spain (CDTI, 2021[10]).

The Ministry of Agriculture, Fisheries and Food (MAPA) is responsible for proposing, formulating, and implementing government policy in the areas of agriculture, agro-food, nutrition, livestock and fisheries and

rural development. Additionally, it represents the state in international organisations dealing with these topics and co-ordinating the actions of ACs in these areas. Moreover, the MAPA manages and provides support at the supra-autonomous level (i.e. in two or more ACs) to operational groups and innovative projects of the EIP-AGRI. To this end, MAPA has co-financed 177 supra-autonomic operational groups under the RDP 2014-2022 and financed the implementation of 124 innovative projects of general interest to the agro-food sector with EUR 62.4 million of total public expenditure granted so far. Beyond that, MAPA develops demonstration thematic networks to encourage knowledge transfer and knowledge exchange programmes among AKIS stakeholders and implements different aid programmes to support training and advisory services in digitalisation (MAPA, 2022[15]).

Within the MAPA, the Directorate-General for Rural Development, Innovation and Agro-food Training co-ordinates and spurs the advisory, training, and knowledge transfer systems in the agro-food sector. To this end, it works on the national AKIS and takes part in various multi-actor projects under Horizon related with the European AKIS (such as FairShare and i2connect under Horizon 2020, and EU farmbook, and Modernakis under Horizon Europe). Additionally, it manages EIP-AGRI innovation aid of rural development at supra-autonomous level, directs the co-ordination and the dialogue with other ministries regarding R&D&I and digitalisation, and is in charge of exchanging with the European Commission on EIP-AGRI related matters.

The Ministry of Industry, Trade and Tourism (MINCOTUR) develops national policies for industrial innovation with relevance to the agro-food sector. ENISA is integrated into the MINCOTUR. It collaborates closely with the MAPA through AgroInnpulso. These projects are expected to result in a business project with a clear innovative and digital component that will contribute to the profitability and competitiveness of the beneficiary SME. Also, MINCOTUR implements the first line of the PERTE Agroalimentario.

The Ministry for the Ecological Transition and the Demographic Challenge (MITERD) relates to the MAPA's work as it has various competencies with respect to the agro-food sector, particularly in environment and forestry, waste management, energy and demographic challenges. To this end, it develops strategies, by proposing and implementing policies and elaborates state legislation in its fields of responsibility. Especially its strong focus on climate change mitigation and biodiversity protection should be highlighted. Attached to MITERD is the Biodiversity Foundation, a publicly owned entity. It executes activities related to the study, conservation, and sustainable resource use of the environment, specifically natural habitats, and biodiversity. Its main goals include fostering scientific education and research in the area and serving as a platform for exchange. Moreover, it supports innovative projects and entrepreneurial activities in biodiversity matters and has launched funding lines for sustainable agriculture projects.

Additionally, the Ministry of Universities and the Ministry of Education and Vocational Training (MEFP) define and co-ordinate education policies, with important implications on innovation capacities for sustainable agriculture, and the Ministry of Economic Affairs and Digital Transition (MINECO) also runs several programmes of digital development with repercussions in the agricultural sector.

Regional bodies

The allocation of funding shows some territorial imbalances, indicative of the heterogeneity of the Spanish regions

One of the most important changes derived from the decentralisation process is that competencies in agriculture, research and education were transferred to the ACs. This led to the development of local entities with their own and diverse dynamics, which form regional AKIS. Despite the general trend towards a greater involvement of regional governments in science and innovation policies, there are large differences in the scale and scope of such policies driven by income inequalities across autonomous regions, the heterogeneity of regional industrial specialization patterns, their different institutional profiles, and their different use of EU structural funds over the past decades (OECD, 2021[4]).

In brief, the funding for agricultural research at the regional level comes from regional sources (such as EIP-AGRI regional co-operation projects or regional R&D&I projects funded by the departments responsible for research and innovation), national sources (such as the PEICTI calls managed by the AEI, national co-operation measures of the EIP-AGRI, projects funded by the CDTI, and the PERTE Agroalimentario), and from European sources (from programmes such as Horizon 2020, LIFE, Interreg POCTEP, Interreg Sudoe and Interreg Atlantic Area, among others).

Advisory services are under the responsibility of the ACs and funded through their regional budget or support granted to them in the regional RDP. Formal training (both vocational and university training) is funded by the ACs, while non-formal training is funded by the regional RDP (Section 3.4.1).

3.2.3. The Autonomous Communities

According to the OECD survey of AC authorities, seven out of the eight ACs that responded have a long-term strategy for agro-food innovation (OECD, 2022[16]). However, the ACs are very heterogeneous in several areas. In terms of R&D&I, the interregional differences are due to differences in the level of economic and scientific development and of political support and commitment.

Unfortunately, the information on R&D investment for the agricultural sector at the regional level is not available. However, as an indicator to illustrate the heterogeneity, Table 3.1 shows the differences in the total investment on R&D in all sectors and the share of each AC. Two ACs, Madrid and Catalonia add up to 50% of total R&D, while smaller ACs do not even reach 1% of total funding. Similarly, there is high disparity in the number of employees and researchers in the different ACs. More importantly, the indicator of R&D per researcher also shows heterogeneity, indicating that the differences are not only related to the different sizes of the ACs but also to differences in available resources. The information on agricultural R&D&I for the regions is not easy to gather, reflecting the need of more public information and a co-ordinating agent for the generation of systematic data on the agro-food innovation efforts in Spain across all ACs.

The left panel of Figure 3.3 shows some differences in the key priorities and the focus areas of innovation in the ACs, according to the survey (OECD, 2022[16]). Six out of the eight responding ACs indicated that sustainable natural resources management in the agro-food sector is a key priority. Digital technologies in farming and along the supply chain, and increased value added from the agriculture and agro-food sectors are key priorities in four out of eight ACs. Other less common priorities are adaptation to climate change (three out of eight), collaboration along the agriculture and agro-food supply chain (two out of eight), and animal health and welfare and plant health. Only one AC identified modernisation of rural areas and restructuring of farms and agro-food firms as a key priority. Similarly, the right panel of Figure 3.3 shows that digitisation is a main research area for innovation in six out of eight ACs. It is followed by bioeconomy and food systems (four out of eight), circular economy and organic farming (three out of eight), and education and skills (indicated by only one AC).

In brief, the differences seem to be linked to the specific features of each region that derive from a variety of factors such as the stability of regional governments that allows to develop long-term projects; the strategic planning at regional level for the agro-food sector; the regional economic development; the relevance of the agro-food sector in the regional economy; and improvements in the administrative structure of the centres, especially regarding the economic and human management, which have increased their capacity to compete.

Table 3.1. Two Autonomous Communities contribute half of Spain's total R&D expenditure

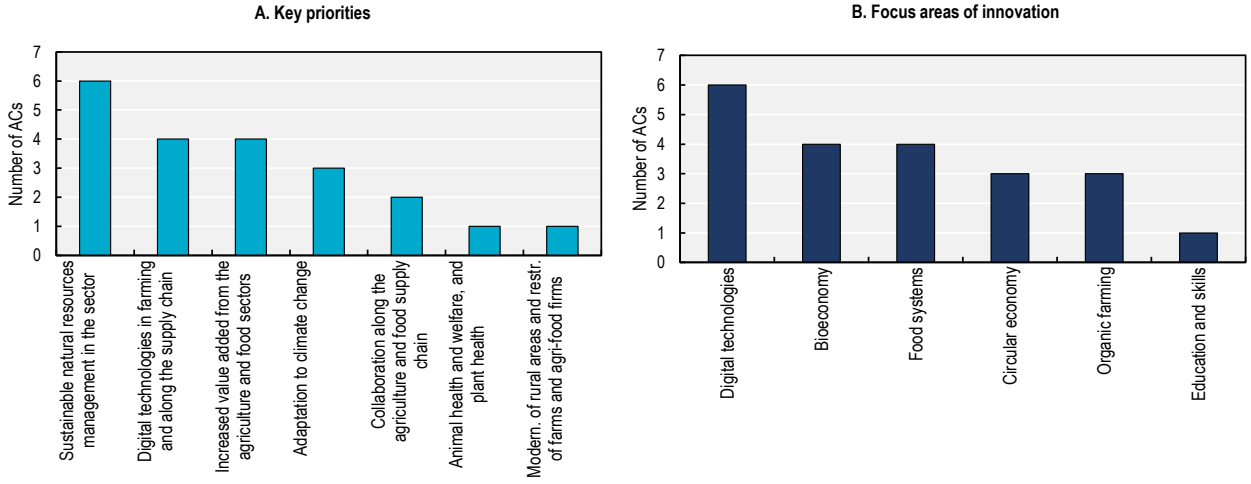
Expenditure (from all sources) and personnel in internal R&D by autonomous communities where R&D activities were carried out, 2021

	Internal R&D		Employment		R&D / Researcher
Autonomous Community	Thousands of EUR	%	Employees	Researchers	
Total	17 249 249	100.0	249 648	154 147	111.9
Madrid	4 536 155	26.3	61 120	38 128	119.0
Catalonia	4 078 729	23.6	55 885	31 579	129.2
Andalusia	1 703 533	9.9	27 044	15 543	109.6
Basque Country	1 666 316	9.7	21 504	14 431	115.5
Valencia	1 358 519	7.9	22 178	13 962	97.3
Castile and Leon	795 797	4.6	11 120	7 223	110.2
Galicia	697 484	4.0	11 435	7 462	93.5
Navarra	389 937	2.3	5 300	3 163	123.3
Aragón	386 705	2.2	6 671	4 356	88.8
Murcia	351 404	2.0	6 787	4 559	77.1
Castile - La Mancha	339 418	2.0	3 861	1 975	171.8
Canary Islands	238 546	1.4	4 009	2 947	81.0
Asturias	204 172	1.2	3 384	2 391	85.4
Extremadura	149 074	0.9	2 766	1 868	79.8
Balearic Islands	146 031	0.8	2 997	2 244	65.1
Cantabria	133 156	0.8	2 159	1 382	96.3
La Rioja	65 065	0.4	1 308	842	77.3

Note: All sources include the public sector, the business sector, non-profit private enterprises (IPFL), and the higher education sector.
Source: Authors' calculation based on INE (2020), https://www.ine.es/dynt3/inebase/es/index.htm?padre=8351&capsel=8352.

Figure 3.3. The sustainable management of natural resources is a priority in many regional innovation strategies

Priorities of the agro-food innovation strategy and focus areas of the agro-food innovation policy of ACs



Note: Partial results based on the replies of the following Autonomous Communities: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, and Madrid.
Source: OECD (2022[16]).

3.2.4. Public national and regional R&D&I organisations

The CSIC is the main public research organisation in Spain. It provides R&D&I services in many sectors and has 13 330 employees (4 345 of which are researchers). In 2021, the CSIC had revenues of EUR 799 million. The CSIC is organised in 121 research institutes (50 of them are joint centres with other organisations) and three national centres, among them the National Institute for Agricultural and Food Research and Technology (INIA). It produces an important scientific output. In 2021, the CSIC took part in 4 226 national projects and 586 projects of the Framework Programme. In addition to the research activities, the national centres provide expert technical advice to the public sector. CSIC's institutes are spread all over the country, although with a large concentration in Madrid (42 institutes), Andalusia (20 institutes) and Catalonia (18 institutes). The CSIC is the Spanish organisation receiving more funding from the Horizon 2020 programme. The CSIC has 36 centres or institutes related to agro-food sector, 215 research groups, and 1 694 projects in progress.[4] Particularly relevant are the Centre for Edaphology and Applied Biology of Segura (CEBAS-CSIC) in Murcia, the Aula Dei experimental station (EEAD) in Zaragoza and the Institute for Sustainable Agriculture (IAS), in Córdoba.

The INIA is an institute of reference in the agro-food science and technology research at national and international level. It participates in numerous projects in the areas of biotechnology, environment, animal genetics improvement, plant protection, animal breeding and food technology. The main sources of funding are the PEICTI and Horizon 2020. The INIA collaborates closely with the MAPA through specific mandates or contracts. At the European level, the INIA-CSIC represents Spain in the Standing Committee on Agricultural Research (SCAR), which is responsible for co-ordinating agricultural research in Europe. Moreover, the INIA-CSIC participates in different European networks of national and regional funding agents, such as ERA-NET or PRIMA. Some of the institutes or centres attached to the INIA are the Forest Science Institute (ICIFOR), the Animal Health Research Centre (CISA), the Biotechnology and Plant Genomics Centre (CBGP), and the Plant Genetic Resources and Sustainable Agriculture Centre (CRF).

The regional agricultural research centres show large differences in terms of resources and interests

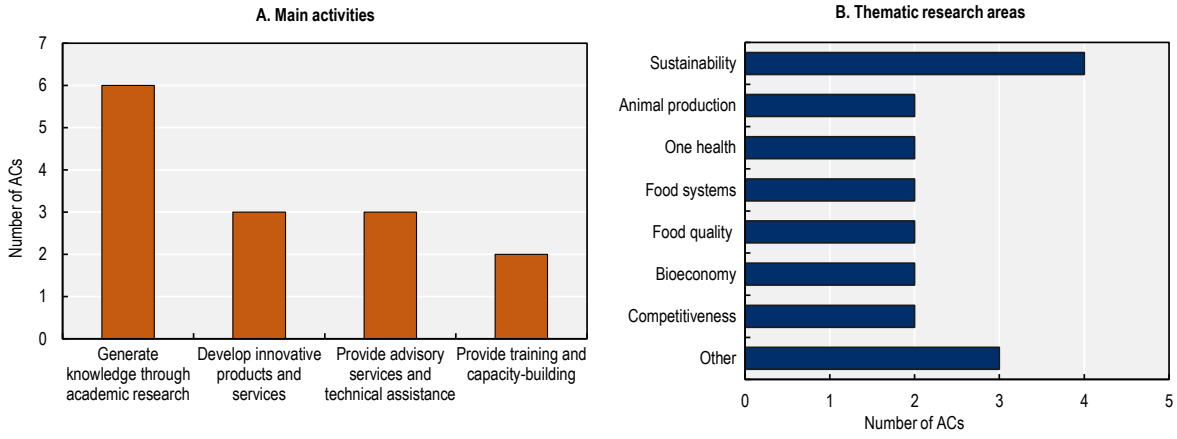
All ACs have a public research centre focusing on R&D&I in the agro-food sector. These regional centres have focused their research in the areas more relevant and in line with the needs of agriculture in their region. In addition to undertaking research projects, regional research centres have other duties: promoting the conservation of plant varieties, performing official food and agricultural analysis, and organising technology transfer actions for the agricultural sector (field trials, technical seminars, visits, etc.).

Altogether, the regional centres employ more than 3 500 people, including more than 850 researchers, and manage a budget of over EUR 250 million for personnel costs, infrastructure, and R&D&I.[5] In addition, some of the regional centres have additional functions beyond research, such as advisory services, testing laboratories, analysis services and ensuring food quality, among others. Figure 3.4 (left panel) shows that almost all the regional agricultural research centres have the aim of generating knowledge through academic research as one of their main activities. Others also aim at developing innovative products and services, providing advisory services and technical assistance, and providing training capacity building. In the right panel of Figure 3.4, we observe that half of the responding regions have sustainability as one of the thematic research areas. Animal production, one health, food systems, food quality, bioeconomy, and competitiveness are thematic research areas mentioned by less ACs, but nonetheless relevant.

