Challenge #4

BECOMING A CARBON-NEUTRAL, SUSTAINABLE AND CLIMATE-RESILIENT SOCIETY

EXECUTIVE SUMMARY

— Throughout the 20th century, most countries in the world adopted a pattern of economic growth based on the abusive and linear use of natural resources ("extract, produce, consume, and dispose"). This pattern has caused unprecedented environmental degradation and has precipitated a climate crisis that could have catastrophic effects in the near future.

— Spain has been part of this process. Since the mid-1960s, our ecological footprint has increased significantly: if all of humanity consumed as we do today, it would take two and a half planets to meet these needs. Factors behind this excess include our high dependence on fossil fuels in sectors such as transport and energy, our insufficient commitment to eco-innovation, our low levels of environmental taxation and the shift in our population's behaviour towards greater consumption of animal-based foods, electronic devices and fast fashion.

— The effects of past abuses will be felt in the future. The Spain of 2050 will be warmer, drier and more unpredictable than today. If we do not take decisive action quickly, droughts will affect a further 70% of our territory; fires and floods will become more frequent and destructive; sea levels and temperatures will rise; key industries such as agriculture and tourism will suffer severe damage; 27 million people will live in water-scarce areas; and 20,000 people will die each year from rising temperatures.

— Climate change is already inevitable, but there is still time to avoid its most destructive effects and prevent them from conditioning the well-being of present and future generations, while conserving the biodiversity of our territory. To achieve this, we will need to become a carbon-neutral, resource-sustainable and resilient society by 2050. This will involve, among other things, radically changing the way we generate energy, move around, produce and consume goods and services, and how we relate to nature. We will need to harness all our wealth of renewable energy sources; reinvent value chains; improve water management; adapt our infrastructure and boost green taxation. All this must be done without leaving anyone behind and without widening social inequalities.

— The goal is ambitious, but it is also possible. Spain has the natural resources, capacities and institutions necessary to become the sustainable country it should be by the middle of this century. The ecological transition will pose challenges, but it will also be a unique opportunity to modernise our productive network, generate wealth and employment, and reduce our foreign energy dependence. At the end of the process, the balance will be overwhelmingly positive. The resulting Spain will be more sustainable, healthier and more competitive than it is today, and all citizens will benefit from this.

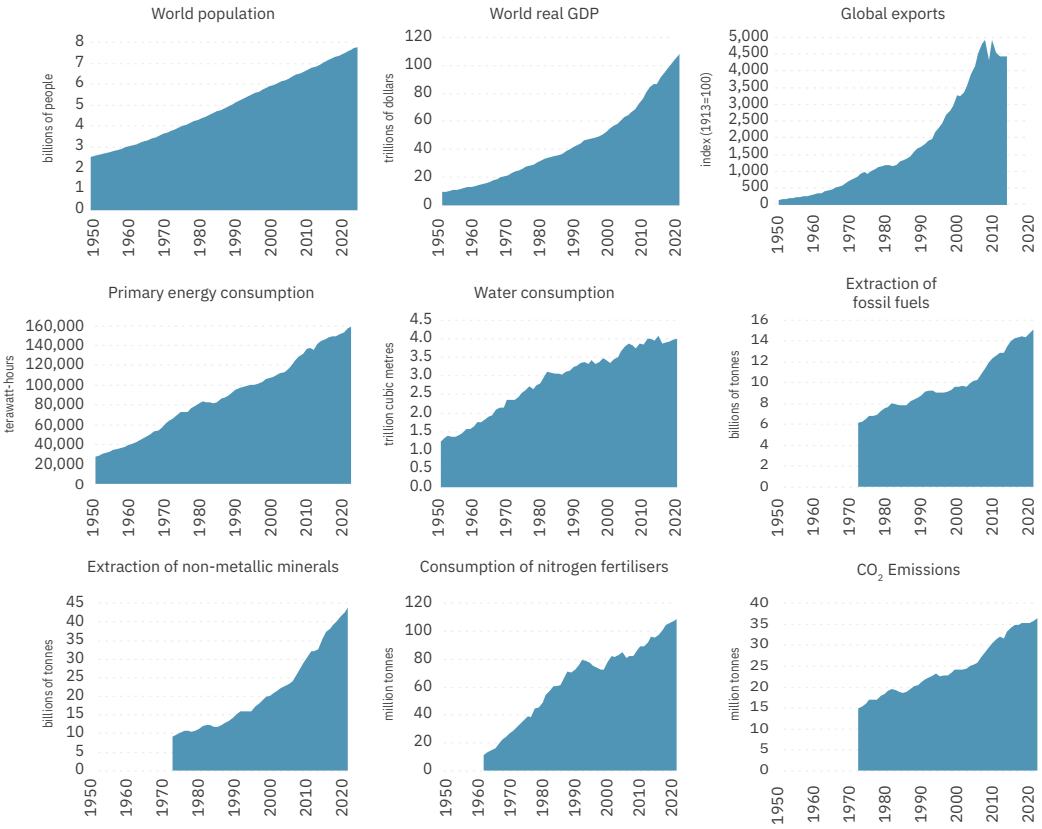
THE PRESENT: WHERE WE ARE AND HOW WE GOT HERE

Over the course of the second half of the 20th century, humanity developed **a pattern of economic growth based on the intensive and linear use of natural resources and burning fossil fuels on a massive scale**.[1] This model has made it possible to generate more wealth than in any other period in our history and to improve the living conditions of millions of people. Since, 1950, the world's population has tripled,[2] GDP has increased 12-fold,[3] life expectancy at birth has increased by 25 years,[4] and the percentage of humanity living in extreme poverty has fallen from 63% to 10%.[5]

This spectacular growth has, however, come at a cost to the planet, through the drastic increase in the use of natural resources and the impact on the environment [Fig. 1]. Since 1970, global extraction of fossil fuels, minerals, metals and biomass has tripled,[6] water use has increased by more than 60%,[7] and carbon emissions have increased by a factor of 2.5.[8] As a result, **it is estimated that humanity currently consumes resources and generates waste at a rate 60% higher than the Earth's capacity to regenerate them**.[9] This has pushed us beyond some of the biophysical limits of the planet within which we can operate safely.[10] **If this situation continues, it will dramatically increase the risk of an unprecedented climate and environmental crisis that will force thousands of plant and animal species into extinction**[11] **and have catastrophic consequences for humans**.[12]

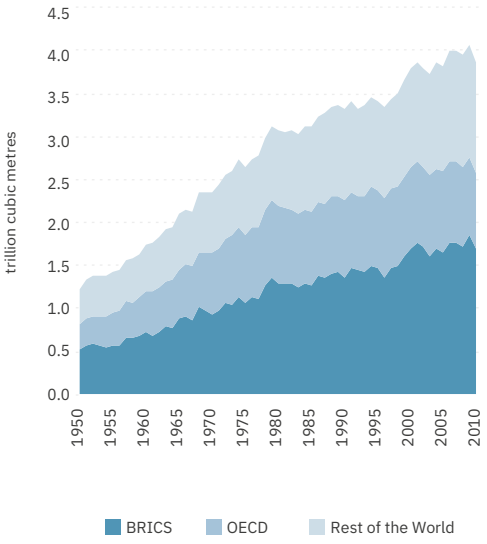
Fig. 1. Global use of natural resources and environmental impact from 1950 to latest available year

Sources: Drafted by the authors based on data from Global Carbon Atlas, United Nations, Our World in Data and *WU Vienna*[13]



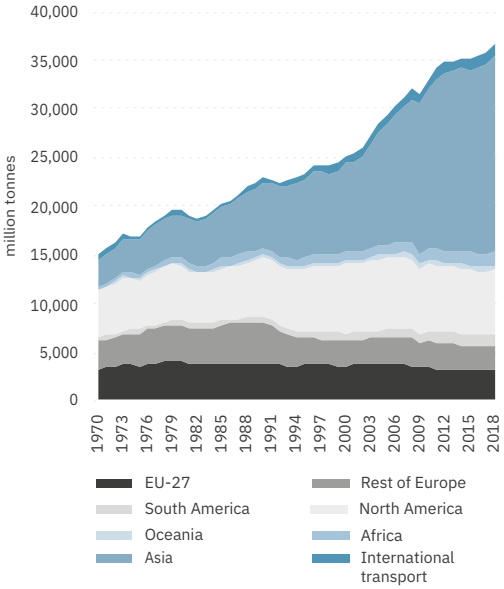
All regions of the world have contributed to this process, although the G20 countries have been primarily responsible for the increase in resource demand and the bulk of emissions [14] [Figs. 2 and 3]. In addition, there is the role of international transport, which in 2018 emitted as much carbon as the whole of South America.[15]

Fig. 2. Annual world water consumption by region



Source: Drafted by the authors based on data from Ritchie.[16]

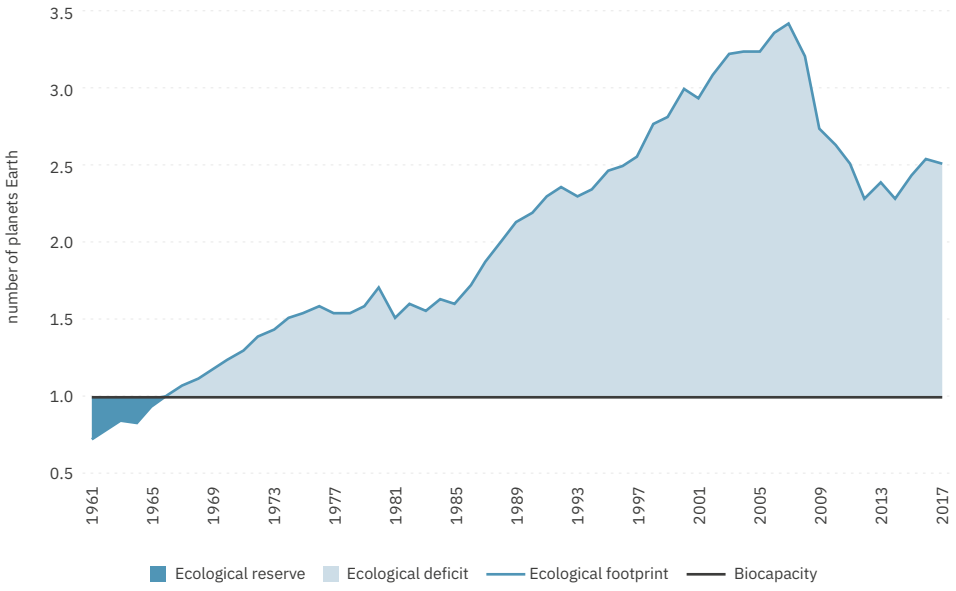
Fig. 3. Annual global carbon emissions by region



Source: Drafted by the authors based on data from Ritchie and Roser.[17]

Spain has also seen a significant increase in its ecological footprint,[18] especially since the 1960s [Fig. 4]. This increase is mainly due to an increase in the use of natural resources. Today's generations consume more water, minerals and fuels than past generations and waste a greater proportion of these resources and the goods we produce from them.[19]

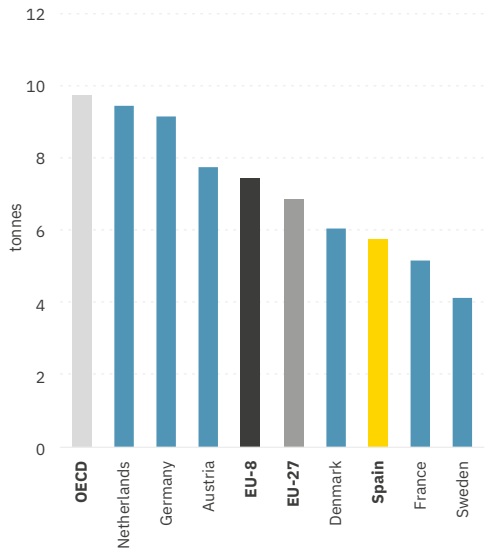
Fig. 4. Ecological footprint in Spain



Source: Drafted by the authors based on data from the *Global Footprint Network*.[20]

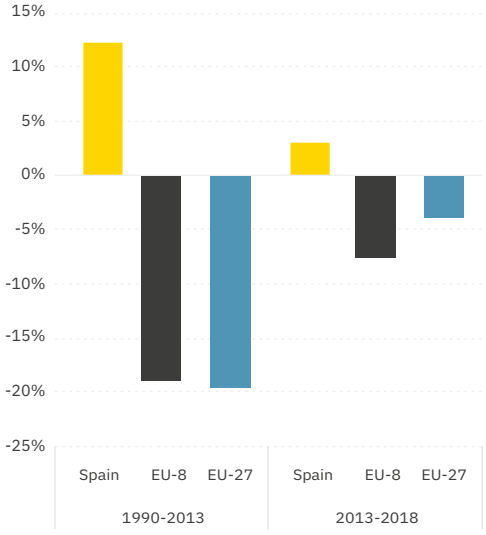
One of the main consequences of this linear and abusive use of natural resources has been **the increase in greenhouse gas emissions**. In Spain, the **level of carbon emissions** per capita[21] is relatively low compared to OECD countries, and lower than the EU-27 average [Fig. 5]. **This is not to say, however, that we have performed well, or that we do not have hard work ahead of us on this front.** Between 1990 and 2007, our country's greenhouse gas emissions increased by more than 50%.[22] The downturn in economic activity caused by the crises of 2008 and 2011 led to a reduction in emissions in those years. However, as the economy recovered from 2013 onwards, emissions started to grow again and, although they grew at a slower rate than in the previous expansionary period,[23] this growth contrasts with the situation in the EU-27, where emissions fell by 4% on average [Fig. 6].

Fig. 5. Carbon emissions per capita, 2018



Source: Drafted by the authors based on data from the *Global Carbon Atlas*.[24]

Fig. 6. Trends in greenhouse gas emissions



Source: Drafted by the authors based on data from Eurostat.[25]

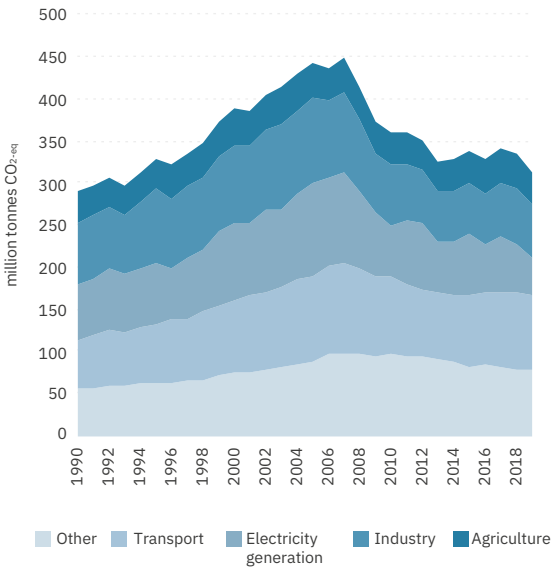
The factors behind the increase in our ecological footprint in recent decades are complex and numerous. **Here we highlight three.**

Firstly, the lack of ambition of public stakeholders who, for many years, showed a lower level of commitment to the climate and environmental agenda than other European administrations. This lower ambition resulted in the absence of a defined and comprehensive decarbonisation and resource use strategy; in the fact that legislative advances have mainly taken place through the adoption of European regulations;[26] and in the fact that, in many cases, certain activities have been indirectly promoted without considering their potential environmental impact. In addition, this reduced ambition was reflected in **greater fiscal laxity**.[27] Energy-environmental taxes are one of the main tools available to states to discourage unsustainable activities by incorporating their negative externalities into the price of goods and services.[28] Our country, however, has made limited use of them, partly in order not to harm the international competitiveness of certain economic sectors. This explains, for example, why the price of water in Spain is one of the lowest in Europe (despite the relative scarcity of this resource in the country),[29] or why **our country is well below the European average in terms of environmental tax revenue as a percentage of GDP** (in 2019, environmental tax revenue in Spain reached 1.8% of GDP compared to 2.4% in the EU-27 and 2.6% in the EU-8).[30]

A second factor that explains the increase in our ecological footprint is the insufficient commitment to the adoption of environmentally sustainable solutions, whether domestic or imported. The use of new technologies is and will be key to decoupling economic activity from greenhouse gas generation, pollution and resource intensity. Today, Spain is slightly above the EU-27 average in terms of its performance in eco-innovation, but it is still far behind the leading European countries in this field.[31] This is largely due to Spain's lower R&D efforts [see chapter 1], but also to a number of specific difficulties encountered by the eco-innovation sector, such as the uncertainty associated with the green transition, high investment costs, low market demand for environmentally sustainable technologies, the absence of a robust innovation ecosystem, and limited public and private funding.[32] In 2019, our public energy R&D budget was €3.3 per capita, compared to €9.3 for the EU-27.[33]

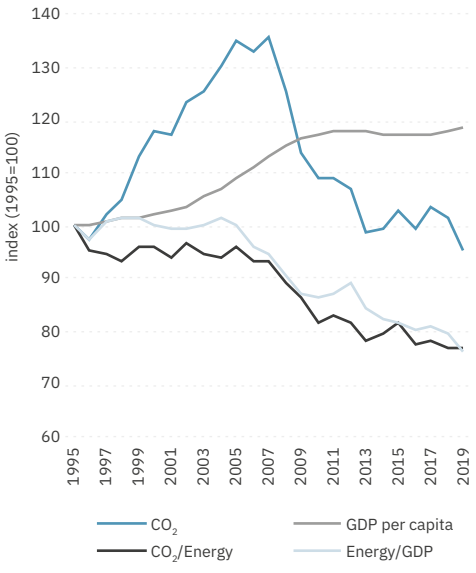
To the above factors we must add **a third, which is key and arises from the pattern of economic growth** observed in Spain over the last decades and the particular evolution of some of its main sectors [Figs. 7 and 8].[34]

Fig. 7. Greenhouse gas emissions by sector in Spain



Source: Drafted by the authors based on data from MITECO.[35]

Fig. 8. Spain's greenhouse gas emissions, per capita income, energy intensity and carbon intensity



Source: Drafted by the authors based on data from Eurostat.[36]

One of these is **the transport of goods and persons**, in particular by road.[37] This is the sector that generates the most emissions, both in Spain[38] and in Europe.[39] Its high incidence is due, among other things, to the large-scale construction of motorways (to the detriment of railway lines), the dependence on private vehicles for interurban mobility, the increase in the average size and power of cars in recent years,[40] the low tax burden on transport,[41] and the unequal population distribution of our territory [see chapter 6].

The evolution of total emissions has also been strongly influenced by the **electricity sector**. Spain has all the attributes to be a world power in clean energy production. Since the end of the 20th century, important measures have been put in place to achieve this.[42] As a result, in the last

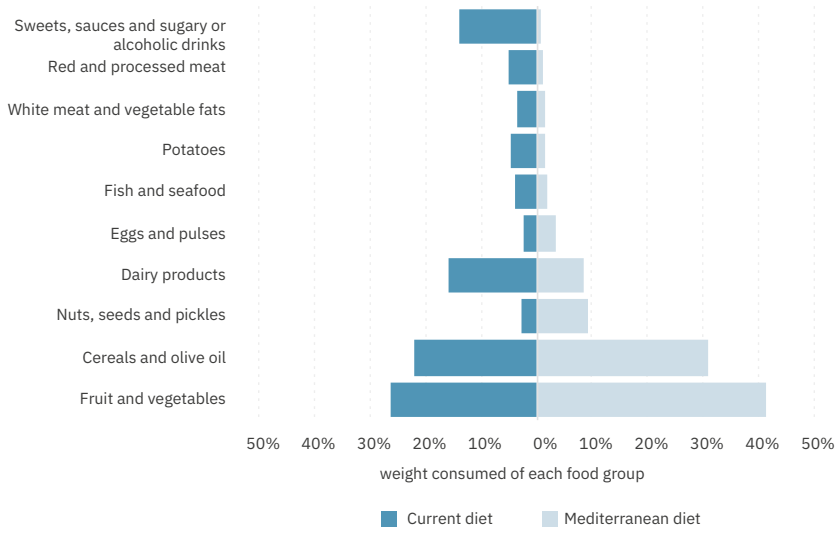
decade, our country has doubled the percentage of electricity generated with renewable energies.[43] Even so, the use of fossil fuels in our electricity system remains high, due to the presence of combined cycle plants, the high level of fossil-fuelled electricity generation on the islands, and the maintenance of some coal-fired plants (now in the process of closure). Between 2012 and 2017, moreover, the decarbonisation of the sector slowed as a result of the effects of the fall in electricity demand, regulatory uncertainty regarding the conditions of remuneration for renewable energy and regulations that were not favourable to self-consumption,[44] among other factors.

