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Transformative Innovation for better Climate Change Adaptation – Case Study: Granada - Andalucia, Spain

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Contents

Abstract

The aim of this report is to investigate the potential for harnessing key features of Transformative Innovation to improve the design and the implementation of Climate Change Adaptation (CCA) strategies, based on empirical analyses. The study draws on the conceptual framework on this question previously defined for the JRC (European Commission, 2024), and the methodology for case studies articulated in the same report. The case study research comprises overall 14 case study reports covering 16 different territories from across the EU and beyond, casing various institutional contexts, a variety of biogeographical regions within different climate risks, different ranges of population sizes, and representing a diversity of approaches to CCA and transformative innovation.

The framework takes the form of an analytical grid, structured into seven sections, each of them representing a key feature of the 'transformative innovation' approach where the features are understood as essential conditions for the design and implementation of CCA strategies with this high level of ambition. Each section sets out the main question(s) to be addressed in relation to its respective transformative innovation feature. This report provides the findings for the region of Andalusia, Spain, with a particular focus on the city of Granada, as of November 2023. It is the result of a collaboration between the Joint Research Centre (JRC), DG CLIMA and DG RTD.

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Executive summary

Policy context

Spain, like many other countries worldwide, had its share of severe weather events, such as the recent Depresión Aislada en Niveles Altos (DANA), that struck the Valencia region on October 29, 2024. This isolated high-altitude depression caused catastrophic flash floods, resulting in over 200 deaths and widespread damage.

Adapting to climate change has become an increasingly urgent priority for the EU and its territories. Given this urgency, and the systemic nature of climate resilience, new ways to accelerate adaptation are considered. Transformative innovation (TI) is at the focus of this report, particularly how it can help support and accelerate adaptation to climate change. The analysis in this report draws lessons for Andalusia region in Spain and the city of Granada, on how a TI approach is already helping the territory in increasing climate resilience, and what can be done in addition, to further accelerate adaptation. The analysis is based on a theoretical framework along seven dimensions designed to compare TI and Climate Change Adaptation. It is one out of a series of 14 different case study reports in European territories.

Main findings

Spain is experiencing declining annual rainfall, reduced river flow, and diminished water resources, leading to increased water stress and expansion of semi-arid areas. Spain's surface and marine waters are affected by warming, increased salinity, acidification, and rising sea levels, with noticeable impacts on both the Atlantic and Mediterranean coasts. The Mediterranean Sea, in particular, has shown variable sea level trends but an overall rise in recent decades. Rising temperatures and intensified heatwaves have contributed to longer, hotter summers, with projections of further warming. These environmental shifts heighten risks of forest fires, soil dryness, and more frequent extreme weather events, posing ongoing challenges for Spain's climate resilience. Semi-arid climate conditions are expanding, seawater temperatures are rising, and sea levels are increasing. While similar vulnerabilities exist in Andalusia and Granada as those at the national level, some impacts are expected to be more severe locally. These climate changes affect key sectors like tourism, agriculture, and livestock, while also threatening cultural heritage, particularly in coastal areas.

Goals and directionality

The National Plan for Adaptation to Climate Change (PNACC) has been the guiding framework for climate change adaptation (CCA) in Spain since 2006. PNACC aims to reduce climate-related damages and build resilience through coordinated actions across multiple sectors, with objectives ranging from enhancing climate observation to integrating CCA into public policies. Various autonomous communities, including Catalonia, the Balearic Islands, and Andalusia, have developed their own climate change laws and strategic plans. Andalusia's Climate Action Plan (PAAC), based on Law 8/2018, aims to integrate climate change mitigation and adaptation into regional and local planning, aligning with national, European, and global initiatives like the European Green Deal and the Paris Agreement. In Granada, the Plan for Adaptation to Climate Change (PPACCGr), approved in April 2023 introduced a unique methodology combining scientific climate analysis, vulnerability assessment, and stakeholder participation, filling the gap in supra-municipal adaptation planning.

Articulating instrument portfolios and defining synergies between funding sources.

Spain's climate adaptation funding draws significantly from EU instruments. Specific initiatives like the PIMA Adapta programme (since 2015) target vulnerability reduction. In Andalusia, the PAAC and the Smart Specialization Strategy for Sustainability (S4Andalucia) 2021-2027 drive regional climate adaptation and mitigation efforts, promoting collaboration in EU programmes like Horizon Europe, LIFE, and Interreg. The PPACCGr implement projects drawing funds from various funding pro-

grammes. In Spain, it is evident that significant efforts were invested in articulating various instruments. However, certain bottlenecks continue to hinder an efficient implementation. For instance, engaging the private sector effectively requires more tailored incentives. Improved policy alignment and dialogue across governance levels could ensure streamlined action. Municipalities would benefit from simplified processes to access funding, facilitating their participation. Addressing specific regional data needs and strengthening coordination between regional and local bodies could further enhance the cohesiveness and impact of adaptation strategies.