The development of the regional research centres in the last decades has been heterogeneous both in terms of funding levels and staff increase. This has led to divergences not only in terms of the research carried out, but also in terms of transfer of results and advisory services. Some ACs such as Catalonia, Andalusia or the Basque Country have very robust centres, while the centres of other ACs have lost relevance due to the low public investment and lack of a clear commitment from some regional governments with agricultural innovation.

Figure 3.4. Sustainability is an important research area for some regional centres

Main activities and thematic areas of the regional agricultural research centres



Note: Partial results based on the replies of the following Autonomous Communities: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, and Madrid.
Source: OECD (2022[16]).

Table 3.2. Regional agricultural research centres have different sizes and legal forms

Regional agro-food institutes belonging to the regional agricultural research centres-AC network

Region	Name of the institute	Legal status	Staff
Andalusia	Institute for Research and Training in Agriculture, Fisheries, Food and Ecological Production (IFAPA)	Independent body	797
Aragón	Agro-food Technology and Research Centre (CITA)	Public-law entity	249
Asturias	Regional Agro-food Research and Development Service (SERIDA)	Public research organisation	169
Balearic Islands	Agriculture and Fisheries Research and Training Institute (IRFAP)	Administrative organisation with no legal personality	14
Canary Islands	Canarian Institute for Agricultural Research (ICIA)	Independent body	140
Cantabria	Agricultural Research and Training Centre (CIFA)	Administrative unit	32
Castile-La Mancha	Regional Institute for Agro-food and Forestry Research and Development (IRIAF)	Independent body	204
Castille and León	Castilla-León Agricultural Technology Institute (ITACyL)	Public entity subject to private law	144
Catalonia	Institute for Research and Technology in Food and Agriculture (IRTA)	Public company under private law	882
Extremadura	Extremadura Scientific and Technological Research Centre (CICYTEX)	Public-law entity	259
Galicia	Galician Agency for Food Quality (AGACAL)	Public agency	331
La Rioja	Directorate-General for Research and Rural Development	Administrative unit	...
Madrid	Madrilenian Institute for Agricultural Research and Agriculture and Food Rural Development (IMIDRA)	Independent body	335
Murcia	Murcia Institute for Agriculture and Food Research and Development (IMIDA)	Independent body	190
Navarra	Navarrese Institute for Agro-food Technology and Infrastructure (INTIA)	Public company	223
Basque country	NEIKER Tecnalia, Basque Institute for Agricultural Research and Development	Public company	191
Valencia	Valencia Institute for Agricultural Research (IVIA)	Independent body under private law	222

Source: Authors, based on expert's input and websites of the regional agricultural research centres.

Over the last 20 years, many ACs have developed their agricultural research management, aiming to enhance the autonomy of the research centres through the creation of organisations with their own legal personality to have greater operational capacity to achieve their goals within the AC. These changes aimed at finding more agile and specialised practises for staff management, promoting public-private collaboration, and facilitating access to funding. Some centres have adopted the form of societies and public companies with greater autonomy for economic and staff management. Others took the form of agencies or other bodies governed by public law; these have been more affected by public expenditure and recruitment limitations established in the aftermath of the 2008 economic crisis.

Most of the regional agricultural research centres are agencies or bodies governed by public or private law (Table 3.2). In the regions with more developed systems, they tend to be public companies. For instance, this is the case of the INTIA in Navarra, the NEIKER in the Basque country and the IRTA in Catalonia.

3.2.5. The role of the agricultural research centres as agents of knowledge generation and transfer

The INIA is the co-ordinator of the regional agricultural research network, though successive reforms have limited its role and competences

Different reforms enacted since the 1980s have caused the INIA to lose some of its competences. As part of the decentralisation process, the responsibilities around agriculture were transferred to the ACs. This included the transfer of research material, human, and budgetary resources from the national level, with the purpose of building the regional research services. The ACs took on very broad powers in agricultural research. Among them are directing and managing the research units transferred; implementing national research projects and those linked to international agreements; processing agricultural research projects of interest for their territories; selecting, implementing, monitoring and controlling agricultural research projects not included in the national programmes; co-ordinating agricultural research, experimentation, dissemination and information in their territories; and negotiating and reaching agricultural research and experimentation agreements with public and private entities.

The responsibilities maintained by the national government maintained include: establishing the basic national objectives and general guidelines for agricultural research policy; directing and managing the units that were not transferred to the regions; implementing research projects under the responsibility of these units; co-ordinating the projects included in the national agricultural research programmes; maintaining international scientific relations in the area of agricultural research; and disseminating the results of national agricultural research programmes (Fundación Alonso Martín Escudero, 2003[17]).

The Co-ordinating Commission on Agricultural Research was created in 1987. This collegial body involves the central state administration through the INIA (which holds the presidency), the ministry in charge of the public administration, the MAPA and the representatives from the 17 ACs. The INIA was chosen as co-ordinator because it had been leading agricultural research through the Regional Centres for Agricultural Research and Development until the transfer of responsibilities to the regions.

Up until 2017, the INIA acted as a research centre and a funding body for the regional research centres, managing calls for proposals, for pre and postdoctoral researchers, for infrastructure and to invest in machinery, laboratory equipment, etc. These calls were vital for the regional centres – especially the less competitive ones and those that received less funding – as they allowed them to fund research directed at the problems of regional agriculture through restricted calls where they did not have to compete with public research organisations, universities and others. In 2017, INIA's funding competences were transferred to the AEI, and the INIA only maintained its research responsibilities. In 2021, the INIA merged into the CSIC, losing its status as a public research organisation of the MCIN. This watered down its importance within the AKIS and its capacity to effectively lead and co-ordinate the network of regional research centres.

Responsibility for the INIA has also been assigned to different ministries: while it initially belonged to MAPA, it was later transferred to the Ministry of Education, and later to the MCIN, under which it currently operates.

The existence of a decentralised set of research centres can be a source of strength and diversity to the extent that they are integrated through adequate mechanisms to facilitate the flow of knowledge and the co-operation in innovation activities. A scattered set of resources that are not aligned through a strategic vision of priorities may undermine the capacity of the innovation system to respond to the big challenges ahead of the agro-food sector.

3.2.6. The role of the private sector

The private sector has an increasingly important role promoting innovation…

The agro-food private sector comprises a variety of players: companies of different sizes, from SMEs to multinational enterprises, industry associations, farmers, farmers' organisations, and agro-food co-operatives. These actors play a key role in the adoption of new technology and the promotion of innovation in the agricultural sector.

Agro-food companies often have links with the business-supporting public authorities and research centres to facilitate knowledge flows and the promotion of their innovations. They do so, for example, by participating in the EIP-AGRI funding lines implemented both at a supra-autonomous level by the MAPA and at an autonomous level by the ACs. By including the participation of the private sector, operational groups seek to engage companies in the innovative project, for it to respond to a need of the sector and to improve the adoption of innovations.

Another example are public-private partnerships through technology platforms or Agro-food Clusters/Innovative Enterprise Clusters (IEC). Technology platforms are industry-led exchange networks where relevant actors of the AKIS collaborate on technological research and innovation needs. In Agro-food Clusters/IECs, companies collaborate with public/private research and training centres on specific topics of the sector within a region. Such initiatives are often promoted by the national administration (MINCOTUR). There exist several examples of agro-food technology platforms (Wine Technology Platform, Spanish Technological Platform for Plant Biotechnology, Spanish Technological Platform for Biomass – BIOPLAT, Spanish Technology Platform Food for Life – Spain), and agro-food clusters or IECs (INOLEO, AEI of the olive sector, AGROFOOD, Agro-food Cluster Foundation of the Region of Murcia, VITARTIS, Association of the Food Industry of Castilla y León, CLUSAGA, Food cluster of Galicia) (i2Connect, 2020[8]).

The Spanish Federation of Food and Beverages Industries (FIAB) is another example of a private sector organization promoting innovation. This federation groups almost fifty associations and represents the Spanish agro-food industry while working on the future challenges of the sector. It aims at promoting and fostering the sector economically, socially, and environmentally, with innovation at the core of its activities. To promote business innovation, FIAB collaborates with companies and actors that perform research to boost R&D&I in the industry. At the national level, FIAB is actively engaged in some of the public administration's R&D&I projects, tackling issues concerning the consolidation of public-private collaboration in R&D&I.[6] In collaboration with MAPA and the Plataforma Tecnológica Food for Life-Spain (PTF4LS), FIAB gives out the Ingenia Startup Prizes, rewarding innovation and entrepreneurship efforts in private R&D&I efforts.[7]

There are also important technological centres such as the National Centre for Technology and Food Safety (CNTA), the Extremadura National Agro-Food Technological Centre (CTAEX), and the Technological Institute of Food (AINIA), a private technology centre with more than 30 years of experience in R&D&I (Box 3.1). The Spanish Federation of Technology (FEDIT) has worked since 1996 to encourage

innovation, technology development and private research so as to increase the competitiveness of companies by improving technology via 43 technology centres across the country.

In addition to agro-food companies, Professional Agricultural Organizations (OPAs) and agro-food co-operatives play a key role in knowledge transfer and innovation on the farm . In particularly, several OPAs work closely with farmers, acting on their behalf , and as the bridge linking research, politics, and farmers as recognised partners of the government. There are three main OPAs: the Co-ordinator of Organizations of Farmers and Stockbreeders (COAG), the Agricultural Association of Young Farmers (ASAJA), and the Union of Small Farmers (UPA).

Box 3.1. AINIA

Adding to the country's R&D efforts are private technology and research centres, such as AINIA, based in Paterna (Valencia). AINIA aims at increasing companies' competitiveness by means of innovation, and offers consulting, specialised training, analytical services, and certified industrial services besides its research activities. The private technology centre has 700 associated companies and 1 600 clients and is driven by its values of sustainable development, integrity, personal connection, and profitability for growth. With over 230 staff members, it conducts innovation-targeting research in a series of areas, including food-related topics, as well as sectors such as cosmetics, packaging, and pharmacy. Specific research and innovation relate to the future of food studies, fermented foods, plant-based foods, and alternative proteins, among others. Underscoring its commitment for a sustainable society, AINIA is a member of the United Nations Global Compact for sustainability and has received awards for SDG 6-related efforts and for its commitment to equality.

Source: https://www.ainia.es/.

… but the role of the private sector still depends on the interaction with public entities and on public R&D&I for knowledge generation

Although private companies have taken on an increasingly relevant role in the Spanish AKIS, it is still below international comparatives. Spanish companies leave most of the responsibility for high-level knowledge generation to the public sector (OECD, 2021[4]). Therefore, the AKIS is highly government-driven, and private innovative outputs to promote a sustainable agro-food sector are low. Among the reasons for the low private sector contribution is the low rate of collaboration between private business actors and public research. The limitation in the usage rights of research results from public funding is one of the reasons. Another reason is the limited scope of the central government's R&D programmes financing, which are not necessarily tailored to the private sector's needs.

Private investments are still low, especially considering that the mobilisation of private funding for R&D&I activities will be critical to sustain investments once European recovery funds run out, and a prerequisite to avoid a sharp funding reversal as damaging as that caused by the global financial crisis (OECD, 2021[4]).

3.3. Policies facilitating innovation

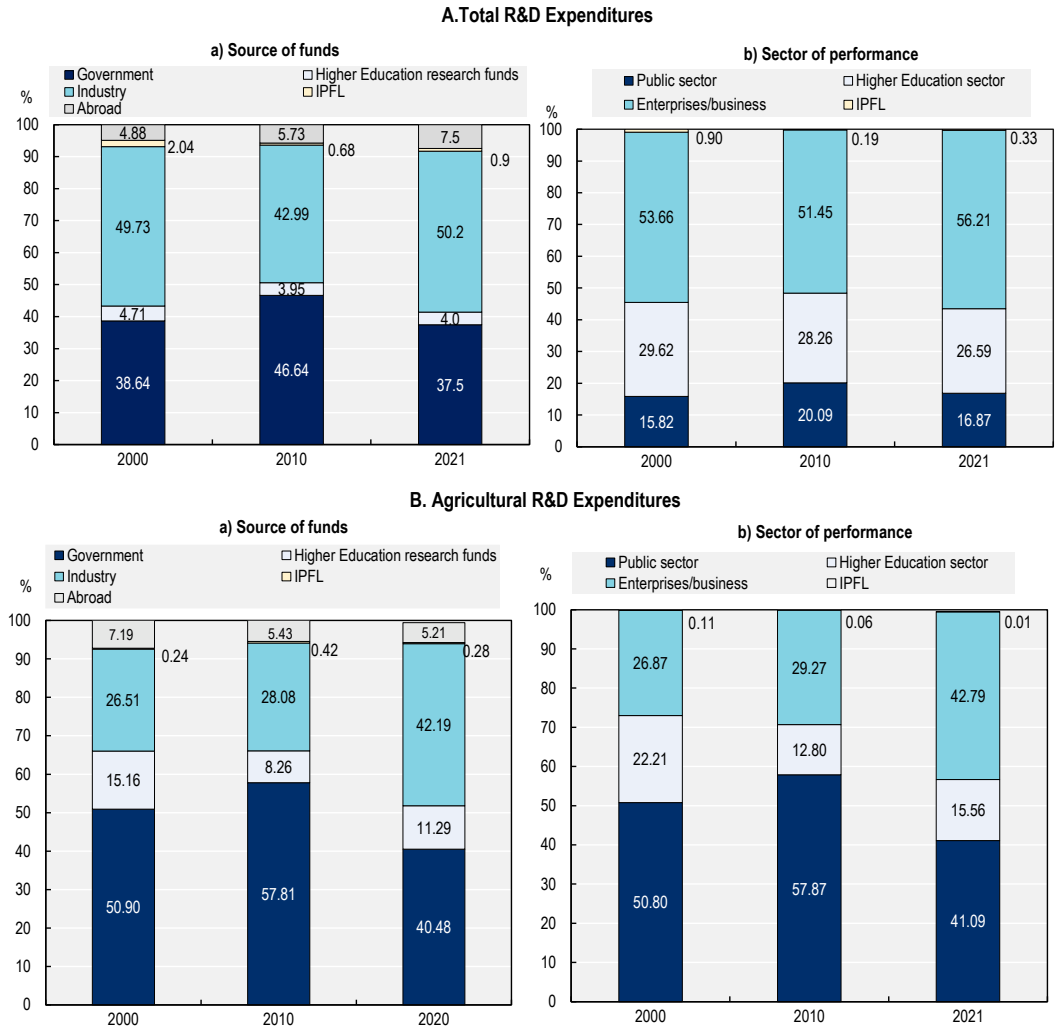
3.3.1. Public and private investments in agricultural R&D

Total research and development (R&D) funding in Spain is mostly financed and performed by the business sector

The business sector is the main source of funding for R&D (upper panel of Figure 3.5), accounting for 50.2% of the funds (2021), followed by the government (37.5%). It is also the main actor undertaking R&D activities (56.2%), followed by the higher education sector (26.6%) and the government (16.9%).