Similarly, one of the main reasons for the increase in emissions has been **the poor progress made in the industrial and agricultural sectors** which, in addition to registering a high level of greenhouse gas emissions (33% of the total in Spain in 2019),[45] make a very intensive use of natural resources (for example, agricultural uses account for 80% of the water consumed each year in our country).[46]

The aforementioned structural factors are closely linked to other cultural factors related to changes in the consumption and priorities of the Spanish population. These include the progressive abandonment of the Mediterranean diet and increased consumption of products of animal origin [Fig. 9], responsible for 80% of the emissions associated with our food.[47] In fact, food consumption is today the main source of environmental impacts generated by EU inhabitants.[48]

The effect of the more widespread dissemination of fast and low cost fashion is also significant. European countries now buy 40% more clothing than they did in 1996,[49] which has contributed to a drastic increase in the ecological footprint of the textile sector. At the same time, the generation of electrical and electronic waste per capita in Spain has more than doubled over the last decade, as a result of the increased consumption of these devices, whose useful life is increasingly shorter.[50]

Fig. 9. **Composition of current vs. Mediterranean diet, Spain**



Source: Drafted by the authors based on data from Blas et al.[51]

These changes in consumption patterns have also, in some cases, neutralised the efficiency gains in production processes generated by the scientific and technological advances of recent decades,[52] resulting in greater use of resources and increased waste generation (known as the "rebound effect").[53] Consider, for example, the transformations that have taken place in the automotive sector. Efficiency gains in engines, components and fuels have, to some extent,

been "cancelled out" by a growing presence of ever more powerful, larger and heavier cars, often exceeding the daily needs of the population.[54] Similarly, the modernisation of irrigation systems has paradoxically led to an increase in water use in some regions of the country. This is due, among other factors, to the introduction of crops with a larger water footprint, the possibility of doubling harvests and the increase of the cultivated area.[55] Thus, **water demand at national level has remained more or less stable over recent decades, despite the efficiency improvements achieved in the use of this resource**.[56]

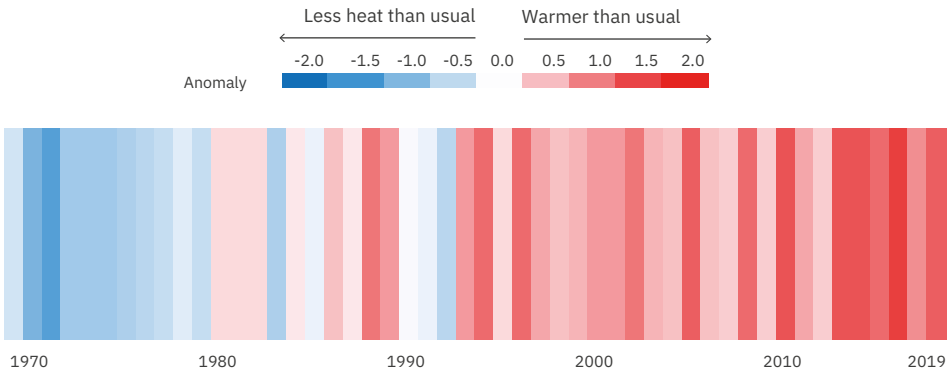
As a result of all of the above, in Spain, much like in the rest of the world, a linear economic model based a pattern of "extract, produce, consume, and dispose" **has become the norm.** Not only has this model already had severe impacts on the health of our ecosystems and our citizens, but it is also completely unsustainable for the future. **If the whole of humanity were to consume as much as Spanish society does, it would take two and a half planets to satisfy our needs**.[57]

The impact the climate and environmental crisis is already having on our lives

Climate change is not only a threat for the coming decades; it is also a present reality that is already transforming Spain and the lives of at least two thirds of the population.[58] Its extensive maritime coastline, its geographical location, and its socio-economic and environmental particularities make our country particularly vulnerable to climate change, and it suffers its negative consequences more severely than other parts of Europe.[59]

Over the last four decades, **the average temperature in Spain has increased by around 1.8ºC**,[60] with significant peaks in some areas and years [Fig. 10]. The thermal summer is now five weeks longer,[61] the number of heatwave days per year has doubled,[62] and the temperature in 2020 was the highest on record.[63]

Fig. 10. **Annual mean temperature anomalies in Spain (ºC)**



Source: Authors' own, based on AEMET data.[64]

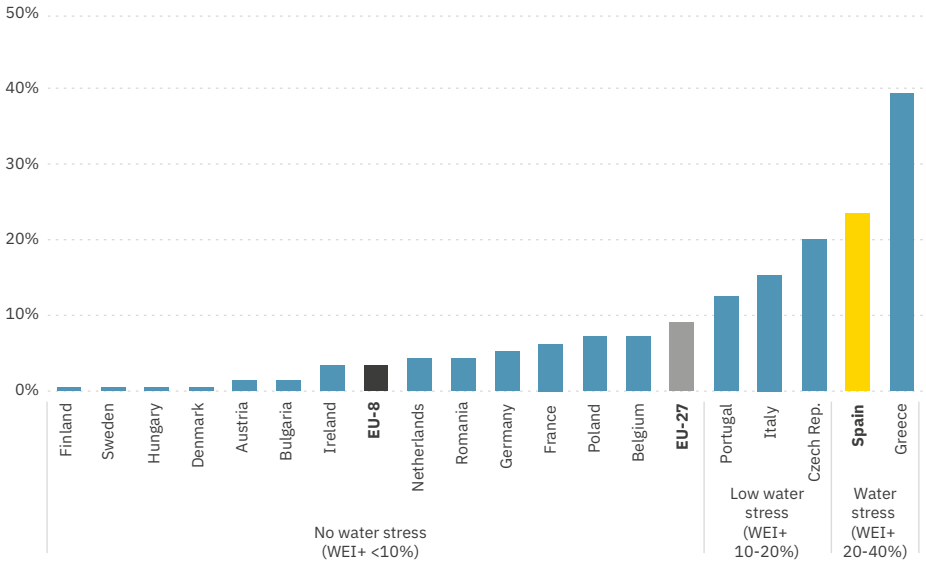
Global warming has caused the surface water of the Mediterranean Sea to increase by 0.34ºC every decade since the early 1980s.[65] Our glaciers have shrunk by 90% since the beginning of the 20th century,[66] and the semi-arid territories have increased in size by some 30,000 km^2, the equivalent of the total surface area of Galicia.[67] The Iberian Peninsula is also becoming **increasingly drier**. Although torrential rains have become more frequent and destructive, especially in the Mediterranean area,[68] average rainfall over the national territory has fallen[69] and droughts have increased in frequency and severity.[70]

These trends, coupled with a use of natural resources that is not always efficient and sustainable, have led to **a significant decrease in the quantity and quality of available water resources.** Proof of this is that Spanish rivers carry less water today than they did 40 years ago[71] and that several of the most water-stressed river basins in Europe are located in Spain.[72] Another anomaly in the rivers is the change in the natural regime of some of them which, due to transformations such as the construction of reservoirs, have acquired more flow in summer than in winter.[73]

The state of our groundwater is not much better. It is estimated that **36% of our aquifers are at risk of overexploitation and that more than half are highly polluted by nitrates**, mainly due to the use of synthetic fertilisers and liquid manure in agriculture.[74] The intensive use of pharmaceuticals (for humans and animals) is also an important source of contamination, with Spain being one of the countries in the world with the highest presence of pharmaceuticals detected in drinking water.[75] As a result, 40% of surface water bodies (rivers, lakes and coastal waters) and 45% of groundwater bodies are not, at present, in good condition.[76]

This situation is particularly serious in our country because, for some decades now, there has been a very tight balance between available water and the water consumed by agriculture, livestock, industry and households.[77] Although significant progress has been made in increasing our desalination capacity,[78] modernising irrigation systems and changing consumption habits, **Spain still has one of the highest water exploitation indexes**[79] **in Europe** [Fig. 11]. This reality is still invisible to most citizens, but it should be known that some 22 million people in our country currently live in places where water consumption exceeds the amount available and that, among them, 3.3 million live in areas suffering from severe water scarcity.[80]

Fig. 11. **Water Exploitation Index (WEI+), 2017**



Source: Drafted by the authors based on data from the European Environment Agency.[81]

Climate change and overexploitation of water bodies, pastures and forests have also aggravated the chronic problem of desertification, a process of degradation in dry lands that generates effects such as lower soil productivity or lower water quality.[82] At present, **more than two thirds of the Spanish territory is susceptible to desertification** and 18% is at high risk.[83]

The **risk of forest fires has** also **risen** due to higher temperatures and phenomena such as rural depopulation or inadequate forest management.[84] **In today's Spain, there are fewer fires than at the start of the century, but they are becoming increasingly devastating and difficult to control**.[85] A representative fact is that the European Mediterranean countries (Portugal, Spain, Italy, Greece and France) account for about 85% of the total burned area on the continent.[86] Increased potency of fires not only destroys natural resources, but it also has serious impacts on the economy and the health of the people affected.[87]

Climate change has also severely impacted our seas, causing sea surface temperatures to rise by 0.2-0.7°C per decade,[88] increased acidification, altered storm and wave patterns, and an average sea level rise of 2-3 mm/year over the last century.[89] The rise in sea level has been particularly noticeable in the area of the Strait of Gibraltar, the Canary Islands, the Atlantic coast[90] and the Mediterranean arc. In the latter, increases of up to 10 mm/year have been observed since the mid-1990s.[91]

These effects have been aggravated by **the overexploitation of the coast and marine resources, both of which are essential for the development of the so-called "blue economy", of which Spain is the leading power in the EU**.[92] The functioning of entire ecosystems, such as the Mar Menor, has been severely affected,[93] and coastal areas and dune systems such as the Doñana National Park or the Maspalomas dunes have been seriously damaged.[94] The construction of housing, infrastructure and paved areas has doubled in the last 30 years, so that the area occupied by these has increased by some 290,000 hectares, equivalent to five times the size of the city of Madrid.[95]

All these impacts on terrestrial and marine ecosystems have severely damaged biodiversity, which in Spain is among the highest in Europe.[96] Spain is home to around 85,000 species of animals, fungi and plants (54% of the species that inhabit the continent), of which 10% are threatened with extinction.[97] In addition, climate change is altering the behaviour of many wild species and causing major disruptions to their biological rhythms.

Climate change and resource-intensive use have also impacted our health. Science has shown that one in four deaths worldwide is linked to the environment.[98] In Spain, the heat caused an excess mortality of 13,000 people in the first decade of the 21st century,[99] while increasing the spread of viruses borne by vectors like mosquitoes and ticks,[100] and gastrointestinal diseases caused by issues with water and food quality.[101]

Even more severe are the effects caused by air pollution. Despite the improvements in air quality achieved in recent years,[102] it is estimated that **more than 90% of the Spanish population is exposed to air pollution levels that exceed the limits recommended by the World Health Organisation**.[103] In 2018 alone, over 23,000 people died prematurely in Spain from causes attributable to poor air quality,[104] which is associated with chronic respiratory, cardiac and neurodegenerative diseases, cancer, diabetes or problems during pregnancy and in cognitive development during childhood.[105]

Finally, it is worth noting that our relationship with the environment is also behind the coronavirus pandemic. Zoonotic pandemics such as this one (caused by diseases transmissible between animals and humans) are the result of the way humans obtain and grow food, and trade and consume animals, altering natural ecosystems, reducing biodiversity and facilitating the spread of pathogens.[106] Advances in climate change, demand for animal protein, and overexploitation of wildlife have increased the likelihood of such pandemics, which now account for 75% of emerging infectious diseases.[107] It is estimated that there are as many as 850,000 unknown viruses with the capacity to infect people, highlighting **the urgency of radically transforming the relationship between humans and nature**. Otherwise, pandemics will become increasingly frequent and devastating.[108]

Change is necessary, but it is also possible

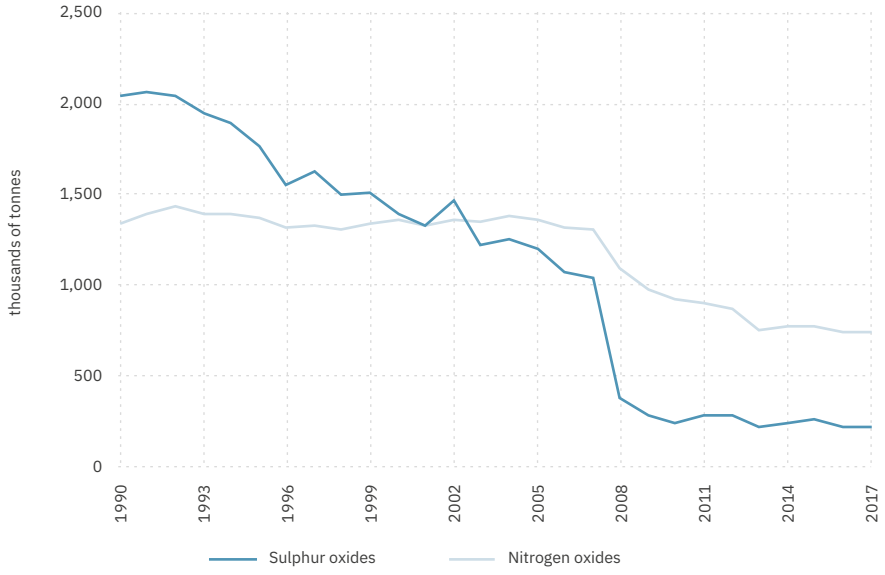
The impacts of climate change and environmental degradation have not gone unnoticed in our country. In fact, they **have generated considerable concern among citizens** (higher than the European average)[109] **and have generated changes in public and private institutions** which, although in many cases insufficient, show that the country is capable of delivering major change when it sets its mind to it.

Over the last four decades, Spain has signed up to all the major international environmental agreements, from the 1981 Montreal Protocol to protect the ozone layer to the 2015 Paris Agreement.[110] At present, and at EU level, Spain is part of the European Green Pact[111] and observes more than 500 EU directives[112] and regulations on issues such as air and water quality, waste management and polluting products or the protection of biodiversity, and is a pioneer in some areas.[113] It also has a strong and ambitious strategic framework at national level[114] to ensure transformation into a carbon neutral, sustainable and climate resilient society.

In addition, Spain is currently holding the first position in the UNESCO world ranking for the number of Biosphere Reserves,[115] and is one of the European states that contributes the most surface area to the EU's Natura 2000 Network.[116] Since the 1990s, Spain has significantly expanded its protected areas to cover a third of the total land area,[117] and has created pioneering marine reserves, such as the one that protects 650 square kilometres of Posidonia marina in the waters of the Balearic Islands,[118] or the Mediterranean Cetacean Migration Corridor, which covers an area of 46,385 square kilometres.[119] This has helped preserve thousands of species of flora and fauna such as the Iberian lynx, which has gone from less than 100 specimens in 2002 to more than 800 today.[120]

Advances in environmental legislation,[121] together with technological improvements in sectors such as industry and transport, have also enabled the reduction of emissions of certain greenhouse gases, such as fluorinated gases,[122] and others that are very harmful to health, such as sulphur oxides and nitrogen oxides [Fig. 12].

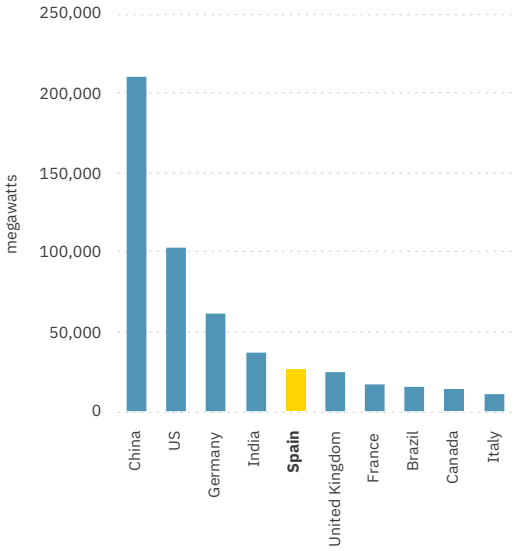
Fig. 12. Emissions of air pollutants



Source: Drafted by the authors based on data from Eurostat.[123]

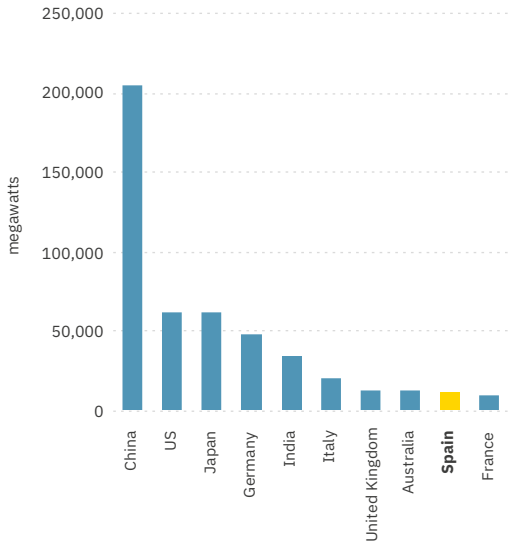
One of the areas where Spain is making significant progress is energy.[124] In 2019, Spain installed more onshore wind power than any other EU country,[125] led the growth of the PV sector at European level and ranked sixth globally.[126] As a result, Spain is today the fifth country in the world in terms of installed wind power capacity and the ninth in terms of solar energy [127] [Figs. 13 and 14]. Electricity generation from renewable sources has exceeded 100,000 gigawatt hours, enough to supply more than half of the country's households.[128] This rapid increase in renewables has also been accompanied by a historic reduction in coal use, which in turn explains the sharp fall in emissions in the power sector in 2019.[129] It is estimated that by the end of 2021, Spain will have closed around 70% of existing coal-fired power plants by early 2019, a rate of decommissioning that has been seen in few other countries in the world and which has been carried out in an orderly manner and with limited social impact.[130]

Fig. 13. **Installed wind power capacity (world ranking)**



Source: Drafted by the authors based on data from the IRENA.[131]

Fig. 14. **Installed solar capacity (world ranking)**

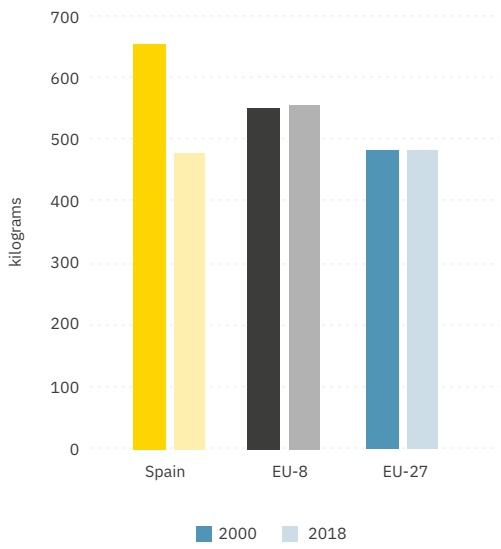


Source: Drafted by the authors based on data from the IRENA.[132]

Our country has also seen improvements in **the use of resources and in waste management** over the last two decades. For example, Spain's per capita water consumption for urban public supply has been reduced by almost 20%[133] and water use efficiency has increased substantially[134] thanks to, among other things, improved irrigation systems, the modernisation of many industrial processes, the introduction of more efficient household appliances and increased public awareness.[135] Spain has also been a leader in water desalination, currently home to 60% of the EU's installed capacity.[136]

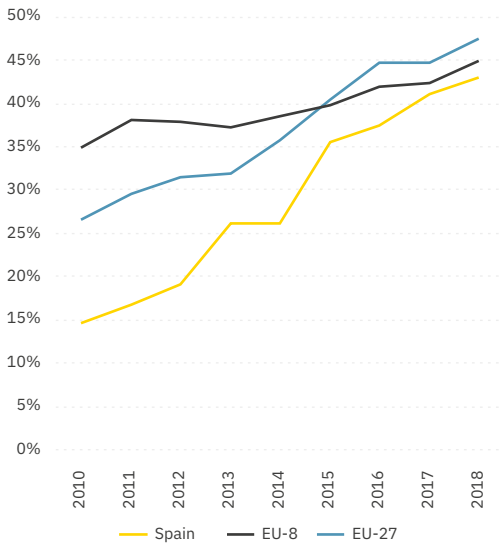
On the other hand, **energy and material productivity** (biomass, fossil fuels, metallic and non-metallic minerals) has increased by more than 25%[137] and 120% respectively, while net material consumption has almost halved.[138] The amount of municipal waste generated per inhabitant has also fallen, and is now below the EU-27 average [Fig. 15].[139] Recycling of municipal waste[140] and electronic waste has also increased [Fig. 16].[141]

Fig. 15. **Municipal waste per capita**



Source: Drafted by the authors based on data from Eurostat.[142]

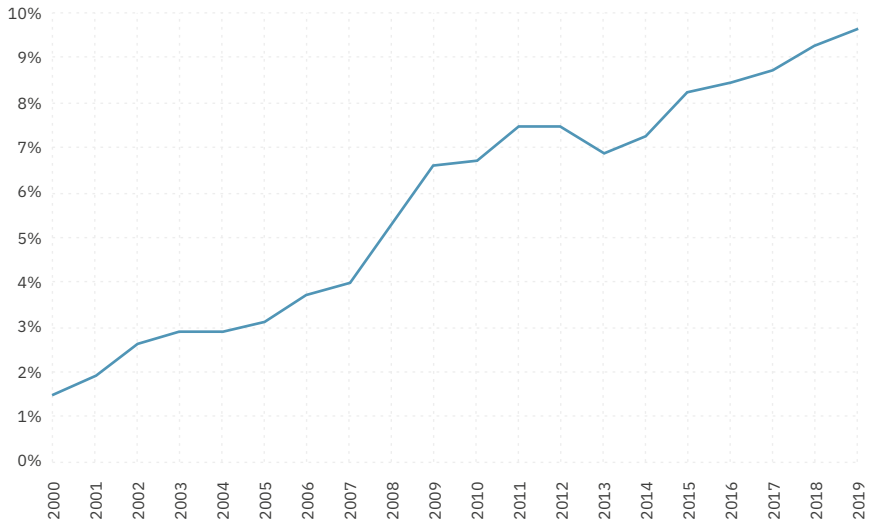
Fig. 16. **Electronic waste recycling rate**



Source: Drafted by the authors based on data from Eurostat.[143]

Developments in **organic farming have also been significant**, whose regulation and promotion began in the late 1980s.[144] Since then, the area under organic cultivation in Spain has grown by more than 30% [Fig. 17], making it the country with the largest surface area in the EU[145] and the fourth largest in the world.[146] Although to a lesser extent, organic livestock farming has also undergone significant growth.[147]

Fig. 17. **Percentage of organic agricultural production as a percentage of total cultivated area, Spain**



Source: Authors' own, based on Eurostat data.[148]

In addition to all these changes, **significant efforts have been made in the area of adaptation**. Spain was the second European country to adopt a strategy in this area (after Finland) when it approved the National Adaptation Plan in 2006. Over the last 15 years, our country has spent

hundreds of millions of euros modifying its infrastructure and production systems to make them more resilient to the impacts of climate change,[149] which has allowed us to minimise the negative effects of droughts on water supply and heat waves.[150] Today, adaptation is already present in different public policies, plans, and strategies on a national, regional and local level.[151]

In summary, over the **last three decades, our country has undertaken significant reforms and initiatives that have reduced our environmental impact in many respects**. **As a result, Yale University's latest** *Environmental Performance Index* ranks us as the 14th most sustainable country on the planet.[152]

It is clear that **what has been achieved so far still falls far short of what is needed**. As we will see below, the changes that will be required over the next three decades will be of a complexity and scale unprecedented in our history. But when it comes to tackling them, it is important to remember that **Spain is not starting from scratch. Valuable initiatives are already underway and, when we set our mind to it, we can deliver profound transformations in just a few decades**.

THE FUTURE: POSSIBLE DESTINATIONS

The short term: the environmental crisis during the coronavirus pandemic

It is difficult to predict what effect the coronavirus pandemic will have on the global climate agenda. On the one hand, mobility restrictions and the contraction of economic activity have led to temporary improvements in air quality, and caused 2020 to close with a fall in greenhouse gas emissions and a reduction in the use of natural resources.[153] On the other hand, **history shows that such improvements associated with economic crises are short-lived** and that exits from crises are usually accompanied by an accelerated recovery, and even an increase in emissions and consumption ("rebound effect").[154] In fact, global greenhouse gas emissions during the first months of 2021 have already exceeded those recorded in the same period of the previous year.[155] Moreover, the economic downturn and the disruption of global supply chains are likely to hamper the fight against climate change in many countries (especially low-income countries), limiting the investment capacity of governments and businesses, hindering the acquisition of clean technologies, and diverting attention to the health and economic front.

In Europe, however, **the coronavirus pandemic could serve to accelerate and reinforce the green transition**. Instead of relegating it to the background, European governments have reinforced their environmental commitment, increasing the ambition of decarbonisation targets for 2030 and making the green transition one of the key pillars of the Recovery Plan.[156] The funds will allow states to carry out far-reaching reforms to reduce emissions and improve their use of resources, which, together with the aforementioned transformation of global value chains, will help limit the rebound effect and provide a perfect opportunity for many companies to adopt more circular and sustainable production formulas. Moreover, the pandemic will remind citizens that human beings are not immune to natural processes, that it is crucial to be guided by scientific knowledge, and that society can implement profound and coordinated changes in a very short time when determined to do so. In this light, **the coronavirus pandemic is set to become the great catalyst for green transition in Europe and in Spain**.

The medium and long term: the environmental crisis after the coronavirus

It is impossible to predict how climate change and environmental degradation will evolve between now and 2050. This will depend on the performance of the global economy, on technological developments in the near future, and on how countries react to the climate emergency, especially major polluters.[157] In recent years, 195 countries have committed to taking the necessary measures to limit the global average temperature increase this century to 2°C above pre-industrial levels, and to do everything possible to ensure that this increase does not exceed 1.5°C. Achieving this goal will not stop climate change from happening (it is already too late for that),[158] but it will help to avoid its most destructive and irreversible effects.

In any case, **uncertainty about compliance with the *Paris Agreement* is very high**.[159] Global greenhouse gas emissions continue to grow and it is difficult to know when they will peak. In fact at the current rate, by 2030 levels of $CO_{2\text{-eq}}$ emissions into the atmosphere will be more than double what they should be[160] and the 1.5°C limit will be exceeded well before 2050.

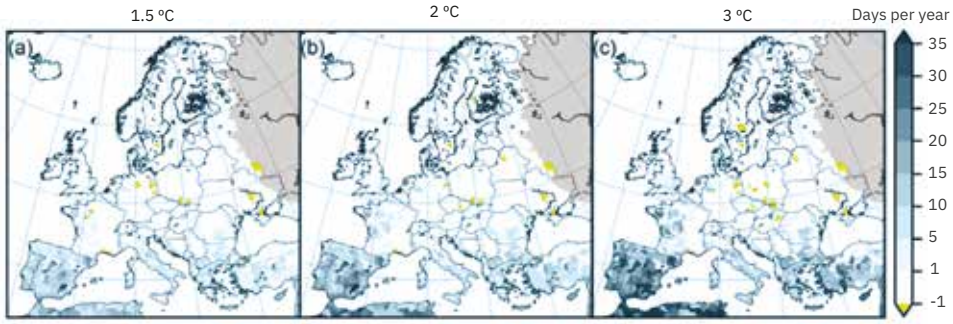
What will happen then? **It is difficult to know**. To offer an approximate prognosis, we take as a reference here **one of the most probable scenarios, although not the most desirable**: one in which, **although the Paris objectives are not fully met by all countries, root and branch reforms are implemented for a moderate reduction in the current rate of emissions, leading to a global temperature increase of around 2ºC by 2050 and 2.5ºC by the end of the century**.[161] In addition to this emissions pathway, there is also a growing trend in the use of natural resources, whose global demand could double in the coming decades,[162] a 70% increase in waste generation[163] and an increase in the amount of plastics dumped into the oceans, which could almost triple by 2040.[164] The sum and interaction of these trends, strongly influenced by others such as global demographic dynamics, changes in lifestyles and technological advances,[165] gives us the future scenario for our country that we present below.

Spain's climate and environment in 2050

The Spain of 2050 will be much warmer, drier and more unpredictable than today.[166] Average temperatures will increase, especially in the interior of the peninsula and the Mediterranean arc. Madrid will have a climate similar to that of Marrakesh and Barcelona's will be similar to that of Tunis.[167] Precipitation will tend to decrease, especially in the southwest and in the archipelagos.[168] The summer will be longer and more intense and droughts will be more frequent and longer,[169] affecting 70% more of the territory than today. At the same time, torrential rainfall events and coastal flooding will increase, potentially affecting more than 50,000 Spaniards by 2050.[170]

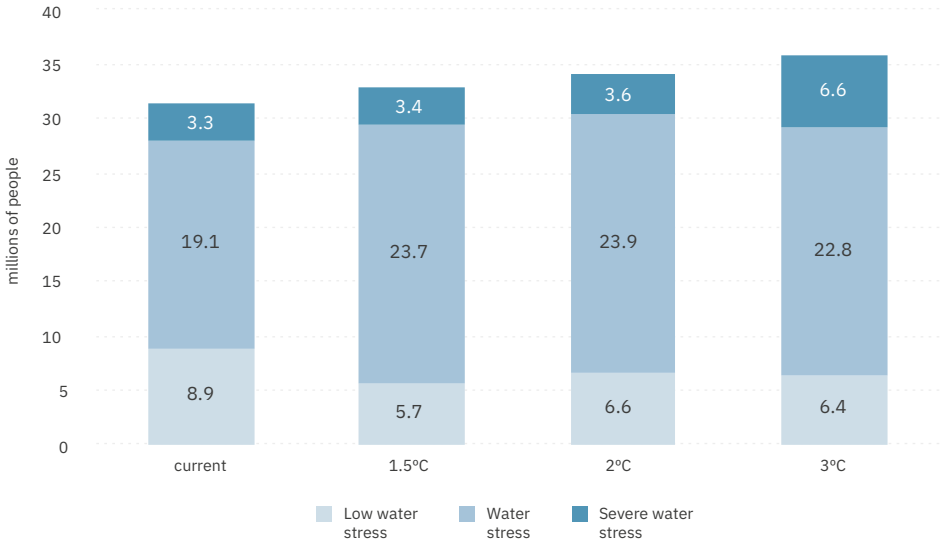
These climate changes will magnify the environmental problems of recent years, starting with one of the most pressing in our country: water stress. **Spain will be one of the countries in Europe whose freshwater availability will be most reduced in the coming decades**[171] [Fig. 18]. Lower rainfall and increased droughts will be accompanied by a decrease in seasonal snow accumulation in mountain areas, in the average flows of our rivers and in the recharge of our aquifers.[172] In addition, there will be a worsening of the quality of our water bodies due to salinisation processes (associated with rising sea levels) and the concentration of pollutants.[173] This reduced water availability will go hand in hand with increased demand due to rising temperatures,[174] and could lead to an **estimated 27 million people living in water-scarce areas of Spain by 2050** [Fig. 19].

Fig. 18. **Projected change in water-scarce days under a 1.5, 2 and 3°C global temperature increase scenario, compared to the current situation**



Source: Bisselink *et al*[175]

Fig. 19. **Population exposed to water scarcity in Spain due to climate change for different scenarios of temperature increase**

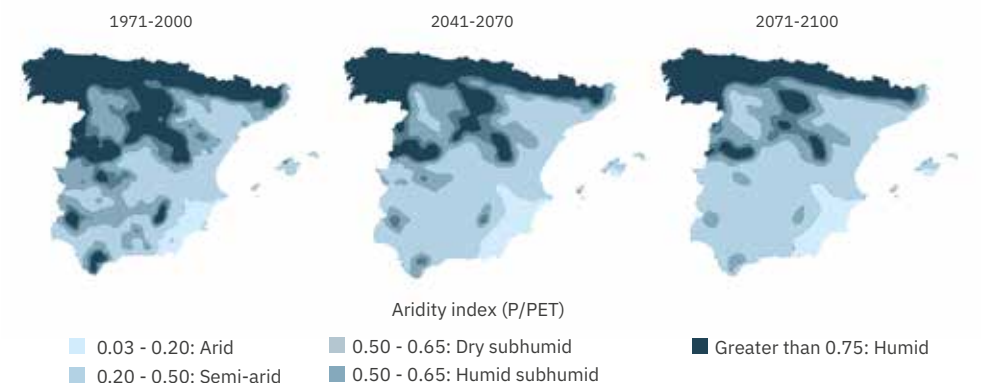


Source: Drafted by the authors based on Bisselink *et al.*[176]

This does not mean that the population will suffer water shortages in their homes, but it does mean that we will have to rethink the way in which we have managed this resource up to now. The development of alternative sources of supply, such as reuse or desalination with renewable energy, should be encouraged; reducing losses in the sewerage and supply network; and ensuring high standards of water quality. “Renewable water" together with more moderate consumption, can help alleviate the pressure on water resources in many parts of our country.

Reduced water availability and rising temperatures will also lead **to the transformation of our ecosystems**, altering some landscapes and destroying others. In 2050, there will be more arid, semi-arid and dry sub-humid areas in Spain, and the area at high risk of desertification will increase considerably [Fig. 20].[177] In the north, the Atlantic forests of Galicia, Asturias or Cantabria will begin to resemble those that exist today on the Mediterranean coast,[178] and Pyrenean tundra coverage will fall by 90%.[179]

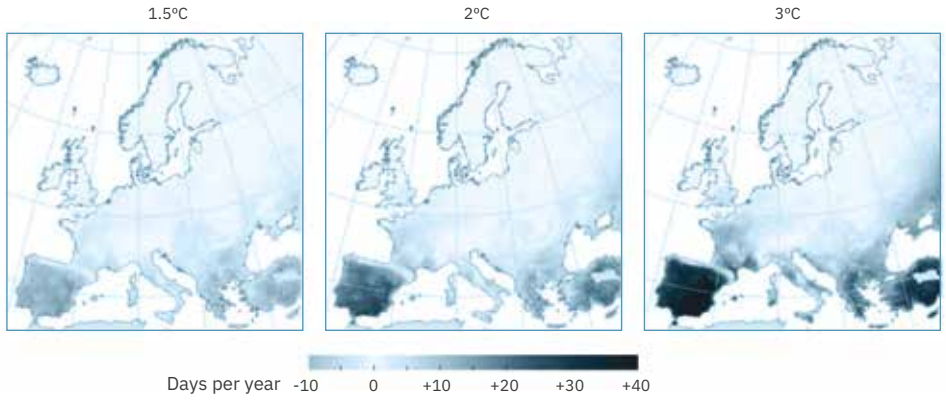
Fig. 20. **Increase in the area of land classified in the highest aridity categories**



Source: MAGRAMA.[180]

Fires may become more frequent and destructive[181] as a result of increased dryness, lack of rainfall and depopulation of rural areas.[182] In fact, **Spain will be one of the EU countries with the highest number of days per year with extreme-high fire danger** [Fig. 21]. This increase in fires, coupled with an increase in other threats (such as pests or windstorms), will seriously endanger our forest ecosystems, threatening human and other species' lives and limiting the important role that forests play in carbon sequestration, soil erosion control, water regulation or timber supply.[183]

Fig. 21. **Number of additional days per year with extreme-high fire danger compared to the current situation**



Source: Costa *et al.*[184]

Climate changes will also **severely affect our agro-ecosystems,** leading to productivity losses in livestock farms[185] and crop fields.[186] These impacts will be particularly important to us, because Spain is the leading exporter of fresh fruit and vegetable products in the EU.[187] In the case of grapes, for example, their quality will be compromised and some varieties will likely no longer be suitable for the areas where they are currently grown.[188] Citrus production, which is of growing value to our economy, could suffer as it is concentrated, above all, in areas that suffer high water stress.[189] In addition, many local species will be lost and new invasive species will emerge.[190] The adoption of various adaptation measures, such as changing the species cultivated, modifying the sowing date, developing more efficient irrigation techniques, or using biotechnological advances will help us to deal with these threats.[191] In some cases, however, these solutions may not be sufficient to avoid the negative impacts mentioned above.

Climate change will also alter much of our country's coastal and marine ecosystems. The rise in sea level (which will be around 17-25 cm by 2050)[192] could lead to the loss of low-lying areas, which will be permanently flooded; the salinisation of numerous aquifers and agricultural soils; and the destruction of wetlands, marshes and estuaries, including some of great ecological value, such as the Ebro Delta and Doñana National Park. Spain will also see many of its beaches affected, not so much directly by the rising sea levels as by the increased frequency of extreme events and coastal erosion that will make it unviable to replenish the sand on many of them.[193] Spanish ports will, in turn, be threatened by strong winds, storm surges and flooding of quays and warehouse areas.[194]

Rising sea levels will be accompanied by **a significant increase in sea surface temperature** along the Spanish coastline, which will be higher along the Mediterranean coast and in the Balearic islands.[195] This increase, coupled with the direct impact of human activity and the progressive acidification of the oceans associated with greenhouse gas emissions, will have severe consequences for fish stocks and marine ecosystems.[196] Over the coming decades, the distribution of many marine species will change and key ecosystems will shrink, like seagrass meadows, which provide food and shelter for millions of fish, reduce coastal erosion and sequester carbon from the atmosphere.[197]

All these environmental changes will have an **immense impact on the Spanish economy and society,** mainly due to the increase in mortality, droughts and coastal flooding,[198] and labour productivity losses, which could be as high as 5% by 2050.[199] All sectors will suffer the consequences, although tourism,[200] agribusiness and, in general, those particularly dependent on environmental conditions and natural resources, will be the most vulnerable.

As a result, the **differences that currently exist between regions specialising in agriculture and industry and those with a greater emphasis on the service sector could widen.**[201] Territorial tensions over water management and access to other natural resources; migration (internal and external);[202] and levels of inequality and poverty could also increase, as the negative impacts of climate change will hit the most disadvantaged and vulnerable people the hardest.[203]

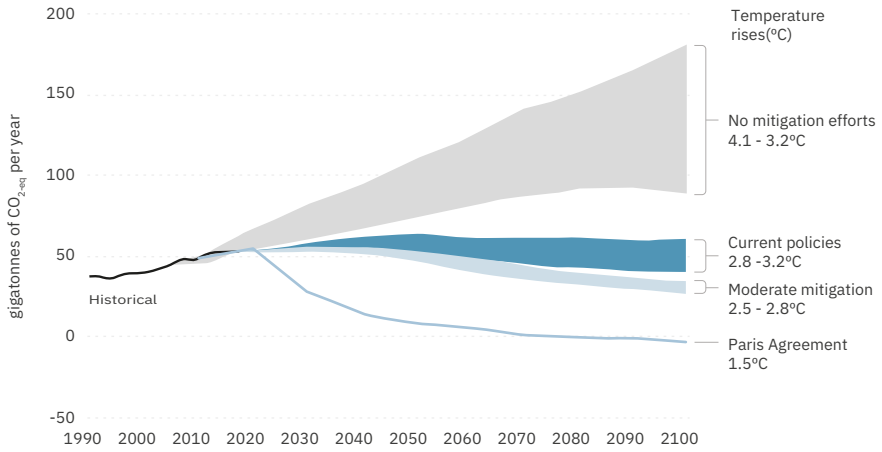
The repercussions on our health will be equally severe. Rising temperatures and heatwaves are expected to kill an estimated 20,000 people per year in Spain in 2050,[204] but this does not mean that cold-attributable mortality will disappear.[205] They will also facilitate the spread of food-borne and animal-borne diseases such as mosquitoes, and make viruses such as dengue, Zika and the Nile virus increasingly common in our territory.[206] Higher temperatures and lower precipitation could also aggravate air pollution, causing harmful elements to stay in the air longer, enhancing the formation of other pollutants (like tropospheric ozone),[207] or increasing the frequency of phenomena such as mega-fires and desert dust storms.[208] In this context, neurodegenerative,[209] water- and food-borne diseases[210] will worsen and the number of people susceptible to pollen allergy will increase significantly.[211] Extreme events and climate change will also have a negative impact on mental health.[212]

In addition to all these harmful effects caused by climate change, there will be further adverse effects from the intensive use of resources. For example, excessive use of drugs in humans, animals and plants will contribute to **antibiotic resistance,**[213] which could cause around 40,000 deaths per year in Spain alone by 2050.[214] In fact, on a global scale, antibiotic-resistant diseases could overtake cancer as the leading cause of death.[215] Other health risks will come from the **overuse of pesticides** and other chemicals,[216] and from the presence in air and water of **microplastics and other emerging pollutants**, the harmful effects of which we are only just beginning to see.[217]

The green transition that Spain will undergo in the coming decades

The impacts described so far correspond, as mentioned above, to a likely scenario of moderate mitigation in which, albeit short of meeting the Paris targets in full in all countries, the global temperature increase will be limited to around 2ºC in 2050 and 2.5ºC in 2100. Achieving this moderate increase will, in any case, not be easy and will be strongly conditioned by the evolution of the world economy, social changes, and technological advances in the coming decades. **In fact, if only current targets and policies are met, global temperature at the end of the century would reach a value close to 3°C above that of the pre-industrial period** [Fig. 22].

Fig. 22. **Projected scenarios for global greenhouse gas emissions and associated temperature increase range**



Source: Drafted by the authors based on data from the Climate Action Tracker Project.[218]

In a room, 0.5°C more or 0.5°C less is practically imperceptible and innocuous. But on a planetary scale and on a sustained basis, **an increase of 0.5° or so could make a crucial difference in the severity and irreversibility of climate impacts**.[219] For southern European countries, limiting the temperature increase to 2°C would halve welfare losses in comparison to a scenario of a 3°C warming. If the increase in temperature can be limited to 1.5°C, it would reduce them by almost 75%.[220]

Time is of the essence. It is therefore essential that all countries of the world take urgent and decisive action to reduce their emissions, to make a more sensible and sustainable use of natural resources and to adapt to a changing climate. This should be done, in any case, with respect for the principles of fairness and the different degrees of responsibility of each party.[221] International cooperation and technology transfer to lower income countries will be essential to achieve this common goal.[222]

Spain is on the right track. Thanks to the efforts (public and private) made in recent years and the recent boost from European recovery funds, **our country is likely to achieve the emission reduction targets set for 2030**,[223] **even in scenarios that are not particularly favourable in terms of technological innovation and economic growth**.[224] We cannot afford, however, to rest on our laurels. **Achieving the goal of climate neutrality by 2050** is a much bigger challenge, **going beyond the adoption of new technologies, and will require a structural transformation of our economy and social patterns** towards low-emission and resource-efficient patterns of living, production and consumption. Moreover, the uncertainty about what climate scenario we will face in the future makes it clear that **we need to dramatically increase efforts to improve our resilience to climate change.**[225]

Thus, **four major transformations** are on the horizon, which must be implemented as soon as possible:

I. The way we generate, store and consume energy will change

By 2050, many of the devices that we power today with fossil fuels (radiators, kitchens, and cars) will run exclusively on electricity from renewable sources. In fact, it is estimated that, by the middle of the century, the ratio of electricity consumption to final energy will double in the EU,[226] and that, in Spain, 100% of electricity will come from renewable sources.[227] This change will not be immediate, nor will it be easy. Spain will have to close its last coal-fired power plants,[228] **bring about a change in consumption habits among citizens** and **greatly improve energy efficiency in all sectors**. It will also be necessary to adapt infrastructures and develop a smart, digitalised and flexible electricity grid throughout the territory; develop energy storage;[229] strengthen the value chain of batteries, ensuring that they are efficient, recyclable and affordable;[230] install recharging points to boost electromobility, and deliver the large-scale roll-out of renewable energy sources.[231]

In this respect, **photovoltaic solar energy** is set to play an essential role over the coming years. Spain is one of the countries in the world with the highest installed solar capacity and among the European countries that receive the most hours of sunshine per year. However, only 6% of the electricity generated in our country comes from photovoltaic solar energy,[232] a proportion that has doubled in the last year but is still lower than in other neighbouring countries (e.g. Germany).[233] One of the avenues for expansion could be the creation of local energy communities[234] and the popularisation of distributed generation through self-consumption photovoltaic installations on rooftops,[235] which would bring numerous benefits for the country as a whole: greater efficiency associated with electricity generation close to consumption, diversification of the players in the electricity sector, awareness of the users of these installations, mobilisation of additional resources for investment in renewables, new jobs, and reduction of the impact of renewable production on the territory [see chapter 6].

Increased investments, advances in innovation and the increase in demand itself have led to a sharp reduction in the costs of renewable energy generation over the last decade. All indications are that this trend will continue in the future, greatly facilitating the energy transition.[236]

Another transformation vector that can play a key role in the decarbonisation of our energy system is the use of **renewable hydrogen**[237] in sectors such as industry and heavy transport, both of which are difficult to electrify.[238] Hydrogen could also be used to store energy from renewable sources to help secure supply when it dominates our energy system. It can be developed through, among other channels, the deployment of electrolysers that convert water into hydrogen using renewable energies, recharging stations for transport vehicles and the construction of the necessary facilities for its use in industry.[239]

There is no doubt that the energy transition will be a major challenge for Spain. Among many other things, it will be necessary to mobilise the necessary financing, transform companies and households, change the vehicle fleet, reduce total energy use, modify our consumption patterns, develop technological solutions, minimise the territorial and environmental impact of photovoltaic and wind installations, and articulate conversion plans to cushion the impact of decarbonisation in certain areas of our country.[240] All this in a context of reduced water availability for hydropower production and more frequent extreme events, which will affect energy systems.[241]

However, **the opportunities that the energy transition will bring are enormous:** we have a high photovoltaic and wind potential, we have leading companies in the field of renewable energies,[242] and several ambitious strategies in place that set the roadmap for the decarbonisation process in the medium and long term. Well executed and accompanied by the modernisation of our productive network [see chapter 1], the transition could generate significant gains in employment and activity, and substantial savings on Spain's annual bill for the import of fossil fuels. The Department for Ecological Transition and the Demographic Challenge has calculated that, with the implementation of the *National Integrated Energy and Climate Plan 2021-2030* (PNIEC) until 2030 and the *Long Term Decarbonisation Strategy* 2050 (ELP), there would be a **net increase in employment of around 250,000 people, on average per year, and an increase in GDP of close to 2% compared to a baseline scenario in 2050**.[243] Reducing our dependence on foreign energy is another major anticipated benefit.[244] By replacing fossil fuels, Spain could save more than 340 billion euros in imports over the next three decades,[245] the equivalent of seven years' worth of public spending on education. In fact, the complete electrification of our current car fleet alone by 2050 would already generate savings of almost 18 billion euros in imports compared to the total volume in 2019.[246]

II. The way we move and transport goods will change

In 2050, there will be **fewer private cars and more car sharing, more bicycles and more public transport** [see chapter 6]. Mobility will be transformed by the massification of the **electric car**, which will become increasingly economical and competitive, and will make up the bulk of the Spanish vehicle fleet by the middle of the century.[247] It is likely that, by then, internal combustion vehicles will still exist, especially in the heavy-duty and long-distance transport sectors. But they will be much more efficient and use less polluting fuels than today.[248]

The advent of the **autonomous vehicle** will only encourage this trend, helping to reduce emissions and traffic, and free up public space in our cities [see chapter 6]. This technology still has several years of development (technical and regulatory) to go, so it is not clear when it will become widespread in Europe, but it is likely that this will start to happen before 2050, at least in certain mobility segments.[249]

The future of road freight transport will depend both on the evolution of production chains and on potential technological developments, the penetration of new fuels and electrification. In road transport, **the lorry** will continue to play a predominant role, at least in the short term, given the advantages it still has over rail (a large and competitive lorry fleet, with an extensive road network, compared to a rail network with few loading bays and terminals and, therefore, little capillarity in the country). In any case, in the medium and long term, **rail** should become more and more competitive, as it is the best way to transport passengers and freight over long distances with lower emissions.[250]

Passenger air transport will also have to undergo a profound transformation.[251] It will have to become much more rational and efficient,[252] with cleaner aircraft that are already being tested.[253]

For **shipping**, which is essential for international trade, non-pollutant technological alternatives have yet to be developed. The International Maritime Organisation estimates that, under a business-as-usual scenario, global emissions from this sector could increase by up to 50% by 2050 compared to 2018 levels.[254] To avoid this, more efficient ships, electric and hybrid ferries, and the widespread use of fuels such as renewable hydrogen, ammonia, biofuels or wind-assisted propulsion will need to be developed.[255] In addition, low-emission zones for shipping will have to be further developed to limit air pollution from ships in coastal areas and port cities.[256]

Given the high degree of uncertainty about the technological future of many alternatives, it is essential to take into account the potential negative costs of committing to the wrong technology.[257] It will also **be important to adapt taxation to the new reality of transport in order to correct its negative externalities**[258] **and establish unequivocal signals that guarantee its decarbonisation in the longterm.**

III. The way we produce goods and services will change

To combat and adapt to climate change, our country will also have to change the way it produces goods and services. This change will be twofold. Firstly, **we will move from a model of linear economy, such as we have now, to a circular one**, in which the value of products, materials and resources is maintained for as long as possible, minimising the generation of waste and making the most of those that cannot be avoided.[259] Secondly, **we will redesign our economy so that more and more services are sold instead of goods**.[260]

In the Spain of 2050, **no municipal waste will be sent to landfill**.[261] This is not an impossible goal. In countries like Switzerland, all municipal waste is recycled or used to produce energy.[262] Virtually all organic products, packaging, household appliances, furniture, clothing and other items will be recyclable and recycled. This will reduce greenhouse gas emissions and pressure on our ecosystems, generating new business and employment opportunities.[263] It will also increase the autonomy and resilience of our production chains by reducing dependence on raw materials sourced from abroad or potentially vulnerable to climate risks. Furthermore, **achieving greater efficiency in the use of materials is essential to preventing the future digital and ecological transition**, which will require greater use of raw materials such as lithium, graphite, cobalt or nickel, **from leading to greater environmental impacts**,[264] and to ensure the country does not replace its foreign dependence for foreign fossil fuels with another foreign dependence for these resources.[265]

Achieving this circularity will take decades and will require the coordinated efforts of businesses, public administrations and households. New manufacturing processes and products that are more durable and rely on secondary raw materials will have to be designed, recycling circuits will have to be highly sophisticated, and the right regulations and tax incentives must be put in place.[266] Innovation ecosystems will be key to these transformations, not only in terms of technology, but also in terms of social innovation, aimed at building alternatives to traditional consumption and production models.[267]

All sectors of our economy will have to adapt. The **tourism sector** will have to drastically reduce its negative externalities,[268] implementing measures to save energy, reduce emissions, protect the environment and contain its consumption of natural resources such as water, especially in those areas where there is a significant concentration of tourists in certain months of the year (bearing in mind that the average water consumption of tourists visiting Spain is between two and six times higher than that of a resident).[269] The sector itself will also have to reformulate its offer to respond to the effects of climate change on the distribution of tourist flows, both in terms of time and territory. Some destinations, such as the north of the peninsula and mountainous areas, could benefit from the new conditions, while others, such as the interior of the peninsula, will be less attractive in certain months of the year, and could experience significant decreases flow of visitors they are accustomed to seeing.[270] In addition, some natural resources that sustain the sector, such as snow, beaches, coastal ecosystems and forests, will see their conditions significantly altered, forcing leisure and tourism companies to innovate in their service provision.