Figure 3.5. Business is the main source of funds for agricultural R&D

Gross domestic R&D expenditure in Spain



Notes: Agro-food sector includes Agriculture, livestock, forestry and fishing, and Manufacture of food, beverages and tobacco (Classification CNAE 10,11,12). IPFL refers to non-profit private enterprises. Abroad includes funds from European Union Funds. 2021 figures are estimated.
Source: Authors' calculation based on INE (2021) (Estadísticas sobre actividades en I+D).
https://www.ine.es/dynt3/inebase/es/index.htm?padre=8853&capsel=8859.

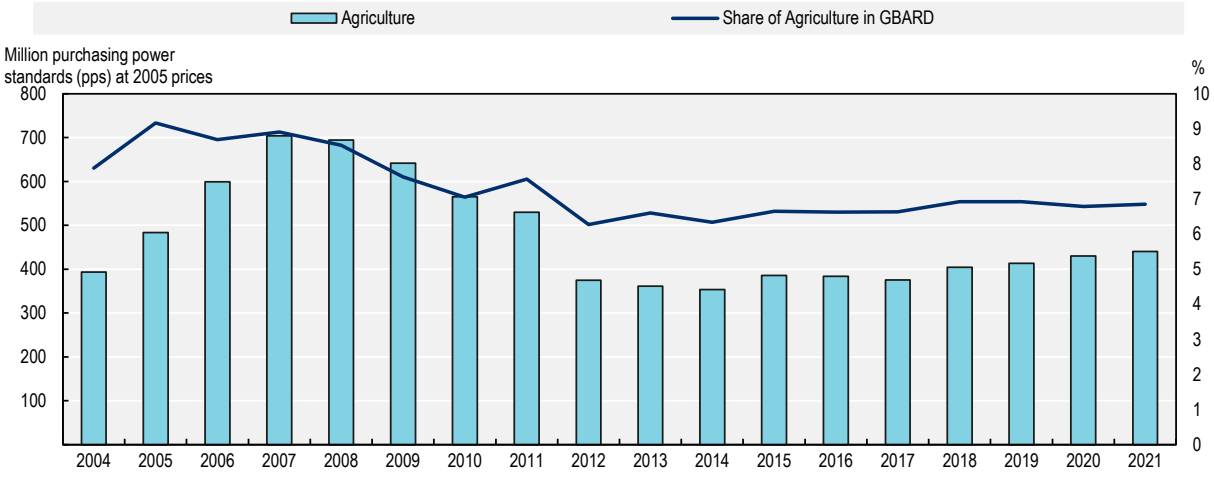
In the specific field of agro-food, the source of funds changed significantly in recent years (lower panel of Figure 3.5). The share of the government decreased with respect to previous years while the share of the business sector notably increased from 26.5% in 2000 to 42.2% in 2021. Agro-food companies stand out as important investors in R&D, however, the number of innovative firms in the agro-food sector has decreased in the last ten years (MAPA, 2022[11]). According to the National Statistics Institute's (INE) Innovation in Businesses Survey, which includes companies with more than ten employees, there a total of 2 103 companies in the agro-food sector (Agriculture and Forestry, and Food, Beverages, and Tobacco) were carrying out innovation activities in 2020 with an expenditure of EUR 959 million. The data show that 22.5% of companies in the Food and Beverages sector invest in R&D activities, higher than many other manufacturing sectors in Spain (Instituto Nacional de Estadística, 2020[18]). This not the case, however, in the primary sector, where only 7.4% of firms with more than ten employees invest in R&D and innovation activities, which is below the average of all sectors.

Agricultural R&D investments are relatively high, but the levels are well below those existing before 2008

The Spanish Government supported R&D aimed at promoting agriculture with nearly 7% of the entire R&D budget in 2021 (Figure 3.6). This significantly exceeds the EU27 average of 3%. An additional percentage is dedicated to support agricultural and veterinary science through funding for the general advancement of knowledge.

Figure 3.6. Government funds for agricultural R&D have not recovered their pre-crisis levels

Government budget allocation for R&D in Spanish agriculture, million purchasing power standards (PPS) at 2005 prices



Note: 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. However, it provides only a partial indicator of investment in public agricultural research, since it refers to research funding instruments dedicated specifically to agriculture.
Source: Authors' calculation based on Eurostat (2022), [Joint OECD-Eurostat international data collection on resources devoted to RD] GBARD by socioeconomic objectives (NABS 2007) (database), [GBA_NABSFIN07], (Eurostat, 2022[19]) (accessed August 2022).

However, resources directly allocated to R&D for agriculture decreased in real terms from their peak in 2007 at a faster rate than the entire R&D budget between 2007 and 2021, with the main decline following the financial crisis of 2008 and continuing until 2014. Since 2017, the total government budget allocation for R&D for agriculture has been slowly increasing in real terms, although there is still a large difference with respect to the pre-crisis levels.

Agricultural R&D intensities are below the EU average although higher than in Italy and France, but low shares go to the private sector

Spain's overall gross domestic expenditure on R&D (GERD, which covers public and private expenditure on R&D carried out by all residents in a country) increased by 18% in real terms between 2006 and 2019 (OECD, 2022[20]). It reached 1.4% in 2019, below the 2.2% of the European Union (Table 3.3). This level was comparable with those of Italy, Portugal and Canada, but significantly lower than in the Netherlands, France, and Germany.

Table 3.3. The agricultural R&D intensity in Spain is close but below the EU average

Field of R&D	All		Agriculture		All		Agriculture		All		Agriculture		Food and beverages	
Sector of performance	All sectors		Public (government and higher education)		All sectors		All sectors		Business		Business		Business	
Source of funds	All sources		All sources		Government		Government		All sources		All sources		All sources	
Indicator	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 beverages BERD[7] as a % of sector's value added	
	2006	2019	2006	2019	2006	2020	2006	2020	2006	2020	2009	2019	2009	2019
EU27	1.70	2.20	...	...	0.66	0.77	1.42	1.33	1.07	1.44	0.29	0.43	0.86	0.95
Spain	1.18	1.36	1.41	1.21	0.67	0.62	2.42	1.34	0.65	0.78	0.23	0.31	0.86	0.90
Portugal	0.95	1.62	1.90	1.04	0.41	0.37	0.47	0.41	0.44	0.92	0.05	0.30	1.31	1.48
France	2.05	2.35	..	..	0.79	0.74	0.79	0.93	1.29	1.56	0.49	0.59	0.83	0.85
Germany	2.47	3.14	3.97	3.70	0.74	1.10	2.26	4.15	1.73	2.11	0.77	0.68	0.89	0.61
Italy	1.08	1.53	1.05	0.86	0.59	0.67	1.21	0.89	0.53	0.93	0.01	0.07	0.63	0.96
Netherlands	1.74	2.29	1.21	2.96	0.73	0.79	1.83	1.72	0.94	1.54	0.68	1.94	2.36	2.07
Canada	1.94	1.70	...	...	0.56	0.49	...	2.04	1.1	0.86	0.59	0.38	0.71	0.49

Notes: 2006, 2008, 2019 and 2020 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.

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.

Source: Authors' calculation based on OECD (2022[20]), 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).

Similarly, the intensity of the agricultural R&D in Spain from all sources was relatively low and has decreased in time: public gross domestic expenditure on R&D on agricultural innovation represented 1.2% of the sector's value added, lower than in some EU peers and other leading OECD countries, and lower than the 1.4% shown in 2006. However, an examination of the data by source and sector of performance shows a mixed picture. The government budget allocation for R&D as a percentage of sector's value added (1.34%) was slightly above the EU aggregate of 1.33% and higher than for France, Italy, the Netherlands, Canada, and Portugal. Moreover, in 2020, the investment from all sources for private R&D as a percentage of the GDP (BERD) was 0.8%, and in 2019, the investment from all sources for the development of private R&D in the agricultural sector (BERD) was of 0.3%, both figures below most OECD countries and the EU27 average. In the food and beverages sector, it was of 0.9% of the sector's value added, which was close to the EU total and above the shares of Germany and France.

The investment intensities for private R&D in agriculture and in the food and beverages sector have both increased between 2009 and 2019. Conversely, the intensity of the government investment in agriculture (GBARD on Agriculture) has decreased, as has the intensity of the public R&D from all sources.

3.3.2. Digitisation, connectivity, deployment and use of digital technologies

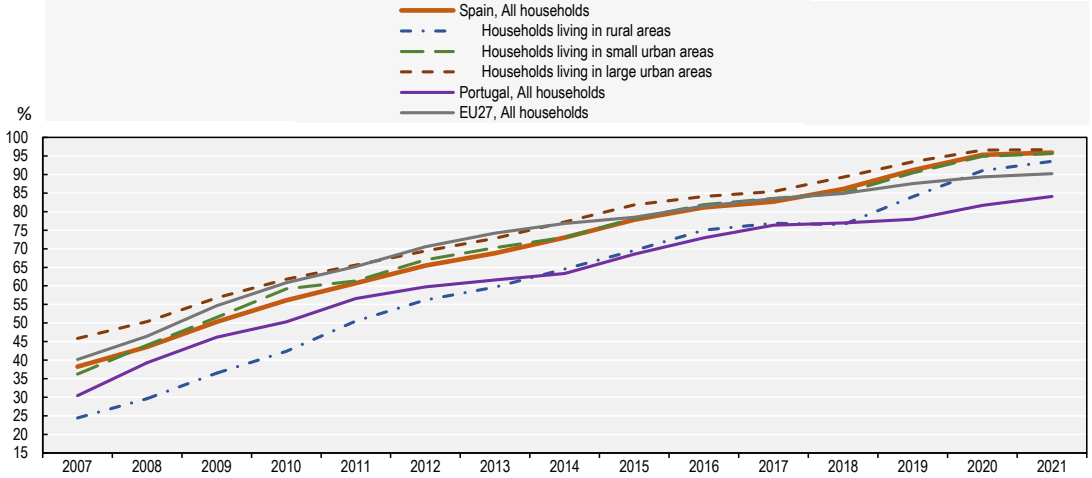
In recent years, Spain made remarkable progress in reducing the gap in access to digital technologies between rural and urban areas

Spain has a generally well-developed communication infrastructure, notably high-quality broadband, such as fibre networks. The country has made considerable progress in improving access and in reducing the difference in access between urban and rural areas.

Less than 40% of households in Spain had internet access in 2007, close to but below the 40% in the European Union, and above the 30% of households in Portugal (Figure 3.7). Coverage has increased dramatically since then, reaching almost 96% in 2021. The average number hid notable differences between the households living in rural areas and those living in small and large urban areas that have been diminishing over time. In 2007, only 25% of the households in rural areas had broadband internet access at home, while 46% of households in large urban areas could access internet at home. Although the gap persisted through the years, it has recently narrowed. In 2021, 94% of households in rural areas, 96% in small urban areas, and 97% in large urban areas had broadband internet access at home.

Figure 3.7. Overall broadband coverage has increased, and the urban-rural gap has narrowed

Percentage of households with broadband internet access at home, 2007-2021



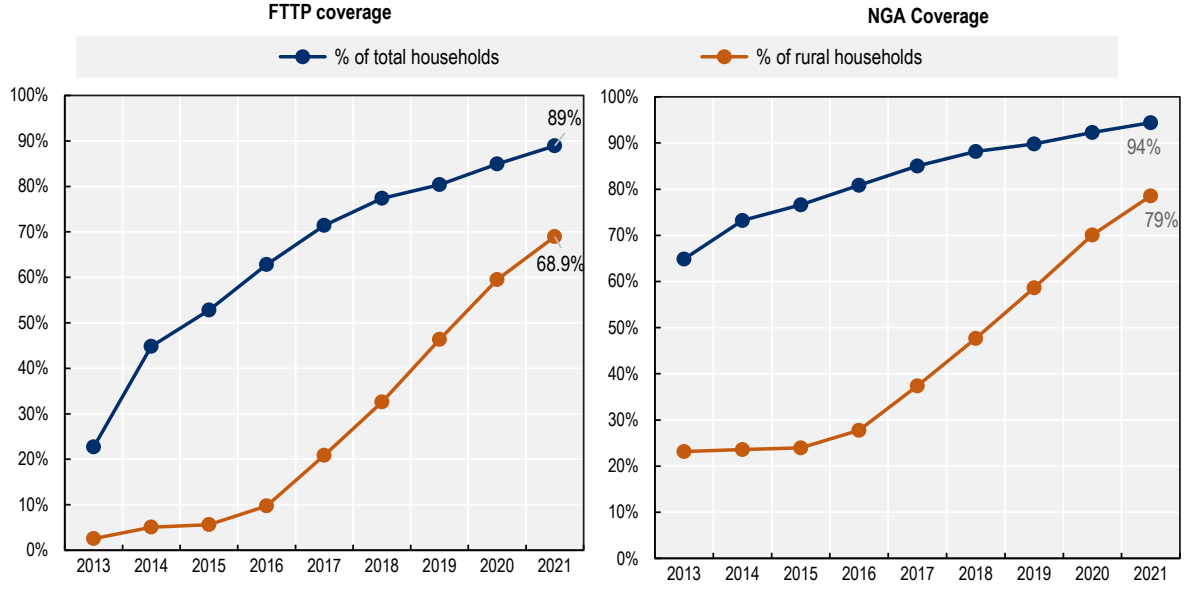
Source: OECD (2022), Information and Communication Technology database (ICT Access and Usage by Households and Individuals table), http://stats.oecd.org/.

Despite improvements in recent years, the digital divide persists in access to high quality broadband

Despite this progress, other indicators still show a gap between rural and urban households' digitisation. Large differences persist in the coverage of high-quality broadband access and in next generation access, which includes fixed-line broadband access technologies capable of achieving download speeds meeting the EU Digital Agenda objective of at least 30 Mbps coverage (Figure 3.8). The indicator of Fibre to the Premises (FTTP) coverage shows that a gap remains, even if it has become smaller. In 2016, the digital divide in this area was of 53%. In 2021, this difference had narrowed to 20%, as coverage reached 89% of total households and 69% of rural households. Regarding Next Generation Access (NGA), the digital divide also decreased from 53% in 2016 to 16% in 2021.

Figure 3.8. An urban-rural gap in high quality broadband coverage persists, albeit smaller

Fibre to the Premises (FTTP) coverage and Next Generation Access (NGA) in rural areas and total households of Spain, 2013-2021



Note: Fibre to the Premises (FTTP) is a "full-fibre" service, meaning the fibre optic cabling runs all the way into homes. This can deliver incredible performance, but it's costly to install, so coverage is much smaller than FTTC and Virgin Media fibre at present. FTTC is also known as Fibre to the Home (FTTH). Next Generation Access (NGA) includes fixed-line broadband access technologies capable of achieving download speeds meeting the Digital Agenda objective of at least 30 Mbps coverage, such as combination of VDSL, DOCSIS 3.0, and FTTP.
Source: OECD (2022[20]).