Industry will also have to make major changes, both to reorient itself towards the emerging sectors arising from the green transition, and to reduce its emissions and achieve greater circularity in its processes. The levers that will accelerate the transition will be energy efficiency improvements and the implementation of renewable energy in strategic sub-sectors. The challenge will be particularly great in certain activities that are difficult to decarbonise, such as energy-intensive industries (cement, steel or chemical manufacturing), where the development

of alternative products,[271] less polluting manufacturing processes, offsetting emissions through natural carbon sinks, or the use of technological devices to capture, store and use carbon dioxide will be essential.[272]

The **construction sector** should focus less on the creation of new buildings and more on the rehabilitation, restoration and regeneration of existing ones.[273] Environmental criteria will be key, promoting durability, the reuse and recycling of materials,[274] the use of alternative materials that reduce the carbon footprint, greater presence of green infrastructure (such as roofs or green walls), improved energy efficiency, the installation of systems that allow for better use of resources (such as rainwater harvesting systems), and the promotion of zero-emission housing construction [see chapter 6].

The **agri-food sector** will also undergo a profound transformation in the coming decades. Meeting climate commitments requires drastic changes in food consumption and the food production system, a major source of global emissions that has received little attention to date.[275] Among other things, it will be necessary to adjust the use of fertilisers to the needs of crops; the progressive replacement of traditional synthetic fertilisers with improved fertilisers and animal manures, which promote the circularity of livestock systems;[276] the spread of new production systems (e.g. hydroponic crops and vertical farms); the renewal of agricultural machinery (today mostly fossil), and the introduction of new technologies such as drones, autonomous vehicles, sensors or Artificial Intelligence systems to optimise the use of resources in production systems.[277] This increased technification will be accompanied by a strong re-skilling of agricultural workers and a greater commitment to R&D, but also by a greater role for agro-ecological systems based on traditional knowledge and innovation aimed at offering fair production and consumption alternatives. It will also be essential to improve the use of water resources to ensure greater efficiency and real water savings for rivers and aquifers, through the modernisation of irrigation systems, wastewater treatment and the development of alternative sources of supply, such as water reuse or desalination through renewable energies,[278] an option that could be key for the countryside of the Mediterranean arc.[279] At the same time, the fight against deforestation related to agricultural production[280] and the promotion of the absorption capacity of croplands and pastures should be promoted, which, in addition to contributing to carbon neutrality, will facilitate the regeneration and structuring of the landscape and the protection of biodiversity.[281]

Finally, we must also mention the major transformation that will take place in the **financial sector**.[282] In the coming years, financial institutions will become one of the main catalysts of the climate and environmental agenda, encouraging more responsible and circular practices among their customers, creating incentives for risk prevention and helping to mobilise the more than 200 billion euros in investments that Spain will need to finance the energy transition over the next decade.[283] In addition, climate criteria will be incorporated into the supervision to which these institutions are subject. Change, however, will not come overnight. In this process of adapting the financial business to the sustainability paradigm, institutions will have to find a subtle balance between, on the one hand, reducing their exposure to carbon-intensive activities, which may affect the value of their own investments or the payment capacity of companies operating in these sectors; and, on the other hand, progressively promoting more sustainable businesses, with longer-term maturity processes. In the future, the issuance of green bonds may become a important source of financing for many companies in Spain.[284] In this respect, it will be key to provide more and better information on the greening of financial investments, an area in which the EU is already taking important steps.[285]

IV. The way we consume goods and services will change

For Spain to become a carbon-neutral, climate-resilient, and resource-sustainable society, it **will not be enough to merely transform the way we produce goods and transport them; we must also change the way we consume them**. As we have seen, humanity has already exceeded several of the planet's biophysical limits and, if it remains on its current course, will eventually cause an unprecedented environmental catastrophe.

The transition to a circular economy and technological advances in the future will help to avoid this collapse. However, they will not be enough on their own.[286] **It will also be necessary to reduce the consumption of certain raw materials and products.** This means that, in the coming decades, Spaniards will have to reduce their intake of animal-based foods, the amount of clothing they buy, or the number of new digital devices and household appliances they purchase every year. They will also have to become more restrained in the extent to which they travel (especially when using highly pollutant forms of transport), and keep an eye on the carbon footprint of their consumption beyond national borders.[287]

This reduction in certain forms of consumption will not lead to a worsening of the living conditions or welfare of citizens. In fact, it will probably help to improve them. Numerous studies show that the Spanish population's meat consumption is between two and five times higher than recommended,[288] that 55% change their mobile phone when the previous one is still working,[289] and that energy consumption is much higher than necessary.[290] On a broader level, there is literature showing that higher spending on food, housing, cars or other services is not directly related to a higher level of life satisfaction[291] [see chapter 9].

Nor does this change in consumption patterns necessarily have a negative impact on our activity and employment levels. Less consumption of certain products does not necessarily imply less demand, as the money we no longer spend on certain things (e.g. new clothes) will be spent on others (e.g. sustainable leisure). It should also be borne in mind that virtually all business activities can adapt to survive and even thrive in this new paradigm of sustainability. In 2050, we will eat less animal and ultra-processed products, but we will consume more local, organic and seasonal products. We will buy fewer new appliances and digital devices, but we will use manufacturers' repair and upgrade services more. We will buy fewer new clothes, but will be more involved in buying and selling second-hand clothes, and will require more customised tailoring services. In addition, the clothes we buy will be much more durable than they are now, and will be made from secondary raw materials, such as plastic from packaging or natural fibres extracted from plant waste.[292] **In short, the circular and sustainable economy need not be less dynamic and prosperous than the linear and unsustainable one; quite the contrary.** The key is for our companies (including small ones) to invest in transforming their production systems and business models to an emission-neutral and highly circular scheme as soon as possible, and for consumers to adapt their demand patterns to it.

An unavoidable, urgent transition for all people

All the changes described here will have to take place because without them, the future of the planet will be at risk. We need to prosper in a more balanced way, meeting people's needs within the planetary boundaries.[293] The green transition is an unavoidable obligation that will have to be carried out in an accelerated and, at the same, socially just manner[294] that addresses and seeks

to correct the vulnerabilities and inequalities that exist today among the Spanish population [see chapter 8]. In this context, the training of qualified professionals [see chapters 3 and 7] and a strong commitment to innovation [see chapter 1] will serve as catalysts and will be essential for the impacts achieved to be sustained in the long term.[295]

How can this be achieved? The following pages suggest a number of key measures to move in the right direction.

WHAT NEED TO BE DONE TO RESPOND TO THE CLIMATE EMERGENCY

In the coming decades, **Spain will have to** carry out **profound transformations in order to become a carbon neutral and resource efficient country, with conscious and responsible consumption and production patterns**. The incorporation of the notion of planetary boundaries and broad indicators of well-being into the design, implementation and evaluation of all public policies will be essential for moving in this direction. At the same time, **we will need to increase our resilience to climate change and protect our biodiversity, adapting to emerging risks and changing the way we relate to the natural environment**.[296] This is the only way to minimise the damage caused by environmental degradation and to make the most of the opportunities that emerge from the ecological transition.

For these transformations to materialise, the path set by international agreements and the EU will have to be followed. Spain already has in place an extensive network of institutions, plans and strategies (public and private) that map the path and provide the necessary tools to do so.[297] It is therefore essential that, over the coming years, our country agrees, through a social partnership process, on a **table of measurable indicators and a list of concrete targets** that will allow us to monitor progress and guide the ambition of these reforms.

Here are some suggestions, following the principles outlined in the Introduction to this *Strategy*:

Goal 21. Reduce our greenhouse gas emissions by 90% by 2050, meeting our commitment to achieve climate neutrality by the middle of the century (the remaining 10% will come from the absorption of carbon sinks).

Goal 22. Drive the water transition as an essential pathway for adaptation to climate change, achieving a reduction in total water demand of 5% by 2030 and 15% by 2050.[298]

Goal 23. Reduce primary energy intensity by 36% by 2030 and 63% by 2050 compared to 2015 values, in line with the targets set in the PNIEC (National Integrated Energy and Climate Plan) and the ELP.

Goal 24. All electricity to be generated from renewable sources by 2050, with this percentage reaching 74% by 2030, in line with the targets set in the PNIEC and the ELP.[299]

Goal 25. Strengthen the role of environmental taxation, incorporating criteria that promote a just ecological transition into its design and application. Spain should reach the current average of European countries by 2030, and increase its ambition over the following two decades, in order to ensure that decarbonisation is completed and the circular economy and environmental protection are strongly promoted.

Goal 26. Increase the area of organic agricultural production to 25% by 2030, in line with the EU's *Farm to Fork* initiative,[300] and to 60% by 2050.

Goal 27. Increase wooded forest areas in order to protect biodiversity, improve ecosystem resilience and increase the capacity of carbon sinks, essential to achieving climate neutrality by 2050. Spain should adopt an average reforestation rate of 20,000 hectares per year during the period 2021-2050 (in line with the ELP targets), compared to the current 15,000 hectares.

Scoreboard of indicators and targets

Indicators	Place	Average 2015-2019 or latest data available*	Targets		
			2030	2040	2050
21 GHG emissions (thousands of tonnes of $CO_{2\text{-eq}}$)[301]	Spain	330,640	223,000[302] (-23%)	126,000 (-57%)	29,000[303] (-90%)
	EU-27	n.d.	–	–	–
	EU-8	n.d.	–	–	–
22 Water demand (hm^3/year)[304]	Spain	30,983*	29,434[305] (-5%)	27,885 (-10%)	26,335 (-15%)
	EU-27	n.d.	–	–	–
	EU-8	n.d.	–	–	–
23 Primary energy intensity (kilograms of oil equivalent/ thousands of euros)[306]	Spain	115	73[307] (-36%)	56 (-51%)	42[308] (-63%)
	EU-27	125	–	–	–
	EU-8	122	–	–	–
24 Electricity generated by renewable energy sources (% of total)[309]	Spain	36%	74%[310]	87%	100%[311]
	EU-27	31%	–	–	–
	EU-8	40%	–	–	–
25 Environmental tax (% of GDP)[312]	Spain	1.8%	2.6%	4.0%	5.0%[313]
	EU-27	2.4%	–	–	–
	EU-8	2.6%	–	–	–
26 Organic farming area (% of total cultivated area)[314]	Spain	10%*	25%[315]	43%	60%
	EU-27	8%*	–	–	–
	EU-8	12%*	–	–	–
27 Annual reforestation rate (hectares/year)[316]	Spain	15,103	20,000[317]	20,000	20,000
	EU-27	n.d.	–	–	–
	EU-8	n.d.	–	–	–

To achieve these goals, **Spain will have to undertake far-reaching reforms and launch ambitious initiatives on a number of fronts.** The following suggestions are intended to complement and reinforce national or Community plans and strategies already in place:

Front 1: Consolidate a comprehensive vision of the green transition that, in addition to driving decarbonisation and the circular economy, better exploits the synergies between them

A zero-emissions economy will never be viable without a reduction in the use of energy, materials and products. It is therefore desirable:

- **To establish increasingly specific and detailed decarbonisation and resource use reduction pathways for each sector, with defined time horizons**.[318] The aim is to provide the country with a detailed transformation plan to guide the actions of the public sector, to protect sectors undergoing conversion and to provide some security for private sector investments.[319]

- **To establish a quota obliging companies to achieve a minimum percentage of recycled materials and to reduce the use of resources in their production processes,** following EU guidelines.[320]

- **To create production standards that oblige producers to comply with certain requirements on the shelf life of their products and a minimum duration of guarantees** in line with European regulations in this respect.

- **To simplify materials from the design phase, so as to encourage the marketing of those products with the longest useful life and whose waste has a recovery channel for reuse or recycling.** This will help to increase the availability and ease of use of secondary materials in manufacturing processes.

- **To implement "pay-as-you-throw" waste** as a consumer responsibility measure, which will also be extended to manufacturers, who will be responsible for waste management and bear the full costs associated with it, thus relieving municipalities of this burden. This will make it more feasible to meet the target of reducing the percentage of waste going to landfill [See chapter 6].

- **To encourage the urban green transition**, reducing the consumption of resources in cities and improving their management. Possible measures include the promotion of energy efficiency in housing, the use of renewable energy, the promotion of sustainable water management systems and the reduction of municipal waste generation [see chapter 6].

Front 2: Pay greater attention to the interplay between climate change, environmental degradation and people's health

It is proposed to **incorporate the *One Health* concept**,[321] which emphasises the close relationship between the health of people, animals and ecosystems, into the design of public policies. Taking this holistic view of planetary well-being helps to better understand the pros and cons of each decision and to adopt more coherent, holistic and resilient policies over time.[322]

Front 3: Create a framework of fiscal incentives and instruments to ensure an efficient and socially just green transition

The design of environmental taxation should aim at correcting negative externalities in the environment (both emissions and excessive use of resources), so as to increase the competitiveness of sustainable products and services, while limiting their potential regressive social impact. Over the next decade, Spain should align its environmental revenue collection with the European average, adjusting it thereafter in line with the progress made in the green transition and new externalities that arise along the way.

In addition to implementing the tax measures detailed on the other fronts, it will be necessary:

- **To progressively strengthen environmental taxation to reflect the full social cost of carbon[323] by the middle of the century.** Taxes on energy and transport will be particularly important, given the considerably lower weight of these taxes in Spain compared to neighbouring European countries.[324]

- **To promote an accelerated rate of reduction in emissions allowances traded in the EU Emissions Trading Scheme (EU ETS)**, with the aim of ensuring an ambitious fall in emissions over the next decade.

- **To promote measures, at national and European level, to ensure that all sectors take into account the negative externalities of carbon emissions.** In the various sectors (e.g. transport, agri-business, household or service sectors), currently outside the carbon market, a taxation scheme will be promoted to ensure their timely decarbonisation. Support should also be given to the implementation of mechanisms that incentivise reductions in emissions beyond the borders of each country, for example with the establishment of the carbon border adjustment mechanism.[325]

- **To establish compensatory measures to mitigate the potential regressive effects of higher environmental taxation or higher carbon prices.** Among the options available, climate rent is one that could be explored, a mechanism designed to return part of the proceeds from green taxes to the population.[326] That rent would help mitigate asymmetries in transition costs, facilitate the acceptance of higher environmental taxation, and correct the inequality-generating effects of these taxes. Another option is the creation of a **Climate Justice Resilience Fund, complementary to Just Transition funding sources**,[327] to protect and assist those people, communities and sectors that could be most affected by both the ecological transition and the direct effects of climate change.

Front 4: Foster innovation in the energy and ecological transition

– **Substantially increase R&D funding for decarbonisation and sustainability**, following the principles set out in Chapter 1 of the Strategy. Key areas to be prioritised include electrification of production and transport, circular economy processes (in particular water management), renewable energy storage technologies, development of hydrogen and other low-carbon fuels, nature-based solutions and social innovation. It will also be necessary to i**ncorporate a more comprehensive and longer-term vision** that provides working with longer investment and review cycles, and to increase the tolerance for failure, which is particularly relevant for innovations in the climate and energy fields.[328] In this respect, new institutions with a more risk-taking culture, such as the US *Advanced Research Projects Agency-Energy* (ARPA-E), could be envisaged.[329]

– **Support eco-innovation in SMEs**, given their relative importance in our productive network.[330]

Front 5: Transform mobility, reducing emissions from the Spanish transport sector to 2Mt[331] by 2050

It will be essential to pay particular attention to inter-urban road freight and passenger transport, the main contributors to emissions in this sector.[332]

– **Stimulate a shift in transport usage,** favouring alternatives to private car use such as active transport and public transport.[333]

– **Ensure the replacement of internal combustion vehicles (petrol and diesel) with zero direct CO_2 emission vehicles.** To this end, it would be advisable to:

  • Develop a cross-sector strategy that facilitates the creation of the ecosystem required by the electric car, promoting the domestic manufacture of this type of vehicle; promoting the production, reuse and recycling of batteries; increasing the number of fast charging points and promoting the purchase of these vehicles, taking into account the possible distributive implications of these types of subsidies.[334]

  • Progressively raise tax rates on diesel and petrol until both are equal to the average petrol tax rate in the EU-8.[335]

– **Adjust road transport taxation to the actual use of the vehicle**, addressing all negative impacts generated and ensuring greater consistency between the type of vehicle purchased and the needs of the service. To this end, it is proposed to move from the current purchase, circulation, and fuel taxes to a tax on the actual measured use of the vehicle, taking into account its characteristics: weight, power and emissions of atmospheric pollutants and greenhouse gases.

– **Improve the rail network for freight and passenger transport.** For freight, it is necessary to extend the electrification of the rail network, to use hybrid trains with renewable hydrogen for non-electrified sections, to increase the efficiency of inter-modal terminals, and to incorporate rail at those ports and airports that do not currently have connections. In terms of passenger transport, it is necessary to extend existing suburban networks,[336] modernise non-high-speed lines, relaunch night train services, update and finalise cross-border connections[337] and promote demand by applying a fair fare system that takes into account the lower environmental and health impact of rail compared to other means of transport.

– **Reduce the environmental impact of air transport** by introducing a frequent flyer tax or by taxing air fares according to the proximity of the destination. This will help to limit negative externalities and bring taxation of the sector into line with other modes of transport.[338] It is also recommended that flights be banned on journeys that can be made by train in less than 2.5 hours.

– **Transform urban and metropolitan mobility**, in line with the measures outlined in chapter 6.

Front 6: Manage water resources adequately, preparing the system for a future where there is less water availability

By 2050, Spain should have overcome the threat of water stress. To achieve this, Spain should adopt an integrated water management strategy that, in addition to the measures contained in the already approved state plans,[339] delivers the following:

– **Encourages water reuse and desalination** until the price of water is competitive, i.e. similar to the price of water from traditional sources (e.g. dams).

– **Improves the efficiency of urban supply, agricultural irrigation and drinking water and wastewater treatment systems by modernising infrastructures and introducing new technologies** such as sensors and big data, which make it possible to detect leaks and abuses almost immediately, monitors the water needs of crops in real time, controls the use of fertilisers and pesticides, and measures water quality.

– **Reorganises agricultural uses and crops**, acting on the current concession regime and prioritising sustainable and socially just agriculture.

– **Modifies the economic and financial regime of the Water Law, based on the "polluter pays" principle**. The aim should be to increase the level of recovery of public investments, to introduce taxes on certain water uses that generate pressures on the environment, and to integrate the risks to water availability caused by climate change, so that the cost of the service can cover the costs arising from the adaptation and modernisation of the infrastructure that will have to be delivered over the coming decade.

– **Increases the resilience of agricultural holdings** so that they can better adapt to climate change and water deficits, and recover more quickly from adverse situations such as droughts. This means promoting the transformation of crops and production systems, improving farm management training, and creating appropriate financial and governance mechanisms.

– **Implements an ambitious strategy for the restoration of rivers, aquifers and other inland aquatic ecosystems, and strengthen the network of river reserves and other protected areas**. Measures must also be introduced to ensure that water is returned to watercourses with a level of quality equal to or even batter than when it was collected.

Front 7: Move towards sustainable and healthy agri-food systems

– **Make sustainable livestock production systems linked to the territory universal**, such as extensive meadow and pastoral systems.

– **Promote a national programme to promote healthy and sustainable eating habits** in line with WHO guidelines and the recommendations of the scientific community.[340]

– **Develop a National Plan for the reduction of food waste** following the path set out in the *Spanish Strategy 2017-2020. More food, less waste*,[341] with the aim of reducing the amount of food wasted in Spain by 50% by 2050. Such a plan should build on the previous initiatives of the National Environmental Education Centre[342] and involve all stakeholders in the agri-food chain, from production to consumption, distribution, and sales.

– **Establish mandatory food labelling with information on environmental impact**, as France[343] and the UK[344] have already done, so that citizens can easily find information on the carbon footprint, nitrogen footprint, water and energy use of the products they consume, including the impacts produced outside our country.

– **Reduce the environmental impact of the meals offered in public institutions,** incorporating the sustainability and health criteria recommended by international organisations such as the WHO, the FAO and the IPCC into tender specifications for catering companies and encouraging the incorporation of vegetarian and vegan options on a daily basis.

Front 8: Reduce the risk of forest fires and improve the adaptive and sustainable management of our forests[345]

- **Reduce the volume and connectivity of forest fuel** through measures that incentivise good management through economic incentives or the promotion of agricultural and forestry insurance. The maintenance of agricultural areas adjacent to rural populations should also be developed for their protective role against fire, and extensive grazing and agro-forestry landscapes should be promoted as a management tool in high-risk areas, using, for example, programmes for the settlement of young people in rural environments.

- **Encourage the development of the forestry economy**, adapting the regulation of forest exploitation and offering commercial outlets for forestry products and other complementary products such as wild mushrooms, honey, vegetable fibres and aromatic and medicinal plants. To this end, it would be advisable to expand sustainable forest certification programmes and to promote the exchange of plots of land or abandoned land banks, already in use in some autonomous communities.[346]

- **Improve training in controlled burning for agriculture and forest management** in order to regulate and limit the use of fire under strict conditions, reducing the risk and severity of fires, and improving ecological parameters such as the quality of wildlife habitat or the promotion of plant species suitable for the pasture.[347]

- **Use the restoration of burned forests to promote fire and climate change resilient landscapes**, encouraging post-fire recovery measures focused on reducing erosion of the burned area, preserving water quality, and preventing the spread of invasive species.

- **Introduce fire risk as a criterion in urban planning and construction design in Forestry-Urban Interface (IUF) areas,** taking into account the compulsory creation and maintenance of safety perimeters in housing developments and homes surrounded by, or very close to, forest areas, establishing contingency plans for the defence and/or evacuation of these areas, and providing training courses for technical staff and rural inhabitants on how to respond in the event of fire.

Front 9: Manage our coasts and marine areas adequately to make them more sustainable and resilient to climate change

- **Promote the development of a "blue economy" based on the sustainable use of coastal and marine resources**. Among the many opportunities in our country are the generation of marine-based renewable energy (from waves and currents, off-shore wind and hydrogen production), the development of genetic and biotechnological products, and foodstuffs in growing demand, such as seaweed.

- **Decisively and forcefully tackle the transformation of sectors such as fisheries, aquaculture, maritime transport, and tourism**, in order to reduce their high environmental impact and achieve greater sustainability in these sectors.

- **Increase the resilience of our coastal and marine infrastructures and human settlements located on the coast**, using infrastructures, new technologies and nature-based solutions, such as the regeneration or restoration of salt marshes, posidonia meadows, dune systems and beaches.

- **Promote regulatory measures aimed at reducing societal action on the coast and in the marine environment.** Among others, it is proposed to expand marine reserve areas and to stimulate the restoration of ecological connectivity in degraded areas.

Front 10: Improve the environmental education of citizens

None of the above-mentioned measures will work if Spanish citizens do not know, understand or accept the challenges that climate change will bring and the imperative need to adapt our society to a low-emission, resource-sustainable and resilient model. For this reason, it will be essential to **promote environmental education for people throughout the life cycle**, following the lines of work set out in the *Environmental Education for Sustainability Action Plan*[348] drawn up by the Department for Ecological Transition and the Demographic Challenge and the example of countries such as Finland [see chapter 2].

Front 11: Strengthen public institutions so that they can continue to develop effective, comprehensive and ambitious policies, and foster partnerships between the public sector, the private sector and civil society

The green transition is a systemic process that can only be completed with the leadership of the public sector and EU and international bodies. It is therefore essential to **further strengthen the capacity of our public institutions**, so that they can expand their legislative and research activity, establish increasingly concrete and smart adaptation, decarbonisation and resource use reduction pathways, and promote transformations through their own mechanisms, such as innovative and sustainable public procurement [see chapter 1], auctions, co-financing, and fiscal incentives.

In this regard, it is recommended to strengthen the role of **the Spanish Climate Change Office or, alternatively, to consider the creation of an Environment and Climate Agency**, following the model of the UK's Environment Agency or France's *Agence de la transition écologique*.[349] Coordination between the different levels of public administration should be reinforced, public-private partnerships should be strengthened, and the availability and quality of statistical information should be improved.