According to the SWOT analysis done for the preparation of the new CAP Strategic Plan, this significant gap in connectivity is because the infrastructure deployment plans have so far been based on the distribution of population rather than on the territorial distribution (MAPA, 2021[6]). The private sector is the largest source of investment in communication infrastructure in Spain. Rural and remote areas are less attractive for commercial operators given deployment costs, as core networks are typically located closer to densely populated areas, thus requiring further investment (OECD, 2021[21]).

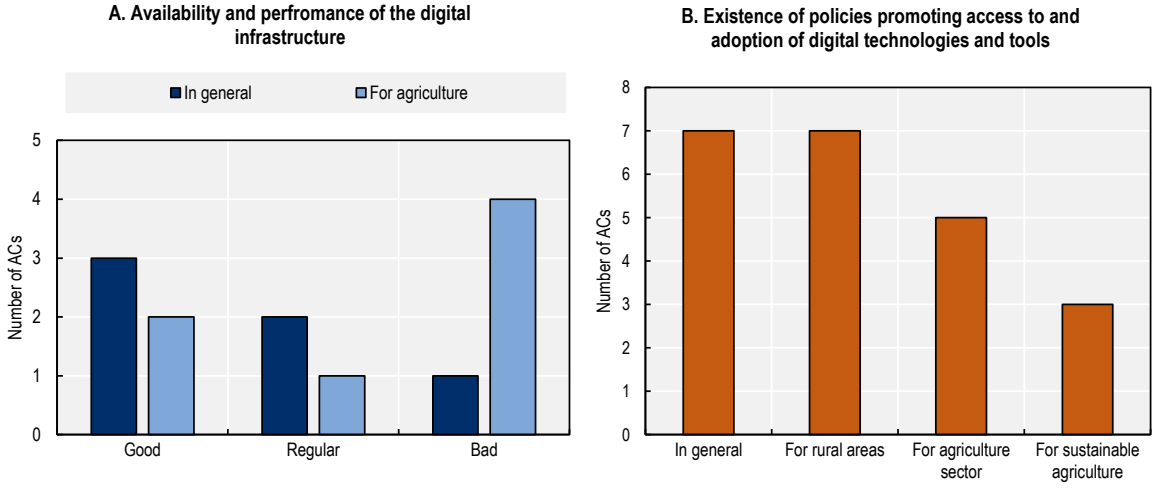
The OECD survey also reveals differences between digitisation in ACs and, within ACs, between agriculture and in general. While availability and performance in general are seen as good, they are mostly perceived as being of bad quality for agriculture. Figure 3.9 shows that the availability and performance of the digital infrastructure in agriculture is evaluated as good in two ACs, regular in one AC, and bad in four

(OECD, 2022[16]).Similarly, the survey reveals differences in the existence of policies promoting access to and adoption of digital technologies and tools. All seven ACs that replied to this question have a general policy as well as a specific policy for rural areas. However, five have a specific policy for the agricultural sector and only three have a policy for sustainable agriculture.

The European Commission has recommended that Spain expands broadband coverage in rural and remote areas to achieve the EU Green Deal Target of 100% fast broadband coverage by 2025. Spain should also accelerate the digital transition of its farming sector through large-scale training efforts and by exploiting the most advanced technology to better monitor and optimise agricultural production processes (European Commission, 2020[22]).

Figure 3.9. The availability and performance of digital infrastructure are perceived as worse for agriculture in some ACs

Digital infrastructure and policies for digital technologies in the ACs



Note: Partial results based on the replies of the following Autonomous Communities: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, and Galicia.
Source: OECD (2022[16]).

Beyond coverage, there is another digital divide on skills and the ability to use digital technologies

Several studies have identified a large divide in the use of digital technologies, which is due to both economic and educational factors (OECD, 2021[21]; MAPA, 2021[14]). Although Spain ranks 10th in the EU-27 in terms of digital skills, only 64% of the Spanish population has at least basic digital skills. This is slightly above the EU average, but still far from the goal of 80% of the European population having at least basic digital skills by 2030 (European Commission, 2022[23]). In addition, 36% of the Spanish workforce still do not have basic digital skills, which hinders the progress of the digitisation of companies and the acceptance of advanced digital technologies. The gender imbalance remains significant and the percentage of women among all information and communication technologies specialists is still only 10% (in line with the EU average) (European Commission, 2022[23]).

A recent study revealed that only 3% of farms owners are under 35 years, which indicates that a generational change in Spanish farms is still far off. This generation, the so-called “agro-millennials”, consider agriculture to be a long-term stable job (87%) and express a high level of satisfaction for the daily performance of their professional activity (8.48 out of 10). They are usually informed by social networks

(76%) and digital press (55%), and much less by traditional media such as radio (38%), television (36%), and print media (10%). They argue that excessive bureaucracy and access to land are the main obstacles to their generation becoming farmers. They understand digital transformation as a necessary tool to achieving more profitable and sustainable farms (Juventudes Agrarias COAG, 2022[24]). Young people who join the agricultural sector have a higher than average academic education for their generation. Almost four out of ten have a university degree and at least 65% have a bachelor's degree or higher vocational training, compared to 48.7% for the Spanish population overall.

Public and private measures of digitalisation that can help improve farms' sustainability

The Digitisation Strategy for the Agro-food and Forestry Sector and Rural Areas, which started being developed by MAPA in 2019 and financed by the Next Generation EU Funds through the Spanish Recovery, Transformation and Resilience Plan (RTRP) and the PERTE Agroalimentario, defines the strategic lines and measures necessary to boost digital transformation in the agro-food and forestry sector and rural areas, and the instruments for their implementation. It follows three key objectives: 1) better connectivity between rural and urban areas; 2) better use of agricultural data; and 3) fostering business development and new business models while leveraging the potential of new technologies.

The general aims of these measures are to reduce barriers to the digital transformation of rural areas, encourage the use of data, and promote economic growth and development of new business models. As stated in the European Green Deal and the Farm to Fork strategy, there is a need for a smarter agriculture to improve productivity and reduce the environmental impacts of the sector. To that end, it is essential to improve connectivity and training, so smart solutions can be developed for farmers, businesses, and rural communities.

One of the measures financed by Next Generation EU funds contemplates the implementation of a support programme to encourage the use of precision farming and technologies 4.0 in the agricultural sector, to speed up the modernisation of the equipment and the use of technologies. This is expected to promote a more efficient use of natural resources in production. It also allows the use of equipment that is more energy efficient, increasing the environmental performance of the agricultural sector.

Beyond the Next Generation EU innovation projects of the Spanish RTRP, there are diverse examples of measures and actions to promote digitalisation in agriculture, provide training and advice in digital skills and in information generation and processing, and support digital entrepreneurship.

One example is the development of the farm information system SIEX (Section 1.2.2), which aims to simplify the relations between farmers and the national and regional administrations by integrating all the information that farmers must provide, including the new Digital Farm Notebook for crops and the ECOGAN registry for livestock farms (see also Section 2.4.2).

The Smart Specialisation Platform reports ten Spanish DIHs specialised in the agro-food sector of different characteristics and that are located in different regions: the Andalucía Agrotech Digital Innovation Hub; ARAGÓN DIH; Catalonia Digital Innovation Hub (DIH4CAT); CIDIHUB – Canary Islands Digital Innovation Hub; DATAlife; DIGIS3 Smart Sustainable & CoheSive Digitalization; i4CAMHUB (Innovation for Competitiveness and Advanced Manufacturing); INNDIH: Valencia Region Digital Innovation Hub; IRIS: European Digital Innovation Hub Navarra; and DIH Extremadura Tech4E in Extremadura. The MAPA is working on the creation of a Digital Innovation Hub for the agro-food sector to promote the implementation of digital technologies.

Box 3.2. DATAlife, an example of collaboration for improving digitisation

Three interesting cases of Digital Innovation Hubs (DIH) that stand out are DATAlife in Galicia, IRIS European DIH in Navarra, and Andalucía Agrotech located in Andalusia.

DATAlife has a data and artificial intelligence-driven approach that aims at increasing SMEs competitiveness in the primary (including agriculture), biotechnological and health sectors. DATAlife has been selected by the European Commission through the Digital Europe programme to take part in the initial network of European DIHs (EDIHs), thus receiving funding for the next seven years and strengthening its co-operation network with other European DIHs. In addition, DATAlife is collaborating with other Spanish and Portuguese actors in promoting a multiregional agro-digitalisation ecosystem by creating a network of DIHs through the "Hubiberiaagrotech (HIBA)" project. The DIH aims at accelerating and strengthening the digitalisation of the sector within the HIBA framework. To achieve this, HIBA has put forward a number of key recommendations, including strengthening and taking advantage of the Spanish primary sector DIH network and co-ordination with the DIH created by MAPA; making use of existing facilities in order to create a network of testing and demonstration facilities for digital technologies of the primary sector; improve information flows between the sector and the public administration; training on the use of digital tools in degrees and traineeships, in order to foster the new generation's transformational capacities; and training on digital solutions, data handling and new business models for the primary sector.

IRIS European DIH aims at supporting and accelerating digitalisation efforts of companies in the region, and offers a wide range of services across sectors, focused on companies' access to public aid for the digitisation of enterprises. The Hub is based on a public-private co-operation between technology and knowledge providers, as well as a regional development entity and the business sector.

Andalucía Agrotech has a sectoral focus, addressing the transformation of the agricultural sector through digital technologies. It aims at promoting a digital culture and access to digitalisation as a means for enhancing strategic alliances and value creation to increase the competitiveness of the sector. Technological services are paired with the provision of training and the facilitation of aid and financing strategies along a range of technological categories. Through its website, Andalucía Agrotech offers an interface enabling users to search for service providers along categories such as precision farming, big data and artificial intelligence. Additionally, they offer information on degrees and training at different educational levels, open data sources and acceleration and entrepreneurship programmes.

Source: https://www.dihdatalife.com/en/, https://www.irisnavarra.com/ and https://www.andaluciaagrotech.com/.

The use of digital technologies in Spain is increasing, but there is not enough information to assess the performance of the agro-food sector

The adoption of digital technologies by farmers, agro-food companies, and enterprises in general, is a key challenge. Spain ranks seventh of 27 EU Member States in the 2022 edition of the Digital Economy and Society Index (DESI) (European Commission, 2022[23]). Spain also ranks seventh in the OECD Digital Government Index, which assesses the adoption of strategic approaches in the use of data and digital technologies by the governments of 33 OECD and non-OECD countries (OECD, 2020[25]). Considering the total economy, Spain is above the EU average on integration of digital technologies by firms and has improved the situation in the last year. Particularly, the percentage of SMEs with a basic level of digital intensity and using social media is above the EU average. But Spain's enterprises are still lagging behind on new and advanced technologies such as cloud or big data. Unfortunately, the data available for the agro-food sector is scarce. The INIA has information on the use of information and communication technologies (ICTs), but it covers only firms with over ten employees, leaving aside a large number of

firms. In addition, there are issues with the sectoral disaggregation. The information at the farmers' level is even more difficult to obtain. Thus, there is not enough data to assess the digitalisation of the Spanish agro-food sector. This requires urgent attention.

3.3.3. Using data for a transition towards a more sustainable model of agriculture

Data is essential to achieve a smarter agriculture. On this basis, the European Union approved the European data strategy in 2020 and the Digital Europe programme 2021-27. The European Union is also promoting the establishment of a Common European Data Space. The objective is to improve the sustainability and competitiveness of the agricultural sector through data processing and analysis. The programme stresses the relevance of the DIHs for the digital transformation of European industry to stimulate the wide acceptance of Artificial Intelligence (AI), High Performance Computing (HPC), and Cybersecurity, as well as other technologies.

In addition, in March 2022 a new European Partnership under Horizon Europe "Agriculture of Data" was presented. It seeks to support a sustainable agriculture in Europe as well as strengthening policy monitoring and evaluation capacities, by using the potential that digital and data technologies in combination with Earth observation and other environmental and agricultural data offer. It is expected to start operating in 2023 and will have a budget of EUR 100 million.

In line with the European framework, Spain has launched the strategies Digital Spain 2025 and 2026 to develop the digital transformation of the country to become a reference in data economy. Axis 4 of the Digital Spain 2026 strategy is devoted to data economy and artificial intelligence. One of the measures to achieve these objectives is the creation of a data office, which will be in charge of designing and proposing strategies to boost data sharing, management and use throughout all the productive sectors of the economy and society, guaranteeing good governance and security. This office is under the responsibility of the Secretariat of State for Digitalisation and Artificial Intelligence in the MINECO. The digital chapter of the main PERTE has also begun implementation. This includes setting up programmes to create big, shared data spaces (data lakes) in strategic sectors, such as the health sector, the tourism sector, the agro-food sector, the economy of care work, and electric mobility.

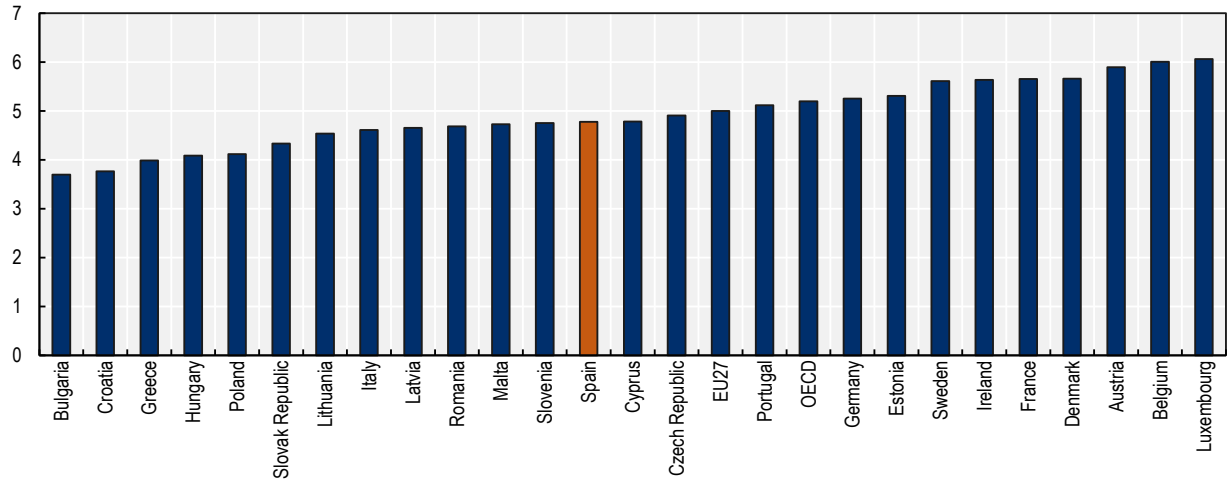
3.3.4. Protection of intellectual property rights

Spain provides a relatively low level of IPR protection compared to other EU Members

Although the European Union has some common framework and supranational institutions governing the protection of intellectual property rights (IPRs), each member has its own national intellectual property protection system. Spain is a member of the European Patent Organisation (EPO) since 1986. According to the index of patent protection of the World Economic Forum, Spain provides a relatively low level of IPRs protection compared to other EU Members (Figure 3.10). In 2019, the index score for Spain was 4.8, lower than the OECD and EU averages, and below peers such as France, Germany, and Portugal.

Figure 3.10. Spain's IPR protection is below the EU average

Intellectual property protection index, 2019



Notes: The scale is from lowest (1) to highest (7) protection.
Source: Authors, based on WEF (2019[26]).

Legal intellectual property protection for plant varieties has increased, bringing Spain closer to the average EU protection level

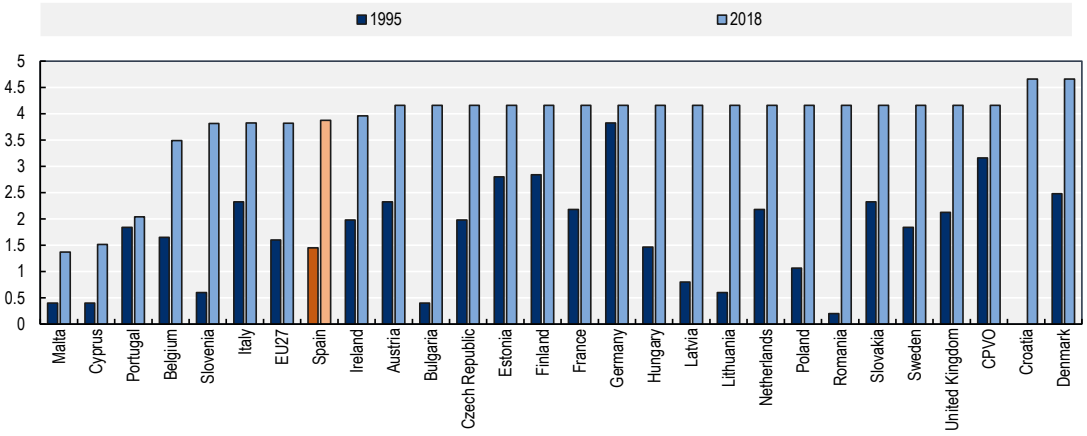
EU Members have national IPRs systems protecting their plant varieties and agricultural-related innovations in place. These nationally defined systems are based in common standards defined by international conventions, such as the International Union for the Protection of New Varieties of Plants (UPOV) and the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), which allows comparisons between them.

Spain has been increasing the legal IP protection provided for plant varieties. The country adhered to the UPOV convention for the first time in 1980 and, in 2007, became a member of the latest UPOV convention of 1991. In 2000, Spain reformed its legislation for the IP protection of plant varieties. An academic study found that the enactment of the Plant Variety Rights has had a positive incentive, especially for the private sector, which increased its market share because of higher appropriability conditions (Diez, 2002[27]). The Spanish plant breeding industry consists of both international and small domestic firms. Many foreign breeders focus their research efforts on hybrid varieties, which provide "natural" property rights. The study states that because of a significance innovative activity of foreign breeders, Spain has expanded seed imports and reinforced technological dependence.

Spain has significantly increased its level of IP protection for plant varieties. Between 1995 and 2018, an index of legal protection for plant varieties increased from 1.5 to 3.9, approaching the average level of protection of the European Union (Figure 3.11). The entry into force of the World Trade Organization (WTO) TRIPS agreement has made IPRs systems worldwide more homogeneous and stronger,[8] a process that is illustrated by the evolution of the index.

Figure 3.11 The level of protection to plant varieties has increased in line with international commitments

Index of legal IPRs protection for plant varieties: EU Member States and EU27 average,1995 vs. 2018



Notes: The score goes from lowest (0) to highest (5) protection. EU27 is the simple average of member-countries indices, which are built using national legislation. CPVO is the Community Plant Variety Office.
Source: Campi and Nuvolari (2021[28]). Data are available at www.openicpsr.org/openicpsr/project/121001/version/V1/view.

As an EU Member, Spain is part of the Community Plant Variety Office (CPVO), the supranational organisation ruling plant variety protection in the European Union. The CPVO oversees implementing the Community Plant Variety Rights (CPVRs) system, an independent protection scheme for new plant varieties with a unitary effect throughout the European Union. CPVRs are a type of "plant breeder's rights" (PBRs), which often refer to the types of IPRs granted by national authorities. Both CPVRs and national-level PBRs provide the breeder of a new variety of plants exclusive control over associated propagating and harvested material for a certain number of years. The CPVR is legally valid throughout the entire European Union, which provides exclusive exploitation rights for a plant variety in all Member States through a single application to the CPVO (Würtenberger et al., 2021[29]).

3.4. Farm advisory services, skills, and training

3.4.1. Farm advisory services

Farm advisory services in Spain have experienced a substantial transformation, from public to private service provision and from production towards CAP policy advice, due to the decentralisation process

The advisory services in the Spanish AKIS have gone through a process of transformation in the last decades. In particular, the roles of public and private advisors changed notably. A set of reforms enacted since the 1980s blurred the functions of the previously existing public extension services. Until then, agricultural advisory services used to involve technical advice and were in general more specialised in productive aspects linked to the agricultural activity. Following Spain's EU accession in 1986 and its adoption of the CAP, agricultural extension officers started focusing more on processing applications for the CAP and on the administrative management of CAP compliance. As a consequence, there are at present almost no public advisory services in Spain, except in some specific regions such as Navarra, which has a public entity providing agricultural advice – the INTIA – and the Canary Islands, whose public

extension offices continue to offer technical advice to farmers and are not funded by the CAP (MAPA, 2021[7]).

The gap left by the diminishing role of agricultural extension public advisors has been partly filled by private advisors, advisory entities and, especially, commercial advisors linked to input providers (plant varieties, plant protection products, fertilisers, and machinery). Although they provide an essential service, their advice is often linked to their commercial interests and might not necessarily cover all farmers' needs.

In the previous CAP period (2014-20), a new type of actor emerged: advisory entities that receive public funding from the Rural Development Program (RDP). Advisory entities include mainly co-operatives and agricultural organisations, although there are also independent advisors. The role of private consulting companies in this area is also increasing (i2Connect, 2020[8]).

It has not been possible to assess the effectiveness of this type of advice, given that both the managing bodies and the advisory entities have had to devote most of their efforts and resources to administrative tasks. It was also not possible to improve the interrelations between advisors and research in the 2014-20 period, except for the joint participation in operational groups (MAPA, 2021[7]).

Among the problems that have been identified in the advisory services model of Spain are the existence of complex and heterogeneous rules and standards for advisory services and the potential of an oversupply due to the coexistence of non-commercial advisory services that compete with those established within the framework of the CAP (MAPA, 2021[6]).

Training needs for technology adoption and use are changing. Advisory services need to adapt to the new requirements and farmers' needs must be better integrated in R&D&I projects

The training needs of the agricultural sector are changing and evolving beyond the current legal requirements governing advisory services, and a good connection between knowledge transfer systems and new forms of business and innovation, including the adoption of new technologies, is key. However, the link between scientists, knowledge transfer systems and the business sector in Spain is weak and affected by several limitations, such as the absence of effective intermediaries, lack of business demand, legal and administrative barriers, lack of skills or experience, and lack of financial or other incentives, among the most relevant (OECD, 2021[4]). Furthermore, there is a low level of training of farm managers: 78% of them have only practical experience and have not had any formal training. There are also generational and gender gaps in the levels of training[9] and a low share of young farmers interested in new digital technologies (Juventudes Agrarias COAG, 2022[24]). The European Commission has recommended Spain to improve the access to knowledge and innovation by the farming community, by fostering the integration and organisation of advisers within the AKIS, improving the interaction of research with farmers and advisors, and better integrating farmers' needs in research and innovation projects (European Commission, 2020[22]). Considering this, the MAPA is developing measures to promote training and advice on digital matters at a supra-autonomous level, included in the digitisation strategy and in the PERTE Agroalimentario.

Figure 3.12 shows that there are heterogeneous interests in the main subjects of regional farm advisory services. The farm advisory services of the ACs that replied to the OECD survey are mainly focused on farm management and compliance with regulations or policy requirements. Conversely, many regional farm and advisory services do not focus on skills development such as digital or entrepreneurial.

Figure 3.12. Advisory services in many ACs focus on farm management and regulatory compliance

Main subjects covered by the farm advisory services offered in the ACs

Note: Partial results based on the replies of the following Autonomous Communities: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, and Madrid.
Source: OECD (2022[16]).

Advisory services should be up to date with the increasingly complex demands of the agricultural sector. A greater public and private effort is required to improve co-ordination among them, strengthen their relationship with farmers, and improve their capabilities and skills to cover all dimensions of sustainability (economic, social, and environmental). Training of advisors must be comprehensive, so they can become *smart advisors*, to strengthen their role as the link between the needs of the agricultural sector and the technical and management solutions. In the years to come, it will be essential to provide training for the advisors in areas such as new technologies to improve sustainability, collaboration, and networking, marketing, and entrepreneurship skills.

In line with the Spanish CAP Strategic Plan 2023-27, the MAPA (at the supra-autonomous level) and 14 of the 17 ACs will implement measures related to advisory services, including granting aid to the creation of advisory and management services and mentoring (MAPA, 2022[30]). The estimated amount of investment for advisory services and digitalisation programmes adds up to EUR 105.3 million. Therefore, there exist financial resources to respond to the needs of a changing sector with sustainability challenges. There are several models that could be followed to improve the efficiency of advisory services (Box 3.3).

Box 3.3. Interesting cases of advisory services in Germany, the Netherlands, and Ireland

In Germany, advisory services are offered by a variety of organisations from the public, private and non-profit sectors. To ensure coordination, some multi-level farmer-based organisations and private entrepreneurial associations fulfil a strong linking and integrating function at the national level, which contributes to the maintenance of an overarching AKIS and its vertical connection with other actors at the state and local level. Most advisory organisations have mixed funding sources, but the national or regional public funds dominate. This signals the prominent role of the public sector for the provision of advisory services. In general, advisors tend to have many years of professional experience and good educational backgrounds. Additional advisory certifications, particularly certification related to methodological skills, such as those offered in the Certificate for European Consultants in Rural Areas

(CECRA) courses, tend to receive more attention and are considered necessary to raise the quality of advisory services (i2Connect, 2021[31]).

Advisory providers establish a strong co-operation with other public advisory organisations, farmer-based organisations, and private companies, showing the important role advisors have in knowledge sharing, service provision, and connecting actors. As an example, the (EU SCAR AKIS, 2019[32]) mentioned the case of Schleswig-Holstein, where agricultural advisors are involved with at least one advisor in all the 30 EIP-AGRI projects (overall in Germany in more than 80%). Often, two or more advisors from different services or associations work together on innovation projects. Advisory services are the lead partners in more than 50% of the EIP-AGRI projects in Schleswig-Holstein. Advisors are not only experts, but also moderators and organisers of operational groups. In other words, they act as translators between scientists and practitioners and help hasten the implementation of innovations.

In the Netherlands, advisory services often act as an important link between innovation projects and farmers. Likewise, the four universities of applied sciences establish strong links between the schools, farmers, and agribusinesses. Furthermore, the independent advice sector has been given an impulse through the government-funded voucher system, whose popularity might give an impulse to other reforms and growth of the independent advice sector (i2Connect, 2020[33]).

In the case of Ireland, farmers have a choice to engage with an advisor from the public, private or industry sector. Publicly funded, mixed funded and private funded services coexist. This allows farmers to choose the provider. The system recognises that, while governments should not be the sole provider of funding for all the services offered by a public advisory service, they do need to support the provision of public goods that otherwise would not be provided due to market weaknesses or failures. Over the last thirty years, the development role of the agricultural advisors has evolved from a “teaching” role to a “facilitator of knowledge exchange” role. This has been enabled by the increased standard of education among farmers, the increased participation in peer-to-peer learning initiatives, such as discussion groups, and the increased availability of farm performance data (i2Connect, 2020[34]).

3.4.2. Skills

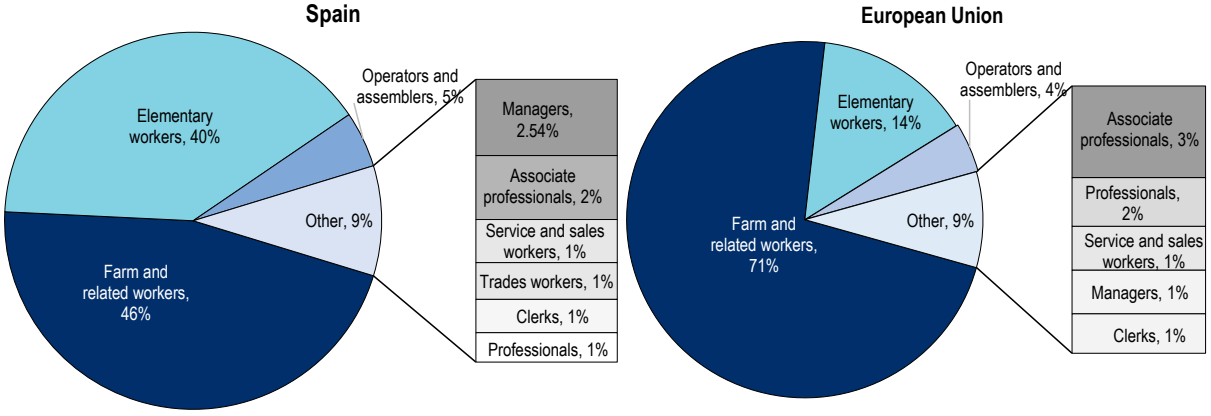
Spanish agricultural workers have a relatively low level of skills and a high level of skills mismatch

Upgrading skills and attaining a right balance of skills is essential for agricultural innovation. Figure 3.13 shows the composition of employment in agriculture, forestry and fishing in Spain and the European Union by broad occupations. The Spanish agricultural sector employs mainly low-skilled occupations. Elementary workers in Spain add up to 40% of total workers, while in the European Union the average is of 14%.

The educational level of workers in the agricultural sector is also relatively low. Figure 3.14 shows the percentage of workers with high, medium, and low educational levels for two types of agricultural workers: agricultural labourers and farmworkers. The first type are agricultural labourers that perform simple and routine tasks as part of agriculture, forestry and fishery production processes. Farmworkers and gardeners, on the other hand, plan, organise, and perform farming operations to grow and harvest field or tree and shrub crops and to produce a variety of animals and animal products for sale or delivery on a regular basis to wholesale buyers, marketing organisations or at markets. They usually need to have completed the first stage of secondary education but in some instances, they will need to have completed the second stage of secondary education, including through specialised vocational education and training (CEDEFOP, 2022[35]).