CHALLENGE 4: BECOMING A CARBON-NEUTRAL, SUSTAINABLE AND CLIMATE-RESILIENT SOCIETY

[1] Steffen, W., *et al*. "The Anthropocene: conceptual and historical perspectives." *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences* 369, nº. 1938, 2011. https://doi.org/10.1098/rsta.2010.0327; and Steffen, W., *et al*. "The Trajectory of the Anthropocene: The Great Acceleration." *The Anthropocene Review* 2, n.º 1, 2015. https://doi.org/10.1177/2053019614564785.

[2] Variation between 1950 and 2020. For further details, see: United Nations. *Total Population by sex (thousands).* https://population.un.org/wpp/DataQuery/.

[3] Variation between 1950 and 2015. For further details, see: Our World in Data. *PIB mundial ajustado por inflación. Based on New Maddison Project Database and World Bank.*. https://ourworldindata.org/grapher/world-gdp-over-the-last-two-millennia?tab=table.

[4] Variation between 1950 and 2020. For further details, see: United Nations. *Life expectancy.* https://population.un.org/wpp/DataQuery/.

[5] Extreme poverty defined as living on less than 1.90 international dollars per day. International dollars are adjusted for price differences among countries and for inflation. Variation between 1950 and 2015. For further details, refer to: Our World in Data. *World population living in extreme poverty, 1820-2015. Based on Ravallion, 2016 and World Bank.* https://ourworldindata.org/grapher/world-population-in-extreme-poverty-absolute.

[6] Up to 2017. For further details, refer to: International Resource Panel. *Global Resources Outlook 2019: Natural Resources for the Future We Want.* Nairobi: United Nations Environment Programme, 2019. https://www.resourcepanel.org/reports/global-resources-outlook.

[7] Up to 2014. Interpolación lineal en años sin datos. For further details, refer to: Hannah Ritchie. *Water Use and Stress 1950-2014. Based on World Bank and Global International Geosphere-Biosphere Programme.* https://ourworldindata.org/water-use-stress.

[8] Up to 2018. For further details, refer to: Global Carbon Atlas. *Country emissions 1970-2018.* Data for 2017 and 2018 are preliminary. http://www.globalcarbonatlas.org/en/CO2-emissions.

[9] Global Footprint Network. "World footprint." Global Footprint Network, https://www.footprintnetwork.org/our-work/ecological-footprint/#:~:text=World%20Footprint&text=Today%20humanity%20uses%20the%20equivalent,we%20use%20in%20a%20year.

[10] Of the 9 planetary boundaries (or basic earth processes), we have exceeded four of them: climate change, biodiversity, land use change and biogeochemical flows. For three others, we are still in the safe zone: stratospheric ozone depletion, freshwater use and ocean acidification; and two others have not been quantified: atmospheric aerosol loading and the introduction of new entities. On this question, see: Rockström, J., *et al.* "Planetary boundaries: exploring the safe operating space for humanity." *Ecology and Society* 14, n.º 2, 2009. https://doi.org/10.5751/ES-03180-140232; and Steffen, W., *et al.* "Planetary boundaries: Guiding human development on a changing planet." *Science* 347, n.º 6223, 2015. https://doi.org/10.1126/science.1259855.

[11] On this question, see, among others: Ceballos, G., *et al.* "Accelerated modern human-induced species losses: entering the sixth mass extinction." *Science Advances*, n.º 5, 2015. https://doi.org/10.1126/sciadv.1400253; and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. E. S. Bonn: IPBES secretariat, 2019. https://ipbes.net/global-assessment.

[12] On this question, see, among others: IPCC. *Climate change 2013: the physical science basis: contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge: Cambridge University Press, 2013. https://www.ipcc.ch/report/ar5/wg1/; and Ripple, W. J., et al. "World scientists' warning to humanity: a second notice." *BioScience* 67, n.º 12, 2017. https://doi.org/10.1093/biosci/bix125.

[13] The data in the figure are from the following sources: World population: United Nations. *Total population by sex.* https://population.un.org/wpp/DataQuery/; Global GDP: Roser, Max. *Economic Growth. A partir de Banco Mundial y New Maddison Project Database. 2011 USD ajustado por inflación.* Https://ourworldindata.org/economic-growth;; Global exports: Ortiz-Ospina, Esteban, and Diana Beltekian. *Trade and Globalization. Based on Federico, Giovanni and Antonio Tena-Junguito. "A tale of two globalizations: gains from trade and openness 1800-2010."* London: Centre for Economic Policy Research, 2016. *Value of overall exports in constant prices relative to 1913.* https://ourworldindata.org/trade-and-globalization; Energy consumption: Ritchie, Hannah. *Energy. Based on Statistical Review of World Energy and Vaclav Smil. Energy Transitions: Global and National Perspectives. ABC-CLIO, LLC, 2017. Energía primaria directa. Interpolación lineal en años sin datos*. https://ourworldindata.org/energy; Water consumption: Ritchie, Hannah. *Water Use and Stress. Based on World Bank and Global International Geosphere-Biosphere Programme. Interpolación lineal en años sin datos.* https://ourworldindata.org/water-use-stress; Extraction of fossil fuels and non-metallic minerals: WU Vienna. *Material flows by material group 2020*. http://www.materialflows.net/visualisation-centre/data-visualisations/?_inputs_&sidebar=%22bar_chart_1%22; Nitrogen fertiliser consumption: Roser, Max, and Hannah Ritchie. *Fertilizers. A partir de FAO.* https://ourworldindata.org/fertilizers; and CO_2 Emissions: Global Carbon Atlas. *Emissions. Data for 2017 and 2018 are preliminary.* www.globalcarbonatlas.org.

[14] G20 members generate 75% of global greenhouse gas (GHG) emissions. For further details, refer to: United Nations Development Programme. *Informe sobre la disparidad en las emisiones de 2019*. Nairobi, 2019. https://wedocs.unep.org/bitstream/handle/20.500.11822/30798/EGR19ESSP.pdf?sequence=17.

[15] Since 2005, aviation emissions have increased by 70%, now accounting for more than 2% of GHG global emissions. For further details, refer to: European Commission. "Reducing emissions from aviation." European Commission, https://ec.europa.eu/clima/policies/transport/aviation_en; y Ritchie, Hannah, and Max Roser. *Annual total CO_2 emissions, by world region. Based on Carbon Dioxide Information Analysis Center and Global Carbon Project.* https://ourworldindata.org/

grapher/annual-co-emissions-by-region?time=earliest..latest.

[16] Interpolación lineal en años sin datos. The acronym BRICS refers to Brazil, Russia, India, China and South Africa. See: Ritchie, Hannah. *Water Use and Stress 1950-2014. Based on World Bank and Global International Geosphere-Biosphere Programme.* https://ourworldindata.org/water-use-stress.

[17] Ritchie, Hannah, and Max Roser. *Annual total CO_2 emissions, by world region. Based on Carbon Dioxide Information Analysis Center and Global Carbon Project.* https://ourworldindata.org/grapher/annual-co-emissions-by-region?time=earliest..latest.

[18] The ecological footprint measures the area of land and water that a population or activity requires to produce the resources it consumes and absorb the waste it generates. In this study, we include in the ecological footprint CO emissions, the extent of fishing grounds, urbanised land, crop land, forest and grazing land, related to five basic consumption components: food, housing, mobility, goods and services. The ecological footprint is measured in global hectares, and is compared to "biocapacity," which is the capacity of ecosystems to regenerate what people or an activity demand from it. If the ecological footprint exceeds the biocapacity, an "ecological deficit" situation arises. For further details, refer to: Global Footprint Network. "Glossary." Global Footprint Network, https://www.footprintnetwork.org/resources/glossary.

[19] One example of this is food waste. In Spanish households, around 4.3% of the amount of food purchased is wasted, of which almost 90% are unprocessed products (wasted as bought), generating a water footprint of more than 130 litres per person per day. For further details, refer to: Blas, A., Alberto Garrido, and Bárbara Willaarts. "Food consumption and waste in Spanish households: Water implications within and beyond national borders." *Ecological Indicators* 89. 2018. https://doi.org/10.1016/j.ecolind.2018.01.057; and Government of Spain. *Plan de acción para la implementación de la Agenda 2030: Hacia una Estrategia Española de Desarrollo Sostenible.* Madrid, 2018. https://www.agenda2030.gob.es/recursos/docs/Plan_de_Accion_para_la_Implementacion_de_la_Agenda_2030.pdf.

[20] Global Footprint Network. *Country trends. Spain. Ecological Footprint (number of earths), 1961-2017.* http://data.footprintnetwork.org/#/countryTrends?cn=203&type=earth.

[21] Calculated from countries' total emissions data, as reflected in their National Inventories. These inventories do not consider emissions produced outside the territory, associated with the consumption of imported products. For example, the agri-food sector of our country produces a high amount of GHGs in other countries in the process of generating animal feed, also associated with high deforestation. For further details, refer to: European Commission. *The impact of EU consumption on deforestation: Comprehensive analysis of the impact of EU consumption on deforestation*. Luxembourg: Publication Office of the European Union, 2013. https://doi.org/10.2779/822269.

[22] Department for Ecological Transition and Demographic Challenge *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2018*. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/Inventario-GEI.aspx.

[23] Emission intensity (the rate at which pollutants are emitted during an activity) shows a reduction from 371 tonnes of carbon dioxide equivalent per million euros of GDP in 2008 to 264 tonnes in 2019. See: Eurostat. *GDP and main components (output, expenditure and income). [nama_10_gdp]; y Greenhouse gas emissions by source sector 1990-2018 [env_air_gge]* (GEI no incluye "usos del suelo, cambios de usos del suelo y silvicultura" ni "memorandum items"). https://ec.europa.eu/eurostat/data/database.

[24] The EU-8, EU-27 and OECD are constructed as the weighted average of the values of the individual countries, with population being the reference for the calculation of weights. Data are provisional. See: Global Carbon Atlas. *Territorial Per capita (tCO_2/person).* http://www.globalcarbonatlas.org/en/CO2-emissions.

[25] The EU-27 is the value reported by Eurostat. The EU-8 is the sum of the values of the individual countries. See: Eurostat. *Greenhouse gas emissions by source sector 1990-2018 [env_air_gge]. (Does not include "land use, land use change and forestry" nor "memorandum items").* https://ec.europa.eu/eurostat/data/database.

[26] For further details, refer to: Burck, J., *et al. Climate change performance index. Resultados 2020*. 2019. https://www.climate-change-performance-index.org/sites/default/files/documents/ccpi-2020-resultados_-_los_principales_resultados_del_indice_de_desempeno_frente_al_cambio_climatico_2020.pdf; and Camargo, J., *et al.* "Mind the climate policy gaps: climate change public policy and reality in Portugal, Spain and Morocco." *Climatic Change* 161, 2020. https://doi.org/10.1007/s10584-019-02646-9.

[27] Gago, A., *et al. Impuestos energético-ambientales en España: situación y propuestas eficientes y equitativas*. Fundación Alternativas, 2019. https://www.fundacionalternativas.org/public/storage/publicaciones_archivos/58ce043c930b1da7b5d92cffac6f5215.pdf.

[28] Conchado, A., Laura Díaz Anadón, and Pedro Linares. *Innovación en Energía en España: Análisis y Recomendaciones*. Economics for Energy y Belfer Center for Science and International Affairs, 2013. https://eforenergy.org/docpublicaciones/informes/Informe_2012.pdf.

[29] Arbués, F., Jaime Sanaú, and José Mª Serrano. "El precio del agua en las ciudades: efectos del modelo de gestión." In Luis Caramés Viéitez (dir.). Madrid: Funcas, *Economía de las ciudades. Papeles de Economía Española,* n.º 153, 2017. 48-64. https://www.funcas.es/wp-content/uploads/Migracion/Articulos/FUNCAS_PEE/153art05.pdf.

[30] The EU-8 is calculated as the simple average of the values of the individual countries. For further details on the construction of the EU-8, see the Metodologic Note number I. See also: Eurostat. *Environmental Tax Revenues [env_ac_tax].* https://ec.europa.eu/eurostat/data/database; and Steffen, W., *et al. Impuestos energético-ambientales en España: situación y propuestas eficientes y equitativas*. Fundación Alternativas, Documento de Trabajo Sostenibilidad, n.º 2, 2019. https://www.fundacionalternativas.org/public/storage/publicaciones_archivos/58ce043c930b1da7b5d92cffac6f5215.pdf.

[31] Eco-innovation means any form of innovation that represents a major advance towards the target of sustainable development. The European Commission's "Eco-innovation Index" is a composite index that assesses a country's performance, considering aspects such as investment, patents and publications, material and emissions intensity in the economy, and the socio-economic impacts of eco-innovation. Spain's score in the "Eco-innovation Index" was 104 in 2019, slightly

above the EU average (100) but below the EU-8 average (124). Moreover, over the last decade, our country has not managed to climb up the European ranking. The EU-28 country with the highest score was Luxembourg (165) and the lowest score was Bulgaria (34). For further details, see: European Commission and Eco-Innovation Observatory. *EU Eco-Innovation Index 2019*. 2019. https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/eio_brief_eu_eco-innovation_index_2019.pdf.

[32] On this question, see, among others: Conchado, A., Laura Díaz Anadon, and Pedro Linares. *Innovación en Energía en España: Análisis y Recomendaciones*. Economics for Energy y Belfer Center for Science and International Affairs, 2013. https://eforenergy.org/docpublicaciones/informes/Informe_2012.pdf; and Pérez Fernández de Retana, Maialen. *Eco-innovation in Spain. EIO Country Profile 2016-2017*. European Commission, 2018. https://ec.europa.eu/environment/ecoap/sites/ecoap_stayconnected/files/field/field-country-files/spain_eio_country_profile_2016-2017_0.pdf.

[33] Eurostat. *Total GBAORD by NABS 2007 socio-economic objectives [gba_nabsfin07]*. https://ec.europa.eu/eurostat/data/database.

[34] Energy intensity is defined as the ratio of energy consumption per unit of output (GDP), and emissions intensity or carbon intensity is defined as the ratio among the emissions per unit of energy produced. See: Díaz, Antonia, Gustavo A. Marrero, and Luis A. Puch. "Cambio climático, crecimiento económico y el papel de las tecnologías energéticas." In Javier Andrés (coord.). *Crecimiento Económico.* Madrid: Funcas, Papeles de Economía Española, n.º 164. 2019. 120-133. https://www.funcas.es/wp-content/uploads/2020/08/PEE164art09.pdf; y Serrano-Puente, Darío. "Are we moving towards an energy-efficient low-carbon economy? An input-output LMDI decomposition of CO_2 emissions for Spain and the EU28." *Banco de España, Documentos de Trabajo*, n.º 2104. 2021. https://www.bde.es/f/webbde/SES/Secciones/Publicaciones/PublicacionesSeriadas/DocumentosTrabajo/21/Files/dt2104e.pdf.

[35] Department for Ecological Transition and Demographic Challenge *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2019.* Madrid, 2021. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/documentoresumeninventariogei-ed2021_tcm30-524841.pdf.

[36] Eurostat. *Complete energy balances [nrg_bal_c]; Energy intensity [nrg_ind_ei]. Energy intensity of GDP in chain linked volumes; GDP and main components (output, expenditure and income). [nama_10_gdp];* and *Greenhouse gas emissions by source sector 1990-2018 [env_air_gge]* (GHG does not include "land use, land use change and forestry" nor "memorandum items");https://ec.europa.eu/eurostat/data/database.

[37] Urban transport accounts for only 35% of energy consumption and emissions from land transport in Spain, with interurban transport being the main contributor to emissions in this sector. See: Economics for Energy. *Estrategias para la descarbonización del transporte terrestre en España. Un análisis de escenarios.* Vigo, 2021. https://eforenergy.org/docpublicaciones/informes/informe_transporte.pdf.

[38] Between 1990 and 2018, emissions associated with transport in our country increased by 54%, almost double the average increase in the EU-28 over the same period. In the period 2013-2018, the increase in emissions in the sector was 13%, compared to a 3% increase in total emissions. For further details, refer to: European Environment Agency. *Evolution of GHG emissions from transport in the EU-28*. Https://www.eea.europa.eu/data-and-maps/daviz/evolution-of-ghg-emissions-in-2#tab-chart_2;; and Department for Ecological Transition and Demographic Challenge. *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2018.* https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/Inventario-GEI.aspx.

[39] European Environment Agency. *Annual European Union greenhouse gas inventory 1990–2017 and inventory report 2019.* Copenhague, 2019. https://www.eea.europa.eu/publications/european-union-greenhouse-gas- inventory-2019.

[40] This increase has prevented greater fuel efficiency from translating into lower emissions. Sanz, Alfonso, Pilar Vega, and Miguel Mateos. *Las cuentas ecológicas del transporte en España*. Madrid: Ecologistas en Acción and Grupo de Estudios y Alternativas, 2014. https://spip.ecologistasenaccion.org/IMG/pdf/info_cuentas-ecologicas.pdf.

[41] European Commission. *Taxation Trends in the European Union*. Luxembourg: Publications Office of the European Union, 2019. https://ec.europa.eu/taxation_customs/sites/taxation/files/taxation_trends_report_2019.pdf.

[42] Such as the "Plan de Fomento de las Energías Renovables (2000-2010)" approved in 1999, and the "Plan de Energías Renovables 2005-2010", approved in 2005. See: Department of Science and Technology. *Plan de Fomento de las Energías Renovables en España 2000-2010*. Madrid, 1999. https://www.idae.es/uploads/documentos/documentos_4044_PFER2000-10_1999_1cd4b316.pdf; and Department of Industry, Commerce and Tourism. Plan de Energías Renovables en España 2005-2010. Madrid, 2005. https://www.idae.es/uploads/documentos/documentos_PER_2005-2010_8_de_gosto-2005_Completo.(modificacionpag_63)_Copia_2_301254a0.pdf.

[43] According to Red Eléctrica de España, 43% of electricity generation in 2020 was renewable, compared to 20.7% in 2007. The share of primary energy generated from renewables has also increased from 8.3% in 2004 to 18% in 2019. For further details, see: Eurostat. *Share of energy from renewable sources [NRG_IND_REN].* https://ec.europa.eu/eurostat/databrowser/view/NRG_IND_REN__custom_238329/default/table?lang=en; and Red Eléctrica de España. *Evolución de la generación renovable y no renovable (%)*. https://www.ree.es/es/datos/generacion/evolucion-renovable-no-renovable.

[44] International Energy Agency. *Review and analysis of PV self-consumption policies*. 2016. https://iea-pvps.org/wp-content/uploads/2020/01/IEA-PVPS_-_Self-Consumption_Policies_-_2016_-_2.pdf; and European Parliament. *Solar energy policy in the EU and the Member States, from the perspective of the petitions received*. Bruselas, 2016. https://www.europarl.europa.eu/RegData/etudes/STUD/2016/556968/IPOL_STU(2016)556968_EN.pdf.

[45] The other two sectors that, together with transport and electricity generation, account for most of the country's emissions are industry and agriculture and livestock farming. Industry is the second largest greenhouse gas emitting sector, accounting for 20% of emissions in 2018, similar to the EU-27 average (18%). The minerals industry, due to cement production, is the largest emitter, followed by the chemical and metal industries. Since 1990, emissions in this sector

have declined slightly due to efficiency gains and a shift in the relative weight of the different industries in this sector, partly due to the effects of the economic crisis of 2008 and 2012. The agriculture and livestock sector is the fourth largest emitter. In the case of agricultural production, almost half of the emissions are associated with the production and use of fertilisers, in addition to emissions linked to irrigation and the high use of fossil fuels for mechanical traction. In the livestock sector, emissions are now seven times higher than at the beginning of the last century. This increase is a response to changing dietary patterns and the sector's transition towards industrialisation of production systems. For further details, refer to: Department for Ecological Transition and Demographic Challenge *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2018*. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/Inventario-GEI.aspx.

[46] Department for Ecological Transition and Demographic Challenge *Informe de seguimiento de Planes Hidrológicos y Recursos Hídricos en España. Año 2018*. Madrid, 2019. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/memoria_infoseg_2018_tcm30-482594.pdf.

[47] On this question, see, among others: Aguilera, E., *et al.* "Emisiones de gases de efecto invernadero en el sistema agroalimentario y huella de carbono de la alimentación en España." *Real Academia de Ingeniería de España*, 2020. http://www.raing.es/sites/default/files/INFORME_RAING_23102020%20%2814.12h%29.pdf; and Blas, A., *et al.* "A comparison of the Mediterranean diet and current food consumption patterns in Spain from a nutritional and water perspective." *Science of The Total Environment* 664, 2019. https://doi.org/10.1016/j.scitotenv.2019.02.111.

[48] The entire food system production chain generates between 21% and 37% of total global GHG emissions It is also estimated that more than one third of the world's land area and almost 75% of freshwater resources are devoted to crop or livestock production, a major cause of desertification and biodiversity loss on a global scale. For further details, see, among others: Castellani, V., A. Fusi, and S. Sala. *Consumer Footprint. Basket of Products indicator on Food*. Luxembourg: Publications Office of the European Union, 2017. https://doi.org/10.2760/66876; Gerber, P.J., *et al. Tackling Climate Change through Livestock. A global assessment of emissions and mitigation opportunities*. Rome: FAO, 2013. http://www.fao.org/publications/card/en/c/030a41a8-3e10-57d1-ae0c-86680a69ceea/; Greenpeace. *La insostenible huella de la carne en España. Diagnóstico del consumo y la producción de carne y lácteos en España*. Madrid, 2018. https://es.greenpeace.org/es/wp-content/uploads/sites/3/2018/03/INFORME-CARNEv5.pdf; IPBES. *Global assessment report on biodiversity and ecosystem services of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services*. Bonn: IPBES secretariat, 2019. https://ipbes.net/global-assessment; IPCC. "Summary for Policymakers." In: *Climate Change and Land: an IPCC special report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems*. 2019. https://www.ipcc.ch/srccl/; Monteiro, C.A., *et al. Ultra-processed foods, diet quality, and health using the NOVA classification system*. Rome: FAO, 2019; Sala S., *et al. Indicators and Assessment of the environmental impact of EU consumption. Consumption and Consumer Footprint for assessing and monitoring EU policies with Life Cycle Assessment*. Luxembourg: Publications Office of the European Union, 2019. https://doi.org/10.2760/403263; and Searchinger, T. *et al. Creating a Sustainable Food Future. A Menu of Solutions to Feed Nearly 10 Billion People by 2050.* World Resources Institute, 2019. https://research.wri.org/sites/default/files/2019-07/WRR_Food_Full_Report_0.pdf.

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[50] For further details, see: European Topic Centre on Waste and Materials in a Green Economy. *Electronics and obsolescence in a circular economy.* Mol, 2020. https://www.eionet.europa.eu/etcs/etc-wmge/products/electronics-and-obsolescence-in-a-circular-economy; and Eurostat. *Waste electrical and electronic equipment (WEEE) by waste management operations [env_waselee].* https://ec.europa.eu/eurostat/data/database.

[51] Blas, A., *et al.* "A comparison of the Mediterranean diet and current food consumption patterns in Spain from a nutritional and water perspective." *Science of The Total Environment* 664, 2019. https://doi.org/10.1016/j.scitotenv.2019.02.111.

[52] Despite the fact that the world economy uses 30% less resources today to produce one euro of GDP than 30 years ago, global resource consumption has continued to grow. For further details, refer to: SERI, GLOBAL 2000, Friends of the Earth Europe. *Overconsumption? Our use of the world's natural resources*. Vienna/ Brussels, 2009. https://www.foeeurope.org/publications/2009/Overconsumption_Sep09.pdf;.

[53] Font Vivanco, D., *et al.* "The foundations of the environmental rebound effect and its contribution towards a general framework." *Ecological Economics* 125, 2016. https://doi.org/10.1016/j.ecolecon.2016.02.006.

[54] El Observatorio Crítico de la Energía. *¿Qué hacemos frente a la emergencia climática?* 2019. http://observatoriocriticodelaenergia.org/wp-content/uploads/2019/12/Qu%C3%A9-hacemos-frente-a-la- emergencia-clim%C3%A1tica.pdf.