Figure 3.13. Spain has a higher share of low-skilled workers in agriculture

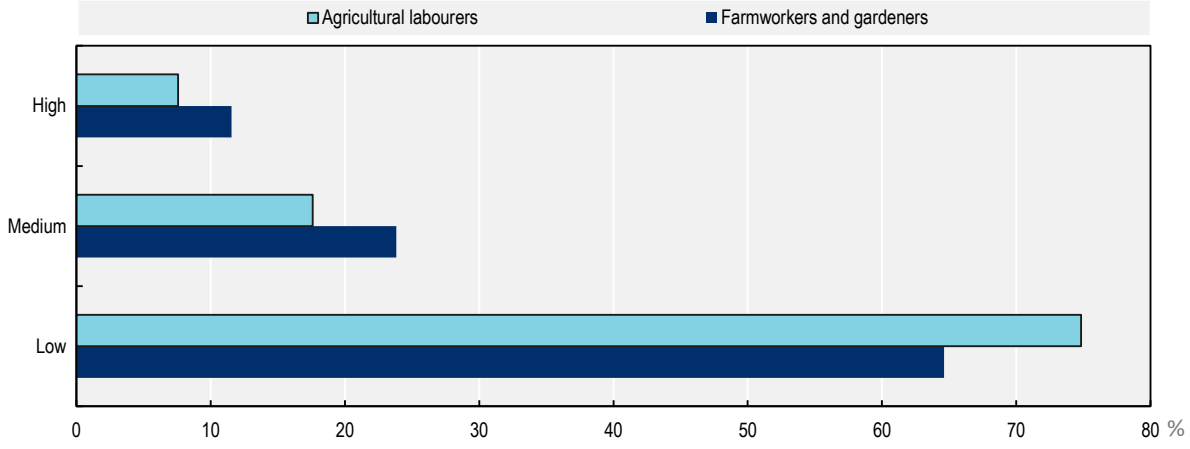
Share of broad occupations (%) in agriculture, forestry & fishing employment in Spain and the EU, 2020



Notes: Occupations are based on ISCO-08 (International Standard Classification of Occupations) 1-digit code, which consist of 10 major occupation groups. According to the ISCO, farm and related workers, are officially labelled as skilled agricultural, forestry and fishery workers (ISCO06). People employed as elementary workers (ISCO09) usually perform simple and routine tasks which may require the use of hand-held tools and considerable physical effort. In the ISCO, agricultural, forestry and fishery labourers are categorized as one of elementary jobs. Their jobs include, for example, routine tasks associated with crop production, livestock rearing, maintenance of gardens and parks, and the conservation of forests (CEDEFOP, 2022[35]).
Source: Authors, based on CEDEFOP (2022[35]).

Figure 3.14. The educational level of Spanish agricultural workers is relatively low

Educational level of "Farmworkers and gardeners" and "Agricultural labourers" in Spain, 2020



Source: Authors, based on CEDEFOP (2022[35]).

Three-quarters of agricultural labourers have a low education attainment, which is striking given the characteristics of their work. However, 64.6% of farmworkers and gardeners also have a low level of education attainment. The general level of education of Spanish agricultural workers is well below that of the European Union: 11% of total agricultural workers have a high level of education in the European Union compared to 8% in Spain, 51% a medium level (18% in Spain), and 38% a low level (75% In Spain).

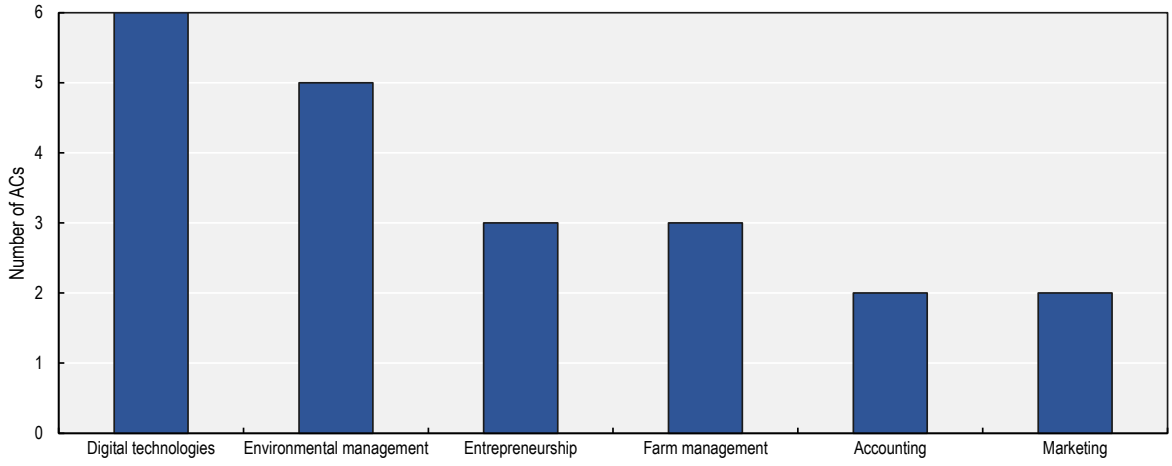
According to the OECD PIACC survey,[10] the level of participation in adult education and training in the Spanish agro-food sector (including agriculture, forestry and fishing, and food and beverages

manufacturing) only reaches 35% while in the all-sector average it reaches 58%, which are well below the rates of participation in adult education observed in the agro-food sectors of other European countries, such as Denmark (66%), the Netherlands (66%), and Ireland (42%), but higher than in France (31%) and Italy (17%).

Most of the ACs that responded the OECD survey identified long-term skills needs and knowledge gaps in digital technologies and environmental management for the food and agriculture sector. A smaller number of ACs recognised gaps in areas such entrepreneurship, farm management, accounting, and marketing (Figure 3.15).

Figure 3.15. There are knowledge gaps at the AC level, particularly in digital technologies

Long-term skills needs and knowledge gaps identified in the AC food and agriculture sectors



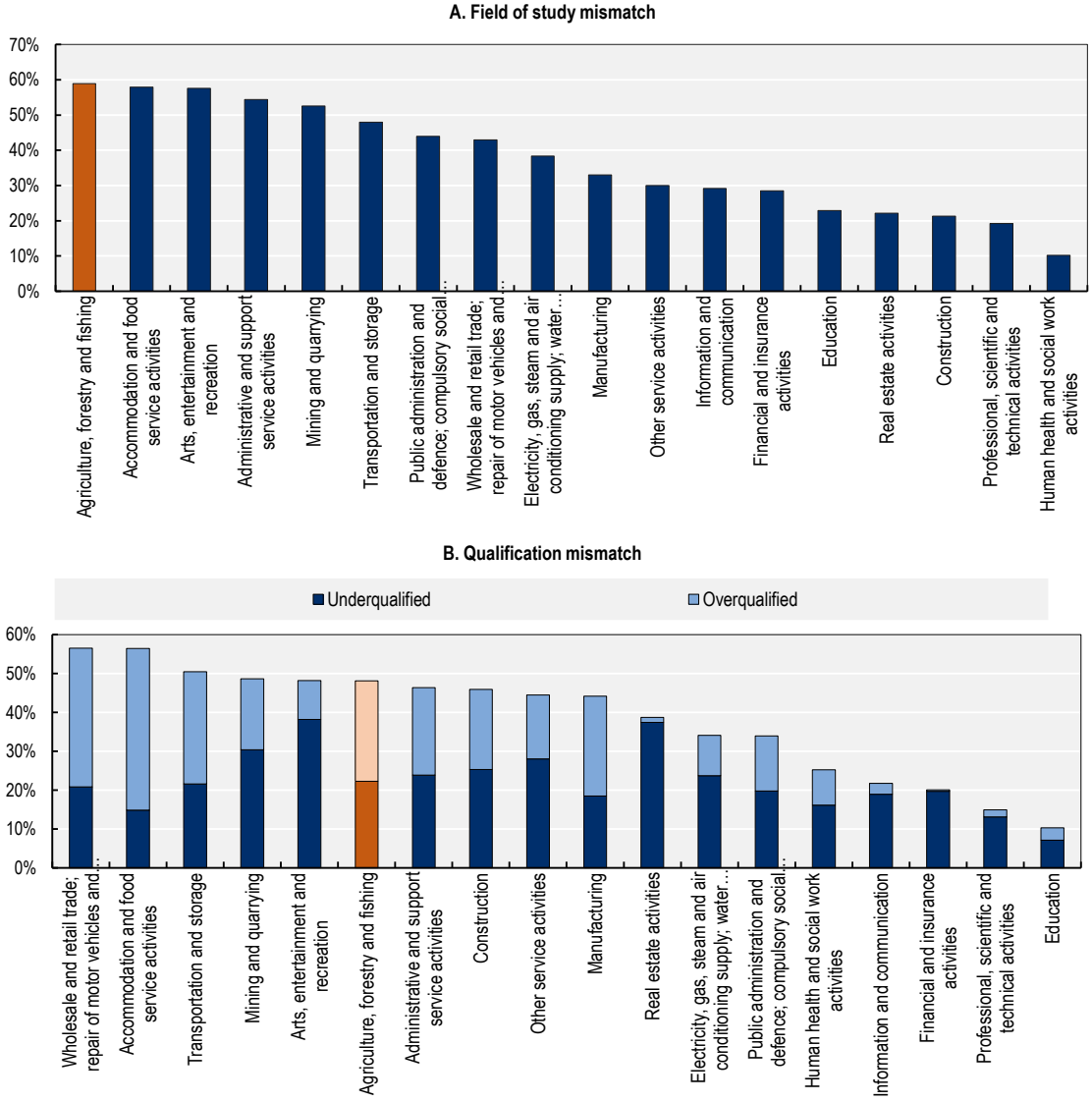
Note: Partial results based on the replies of the following Autonomous Communities: Aragón, Asturias, Basque Country, Cantabria, Catalonia, Castile and León, Galicia, and Madrid.
Source: OECD (2022[16]).

Moreover, there is evidence of field-of-study and qualification mismatches in Spanish agriculture. Figure 3.16 Panel A shows that agriculture, forestry and fishing is the sector with the highest field-of study mismatch, which implies that almost 60% of workers in agriculture were specialised in a different field of study. Panel B of Figure 3.16 also shows the qualification mismatches that arise when workers in an economic sector have an educational attainment that is higher or lower than that required by their job. In the case of agriculture, forestry and fishing there is a total qualification mismatch of 48%. In particular, 26% of workers have a higher education level than that required by their job (overqualified), while 22% of workers are underqualified.

Generating skills and reaching a balance on their use and distribution within the economy is very relevant for sustainable innovation. Skills shortages, skills surpluses, and skills, field-of-study, and qualification mismatches can exert a negative impact on economic growth through their effects on increased labour costs, lower labour productivity growth, slower adoption of new technologies, and lost production associated with unfilled vacancies. Firms experiencing skills shortages may be constrained in their ability to innovate and adopt new technologies and might face larger hiring costs. Skills mismatches can cause individuals to experience a higher risk of unemployment, lower wages, and lower job satisfaction (OECD, 2016[36]; OECD, 2020[37]). Also, some skills mismatches are a potential waste of valuable resources that could be better used.

Figure 3.16. Sixty per cent of agricultural workers in Spain specialised in a different field of study

Field and qualification mismatches in sectors in Spain



Note: Field of study mismatch arises when workers are employed in a different field from what they have specialised in. Qualification mismatch arises when workers have an educational attainment that is higher or lower than that required by their job. If their education level is higher than that required by their job, workers are classified as over-qualified; if the opposite is true, they are classified as underqualified.
Source: Authors, based on data from OECD (2022[38]).

3.4.3. Education and training

Spain offers a wide range of education options for agriculture, but there is a need to improve its link with the rest of the AKIS

Formal education is usually offered by universities and vocational training schools, which are under regional supervision. According to the Integrated System of University Information (SIIU), the national university education offer includes 86 undergraduate courses (91% of them public), 90 master's courses (96% of them public) and 37 PhD programmes in the field of agriculture and related areas. There is a wide

range of higher education courses in the agricultural field, well distributed across the country. They cover different areas of knowledge linked with agriculture and forestry, including agroecology, gardening, and animal health. Some groups of higher education institutions together with other institutions constitute Campus of International Excellence, a programme developed by the Spanish Ministry of Education to enhance strategic alliances and knowledge exchange, and 16 of these Campus are related to the agro-food sector.

There exist three levels of vocational training courses: basic, mid-level and advanced level. Typically, the regional ministries for education are responsible for agricultural vocational training, but in some regions, it falls under the supervision of the regional ministries for agriculture or other public or private institutions. Vocational training can be regulated or non-regulated.[11] Regulated training is provided by regional governments, under the umbrella of the Ministry of Universities and the Ministry of Education. In the case of non-regulated training, there are several actors involved. For example, MAPA offers courses to professionals of the agro-food sector and to advisors. MAPA recently launched a Digital Training Centre for Digital Skills in collaboration with two universities (Universidad Politécnica de Madrid and University of Córdoba) for professionals of the agro-food sector. Additionally, there are several other interventions under the CAP Strategic Plan (CSP), at regional and national level for boosting training and advice.

A 2021 focus group that evaluated advisory services in the Spanish AKIS identified a lack of interaction among the relevant stakeholders who are active in the different types of education (vocational training, university education and lifelong learning) (MAPA, 2021[7]). This may be due to the excessive compartmentalisation of the educational areas and to the split of competences among different government departments at national and regional level. Furthermore, there is a very weak connection between formal education, the agricultural research centres, and the advisors. Improving the links of agricultural education (including both teachers and students) with the rest of the AKIS actors will be vital in the new CAP programming period. An interesting example in this direction is the recently created technological platform of wine[12] with the educational initiative focused on innovation, digitisation and new technologies applied to the wine sector, that seeks to share the experience of the most advanced wine producers with the rest of the sector.

3.5. Adoption of innovations and performance

3.5.1. Outputs of R&D investment in agro-food science

Spain is very good in generating science, but less so in developing innovative products

Spain is the 12th country in the world in scientific production, and 24th in patents. That means that the large number of scientific papers is not necessarily linked to patentable innovations. This points to a disconnection between scientific research and business R&D leading to innovation. In 2019, Spanish universities collected only EUR 4.1 million in licences and other intellectual property agreements. In the same year, 84 spin-off companies (companies created in the university environment to develop knowledge or research results) were created, fewer than ten years ago (118) or the maximum in the last decade (133 in 2013) (Fundación CYD, 2020[39]).

Table 3.4 shows patents and publications in agro-food as outcomes of the agriculture and food science R&D. Spain has a relatively high specialisation in patents on agro-food science, which represented 7% of total patents at the national level. This was above the average of EU (5%) and OECD countries (4%). Patent specialisation in agro-food has generally decreased worldwide over the last decades, from 5% in 1990-96 to 4% in 2014-18. In Spain, this share remained very similar over the whole period, and the country has one of the highest shares of agro-food patents of OECD countries. However, despite this high level of specialisation, Spain's contribution to the world's agro-food patents was of only 1% in 2014-18, well below

the average of the OECD and the European Union, but also below the averages for Germany, France, Italy, and Canada.