[55] Apart from the aforementioned factors, governance difficulties in areas such as the review of concessions have also contributed to limiting the potential favourable effect of efficiency improvements on water consumption savings. On this question, see, among others: Jiménez, M., and D. Isidoro. "Efectos de la modernización de la comunidad de regantes de Almudévar (Huesca) sobre el cultivo del maíz." *Tierras de Castilla y León Agricultura* 193, 2012. http://hdl.handle.net/10532/1958; and Lecina, S., Daniel Isidoro, Enrique Playán, and Ramón Aragüés. "Efecto de la modernización de regadíos sobre la cantidad y la calidad de las aguas: la cuenca del Ebro como caso de estudio." Madrid: Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria, 2009. http://hdl.handle.net/10261/20127.

[56] In 1998, the estimated water demand at a national level was 30,750 hm3/year; in 2009, it was 30,792 hm3 /year; and in 2013-14, 30,983 hm3 /year. For further details, see: Department of the Environment. Libro Blanco del agua en España. 2000. http://www.cedex.es/CEDEX/LANG_CASTELLANO/ORGANISMO/CENTYLAB/CEH/Documentos_Descargas/LB_LibroBlancoAgua.htm; and Department for Ecological Transition and Demographic Challenge. *Informe de seguimiento de Planes Hidrológicos y Recursos Hídricos en España. Año 2018*. Madrid, 2019. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/memoria_infoseg_2018_tcm30-482594.pdf; and Department for Ecological

Transition. *Síntesis de los planes hidrológicos españoles. Segundo ciclo de la DMA (2015-2021).* Madrid: Directorate General for Water. State Secretariat for the Environment, 2018. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/libro_sintesis_pphh_web_tcm30-482083.pdf.

[57] Spain's Ecological Footprint can be measured in the number of planets Earth that would be needed if all of humanity lived as we do in our country. It is the ratio of a country's per capita footprint to the Earth's available per capita biological capacity (1.6 in 2019). For further details, see: Global Footprint Network. *Ecological Footprint (number of earths), 1961-2016.* http://data.footprintnetwork.org.

[58] Of the 58 AEMET observatories analysed, 37 had at least five years in the period 2011-2018 with annual average temperatures within the warmest 20% of the reference period (1971-2000). In terms of population, 32 million Spaniards could already be considered to be affected by climate change, with an accumulation of very warm years in the last decade, longer summers and more frequent tropical nights. For further details, refer to: State Meteorological Agency. "Efectos del Cambio Climático en España." Agencia Estatal de Meteorología, http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha.

[59] Feyen L., *et al. Climate change impacts and adaptation in Europe. JRC PESETA IV final report*. Luxembourg: Publications Office of the European Union, 2020. https://doi.org/10.2760/171121.

[60] The global average temperature was about 1°C higher than in pre-industrial times in 2017. This increase has been significantly higher in some regions, such as Spain. For further details, refer to: State Meteorological Agency. "El primer informe anual del estado del clima muestra una España más cálida y con menor disponibilidad de agua que hace 50 años." Agencia Estatal de Meteorología, http://www.aemet.es/es/noticias/2020/07/Informe_anual_estado_del_clima_2019; y IPCC. "Summary for Policymakers." In Masson-Delmotte, V., *et. al.* (eds.). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. 2018. https://www.ipcc.ch/sr15/chapter/spm/.

[61] The term "summer" refers to the period in which the maximum temperature, for 7 consecutive days from 1 May onwards, equals or exceeds the average of the maximum temperatures recorded between 18 and 24 June in the period 1981-2010. The end of it is obtained by recording the period in which the maximum temperature, for 7 consecutive days and from 31 October backwards, equals or exceeds the average of the maximum temperatures recorded between 18 and 24 September in the period 1981-2010. See: State Meteorological Agency. "Efectos del Cambio Climático en España." Agencia Estatal de Meteorología, http://www.aemet.es/es/noticias/2019/03/Efectos_del_cambio_climatico_en_espanha.

[62] While cold spells have been reduced by 25%. For further details, refer to: State Meteorological Agency. "El calor como nueva normalidad." Agencia Estatal de Meteorología, http://www.aemet.es/es/noticias/2019/12/Rueda_prensa_invierno_2019.

[63] Tied with 2017. For further details, see: State Meteorological Agency. *Avance Climático Nacional de mayo de 2020.* Department for Ecological Transition and Demographic Challenge, 2020. http://www.aemet.es/documentos/es/noticias/2020/Avanceclimaticonacionalmayo2020.pdf.

[64] Temperatures are in Celsius degrees and are represented as anomalies to the average from 1970 to 2000. Each stripe represents a year, with blue stripes representing colder years and red stripes representing warmer years. For further details, refer to: State Meteorological Agency. *Calendario meteorológico 2018. Información meteorológica y climatológica de España.* Madrid: State Meteorological Agency. Department of Agriculture and Fisheries, Food and Environment, 2017. http://www.aemet.es/documentos_d/conocermas/recursos_en_linea/calendarios/cm-2018.pdf.

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[69] Vicente, S., and E. Rodríguez. "Tendencias recientes de las variables atmosféricas en España." *CLIVAR Exchanges* 73, 2017. https://doi.org/10.31978/639-18-002-5.05.

[70] Vicente-Serrano, V., *et al.* "Evidence of increasing drought severity caused by temperature rise in southern Europe." *Environmental Research Letters* 9, 2014. http://dx.doi.org/10.1088/1748-9326/9/4/044001.

[71] The most robust and homogeneous studies on the decrease of available water resources in Spain are those developed continuously by CEDEX, through the "Evaluación de Recursos Hídricos en España en Régimen Natural" (Evaluation of Water Resources in Spain under Natural Regimes) In general, they show an important decrease in the contributions produced from 1980 onwards. Although there are variations from basin to basin, the average inflow values in the Peninsula for the period 1980/81-2017/18 are 11% lower than those of the previous 40 years (period 1940/41-1979/80), reaching a reduction of 22% in basins such as the Tagus and Guadiana. For further details, see: Department for Ecological Transition and the Demographic Challenge and the CEDEX Centre for Hydrographic Studies. "Evaluación de recursos hídricos en régimen natural. Modelo SIMPA 2019. Periodo de simulación: 1940/ 41 a 2017/ 18." Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/agua/temas/evaluacion-de-los-recursos-hidricos/evaluacion-recursos-hidricos-regimen-natural/.

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[74] On this question, see, among others: European Commission. *Report from the Commission to the Council and the European Parliament on the implementation of Council Directive 91/676/EEC concerning the protection of waters against pollution caused by nitrates from agricultural sources based on Member State reports for the period 2012–2015*. Brussels, 2018. https://ec.europa.eu/transparency/regdoc/rep/1/2018/ES/COM-2018-257-F1-ES-MAIN-PART-1.PDF; Department for Ecological Transition. *Síntesis de los planes hidrológicos españoles. Segundo ciclo de la DMA (2015-2021).* Madrid: Directorate General for Water. State Secretariat for the Environment, 2018. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/libro_sintesis_pphh_web_tcm30-482083.pdf; and Department for Ecological Transition. *Documento técnico de apoyo del Ministerio para la Transición Ecológica, por la que se determinan las aguas continentales afectadas por la contaminación, o en riesgo de estarlo, por aportación de nitratos de origen agrario en las cuencas hidrográficas intercomunitarias*. Madrid: State Secretariat for the Environment, Directorate General for Water, 2019. https://www.miteco.gob.es/es/agua/participacion-publica/pp-orden-aguas-continentales-contaminadas-nitratos-documento-tecnico-revision-aguas-afectadas_tcm30-498566.pdf.

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[77] *Ibid.*

[78] European Commission. *The EU Blue Economy Report*. Luxembourg: Publications Office of the European Union, 2020. https://blueindicators.ec.europa.eu/sites/default/files/2020_06_BlueEconomy-2020-LD_FINAL-corrected-web-acrobat-pro.pdf.

[79] The Water Exploitation Index (WEI+) is the percentage of total water extracted annually compared to the total available renewable water resources.

[80] Water stress occurs when the water exploitation index is greater than 10%. When the WEI+ is above 40%, stress is severe. In our country, the average annual WEI+ is 23.7% (2017), with values reaching 50% in some months. For further details, see: Bisselink B., *et al. Climate change and Europe's water resources*. Luxembourg: Publications Office of the European Union, 2020. https://doi.org/10.2760/15553.

[81] The EU-8 and EU-27 are constructed as the simple average of the values of the individual countries. See: European Environment Agency. *Development of the water exploitation index plus (WEI+).* https://www.eea.europa.eu/data-and-maps/daviz/water-exploitation-index-plus#tab-chart_2_filters=%7B%22rowFilters%22%3A%7B%7D%3B%22columnFilters%22%3A%7B%22pre_config_country%22%3A%5B%22Spain%22%5D%7D%7D.filters=%7B%22rowFilters%22%3A%7B%7D%3B%22columnFilters%22%3A%7B%22pre_config_country%22%3A%5B%22Spain%22%5D%7D%7D.

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[85] The data show that the number and average burnt area of fires is decreasing, but that the average annual area burnt by large forest fires, which are responsible for the most severe damage, has increased significantly. Although during the period 1970-2018, large fires accounted for only 0.32% of the total number of fires, they have been responsible for 36.5% of the burnt area (almost three million hectares). For further details, refer to: Greenpeace. *Proteger el medio rural es protegernos del fuego. Hacia paisajes y población resilientes frente a la crisis climática*. 2020. https://storage.googleapis.com/gpes-static/protege-el-bosque/PROTEGE-EL-BOSQUE-v5.pdf; Department of Agriculture, Fisheries and Food. "Anuario de Estadística Forestal 2018." Department of Agriculture, Fisheries and Food, https://www.mapa.gob.es/es/desarrollo-rural/estadisticas/forestal_anuario_2018.aspx; and Department of Agriculture, Fisheries and Food.. *Los Incendios Forestales en España Decenio 2006-2015*. Madrid, 2019. https://www.mapa.gob.es/es/desarrollo-rural/estadisticas/incendios-decenio-2006-2015_tcm30-511095.pdf.

[86] De Rigo, D., *et al. Forest fire danger extremes in Europe under climate change: variability and uncertainty*. Luxembourg: Publications Office of the European Union, 2017. https://doi.org/10.2760/13180.

[87] On this question, see, among others: Kollanus, V., *et al.* "Mortality due to Vegetation Fire-Originated $PM_{2.5}$ Exposure in Europe. Assessment for the Years 2005 and 2008." *Environmental Health Perspectives* 125,

2016. https://doi.org/10.1289/EHP194; and Liu, Jia, *et al*. "A systematic review of the physical health impacts from non-occupational exposure to wildfire smoke." *Environmental research* 136, 2015. https://doi.org/10.1016/j.envres.2014.10.015.

[88] Depending on the area and period studied. For further details, refer to: Kersting D. K. *Cambio climático en el medio marino español: impactos, vulnerabilidad y adaptación*. Madrid: Spanish Climate Change Office, Department of Agriculture, Food and Environment, 2016. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/kersting_2016_cambio_climatico_medio_marino_tcm30-70535.pdf.

[89] Losada, I., C. Izaguirre, and P. Diaz. *Cambio climático en la costa española*. Madrid: Spanish Climate Change Office, Department of Agriculture, Food and Environment, 2014. https://www.miteco.gob.es/es/cambio-climatico/publicaciones/publicaciones/2014%20INFORME%20C3E%20final_tcm30-178459.pdf.

[90] *Ibid.*

[91] Due to atmospheric effects and changes in the circulation of ocean currents. For further details, refer to: Kersting, D. K. *Cambio climático en el medio marino español: impactos, vulnerabilidad y adaptación*. Madrid: Spanish Climate Change Office, Department of Agriculture, Food and Environment, 2016. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/kersting_2016_cambio_climatico_medio_marino_tcm30-70535.pdf.

[92] The blue economy includes all those activities that are based on or related to the sea and coasts, such as fishing, tourism or renewable energies. In terms of gross value added, our country is the largest contributor to the "blue economy" in the EU-27. For further details, see: European Commission. *The EU Blue Economy Report*. Luxembourg: Publications Office of the European Union, 2020. https://blueindicators.ec.europa.eu/sites/default/files/2020_06_BlueEconomy-2020-LD_FINAL-corrected-web-acrobat-pro.pdf.

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[94] Losada, I., C. Izaguirre, and P. Diaz. *Cambio climático en la costa española*. Madrid: Spanish Climate Change Office, Department of Agriculture, Food and Environment, 2014. https://www.miteco.gob.es/es/cambio-climatico/publicaciones/publicaciones/2014%20INFORME%20C3E%20final_tcm30-178459.pdf.

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[96] Convention on Biological Diversity. "Spain-Main Details." Convention on Biological Diversity, https://www.cbd.int/countries/profile/?country=es.

[97] Comité Español de la UICN and Fundación Naturaleza y Hombre. *Análisis de las especies en Lista Roja de la UICN en España: una llamada urgente a la acción*. Málaga-Santander: Unión Internacional para la Conservación de la Naturaleza, 2019. http://www.uicn.es/web/pdf/Analisis_L_Roja_Spain2019.pdf.

[98] WHO. *Infografía: Impacto del Medio Ambiente en la Salud.* 2019. https://www.who.int/quantifying_ehimpacts/publications/PHE-prevention-diseases-infographic-ES.pdf?ua=1.

[99] Carmona, R., *et al*. "Mortality attributable to extreme temperatures in Spain: A comparative analysis by city." *Environment International* 91, 2016. https://doi.org/10.1016/j.envint.2016.02.018.

[100] On this question, see, among others: Iriso, A., *et al*. "Cambio climático en España y su influencia en las enfermedades de transmisión vectorial." *Revista de Salud Ambiental* 17, n.º 1, 2017. https://ojs.diffundit.com/index.php/rsa/article/view/843; and Department of Health, Social Services and Equality. *Impactos del Cambio Climático en la Salud. Executive Summary*. Madrid, 2013. https://www.mscbs.gob.es/ciudadanos/saludAmbLaboral/docs/CCResumen_ESP.pdf.

[101] Morral-Puigmal, C., *et al*. "Weather and gastrointestinal disease in Spain: A retrospective time series regression study." *Environment International* 121, n.º 1, 2018. https://doi.org/10.1016/j.envint.2018.10.003.

[102] Between 2009 and 2018, the number of deaths elated to exposure to particulate matter (PM) has been reduced by 21%, and 36% the number of deaths associated with nitrogen dioxide (NO). During the same period, the number of deaths related to tropospheric ozone (O) has increased by 12%. Improvements in air quality have also been influenced by meteorological conditions, for example in the period 2008-2012. For further details, see: European Environment Agency. *Air quality in Europe-2020 report*. Luxembourg: Publications Office of the European Union, 2020. https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report; Barmpadimos I., *et al*. "One decade of parallel fine ($PM_{2.5}$) and coarse (PM_{10}–$PM_{2.5}$) particulate matter measurements in Europe: trends and variability." *Atmos. Chem. Phys.* 12, 2012. https://doi.org/10.5194/acp-12-3189-2012; and Querol X., *et al.* "2001-2012 trends on air quality in Spain." *Science of the Total Environment* 490, 2014. https://doi.org/10.1016/j.scitotenv.2014.05.074.

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[104] Many of the sources of greenhouse gas emissions (responsible for climate change) are themselves emitters of air pollutants that damage health. In particular, road transport is one of the main contributors, due to high emissions of harmful substances such as nitrogen oxides and particulate matter. Fertilised soils and manure management are another important source of air pollutants, being responsible for 90% of ammonia emissions, which generate problems such as acidification or the formation of fine particles in suspension, and whose impacts on human health can be observed even hundreds of kilometres away, in urban areas. Industry is also an emitter of pollutants that affect air quality, especially metals. Emissions of air pollutants from waste generation, electricity generation and the residential sector should also

be mentioned. On this question, see: European Environment Agency. *Air quality in Europe-2020 report*. Luxembourg: Publications Office of the European Union, 2020. https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report.

[105] On this question, see, among others: Health Effects Institute. *State of Global Air 2020. Special Report.* Boston, 2020. https://www.stateofglobalair.org/sites/default/files/documents/2020-10/soga-2020-report-10-26_0.pdf; and Department of Health, Consumer Affairs and Social Welfare. *Impacto sobre la salud de la calidad del aire en España. Respuesta y desarrollo de la Medida Info 5 recogida en el Plan Nacional del Aire 2017-2019 (Plan Aire II)*. Madrid, 2019. https://www.mscbs.gob.es/ca/ciudadanos/saludAmbLaboral/docs/PLAN_AIRE_Medida_5_19_12_27.pdf.

[106] On this question, see, among others: Gibb, R., *et al.* "Zoonotic host diversity increases in human-dominated ecosystems." *Nature 584, 2020.* Https://doi.org/10.1038/s41586-020-2562-8;; United Nations Environment Programme and International Livestock Research Institute. *Preventing the next pandemic: Zoonotic diseases and how to break the chain of transmission.* Nairobi, 2020. https://wedocs.unep.org/bitstream/handle/20.500.11822/32316/ZP.pdf?sequence=1&isAllowed=y; Rohr, J. R. "Emerging human infectious diseases and the links to global food production." *Nature Sustainability 2, n.º 6, 2019*. https://doi.org/10.1038/s41893-019-0293-3; Secretariat of the Convention on Biological Diversity. *Perspectiva Mundial sobre la Diversidad Biológica 5. Resumen para los responsables de formular políticas.* Montreal, 2020. https://www.cbd.int/gbo/gbo5/publication/gbo-5-spm-es.pdf; and Suárez, Luis., *et al. Pérdida de naturaleza y pandemias. Un planeta sano por la salud de la humanidad*. WWF España, 2020. https://wwfes.awsassets.panda.org/downloads/naturaleza_y_pandemias_wwf.pdf?54120/Perdida-de- naturaleza-y-pandemias-Un-planeta-sano-por-la-salud-de-la-humanidad.

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[110] See: United Nations. *Montreal Protocol on Substances that Deplete the Ozone Layer (with annex).* Montreal, 1989. https://treaties.un.org/doc/Publication/UNTS/Volume%201522/volume-1522-I-26369-English.pdf; and United Nations.. *Paris Agreement*. Paris, 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

[111] European Commission. *The European Green Deal*. Brussels, 2019. https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1588580774040&uri=CELEX:52019DC0640.

[112] European Environment Agency. *The European environment state and outlook 2020: knowledge for transition to a sustainable Europe*. Luxembourg: Publications Office of the European Union, 2019. https://www.eea.europa.eu/publications/soer-2020.

[113] The first National Parks Act passed in 1916 made Spain one of the pioneering countries in Europe in its commitment to nature protection. For further details, see: Department for Ecological Transition and Demographic Challenge "Historia de la Red de Parques Nacionales." Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/red-parques-nacionales/la-red/historia.aspx#:~:text=La%20primera%20Ley%20de%20Parques,la%20protecci%C3%B3n%20de%20la%20naturaleza.&text=A%C3%B1os%20m%C3%A1s%20tarde%2C%20en%201969,1973%2C%20las%20Tablas%20de%20Daimiel.

[114] At present, Spain has the draft of the "Climate Change and Energy Transition Law" which, together with the "Integrated National Energy and Climate Plan (PNIEC)" and the "Fair Transition Strategy", form the three pillars of the "Strategic Energy and Climate Framework" approved by the Spanish Government in 2019. Spain has also developed a "Long Term Decarbonisation Strategy 2050", with ambitious emission mitigation plans, and a "Circular Economy Strategy 2030", with the aim of building a resource-efficient economy that generates more value using less materials. Moreover, the "National Plan for Adaptation to Climate Change 2021-2030" promotes a coordinated and proactive action to address the effects of climate change. For further details, refer to: Department for Ecological Transition and Demographic Challenge "Marco Estratégico de Energía y Clima: Una oportunidad para la modernización de la economía española y la creación de empleo." Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/cambio-climatico/participacion-publica/marco-estrategico-energia-y-clima.aspx.

[115] Biosphere Reserves consist of more than 650 sites in 120 countries. There are 49 such sites in Spain. For further details, see: Department for Ecological Transition. *Perfil Ambiental de España 2018*. Madrid, 2019. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/publicaciones/pae2018_tcm30-504010.pdf.

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[121] Air Plan I (2013-16), Air Plan II (2017-19) and National Air Pollution Control Programme (PNCCA) (2019-2022). For further details, see: Department for Ecological Transition and Demographic Challenge *Planes de mejora de la calidad del aire.* Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/atmosfera-y-calidad-del-aire/calidad-del-aire/planes-mejora/; and Department for Ecological Transition I National Air Pollution Control Programme. Madrid, 2019. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/participacion-publica/i-pncca_spain_borrador_tcm30-496287.pdf.

[122] Law 16/2013, which created a tax in Spain on fluorinated greenhouse gases (HFCs, PFCs and also SF6), served to discourage their use and improve the maintenance and recovery of gases in existing equipment and installations. As a result, there has been a sharp and sustained fall in the use of these gases since 2014. See: Department for Ecological Transition and Demographic Challenge *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2018*. https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/Inventario-GEI.aspx.

[123] Eurostat. *Air pollutants by source sector (source: EEA) [ENV_AIR_EMIS].* https://ec.europa.eu/eurostat/data/database.

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[125] Wind Europe. *Wind energy in Europe in 2019: Trends and statistics.* 2020. https://windeurope.org/wp-content/uploads/files/about-wind/statistics/WindEurope-Annual-Statistics-2019.pdf.

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[127] International Renewable Energy Agency. *Country Rankings. Installed capacity (MW).* https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings.

[128] Spain ranks 15th out of 130 countries analysed according to the World Energy Council's "Trilemma Index". Considering 18.8 million households (latest available data, 2019), the average total energy consumption per household is 9,262 kWh, including heating, cooling, domestic hot water, cooking, lighting, appliances and other uses. The annual generation of electricity from renewable sources in our country is 109,269 GWh (latest available data, 2020). See: INE. *Encuesta continua de hogares. Año 2019.* https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176952&menu=ultiDatos&idp=1254735572981; and Department for Ecological Transition and Demographic Challenge. Instituto para la Diversificación y Ahorro de la Energía. *Estudios, informes y estadísticas. Consumo para usos y energías del sector residencial (2010-2018).* https://www.idae.es/sites/default/files/estudios_informes_y_estadisticas/cons_usos_resid_eurostat_web_2010-18_ok.xlsx; and Red eléctrica de España. "Las renovables alcanzan el 43,6% de la generación de energía eléctrica en 2020, su mayor cuota desde que existen registros." Red eléctrica de España, https://www.ree.es/es/sala-de-prensa/actualidad/nota-de-prensa/2020/12/las-renovables-alcanzan-el-43-6-por-ciento-de-la-generacion-de-2020-su-mayor-cuota-desde-existen-registros.

[129] The 2019 data have shown a fall in the level of total emissions nationally of 6% from 2018 levels (the sharpest year-on-year drop since 2013), mainly due to almost 30% reduction in emissions associated with coal-fired electricity generation. For further details, refer to: Department for Ecological Transition and Demographic Challenge *Inventario Nacional de Gases de Efecto Invernadero (GEI): Resumen Serie 1990-2019.* https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/sistema-espanol-de-inventario-sei-/documentoresumeninventariogei-ed2021_tcm30-524841.pdf.

[130] This process is part of the "Energy and Climate Strategic Framework", which has a "Fair Transition Strategy" as an essential pillar to favour the employability and inter-sectoral mobility of workers in the sectors undergoing reconversion. On this question, see: Department for Ecological Transition and Demographic Challenge *Estrategia de Transición Justa.* Madrid, 2020. https://www.miteco.gob.es/images/es/documentoetj_tcm30-514300.pdf; and Reuters. "Europe steams towards coal exit – research." Reuters, https://www.reuters.com/article/us-europe-climatechange-coal-idUSKCN24M32C.

[131] International Renewable Energy Agency. *Country rankings. Electricity capacity. Total renewable energy*. https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings.