With over 6% of publications in the agro-food science, Spain is relatively highly specialised and above the mean of the European Union and the OECD, even if this specialisation has slightly decreased from around 7% in 2006-16. Moreover, the almost 14% of publications in the fields of agricultural/biological science publications in the top 10% most cited of the world (an indicator of "excellence") indicates a relatively high quality of Spain's research output in agriculture. This is over the EU27 average (13%) and that of the OECD (12%) and close to the countries presented in the table.

Table 3.4. Spain has a relatively high level of specialisation in agro-food science generation

Agriculture and food science R&D outcomes, 2016-2020 (publications and citations) and 2014-2018 (patents)

	Specialisation: Agro-food science outputs as a share of the country's total (%)		Contribution: Country's share of world agro-food science output (%)		Collaboration: Agro-food outputs with foreign partners as a share of the country's total agro-food outputs (%)		Importance/visibility: Outstanding agricultural/biological science publications as a share of the country's total in this field (%)
Country	Patents[1]	Publications[2]	Patents[1]	Publications[2]	Patents[1]	Publications[2]	Publications[2] (top 10% most cited)[3]
Spain	7.3	6.2	1.1	3.0	26.3	39.0	13.8
France	4.2	4.1	4.2	2.2	26.3	46.9	14.6
Portugal	…	5.8	…	0.7	…	46.2	13.8
Italy	6.0	4.9	2.7	3.0	17.1	32.1	15.2
Germany	3.9	3.8	10.4	3.3	21.2	43.4	14.2
Canada	5.9	5.2	2.4	2.6	23.1	35.4	11.9
EU27[4]	4.9	5.0	28.2	22.2	14.3	38.9	12.7
OECD[5]	4.0	4.7	87.5	57.5	10.7	33.8	11.9

Notes: Shares for economies having less than 100 patents in each 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. Agro-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. Top 10% of the world's most cited publications in the field of the agricultural and biological science.
4. EU27 values are the averages of EU Member States, except in the case of Collaboration, where the figures represent collaboration between EU countries and non-EU countries only.
5. OECD values are the averages of OECD countries.
Source: Authors' calculation based on OECD (2022), STI Micro-data Lab: Intellectual Property Database, http://oe.cd/ipstats (accessed August 2022); and OECD (2022), OECD STI calculations based on Scopus Custom Data, Elsevier, Version 1.2018; and 2018 Scimago Journal Rank from the Scopus journal title list (accessed August 2022).

Spain's contribution to the world agro-food science output has decreased from around 4% in 2006-16 to 3% in 2016-20. On the other hand, the collaborations with foreign partners in agro-food publications as a share of the total agro-food outputs have increased significantly, from 27% in 2006-12 to 39% in 2016-20.

Over one-quarter of Spain's patents in agro-food are the result of collaborations with foreign partners. This is similar to France, Canada, and Germany, and well above the share of OECD countries. However, there is relatively less collaboration in the case of publications, with 39%, much closer to the OECD average.

Collaborations with foreign partners are very relevant because they provide avenues for knowledge sharing that can potentially derive in knowledge inflows.

Spain has recently modified the Science, Technology and Innovation Act. One relevant driver for the changes was that the Spanish Science, Technology and Innovation system had achieved excellence in research, but that this excellence in scientific production had not been effectively transferred to the productive sector and to the society, nor had it led to a stronger knowledge-based economy. The main deficits were found in the protection and exploitation of research results, as well as in the lack of investors (Gobierno de España, 2022[40]).

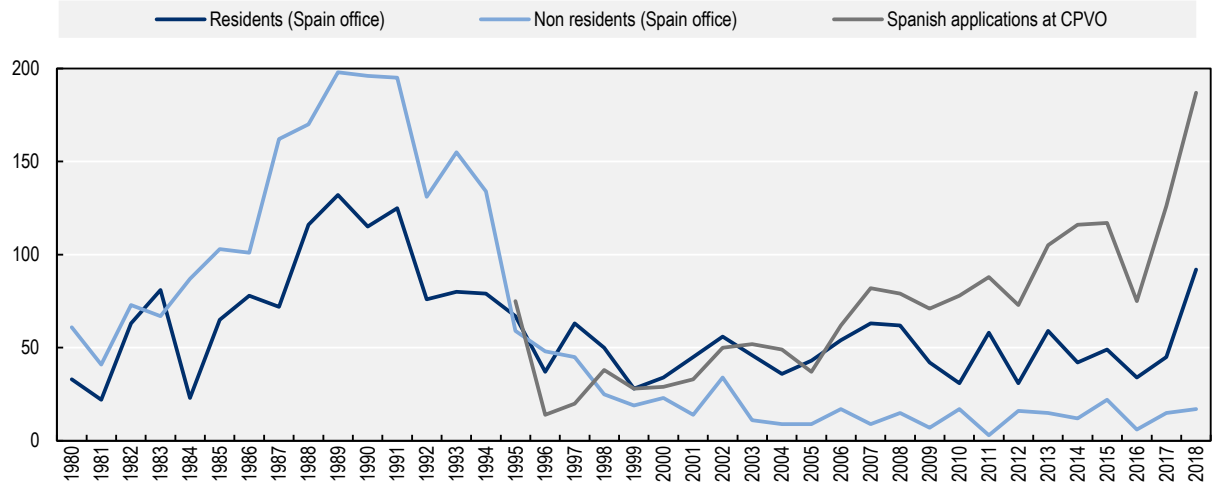
3.5.2. Innovation in plant varieties

Since the creation of the CPVO in 1995, there has been a shift of IPRs applications from national offices to CPVO. Although there are differences depending on the country, in most cases applications at national offices – particularly those made by non-residents – have been decreasing, while applications at CPVO, both from EU Members and from other countries, have followed increasing trends.

In line with this, before the introduction of the CPVO, applications at the Spanish national office where mainly performed by non-residents (Figure 3.17). Since 1995, both residents and non-residents' applications decreased but non-residents' applications decreased more and were outnumbered by residents' applications. In more recent years, there is a slight increase in residents' applications at the national office. In addition, applications at CPVO made by Spanish firms have been increasing since the creation of CPVO.

Figure 3.17. Applications for plant variety protection are increasingly being filed at CPVO instead of at the Spanish national office

Number of PBRs applications at the Spanish office from residents and non-residents (1980-2018), and total applications from Spanish applicants at CPVO (1995-2018)



Source: Authors' calculation based on data from UPOV's PLUTO: Plant Variety Database (https://www.upov.int/pluto/en/) and CPVO plant varieties database (https://cpvoextranet.cpvo.europa.eu/mypvr/#!/en/publicsearch).

3.6. International co-operation in agricultural R&D – European and global

Spain is a member of the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM), an intergovernmental organisation composed of 13 Member States. One of the four institutes through which CIHEAM operates is the Mediterranean Agronomic Institute of Zaragoza, which offers a series of master's degrees and participates in research projects on rural development and animal production, among others (CIHEAM, 2017[41]).

Spain participates in PRIMA-Partnerships on Research and Innovation in the Mediterranean Area, an initiative in R&D&I in the Mediterranean that seeks solutions for a more sustainable management of water systems and the agriculture and agro-food chain through co-operative R&D projects in line with the Sustainable Development Goals (SDGs) of the UN 2030 agenda.[13]

In addition, Spain is a member of two relevant agricultural research organisations: the Global Alliance for Climate-Smart Agriculture (GACSA) and the Global Research Alliance on Agricultural Greenhouse Gases (GRA). GACSA works under the umbrella of the Food and Agriculture Organisation (FAO) and aims to have a positive impact on food security and nutrition under the threat of climate change by promoting the three main pillars of Climate-Smart Agriculture: sustainable productivity improvements, resilience building, and greenhouse gas reduction and removal. For this purpose, the Alliance and its members aim to incorporate climate-smart approaches, share knowledge and support the implementation of climate-smart agriculture, among others (GACSA, 2014[42]). Focusing on GHG emissions from agriculture, GRA intends to strengthen knowledge systems and to foster partnerships to improve research co-operation and increase investment in mitigation practices and technologies. To this end, the Alliance focuses on increasing co-operation, collaboration and investment efforts in research (Global Research Alliance, 2010[43]).

There are also examples of international agricultural development support made by Spain. The Spanish Agency of International Co-operation for Development (AECID) is the country's main actor on matters of development co-operation. Since 2014, the AECID has been financing the line of subsidies Development Cooperation Actions in the field of innovation through competitive competition, for multi-stakeholder consortia, aligned with Spain's priorities in terms of development co-operation. This line finances projects that promote innovative solutions that have already been developed and successfully tested at the pilot level, to demonstrate the possibility of replicating them at a larger scale. Some of the topics of interest are: access to food for people at risk of food insecurity by promoting its production for sustainable consumption, nature-based solutions and circular economy initiatives focused on the reduction, elimination and management of waste, decontamination, soil and water conservation, emission reduction, climate adaptation, and efficient use of resources. A total of 269 initiatives worth EUR 51 million were financed in 2014-22, many in the field of innovation for environmental sustainability. In 2020, more than EUR 40 million were directed to programmes relating to SDG2 (Zero Hunger). The regions receiving the largest share of SDG2-related spending from AECID are Sub-Saharan Africa, Central America, Mexico, and the Caribbean. Programmes targeting good agricultural practices and disaster risk management within the co-operation sector "Rural Development, Food Security and Nutrition", as well as further projects in the sectors "Food Crises" and "Employment Generation" show the strong links between development co-operation, agriculture, and innovation (AECID, 2020[44]). For example, the project "BOVINOS" in Nicaragua links development aid and innovation by providing ranchers with improved technological innovation services to reduce rural poverty (AECID, 2019[45]).

3.7. Examples of innovation for sustainability

3.7.1. Fostering indigenous breeds

Innovation for sustainability can adopt different forms. A Spanish initiative to promote its native livestock breeds is an example of innovation to protect biodiversity

The genetic diversity of Spain's livestock has been affected by landscape changes, rural abandonment and more intensive production, and many of the country's indigenous breeds have become endangered. As these breeds have historically adapted better to the Spanish natural systems, their disappearance could make farming more vulnerable to threats such as climate change. Therefore, enhancing the development of activities linked to indigenous breeds can have a potential interest in terms of innovation for sustainability (FAO, 2016[46]).

Innovation – a new product or a new process – is usually linked to modern technologies. However, novelty can also be related to recovering abandoned practices that are rescued to improve something. In agriculture, there are examples of rediscovering and innovating knowledge, skills, and technologies that have been abandoned, to improve sustainability. These so-called "retro-innovations" arise from the active rediscovery of marginalised and often forgotten knowledge and result in effective linkages between old and new knowledge (Stuiver, 2006[47]). Therefore, retro-innovations might be simply defined as the purposeful revival of historical practices, ideas, or technologies that are fostered by heritage, tradition, nostalgia, and revival (Zagata et al., 2020[48]; Castellano et al., 2013[49]). Retro-innovations can have a large potential for developing viable alternatives for rural development. Some authors identify positive effects on the quality and healthiness of food, social conditions, and environmental sustainability (León-Bravo et al., 2019[50]; Kilis et al., 2021[51]; Ferrario, 2021[52]; Garre, 2022[53]).

Protecting indigenous breeds by combining traditional practises with new technologies and modern innovation has a potential positive effect on sustainability

Spain's initiative to protect endangered native breeds can be analysed as a retro-innovation with potential benefits for environmental sustainability. The MAPA has established a National Program for the Conservation, Improvement and Promotion of Livestock Breeds (see also Section 2.5.2). Being part of the animal genetic heritage of Spain and having a potential impact on social and environmental sustainability, native breeds are being revalued. The production systems linked to native breeds are associated with extensive systems, which might entail beneficial consequences for the sustainability of the rural environment.

The National Program, following the demands of breeders' associations, implements a logo to identify the origin of products that derive from indigenous breeds.[14] This also gives more traceability to consumers that increasingly demand information about the origin of the products they consume. Therefore, a regulatory regime exists for the voluntary use of the "native breed" logo that allows products from native breeds to be recognised by their labelling and where they can be marketed or consumed.

The production of indigenous breeds has several potential environmental benefits beyond the direct impact on the conservation of biodiversity. It allows for the development of a productive activity without large changes in the landscape. Indigenous breeds could bring better adaptation to climate change given that their production systems and genetic resources have been adapted to changing environmental conditions over millennia (FAO, 2015[54]). These breeds are particularly resilient to hard conditions in some remote areas. Most often these indigenous breeds are linked to extensive livestock practices with additional environmental benefits (Box 3.4). However, it was difficult to find breed-specific empirical evidence on these environmental gains. Efforts to gather data and evidence in this direction may help to incorporate this type of retro-innovation in the mainstream policy set.

Box 3.4. Retro innovation for sustainability at work: The Avileña-Negra Ibérica bovine indigenous breed

The Spanish autochthonous *Avileña-Negra Ibérica* breed is one of the 55 bovine indigenous breeds in the official Spanish catalogue. Different institutions work to foster the development of this breed, originally from the Castilian province of Avila. The Spanish Association of Breeders of *Avileña-Negra Ibérica* cattle carries out important characterisation, genetic improvement, selection, and promotion tasks. It provides services to 545 farmers. Its activities include registering the animals in the Genealogical Book, promoting genetic improvement and the extension of the breed and its final products, to ensure that the breed is economically viable. The association also manages the breed logo and guarantees traceability.

The Protected Geographical Indication (PGI) *Carne de Ávila* guarantees the set of characteristics of the meat, according to the mandatory quality requirements. The Association guarantees the geographical scope of production and processing and has a labelling system that certifies identification and traceability.

The Department of Animal Genetic Improvement of the INIA carries out genetic evaluations based on weaning and fattening data of the animals collected in their own production environment.

The *Avileña-Negra Ibérica* is exploited under an extensive regime with potential benefits to reduce environmental pressures. There is a significant presence of transhumance among livestock farms producing this breed. This practice was traditionally carried out on foot and currently mostly in vehicles. The farms are located mainly in uneven terrains, on soils that are mostly of poor quality. It is present in very difficult environments of high environmental value, with good productive yields, high fertility, and longevity, as well as very pronounced maternal qualities. Thus, the breed is adapted to take advantage of the resources of the existing environment. Environmental benefits may include the adaptation to a drier condition following trends on climate change; improving the protection against fires in semi-arid regions; the improvement of the net GHG emissions thanks to extension practices; and possibly improving nutrient balances and other indicators. Unfortunately, there are no empirical studies and data providing quantitative evidence of these gains for this specific breed.

All this makes the breed an interesting case for its potential for mitigating the impacts of climate change and facing the changing environment.

Source: Indicación geográfica protegida carne de Ávila (https://www.carnedeavila.org/); Asociación española Raza Avileña - Negra Ibérica (https://www.razaavilena.com/). Accessed August 2022.

The use of rescued traditional practices can certainly develop along with modern practices and technologies. An interesting example is the virtual fencing for extensive livestock, with GPS location and movement detection collars that allow to monitor and detect abnormal movements to protect cows against predators, thus helping the coexistence of animals and improving biodiversity protection (Blanco et al., 2021[55]). Virtual fencing also helps pasture management.