[132] *Ibid.*

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[159] United Nations Environment Programme *Informe sobre la disparidad en las emisiones de 2019*. Nairobi, 2019. https://wedocs.unep.org/bitstream/handle/20.500.11822/30798/EGR19ESSP.pdf?sequence=17.

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[161] LFuture climate scenarios can be classified into two types: 1) those based on temperature increase thresholds (1.5°C, 2°C, 3°C); and 2) those based on greenhouse gas concentration trajectories (Representative Concentration Pathways or RCPs). The table shows the increase in global average temperature from pre-industrial values (1850-1900) that each of the RCPs would lead to:

Trajectory	Global average temperature increase compared to pre-industrial levels		Concentration of CO_{2eq} in the atmosphere	
	Period 2046-2065	Period 2081-2100	2100	2020
RCP 2.6	1.6 °C	1.6 °C	421 ppm	410 ppm
RCP 4.5	2.0 °C	2.4 °C	538 ppm	
RCP 6.0	1.9 °C	2.8 °C	670 ppm	
RCP 8.5	2.6 °C	4.3 °C	936 ppm	

In order to provide a consistent picture between the results of different analyses, the impacts presented in this report correspond, unless otherwise specified, to the 2°C temperature increase scenario or the RCP 4.5 scenario, without adaptation measures. For further details, see: Feyen L., et al. Climate change impacts and adaptation in Europe. JRC PESETA IV final report. Luxemburgo: Publications Office of the European Union, 2020. https://doi.org/10.2760/171121; Global Monitoring Laboratory. Trends in Atmospheric Carbon Dioxide. https://www.esrl.noaa.gov/gmd/ccgg/trends/monthly.html; e IPCC. Climate change 2013: the physical science basis: contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge: Cambridge University Press, 2013. https://www.ipcc.ch/report/ar5/wg1/.

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[192] For the period 2026-2045, the models project similar values of sea level rise for the moderate mitigation scenario (RCP 4.5) and the high emissions scenario (RCP 8.5). The largest differences are seen for the period (2081-2100), due to the thermal inertia of the seas and oceans. By the end of the century, in an RCP 4.5 scenario, average sea level rises would be between 55 cm and 70 cm along the Spanish coast, with the highest values in the Canary Islands, Balearic Islands and western Cantabrian coast. In a high emissions scenario (RCP 8.5), sea level rise would reach 75 cm along the entire Spanish coast, especially in Galicia, the Balearic Islands (> 80 cm) and the Canary Islands, where sea level rise values of around 1 m are projected. For further details, refer to: Losada, I.J., *et al. Elaboración de la metodología y bases de datos para la proyección de impactos del cambio climático a lo largo de la costa española*. Department for Ecological Transition and Demographic Challenge, 2020 https://www.adaptecca.es/sites/default/files/documentos/2019_metodologia_y_bbdd_proyeccion_impactos_de_cc_costa_espanola.pdf.

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[198] The European Commission estimates that a global temperature increase of 2°C will result in annual welfare losses for southern Europe (Bulgaria, Croatia, Cyprus, Greece, Italy, Malta, Portugal, Slovenia and Spain) of 43 billion euros (equivalent to 1.4% of these countries' GDP). However, the limited nature of such studies should be taken into account, given the difficulty of considering all possible impacts of climate change and their interactions, as well as possible irreversible tipping points. Thus, economic estimates may give overly conservative results. For further details, refer to: Ciscar, J. C. "Impactos del Cambio Climático en España: Una revisión parcial." In María José Sanz, and Mikel González-Enguino (eds.). *Transition to a decarbonised economy*. Madrid: FUNCAS, *Papeles de Economía Española,* n.º153, 2020. 2-8. https://www.funcas.es/revista/transicion-hacia-una-economia-baja-en-carbono-en-espana-abril-2020/; and Szewczyk, W., *et al. Economic analysis of selected climate impacts*. Luxembourg: Publications Office of the European Union, 2020. https://doi.org/10.2760/845605.

[199] Losses compared to current productivity levels, under a 2°C increase scenario, in outdoor activities and without adaptation measures. For further details, refer to: Flouris, Andreas D., *et al.* "Workers' health and productivity under occupational heat strain: a systematic review and meta-analysis." *The Lancet Planetary Health* 2, n.º 12, 2018. https://doi.org/10.1016/S2542-5196(18)30237-7; y Gosling S.N., J. Zaherpour, and D. Ibarreta. *PESETA III: Climate change impacts on labour productivity*. Luxembourg: Publications Office of the European Union, 2018. https://doi.org/10.2760/07911.

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vulnerabilidad y adaptación al cambio climático en el sector turístico. Madrid: Department of Agriculture, Food and Environment, 2016. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/impactosvulnerabilidadyadaptacionalcambioclimaticoenelsectorturistico_tcm30-178443.pdf; y Moreno, A. *Turismo y cambio climático en España. Evaluación de la vulnerabilidad del turismo de interior frente a los impactos del cambio climático.* Maastricht: International Centre for Integrated Assessment and Sustainable Development Maastricht University, 2010. https://www.miteco.gob.es/es/cambio-climatico/publicaciones/publicaciones/Informe%20turismo_tcm30-178476.pdf.

[201] Due to the greater impact it will have on labour productivity in economic sectors such as agriculture or industry, with greater relative weight in some regions. For further details, refer to: International Monetary Fund. *World Economic Outlook: Global Manufacturing Downturn, Rising Trade Barriers*. Washington D.C., 2019. http://dx.doi.org/10.5089/9781513508214.081.

[202] In 2019, almost 1,900 environmental catastrophes triggered 24.9 million new internal displacements in 140 countries and territories, three times the number of new migrations within the same state due to conflict or violence. Climate change and growing environmental crises could intensify migratory movements. According to some estimates, the number of migrants in the world could double by 2060 as a result of climate change. For further details, see: Internal Displacement Monitoring Centre. *Global Report on Internal Displacement*. 2020. https://www.internal-displacement.org/sites/default/files/publications/documents/2020-IDMC-GRID.pdf; International Organization for Migration. *World Migration Report 2020*. New York: UN, 2019. https://doi.org/10.18356/b1710e30-en; and Missirian, A. and W. Schlenker. "Asylum applications respond to temperature fluctuations." *Science* 358, n.º 6370, 2017. https://doi.org/10.1126/science.aao0432.

[203] On this question, see, among others: Chancel, Lucas. *Unsustainable Inequalities*. Cambridge: Harvard University Press, 2020. https://www.hup.harvard.edu/catalog.php?isbn=9780674984653&content=bios; Islam, N. and J. Winkel. "Climate Change and Social Inequality." *UN Department of Economic and Social Affairs (DESA) Working Papers* 152, 2017. https://doi.org/10.18356/2c62335d-en; and Roy, J., P. Tschakert and H. Waisman. "Sustainable Development, Poverty Eradication and Reducing Inequalities." In Masson-Delmotte, V., *et. al. Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Intergovernmental Panel on Climate Change, 2018. https://www.ipcc.ch/site/assets/uploads/2018/11/sr15_chapter5.pdf.

[204] Data corresponding to a moderate emissions mitigation scenario (RCP 4.5) without adaptation. In a high emissions scenario without adaptation, high temperatures alone would be responsible for the deaths of 1,400 people per year in 2050, rising to more than 12,000 in the second half of the century. For further details, refer to: Díaz J., Sáez M., Carmona R., *et al*. "Mortality attributable to high temperatures over the 2021-2050 and 2051-2100 time horizons in Spain: Adaptation and economic estimate." *Environmental Res*earch 172, 2019. https://doi.org/10.1016/j.envres.2019.02.041; Sanz, M.J., and E. Gálan. *Impactos y riesgos derivados del cambio climático en España*. Madrid: Department for Ecological Transition and Demographic Challenge, 2020. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/impactosyriesgosccespanawebfinal_tcm30-518210.pdf; and Ščasný, *et al. Non-market impacts: health. Deliverable of the H2020 COACCH project. 2020*. https://www.coacch.eu/wp-content/uploads/2020/04/D2.6-Non-market-impacts-health-final-version.pdf.

[205] Díaz, J., *et al.* "Will there be cold-related mortality in Spain over the 2021–2050 and 2051–2100 time horizons despite the increase in temperatures as a consequence of climate change?" *Environmental Research* 176, 2019. https://doi.org/10.1016/j.envres.2019.108557.

[206] Department for Ecological Transition and Demographic Challenge *Plan Nacional de Adaptación al Cambio Climático 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/pnacc-2021-2030_tcm30-512163.pdf.

[207] Even at very low concentrations, ozone can be harmful to the respiratory and cardiovascular system. In addition, this pollutant also contributes to global warming and damages vegetation, significantly reducing crop productivity. Although its formation depends mainly on emissions in urban areas, it is mainly rural areas that are affected. For further details, refer to: Department for Ecological Transition and Demographic Challenge "Ozono, efectos en salud y ecosistemas." Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/calidad-y-evaluacion-ambiental/temas/atmosfera-y-calidad-del-aire/calidad-del-aire/salud/ozono.aspx; and WHO. *Health risks of ozone from long-range transboundary air pollution.* Copenhague: Publications WHO Regional Office for Europe, 2008. https://www.euro.who.int/__data/assets/pdf_file/0005/78647/E91843.pdf.

[208] Martin, J.L., *et al.* "Aspectos clave para un plan de adaptación de la biodiversidad terrestre de Canarias al cambio climático". In Herrero, A., and Zavala, M.A (eds.). *Los Bosques y la Biodiversidad frente al Cambio Climático: Impactos, Vulnerabilidad y Adaptación en España*. Madrid: Department of Agriculture, Food and Environment, 2015. 573-580. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/cap53-aspectosclaveparaunplandeadaptaciondelabiodiversidadterrestredecanarias_tcm30-70255.pdf.

[209] High temperatures are associated with aggravation and mortality from neurodegenerative diseases. See: Linares C., *et al.* "Effect of heat waves on morbidity and mortality due to Parkinson's disease in Madrid: A time-series analysis." *Environment International* 89–90, 2016. https://doi.org/10.1016/j.envint.2016.01.017.

[210] European Centre for Disease Prevention and Control. *Assessing the potential impacts of climate change on food-and waterborne diseases in Europe*. Stockholm: ECDC, 2012.https://www.ecdc.europa.eu/en/publications-data/assessing-potential-impacts-climate-change-food-and-waterborne-diseases-europe.

[211] Lake, Iain, *et al.* "Climate change and future pollen allergy in Europe." *Environmental Health Perspectives* 125, 2017. http://dx.doi.org/10.1289/EHP173.

[212] Paz, S., *et al.* "Health." In W. Cramer, J. Guiot, and J. K. Marini (eds.). *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report*. Marseille: Union for the Mediterranean, Plan Bleu , and UNEP/

MAP, 2020. *On the press*. https://www.medecc.org/wp-content/uploads/2020/11/MedECC_MAR1_5_2_Health.pdf.

[213] Recent evidence also points to a possible association of rising temperatures with increased rates of antimicrobial resistance. For further details, refer to: FAO. *Climate change: Unpacking the burden on food safety*. Rome: Food safety and quality series n.º 8, 2020. https://doi.org/10.4060/ca8185en; and Interagency Coordination Group on Antimicrobial Resistance. *No time to wait: Securing the future from drug-resistant infections report to the Secretary-General of the United Nations*. 2019. https://www.who.int/antimicrobial-resistance/interagency-coordination-group/IACG_final_summary_EN.pdf?ua=1.

[214] Spanish Agency for Medicines and Health Products. *Plan Nacional Frente a la Resistencia a los Antibióticos 2019-2021*. Madrid, 2019. http://www.resistenciaantibioticos.es/es/system/files/field/files/pran_2019-2021_0.pdf?file=1&type=node&id=497&force=0.

[215] O'Neil, J. *Tackling drug-resistant infections globally: final report and recommendations*. Review of Antimicrobial Resistance, 2016. https://amr-review.org/sites/default/files/160518_Final%20paper_with%20cover.pdf.

[216] Geissen, V., *et al*. "Emerging pollutants in the environment: A challenge for water resource management." *International Soil and Water Conservation Research* 3, n.º 1, 2015. https://doi.org/10.1016/j.iswcr.2015.03.002.

[217] Zhang, Q., *et al.* "A Review of Microplastics in Table Salt, Drinking Water, and Air: Direct Human Exposure." *Environmental Science and Technology* 54, n.º 7, 2020. https://doi.org/10.1021/acs.est.9b04535.

[218] Climate Action Tracker Project. "Temperatures 1990-2100." Climate Action Tracker, https://climateactiontracker.org/global/temperatures/.

[219] IPCC. "Summary for Policymakers." En Masson-Delmotte, V., *et al.* (eds.). *Global Warming of 1.5°C. An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Intergovernmental Panel on Climate Change, 2018. https://www.ipcc.ch/sr15/chapter/spm/.

[220] It is important to note that the estimate does not include the full range of potential economic impacts caused by climate change due to complexities in their valuation or quantification. For further details, see: Szewczyk, W., *et al. Economic analysis of selected climate impacts*. Luxembourg: Publications Office of the European Union, 2020. https://doi.org/10.2760/845605.

[221] United Nations. *Paris Agreement*. Paris, 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

[222] United Nations. *Paris Agreement*. Paris, 2015. https://unfccc.int/sites/default/files/english_paris_agreement.pdf.

[223] In September 2020, the EU raised the ambition of the 2030 greenhouse gas emissions reduction target. On average, the EU as a whole will have to reduce its emissions by 55% below 1990 levels by that date. In the case of Spain, at present, the PNIEC establishes a decrease of 23% compared to 1990 levels. For further details, refer to: European Commission. *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. Stepping up Europe's 2030 climate ambition. Investing in a climate-neutral future for the benefit of our people*. Brussels, 2020. https://ec.europa.eu/clima/sites/clima/files/eu-climate-action/docs/com_2030_ctp_en.pdf; and Department for Ecological Transition and Demographic Challenge.. *Plan Nacional Integrado de Energía y Clima 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf.

[224] Economics for Energy. *Escenarios para el sector energético en España 2030-2050*. Vigo, 2017. https://eforenergy.org/docpublicaciones/informes/informe_2017.pdf.

[225] The overall rate of return on investments to improve resilience is very high. Therefore, adaptation measures not only serve to prevent possible negative impacts of climate change, but also have important economic benefits and avoid future costs. So-called nature-based solutions, which are inspired and supported by the functioning of ecosystems, are set to play a key role in this process. These include measures such as the restoration of coastal ecosystems to slow erosion and mitigate the impacts of rising seas, reforestation to preserve water quantity and quality, and the creation of natural flood zones to retain water during periods of extreme rainfall. In addition to being key to climate change adaptation, these solutions are one of the cheapest and most effective ways of absorbing CO, and help preserve ecosystems and biodiversity. For further details, see: Global Commission on Adaptation. *Adapt now: A global call for leadership on climate resilience*. 2019. Https://gca.org/reports/adapt-now-a-global-call-for-leadership-on-climate-resilience/:; Department for Ecological Transition and Demographic Challenge. *Plan Nacional de Adaptación al Cambio Climático 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/es/cambio-climatico/temas/impactos-vulnerabilidad-y-adaptacion/pnacc-2021-2030_tcm30-512163.pdf; and United Nations Environment Programme. *Adaptation Gap Report 2020*. Nairobi, 2021. https://www.unep.org/resources/adaptation-gap-report-2020.

[226] According to the energy balance carried out by the Institute for Energy Diversification and Saving (IDAE), electricity consumption over final energy in 2018 was 23%. Depending on the long-term scenarios,as established by the European Commission, the ratios of electricity consumption to final energy in 2050 will reach values between 41% and 53%. For further details, refer to: European Commission. *A Clean Planet for all A European long-term strategic vision for a prosperous, modern, competitive and climate neutral economy.* Brussels, 2018. https://ec.europa.eu/clima/sites/clima/files/docs/pages/com_2018_733_analysis_in_support_en_0.pdf; and Instituto para la Diversificación y Ahorro de la Energía. *Consumo final de energía 2018 (avance)*. http://sieeweb.idae.es/consumofinal/.

[227] Department for Ecological Transition and Demographic Challenge. *Estrategia de Descarbonización a Largo Plazo 2050. Anexos.* Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf.

[228] From 2022 onwards, the contribution of coal to the Spanish electricity mix is expected to be negligible.

[229] Department for Ecological Transition and Demographic Challenge *Estrategia de almacenamiento energético*. Madrid, 2021. https://www.miteco.gob.es/es/prensa/estrategiaalmacenamiento_tcm30-522655.pdf.

[230] There is a need to develop battery production systems that are responsible, circular and fair, with a fundamental change in the way materials are sourced and these technologies are produced and used. For further details, refer to: World Economic Forum. *A Vision for a Sustainable Battery Value Chain in 2030. Unlocking the Full Potential to Power Sustainable Development and Climate Change Mitigation*. Geneva, 2019 http://www3.weforum.org/docs/WEF_A_Vision_for_a_Sustainable_Battery_Value_Chain_in_2030_Report.pdf.

[231] In Spain, 100% of electricity will come from renewable sources. See: Department for Ecological Transition and Demographic Challenge *Estrategia de Descarbonización a Largo Plazo 2050. Anexos.* Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf.

[232] Red Eléctrica de España. *Estructura de la generación por tecnologías 2019.* https://www.ree.es/es/datos/generacion/estructura-generacion.

[233] International Renewable Energy Agency. *Country rankings.* https://www.irena.org/Statistics/View-Data-by-Topic/Capacity-and-Generation/Country-Rankings.

[234] Energy community means an association, cooperative, partnership, non-profit organisation or other legal entity that is controlled by local shareholders or members, generally value-oriented rather than profit-oriented, engaged in distributed generation and in carrying out the activities of a distribution system operator, supplier or aggregator at a local level, including on a cross-border basis. See: Instituto para la Diversificación y Ahorro de la Energía. *Guía para el Desarrollo de Instrumentos de Fomento de Comunidades Energéticas Locales*. Madrid, 2019. https://www.idae.es/sites/default/files/documentos/publicaciones_idae/guia_para-desarrollo-instrumentos-fomento_comunidades_energeticas_locales_20032019_0.pdf.

[235] In Germany, for example, distributed generation accounts for half of all PV generation, covering 9% of the country's electricity mix in 2019. For further details, refer to: Fraunhofer Institute for Solar Energy Systems. *Photovoltaics report*. Freiburg, 2020. https://www.ise.fraunhofer.de/content/dam/ise/de/documents/publications/studies/Photovoltaics-Report.pdf.

[236] According to IRENA (International Renewable Energy Agency), over the last decade (2010 to 2019), the average balanced cost (LCOE measure) of solar PV energy has decreased by 82% (from 0.38$/kWh to 0.07$/kWh); concentrating solar by 49% (from 0.35$/kWh to 0.18$/kWh); onshore wind by 44% (from 0.09$/kWh to 0.05$/kWh); and offshore wind by 25% (from 0.16$/kWh to 0.12$/kWh). The average cost of lithium batteries dropped from 1,160$/kWh in 2010 to 156$/kWh in 2019 (an 87% reduction). On this question, see, among others: BloombergNEF. "Battery Pack Prices Fall As Market Ramps Up With Market Average At $156/kWh In 2019." BloombergNEF, https://about.bnef.com/blog/battery-pack-prices-fall-as-market-ramps-up-with-market-average-at-156-kwh-in-2019/; BloombergNEF. *European Energy Transition Outlook.* 2021; and International Renewable Energy Agency. *Renewable Power Generation Costs in 2019*. Abu Dhabi, 2020. https://www.irena.org/publications/2020/Jun/Renewable-Power-Costs-in-2019.

[237] The European Union has a "European Union Hydrogen Strategy" and the Spanish Government has a "Renewable Hydrogen Roadmap", included in the Integrated Energy and Climate Plan (PNIEC) 2021-2030. The "Recovery, Transformation and Resilience Plan" project also earmarks 1.5 billion euros for its development. On this question, see: European Commission. *A hydrogen strategy for a climate-neutral Europe.* Brussels, 2020. https://ec.europa.eu/energy/sites/ener/files/hydrogen_strategy.pdf; Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf; and Department for Ecological Transition and Demographic Challenge.. *Hoja de Ruta del Hidrógeno: Una apuesta por el hidrógeno Renovable.* Madrid, 2020. https://www.miteco.gob.es/images/es/hojarutadelhidrogeno_tcm30-513830.pdf.

[238] It can also be introduced as a raw material in the chemical industry and refineries, which currently use hydrogen from fossil sources. For further details, refer to: Department for Ecological Transition and Demographic Challenge *Hoja de Ruta del Hidrógeno: Una apuesta por el hidrógeno Renovable.* Madrid, 2020. https://www.miteco.gob.es/images/es/hojarutadelhidrogeno_tcm30-513830.pdf; and Vitoria, M., *et al.* "The role of storage technologies throughout the decarbonisation of the sector-coupled European energy system." *Energy Conversion and Management* 201, 2019. https://doi.org/10.1016/j.enconman.2019.111977.

[239] Department for Ecological Transition and Demographic Challenge *Hoja de Ruta del Hidrógeno: Una apuesta por el hidrógeno Renovable.* 2020. https://www.miteco.gob.es/images/es/hojarutadelhidrogeno_tcm30-513830.pdf.

[240] Economic diversification and the reconversion of territories affected by ecological transition are included in the Spanish Government's Fair Transition Strategy, and are supported by European funding through the Fair Transition Funds. For further details, see: European Commission. "Fuentes de financiación de la transición justa." European Commission, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism/just-transition-funding-sources_es; and Department for Ecological Transition and Demographic Challenge. Estrategia de Transición Justa. Madrid, 2020. https://www.miteco.gob.es/images/es/documentoetj_tcm30-514300.pdf.

[241] Cramer, W., *et al*. "MedECC 2020 Summary for Policymakers." In W. Cramer, J. Guiot, and J. K. Marini (eds.). *Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report*. Marseille: Union for the Mediterranean, Plan Bleu , and UNEP/MAP, 2020. *En prensa.* https://www.medecc.org/wp-content/uploads/2020/11/MedECC_MAR1_SPM_ENG.pdf.

[242] Refer to: Global Wind Energy Council. *Supply Side Analysis 2019*. https://gwec.net/wind-turbine-sizes-keep-growing-as-industry-consolidation-continues/; and Schmela, Michael. *EU Market Europe For Solar Power 2019 - 2023*. Solar Power Europe, 2019. https://www.solarpowereurope.org/wp-content/uploads/2019/12/SolarPower-Europe_EU-Market-Outlook-for-Solar-Power-2019-2023_.pdf?cf_id=5387.

[243] The PNIEC analyses the impact of the effect of the policies and measures set out in the PNIEC against a baseline scenario without additional measures. The net annual employment generated is estimated at between 253,000 and 348,000 people per year in the

period 2021-2030. The ELP assesses the additional effect of policies needed to decarbonise the economy in the period 2031-2050, with its baseline scenario being the PNIEC target scenario until 2030 and no additional policies thereafter. The net annual employment generated is estimated at between 140,000 and 300,000 people per year. See: Department for Ecological Transition and Demographic Challenge *Impacto económico, de empleo, social y sobre la salud pública del Plan Nacional Integrado de Energía y Clima 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/images/es/informesocioeconomicopniecco mpleto_tcm30-508411.pdf; and Department for Ecological Transition and Demographic Challenge.. *Estrategia de Descarbonización a Largo Plazo 2050. Anexos*. Madrid, 2020. https://www.miteco.gob.es/es/ prensa/anexoelp2050_tcm30-516147.pdf.

[244] Recent studies agree that the transition to a decarbonised economy can have positive effects on employment and economic activity, especially for countries or regions dependent on fossil fuels. For further details, refer to, among others: International Renewable Energy Agency. *Transforming the Energy System – and holding the line on the rise of global temperatures*. Abu Dhabi, 2019. https://www.irena.org/publications/2019/Sep/Transforming-the-energy-system; and OECD. *Investing in Climate, Investing in Growth*. Paris: OECD Publishing, 2017. https://doi.org/10.1787/9789264273528-en.