Enhancing the recuperation of genetic diversity is very relevant, especially considering the high levels of biodiversity in Spain. Furthermore, the protection of genetic diversity is one of the targets of the Sustainable Development Goals (SDG). Target 2.5 of SDG2 aims, by 2020, to maintain the genetic diversity of seeds, cultivated plants, and farmed and domesticated animals and their related wild species, and to promote access to and fair and equitable sharing of benefits arising from the utilisation of genetic resources and associated traditional knowledge. The three indicators related to this target show an improvement in terms of genetic diversity in Spain: the proportion of local breeds classified as being at risk as a share of local breeds with known level of extinction risk decreased from 76 in 2000 to 66 in 2022, while the number of

local breeds for which sufficient genetic resources are stored for reconstitution increased from 21 in 2014 to 37 in 2022, and the number of plant genetic resources accessions stored ex situ increased from 69 465 in 2000 to 74 662 in 2020 (United Nations, 2022[56]).

Different AKIS actors collaborate in the development of these initiatives. For example, breeders' associations often work with INIA and the MAPA for analysis. INIA provides knowledge, and its work in genetics is very important for some breeders' associations, such as the *Avileña* association. Other indigenous breeds' associations work with the regional governments, research centres, or universities.

3.7.2. Innovation for sustainability in greenhouse farming

Greenhouse agriculture has emerged as a vital component of the dynamic Spanish fruit and vegetable sector. Occupying less than 0.5% of Spain's utilised agricultural area, it produces with significantly higher yields than other types of cultivation, allowing Spain to grow into one of the most important suppliers of fresh produce to the European market.

Over half of greenhouses in Spain have a medium level of technification. As the agro-climatic conditions and the products grown do not always require heating systems without airtight roofs, only 3% of the greenhouses in Spain are classified as "highly technified", with a rigid cover and climate control or heating systems (MAPA, 2022[57]). Spain is committed to increasing the share of technified greenhouses, with support of the Next Generation EU funds. Most greenhouses in Spain operate on solar energy, with a cover of plastic, anti-insect netting or flexible sheets (Molina-Aiz et al., 2022[58]). These solar greenhouses may contribute to reducing dependence from fossil fuels.

Over half of the Spanish greenhouse area is in the province of Almería, in the south of the peninsula. Almería greenhouse farms are gradually incorporating technology (such as active climate control and productive analysis systems) and making improvements to the greenhouse structures (Valera et al., 2016[59]). The sector increasingly uses biological pest control with predatory insects and mites (Cajamar, 2022[60]), and the use of fertigation for localised application of nutrients is widespread (Gallardo et al., 2023[61]). The activity has driven the development of a supporting industry cluster in areas including plant nutrition and phytosanitary products, seeds, irrigation and climate, packaging, biotechnology, greenhouse materials, and related services. The supporting industry employed 6 200 workers in 2021, an increase of 58% since 2013. Over half of the workers in the industry were qualified (Cajamar, 2022[60]).

While the sector has advanced in incorporating technology, the production system – particularly at the greenhouse level – can still be considered low or mid-tech. Even if downstream agents (e.g. marketing co-operatives) have more sophisticated technology in their facilities, at the greenhouse level the use of technologies such as sensors to increase water use efficiency or control climate conditions is still incipient (Castro et al., 2019[62]). The new requirements on soil nutrition and water use under the 2023-27 CAP also apply to the sector and may trigger sustainable innovations.

Almería's local productive system has the potential to facilitate knowledge and technology transfer to greenhouse farmers and the supporting industry, with support and technical advisory from public and private organisations including sector associations, research centres and the local university. The sector often works together to respond to changes in market signals and promote improvements in greenhouse management practices. Regional and supra-regional actors have joined efforts in several EIP-Agri operational groups to find solutions for the activity's environmental challenges (Box 3.5).

Box 3.5. Innovation partnerships for sustainable greenhouse farming

A group of stakeholders is exploring digital tools to optimise the use of water and fertilisers in Spanish greenhouses

Fruit and vegetable producers from Almería are part of several EIP-Agri Operational Groups, both within the AC of Andalusia and with participants from other ACs. These groups seek to find innovative solutions to the sustainability challenges associated with greenhouse farming.

A recent example is the operational group "Inverconec", which implements the innovative project "Connected greenhouse from cultivation to the final consumer", co-financed by the European agricultural fund for rural development (EAFRD) and the MAPA as part of the National Rural Development Program 2014-22, with a total budget of EUR 529 000. The group was launched in November 2021 and is expected to conclude its activities in 2023.

Inverconec brings together the Association of Fruit and Vegetable Producers' Organizations of Almería (COEXPHAL); Anecoop, a conglomerate of co-operatives of fruit and vegetable producers; Fundación CAJAMAR, a foundation associated with a financial institution; Grupo Hispatec Informática Empresarial S.A., an information and communications technology company; Proexport, the Association of Fruit and Vegetable Producers-Exporters of the Region of Murcia; Agroplaning Agricultura Inteligente, a start-up company in the field of Precision Agriculture and ICT; and the University of Almería.

The Operational Group aims to develop a digital application that allows for a comprehensive management of greenhouse production and for the traceability of sustainability information. Through the interconnection of all factors from the crop to the final consumer, it is expected that the use of agricultural inputs will be reduced, as all aspects that can affect the plants will be controlled through connected sensors (IoT) and sampling of air humidity, light, greenhouse temperature or pests. This monitoring is expected to provide data on the amount of water, fertilisers or phytosanitary products needed at any given moment.

Source: EIP-Agri (n.d.[63]), Proyecto Inverconec (2022[64]), Proexport (2021[65]).

3.7.3. Agro-tech, mechanisation and digital technologies for a more productive and sustainable agriculture

The agro-food sector has been increasingly shifting to a more mechanised and digitalised system of production. Agro-tech companies are important players for the generation and diffusion of modern practices allowing the agro-food sector to take advantage of the latest technologies, enhancing and automating production processes. Although the agro-tech has been recognised as a sector of high relevance that improves the input and output of agricultural processes, it is difficult to have up-to-date information on the sector, including companies. This is because it comprises a variety of technologies such as drones, weather forecasts, automated irrigation, and software for disease prediction that help increase crops yield and disease control.

Undoubtedly, agro-tech companies play an important role in innovation activities in the agro-food sector. Along the entire agro-food value chain, agro-tech companies make up 17% of technology enterprises in the sector, conducting research and engaging in the development of software and data analysis, aiming at increased automatization and monitorisation, and improved input use (Sánchez-Zamora and Gallardo-Cobos, 2022[66]). It is not easy to find data on agro-tech companies. According to the Spanish Association for the Digitalisation of Agriculture, Agrofood, Livestock Farming, Fisheries and Rural Areas (AgroTech España), there are currently more than 750 agro-tech companies in Spain, placing the country among the global leaders (AgroTech España, 2021[67]). This Association aims at promoting the benefits of

digitalisation and new technologies, as well as matching agro-tech companies with their potential users. The entire sector in Spain engages in more than 40 technologies or services, based on data as a tool to drive innovation, and is expecting EU initiatives such as the Green Deal and the Farm to Fork Strategy to further drive growth in the near future (AgroTech España, 2021[67]).

Box 3.6. The successful case of CITRUSTECH

An interesting case of co-operation and use of technology for solving problems

The mechanisation of the citrus fruit sector is generally low and inefficient, meaning that the share of labour-associated costs on total costs is rather high. Mechanisation may overcome this issue, as well as facilitate tasks of harvesting and phytosanitary treatments. CITRUSTECH is a supra-autonomous operational group which implements the innovative project "Technological advances for modernisation and sustainability in citrus production", co-financed by the European Agricultural Fund for Rural Development (EAFRD) and the MAPA as part of the National Rural Development Program 2014-20. It aims at modernising citrus fruit production through technological advances in production technologies, and at increasing the sustainability of production along economic, environmental, and social dimensions.

The project contributes to climate change mitigation efforts by using techniques that promote the establishment and conservation of plant covers in cultivation, for instance through the handling of crop residues. In a specific trial, islands of biodiversity were created, thus benefiting flowering and bloom in the area, and offering refuge to several insects beneficial to pest control (CITRUSTECH, 2021[68]).

Additionally, the use of new technologies for the efficient use of fertilisers and phytosanitary products is encouraged. CitrusVol, a tool whose development was co-financed by CITRUSTECH, delivers spray volume rates calculated on scientific evidence to be carried out with an air-blast sprayer. A study conducted by a consortium including CITRUSTECH has determined the effectiveness of the tool in a practical context. The researchers found that CitrusVol allows for reduced volumes of phytosanitary product application, while maintaining previous results achieved through air-blast spraying without the tool's aid in the control of a specific type of red spider that often plagues clementine cultivation in Spain (Garcerá et al., 2021[69]).

3.8. Conclusions

The Spanish innovation system has a moderate performance relative to other EU countries, although this hides regional heterogeneity. The country has succeeded in generating very good results in agricultural science but has faced difficulties in developing agricultural innovation and inducing adoption of innovations. Low public and private investments, the fragmentation of the agricultural knowledge and innovation system (AKIS), and regional heterogeneity in approaches are the main obstacles to harnessing innovation for a sustainable and resilient agriculture.

Although government spending on R&D for the agro-food sector has been increasing in recent years, it remains below the level observed before the 2008 financial crisis. The private sector has become the main source of agro-food R&D funding, though it relies on increasingly fewer innovative firms. More funding is needed, but also other incentives to induce innovation for sustainability.

The Spanish AKIS involves many actors at the national and regional levels. Autonomous communities (ACs) lead the regional AKIS, which includes R&D, innovation, and knowledge transfer policies. Central and regional governments exercise competences in agricultural-relevant R&D and innovation policies within the EU framework. ACs are very heterogeneous in terms of resources and have not always

committed enough funding to the AKIS. In several ACs, policy responsibilities linked to the development of the regional AKIS are dispersed among different institutions, which are often not able to co-operate effectively with each other, hampering co-ordination at regional level. Spain's 18 public agricultural research centres are heterogeneous, relatively small, and are not well connected and co-ordinated in the whole AKIS system. Spain successfully participates in collaborative multi-actor innovation approaches and multi-country mission-oriented research at the EU level. Yet, a similar collaboration model has not been replicated at the national level among ACs.

Having a diversity of science, technology, and innovation policy experiences at the regional level can help promote innovation initiatives that are more targeted to regional needs. However, the lack of adequate integration through governance mechanisms and knowledge flows, adapted to the reality of AKIS structures in Spain, affects the system.

While a decentralised system allows for the development of local strategies that respond better to the local needs and specificities, it also requires co-ordination and joint planning to strengthen knowledge flows. The co-ordination of the national AKIS has so far been weak, hindering collaboration between ACs, which is needed to face global problems. There is no national strategy specifically defining agricultural innovation priorities, and the only reference to AKIS in the CSP is in relation to the advisory services without designing an overall vision on agricultural innovation.

Spain has made important progress in reducing the rural-urban gap in access to digital technologies. However, differences persist between rural and urban areas in access to high quality broadband and in digital use and skills, often linked to farmers' age and farms' size. Further reducing this gap is critical to ensure that digital becomes an enabling technology that fosters innovation in the agro-food sector. Spain needs to work on an improved system to collect data for monitoring and evaluation that allows self-assessment by farmers and other actors and enables policy assessment and implementation by the government. There are already some initiatives in this direction that should be strongly supported.

The level of education of most agricultural workers remains well below the EU average and there is evidence of skills mismatches, which can exert a negative impact on the dynamism and innovation capacity of the agricultural sector. The training needs of the agricultural sector are evolving, but currently there is a disconnect between the knowledge transfer systems and the new forms of business and innovation, which require high entrepreneurship, digital and environmental skills to facilitate the adoption of new technologies. Spanish advisory services have been transformed in the last three decades. The traditional public agricultural extension services have been partly replaced by private advisors, advisory entities and commercial advisors linked to input providers. There is an important role for advisory services to help Spanish agriculture achieve environmental sustainability, but to do so, they also need to change.

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Notes

[1] The figures on funding correspond to different periods and are indicative. They aim to provide an idea of the magnitude of the different funds.

[2] See https://planderecuperacion.gob.es/como-acceder-a-los-fondos/pertes/perte-agroalimentario.

[3] Eureka is a public network for international co-operation in R&D&I. It was established in 1985 by 18 countries and the European Commission to foster competitiveness and market integration, and to encourage R&D co-operation. At present, over 45 countries are part of Eureka. Iberoeka is a network that supports technological business co-operation among Spain, Portugal and 19 Latin American countries

[4] See https://www.csic.es/es/investigacion/areas-y-produccion-cientifica/area-global-vida/ciencias-agrarias.

[5] These numbers are estimated using data from the websites of regional centres.

[6] See https://fiab.es/fiab-presentacion/areas-de-trabajo/i-d-i/.

[7] See https://fiab.es/la-cuarta-edicion-de-los-premios-ingenia-startup-premia-la-innovacion-y-el-emprendimiento/.

[8] The TRIPS made compulsory the protection of plant varieties either by patents or by a *sui generis* system. Moreover, it made the patentability of microorganisms and non-biological and microbiological processes for the production of plant varieties compulsory for WTO Members.

[9] Information provided by MAPA in response to the OECD questionnaire.

[10] The Programme for the International Assessment of Adult Competencies (PIAAC) is a programme of assessment and analysis of adult skills. Adult education and training (AET) refers to participation in formal or non-formal AET in 12 months preceding survey. Data for AET is from international surveys conducted in over 40 countries/economies in 2012 and 2015.

[11] In Spain, the concept of regulated training (*formación reglada*), refers to training that is regulated by the Ministry of Education and that leads to an official degree with academic validity. Non-regulated training (*formación no reglada*) does not lead to an academic certificate.

[12] See https://escuelaptv.com.

[13] See https://www.cdti.es/index.asp?MP=101&MS=842&MN=2.

[14] The Royal Decree 505/2013, of June 28, regulates the use of the “native breed” logo on products of animal origin. https://www.mapa.gob.es/es/ganaderia/temas/zootecnia/razas-ganaderas/arca/raza-autoctona.aspx (accessed August 2022).

OECD Agriculture and Food Policy Reviews

Policies for the Future of Farming and Food in Spain

Spain has a dynamic and competitive agro-food sector. However, higher productivity has not always reduced environmental pressures. The agricultural innovation and knowledge system could play a key role in addressing the environmental challenges and improving the sector's resilience.

Policies for the Future of Farming and Food in Spain undertakes a thorough examination of the Spanish agro-food sector. It applies the OECD Productivity, Sustainability and Resilience (PSR) analytical framework along with the latest data from the *OECD Agri-Environmental Indicators* to benchmark the country's sustainable productivity performance and to identify the main challenges facing the sector.

This report proposes a new policy approach, which puts innovation at the centre of a strategy to reconcile environmental performance and productivity growth. Its policy recommendations focus on actions to improve the agricultural knowledge and innovation system and make it more responsive to the most urgent environmental pressures. This requires strengthening the institutional and regulatory framework that supports agricultural innovation and creating incentives to tackle the impediments for a more sustainable and resilient agriculture.

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