[245] Department for Ecological Transition and Demographic Challenge. *Estrategia de Descarbonización a Largo Plazo 2050*. Madrid, 2020. https://www.miteco.gob.es/es/prensa/documentoelp_tcm30-516109.pdf.

[246] Estimates of savings from reduced fossil fuel imports have been made under the following assumptions. (i) the vehicle fleet in the year 2019 (latest available data) consisted of 34.4 million units, of which 24.5 million were passenger cars; (ii) the consumption of motor fuels in 2019 was 28.832 kilo tonnes (1 tonne = 7.33 barrels of oil); (iii) the estimated price per barrel of brent for 2030 in euros at constant 2016 prices is 100.77 according to the PNIEC, and it is assumed that by 2050, according to the ELP, this could be close to 120; (iv) it is established that all fossil automotive fuel (gasoline and diesel) that is no longer consumed by substitution with electric vehicles is equal to the fossil fuel that is no longer imported; and (v) the energy that will power electric vehicles will be 100% of renewable sources. See: CORES. *Informe estadístico anual 2019*. https://www.cores.es/es/publicaciones; Department of Interior. Dirección General de Tráfico. *Parque de vehículos. Anuario 2019*. https://www.dgt.es/es/seguridad-vial/estadisticas-e-indicadores/parque-vehiculos/tablas-estadisticas/*; and Department for Ecological Transition and Demographic Challenge. Plan Nacional Integrado de Energía y Clima 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf; and Department for Ecological Transition and Demographic Challenge.. *Estrategia de Descarbonización a Largo Plazo 2050. Anexos.* Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf.

[247] However, the electrification of the car fleet faces two challenges to its sustainability: managing the use of rare elements (such as lithium) and the need to implement strategies for the reuse, recycling and disposal of batteries at the end of their useful life. In addition, electric vehicles do not completely eliminate emissions of air pollutants harmful to health (such as particulate matter from tyre wear, brakes and pavement abrasion), nor do they solve congestion and public space occupation problems. For further details, refer to: United Nations Environment Programme. *Foresight brief: Challenges for the growth of the electric vehicle market.* 2020. https://wedocs.unep.org/bitstream/handle/20.500.11822/33111/FB17.pdf?sequence=7&isAllowed=y; and Khan, R. K., and Mark A. Strand. "Road dust and its effect on human health: a literature review." *Epidemiology and Health* 40, 2018. https://doi.org/10.4178/epih.e2018013.

[248] This category includes advanced biofuels, such as those made from waste, or electro-fuels, made from carbon dioxide and water using electricity. While these provide continuity to existing propulsion systems and logistical supply systems, they do not fully address local pollutant emissions problems and are constrained by the efficiency limits of existing combustion engines. There are also challenges in the manufacturing processes of these fuels to make them cost-effective. On this question, see, among others: Lehtveer, Mariliis, Selma Brynolf, and Selma Brynolf. "What Future for Electrofuels in Transport? Analysis of Cost Competitiveness in Global Climate Mitigation." *Environmental Science and Technology* 53, n.º3, 2019. https://pubs.acs.org/doi/10.1021/acs.est.8b0524; Department for Ecological Transition and Demographic Challenge. *Estrategia de Descarbonización a Largo Plazo 2050. Anexos.* Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf; and Transport and Environment. *What role is there for electrofuel technologies in European transport's low carbon future?*. 2017. https://www.transportenvironment.org/sites/te/files/publications/2017_11_Cerulogy_study_What_role_electrofuels_final_0.pdf.

[249] For further details, see: European Commission. *On the road to automated mobility: An EU strategy for mobility of the future*. Brussels, 2018. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52018DC0283; and Jones, E. C., and B. D. Leibowicz. "Contributions of shared autonomous vehicles to climate change mitigation." *Transportation Research Part D: Transport and Environment* 72, 2019. https://doi.org/10.1016/j.trd.2019.05.005.

[250] On this question, see, among others: Commission of Experts on Energy Transition. *Análisis y propuestas para la descarbonización*. 2018. http://www6.mityc.es/aplicaciones/transicionenergetica/informe_cexpertos_20180402_veditado.pdf; Llevat, M., and G. Llobet. *El Futuro del Ferrocarril de Mercancías en España*. Fedea, Policy Papers, n.º 2016/25, 2016. https://documentos.fedea.net/pubs/fpp/2016/12/FPP2016-25.pdf; and Department for Ecological Transition and Demographic Challenge *Estrategia de Descarbonización a Largo Plazo 2050*. Madrid, 2020. https://www.miteco.gob.es/es/prensa/documentoelp_tcm30-516109.pdf.

[251] The International Air Transport Association estimates that pre-COVID passenger traffic levels will not recover until 2024. See: International Air Transport Association. "Recovery Delayed as International Travel Remains Locked Down." International Air Transport Association, https://www.iata.org/en/pressroom/pr/2020-07-28-02/.

[252] European governments, such as France and the Netherlands, plan to ban domestic commercial flights for journeys where the rail alternative covers the journey in less than two and a half hours

[253] International Civil Aviation Organization. *Destination green. The Next Chapter. Environmental report*. 2019. https://www.icao.int/environmental-protection/Pages/envrep2019.aspx.

[254] International Maritime Organization. *Fourth IMO Greenhouse Gas Study*. 2020. https://theicct.org/news/fourth-imo-ghg-study-finalreport-pr-20200804.

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[304] Total annual demand for consumptive uses (water, once used, is not returned to the environment where it was abstracted or is not returned in the same way as it was abstracted): supply, agricultural use, industrial use and other consumptive uses. The observed figure is from 2013/2014. See: Department for Ecological Transition and Demographic Challenge *Informe de seguimiento de Planes Hidrológicos y Recursos Hídricos en España*. Año 2018. Madrid, 2019. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/memoria_infoseg_2018_tcm30-482594.pdf. Total annual demand for consumptive uses (water, once used, is not returned to the environment where it was abstracted or is not returned in the same way as it was abstracted): supply, agricultural use, industrial use and other consumptive uses. The observed figure is from 2013/2014. See: Department for Ecological Transition and Demographic Challenge Informe de seguimiento de Planes Hidrológicos y Recursos Hídricos en España. Año 2018. Madrid, 2019. https://www.miteco.gob.es/es/agua/temas/planificacion-hidrologica/memoria_infoseg_2018_tcm30-482594.pdf.

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[306] Primary energy intensity is defined as the ratio between the energy consumption and the gross domestic product (equivalent kilogram oil / thousands of euros). In the case of Spain, the current figure is in line with that reported in the ELP for 2015. The EU-27 is the aggregate indicator reported by Eurostat and the EU-8 is obtained as the simple average of the values of the individual countries. See: Eurostat. *Energy intensity [nrg_ind_ei]. Energy intensity of GDP in chain linked volumes (2010)*. https://ec.europa.eu/eurostat/data/database.Primary energy intensity is defined as the ratio between the energy consumption and the gross domestic product (equivalent kilogram oil / thousands of euros). In the case of Spain, the current figure is in line with that reported in the ELP for 2015. The EU-27 is the aggregate indicator reported by Eurostat and the EU-8 is obtained as the simple average of the values of the individual countries. See: Eurostat. Energy intensity [nrg_ind_ei]. Energy intensity of GDP in chain linked volumes (2010). https://ec.europa.eu/eurostat/data/database.

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[313] This level of environmental revenue collection was achieved by countries such as Denmark between 1996 and 2007. See: Eurostat. *Environmental Tax Revenues [env_ac_tax]. Percentage of gross domestic*

product (GDP). https://ec.europa.eu/eurostat/data/database.This level of environmental revenue collection was achieved by countries such as Denmark between 1996 and 2007. See: Eurostat. Environmental Tax Revenues [env_ac_tax]. Percentage of gross domestic product (GDP). https://ec.europa.eu/eurostat/data/database.

[314] It is defined as the proportion of the total utilised agricultural area occupied by organic farming (includes existing organically farmed areas and areas under conversion). The EU-27 is the aggregate indicator reported by Eurostat and the EU-8 is obtained as the simple average of the values of the individual countries. The observed figure is from 2019. See: Eurostat. *Area under organic farming [SDG_02_40]. Percentage of total utilised agricultural area. Utilised agricultural area excluding kitchen gardens. Total fully converted and under conversion to organic farming*. https://ec.europa.eu/eurostat/data/database. It is defined as the proportion of the total utilised agricultural area occupied by organic farming (includes existing organically farmed areas and areas under conversion). The EU-27 is the aggregate indicator reported by Eurostat and the EU-8 is obtained as the simple average of the values of the individual countries. The observed figure is from 2019. See: Eurostat. Area under organic farming [SDG_02_40]. Percentage of total utilised agricultural area. Utilised agricultural area excluding kitchen gardens. Total fully converted and under conversion to organic farming. https://ec.europa.eu/eurostat/data/database.

[315] Target for 2030 according to the European Commission. See: European Commission. *Farm to Fork Strategy: for a fair, healthy and environmentally-friendly food system*. Brussels, 2020. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf. Target for 2030 according to the European Commission. See: European Commission. Farm to Fork Strategy: for a fair, healthy and environmentally-friendly food system. Brussels, 2020. https://ec.europa.eu/food/sites/food/files/safety/docs/f2f_action-plan_2020_strategy-info_en.pdf.

[316] The value corresponds to the sum of hectares resulting from protective afforestation, productive afforestation and afforestation of agricultural land. Annual average over the decade 2009-2018. On this question, see: Department for Ecological Transition and Demographic Challenge *Anuario de Estadística Forestal. Resultados Estadísticos Principales de 2018*. https://www.miteco.gob.es/es/biodiversidad/estadisticas/aef_2018_resumen_tcm30-521680.pdf.The value corresponds to the sum of hectares resulting from protective afforestation, productive afforestation and afforestation of agricultural land. Annual average over the decade 2009-2018. On this question, see: Department for Ecological Transition and Demographic Challenge Anuario de Estadística Forestal. Resultados Estadísticos Principales de 2018. https://www.miteco.gob.es/es/biodiversidad/estadisticas/aef_2018_resumen_tcm30-521680.pdf.

[317] In line with the Long Term Decarbonisation Strategy 2050..See: Department for Ecological Transition and Demographic Challenge *Estrategia de Descarbonización a Largo Plazo 2050. Anexos*. Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf. n line with the Long Term Decarbonisation Strategy 2050. See: Department for Ecological Transition and Demographic Challenge Estrategia de Descarbonización a Largo Plazo 2050. Anexos. Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf.

[318] In line with the Long Term Decarbonisation Strategy 2050..See: See: Department for Ecological Transition and Demographic Challenge *Estrategia de Descarbonización a Largo Plazo 2050. Anexos*. Madrid, 2020. https://www.miteco.gob.es/es/prensa/anexoelp2050_tcm30-516147.pdf.

[319] Component 12 "Spain Industrial Policy 2030" of the draft of the "Recovery, Transformation and Resilience Plan" will allocate more than 2.2 billion euros to support strategic projects for industrial transition through the "Programme to Boost Industrial Competitiveness and Sustainability". Component 12 also includes a "Plan to support the implementation of waste legislation and the promotion of the circular economy". See: Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf.

[320] On this question, see, among others: European Commission. *Circular Economy Action Plan*. Luxembourg: Publications Office of the European Union, 2020. https://ec.europa.eu/environment/circular-economy/pdf/new_circular_economy_action_plan.pdf; and European Parliament and Council of the European Union. *Directive (EU) 2019/904 of the European Parliament and of the Council of 5 June 2019 on the reduction of the impact of certain plastic products on the environment* Brussels, 2019. https://eur-lex.europa.eu/legal-content/ES/TXT/?uri=CELEX%3A32019L0904.

[321] FAO, OIE, WHO, UN System Influenza Coordination, UNICEF and World Bank. *Contributing to One World, One Health*. 2008. https://www.oie.int/doc/ged/D5720.PDF.

[322] Among other aspects, synergies between different environmental health risks should be considered in prevention and risk plans (e.g. between heat and air pollution), potential new risks from emerging pollutants should be monitored and regulated, and public awareness of the relationship between health and environment should be raised. For further details, see: Vandyck, T., *et al*. "Air quality co-benefits for human health and agriculture counterbalance costs to meet Paris Agreement pledges." *Nature Communications* 9, 2018. https://doi.org/10.1038/s41467-018-06885-9; WHO. *Heat and health in the WHO European Region: updated evidence for effective prevention*. Copenhague: Publications WHO Regional Office for Europe, 2021. https://www.euro.who.int/en/health-topics/environment-and-health/Climate-change/publications/2021/heat-and-health-in-the-who-european-region-updated-evidence-for-effective-prevention-2021.

[323] This is the economic cost of an additional tonne of CO emitted into the atmosphere on economic activities, social welfare and ecosystems.

[324] In 2018, environmental tax revenue in our country accounted for 1.8% of GDP, compared to 2.4% in the EU-27. The weight of energy taxes in energy prices is lower than the average weight in the EU-23 (population-weighted average of the 23 EU OECD countries). This strengthening of environmental taxation will bring important co-benefits, such as reduced emissions of air pollutants. For further details, refer to: Eurostat. Environmental Tax Revenues. [env_ac_tax]. https://ec.europa.eu/eurostat/data/database; and Gago, A., *et al*. Impuestos energético-ambientales en España: situación y propuestas eficientes y equitativas. Fundación Alternativas, Documento de Trabajo Sostenibilidad n.º 2, 2019. https://www.fundacionalternativas.org/public/storage/publicaciones_archivos/58ce043c930b1da7b5d92cffac6f5215.pdf.

[325] This mechanism, included in EU plans, may provide an incentive for third countries to incorporate measures similar to those of the EU in order to avoid having to pay this adjustment. Moreover, it can protect sectors that would otherwise face disadvantageous international competition. On the other hand, it will make European efforts more effective by incorporating climate costs into products from third countries.

[326] The climate income, also known as the carbon dividend, is envisaged as a "basic income" that all citizens receive to help them change their consumption and investment patterns. It has already been implemented in other countries, such as Canada or Switzerland, and there are different citizen proposals for its implementation at a national and European level. See: Citizens Climate Initiative. "Apoyo a la Iniciativa Ciudadana Climática Europea." Citizens Climate Initiative, https://citizensclimateinitiative.eu/es/; and Economists' statement. "Economists' statement on carbon dividends organized by the climate leadership council." Economists' statement, https://www.econstatement.org.

[327] Part of these funds could be used to support territories whose activities contribute to the maintenance of ecosystem services to reduce the risks associated with climate change (forest fires, droughts, floods, etc.). European Commission. "Fuentes de financiación de la transición justa." European Comission, https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal/actions-being-taken-eu/just-transition-mechanism/just-transition-funding-sources_es.

[328] Chan, G., *et al.* "Six principles for energy innovation." *Nature* 552, n.º 7683, 2017. https://doi.org/10.1038/d41586-017-07761-0.

[329] Goldstein, A.P., *et al.* "Patenting and business outcomes for cleantech startups funded by ARPA-E." *Nature Energy*, 2020. https://doi.org/10.1038/s41560-020-00683-8.

[330] According to different studies, support for research and innovation in small and medium-sized enterprises by the public sector can have significant positive effects and indicates that relatively small amounts can result in large returns for small firms. For further details, refer to: Doblinger, C., K. Surana, and L.D. Anadon. "Governments as partners: the role of alliances in U.S. cleantech startup innovation." *Research Policy* 48, n.º 6, 2019. https://doi.org/10.1016/j.respol.2019.02.006; Goldstein, A.P., *et al.* "Patenting and business outcomes for cleantech startups funded by ARPA-E." *Nature Energy,* 2020. https://doi.org/10.1038/s41560-020-00683-8; Howell, S. T. "Financing innovation: evidence from R&D grants." *American Economic Review* 107, 2017. https://doi.org/10.1257/aer.20150808; Pless, J. "Are "Complementary Policies" Substitutes? Evidence from R&D Subsidies in the UK." 2019. https://mitsloan.mit.edu/shared/ods/documents/?PublicationDocumentID=5545.

[331] In line with the Long Term Decarbonisation Strategy 2050. See: Department for Ecological Transition and Demographic Challenge. *Estrategia de Descarbonización a Largo Plazo 2050*. Madrid, 2020. https://www.miteco.gob.es/es/prensa/documentoelp_tcm30-516109.pdf.

[332] Economics for Energy. *Estrategias para la descarbonización del transporte terrestre en España. Un análisis de escenarios.* Vigo, 2021. https://eforenergy.org/docpublicaciones/informes/informe_transporte.pdf.

[333] Modal shift is the most efficient and effective measure, and is one of the main measures envisaged in the PNIEC 2021-2030. Economics for Energy. *Estrategias para la descarbonización del transporte terrestre en España. Un análisis de escenarios.* Vigo, 2021. https://eforenergy.org/docpublicaciones/informes/informe_transporte.pdf; and Department for Ecological Transition and Demographic Challenge.. *Plan Nacional Integrado de Energía y Clima 2021-2030*. Madrid, 2020. https://www.miteco.gob.es/images/es/pnieccompleto_tcm30-508410.pdf.

[334] The "Recovery, Transformation and Resilience Plan" project will allocate more than 2.2 billion euros to support strategic projects for industrial transition in its component 12 "Spain Industrial Policy 2030". Among other sectors, support will be given to the development of the automotive sector and electric vehicles. Likewise, component 1 of the "Sustainable, safe and connected mobility shock plan in urban and metropolitan environments" includes an "Incentive plan for the installation of recharging points, the acquisition of electric and fuel cell vehicles and innovation in electromobility, recharging and green hydrogen", with a budget of close to 2 billion euros. See: Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf.

[335] This requires stable and gradual programming over time to mitigate impacts, a scheme that anticipates and addresses the effects on economic activity and income distribution, and a mechanism that periodically adjusts tax rates in line with inflation to avoid reducing their weight in real terms. For further details, refer to: Gago, A., *et al. Impuestos energético-ambientales en España: situación y propuestas eficientes y equitativas*. Fundación Alternativas, 2019. https://www.fundacionalternativas.org/public/storage/publicaciones_archivos/58ce043c930b1da7b5d92cffac6f5215.pdf.

[336] With regard to local transport, the draft of the "National Recovery, Transformation and Resilience Plan" devotes, in its component 6 "Sustainable, safe and connected mobility" 1.6 billion euros to encourage greater use of its services, improving their accessibility, quality and advancing in digitalisation, among other measures. See: Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf.

[337] The draft of the "Recovery, Transformation and Resilience Plan" dedicates in its component 6 "Sustainable, Safe and Connected Mobility" almost 4 billion euros to the promotion of Trans-European Transport Networks. This is intended to build new rail infrastructure on the Atlantic and Mediterranean corridors and modernise the existing network, among other things. On this question, see: AIReF. *Estudio infraestructuras de transporte. Evaluación del gasto público 2019*. Madrid, 2020. https://www.airef.es/wp-content/uploads/2020/07/INFRAESTRUCTURAS/ESTUDIO_INFRAESTRUCTURAS_SPENDINGREVIEW.pdf; Europe on Rail. *Hop on the train: A Rail Renaissance for Europe. How the 2021 European Year of Rail can support the European Green Deal and a sustainable recovery.* Bonn, Berlin, 2020. https://germanwatch.org/sites/germanwatch.org/files/Hop%20on%20the%20Train.%20A%20Rail%20Renaissance%20for%20Europe_0.pdf; y Gobernment of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/

presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf.

[338] For more details on the challenges of taxation in the aviation sector see: Gago, A., *et al. Impuestos energético-ambientales en España: situación y propuestas eficientes y equitativas.* Fundación Alternativas, Documento de Trabajo Sostenibilidad n.º 2, 2019. https://www.fundacionalternativas.org/public/storage/publicaciones_archivos/58ce043c930b1da7b5d92cffac6f5215.pdf.

[339] National Hydrological Plan; Spanish River Basin Hydrological Plans; National Plan for Purification, Drainage, Efficiency, Saving and Reuse (under preparation). The draft of the "Recovery, Transformation and Resilience Plan" will also help to make progress on this front. Thus, in its component 3 "Environmental and digital transformation of the agri-food and fisheries system" and its component 5 "Preservation of coastal space and water resources", it will allocate over 2.5 billion euros to a more efficient management of water resources, in line with the recommendations included in this *Strategy*. For further details, see: Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf; and Department for Ecological Transition and Demographic Challenge.. "Agua. Planes y Estrategias." Department for Ecological Transition and Demographic Challenge, https://www.miteco.gob.es/es/agua/planes-y-estrategias/.

[340] For further details, see: Clark, Michael A., *et al.* "Multiple health and environmental impacts of foods." *Proceedings of the National Academy of Sciences* 116, n.º 46, 2019. https://doi.org/10.1073/pnas.1906908116; EAT. *Diets for a Better Future: Rebooting and Reimagining Healthy and Sustainable Food Systems in the G20*. EAT Lancet Commission on Food, Planet, and Health, 2020. https://eatforum.org/content/uploads/2020/07/Diets-for-a-Better-Future_G20_National-Dietary-Guidelines.pdf; y WHO. "Healthy diet." WHO, https://www.who.int/news-room/fact-sheets/detail/healthy-diet.

[341] Department of Agriculture, Food and Environment. *Más alimento, menos desperdicio. Estrategia 2017–2020.* Madrid, 2017. https://menosdesperdicio.es/sites/default/files/documentos/relacionados/estrategia_17-20.pdf.

[342] Such as the "Practical guide to reduce food waste in schools". For further details, refer to: Department of Agriculture, Food and Environment. *Guía práctica para reducir el desperdicio alimentario en centros educativos.* Madrid, 2014. https://www.miteco.gob.es/es/ceneam/recursos/pag-web/guia-reducir-alimentos-centro-educativos.aspx.

[343] République française. "L'affichage environnemental des produits et des services." Ministère de la Transition écologique, https://www.ecologie.gouv.fr/laffichage-environnemental-des-produits-et-des-services-hors-alimentaire.

[344] Carbon Trust. "Product carbon footprint certification and labelling." Carbon Trust, https ://www.carbontrust.com/what-we-do/assurance-and-certification/product-carbon-footprint-label ?kw=%20carbon-%20footprint-%20label-Broad.

[345] The draft of the "Recovery, Transformation and Resilience Plan" includes in its component 4 "Conservation and restoration of ecosystems and their biodiversity" specific investments for sustainable forest management. See: Government of Spain. *Recovery, Transformation and Resilience Plan*. Madrid, 2021. https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/130421-%20Plan%20de%20recuperacion%2C%20Transformacion%20y%20Resiliencia.pdf.

[346] A Land Bank is an instrument to facilitate rural land leasing contracts between landowners and farmers, with the aim of mitigating the abandonment of farmland. Autonomous regions such as Galicia, Aragon and Asturias already have these instruments in place. For further details, refer to: Santiago, Diana. "La organización administrativa del banco de tierras de Galicia: la sociedad pública bantegal y la comisión técnica de precios y valores." *Dereito* 19, n.º1,2010. https://minerva.usc.es/xmlui/bitstream/handle/10347/7941/03.Santiago.pdf?sequence=1&isAllowed=y.

[347] This measure is relevant because more than half of the fires are caused by the use of fire in agricultural and livestock practices. For further details, see: Department of Agriculture, Food and Environment. *¿Qué sabemos de los incendios forestales?* Madrid, 2015. https://www.mapa.gob.es/es/desarrollo-rural/estadisticas/tripticoincendios-junio2015v6_tcm30-419121.pdf.

[348] Department for Ecological Transition and Demographic Challenge "Plan de Acción de Educación Ambiental para la Sostenibilidad." Centro Nacional de Educación Ambiental, https://www.miteco.gob.es/es/ceneam/plan-accion-educacion-ambiental/documento-participacion-experta-paeas.aspx.

[349] This institution should have the following characteristics: 1) be a politically relevant, but not politically prescriptive public body; 2) be independent, with criteria of transparency and inclusiveness; 3) be in charge of developing sectoral and policy projections, assessments and monitoring; and 4) foster the relationship between science and policy, through multi-directional "science-planning-management" coordination and exchange (including the public and private sectors), for the identification of knowledge gaps, co-creation, co-design and co-development of R&D&I.