Ensuring cross domain synergies

PNACC 2021-2030 prioritizes coordinated action across 13 key sectors like water, biodiversity, energy, and urban planning, promoting collaboration among institutions, consistency in policies, and accessible climate information. This interdisciplinary approach is also supported by the Strategy for Science, Technology, and Innovation 2021-2027. In Andalucía, managed by the Andalusian Climate Change Office and backed by intersectoral working groups, the Andalusian Climate Action Plan (PAAC) and Law 8/2018 strengthen regional and local alignment with national climate policies. Granada's Adapta Granada Plan focuses on 11 specific sectors aligned with the PNACC. Some challenges still remain and include, resource disparities across government levels, siloed operations within sectors, and limited local (at the level of municipalities) resources for implementing complex adaptation projects, which can impact cohesive strategy application and slow progress in areas like urban planning and tourism.

Increasing breadth and depth of stakeholder involvement

The (PNACC) 2021-2030 in Spain was developed through an inclusive process involving experts, public administration, private sector representatives, and civil society, ensuring a broad stakeholder representation. Similarly, the Spanish Strategy of Science, Technology, and Innovation (EECTI) 2021-2027 was co-designed with diverse stakeholders. In Andalucía, the Andalusian Climate Action Plan (PAAC) was designed with public participation and transparency at its core. Public workshops and consultations shaped a collaborative plan involving economic, social, and administrative stakeholders. In Granada, the Provincial Council developed a tailored approach for climate adaptation, establishing Territorial Management Units and committees to involve local representatives in the planning and monitoring phases. Challenges include a need for more structured guidelines for stakeholder involvement at local levels.

Setting up effective multi-level governance models

Spain has established robust coordination mechanisms and organizational structures to support climate adaptation across national, regional, and local levels. This framework includes structured committees, commissions, and offices that promote cross-sector collaboration and integrate local insights into broader climate strategies. Key national bodies, such as the Spanish Climate Change Office within MITERD, the National Climate Council, the Climate Change Policy Coordination Commission (CCPCC), and the Interministerial Commission for Climate Change and Energy Transition, play crucial roles in overseeing climate adaptation policies and fostering inter-institutional coordination. The Andalusian Office of Climate Change, the Interdepartmental Commission on Climate Change ensure alignment and collaboration across local, regional, and national levels, in coordination with national bodies. In Granada, coordination is supported through a Technical Committee of experts and Territorial Committees within nine Territorial Management Units, which focus on gathering local data and addressing adaptation needs with diverse stakeholder input. Challenges include potential complexity from multiple coordinating bodies, which could lead to overlapping responsibilities and slower communication. In some cases, local entities, especially smaller municipalities, may need ad-

ditional methodologies, technical resources, and funding to fully engage in climate adaptation efforts, potentially causing inconsistencies in regional implementation.

Making room for experimentation

PNACC places limited emphasis on experimentation. In Andalusia, interviews reveal minimal experimentation. Some projects, though not widely visible, exist. The Government of Andalucía is implementing an innovative risk management model. Seville's CartujaQanat project takes an innovative approach to urban heat mitigation by creating adaptable, socially inclusive spaces. Granada's Provincial Climate Adaptation Plan itself can serve as an example of policy experimentation. In terms of opportunities for experimentation, Granada's Provincial Climate Adaptation Plan implement various adaptation projects, enabling the region to gather insights for refining adaptation measures that are sustainable, scalable, and tailored to local needs. While there is some interest in experimentation in climate adaptation initiatives, the lack of visible examples and a public database of successful practices limits their broader impact and potential for scalability.

Securing high levels of policy intelligence, learning and strategic capacity

The Climate Change Adaptation Plans at national, regional level stongly emphasise stakeholder engagement. The Action Plan for Environmental Education for Sustainability (2021-2025) supports the integration of climate education across all levels and sectors. Portal Andaluz de Cambio Climático, a dedicated climate change portal, provides information, practical tips, and examples of sustainable practices for citizens. The AdaptaGranada Plan includes a specific objective to increase local climate awareness. The "*Campaign for Raising Awareness about Climate Change*" offers some public resources, although limited information is currently available.

There is a clear emphasis on data-driven adaptation, comprehensive monitoring, and accessible information sharing at all leveles (national, regional, local). Yet, information gaps are acknowledged. Climate projections and digital tools like the AdapteCCa platform, Portal Andaluz de Cambio Climático and SICMA platform provide accessible, region-specific information. These resources support stakeholders with localized climate projections and future scenario mapping.

Key conclusions

Spain's established framework for climate change adaptation (CCA) provides a robust foundation for addressing climate risks. However, the devastating impacts of the recent **DANA** (Depresión Aislada en Niveles Altos) in the Valencia region highlight significant gaps and challenges in implementation and preparedness. DANAs are naturally occurring meteorological phenomena, but their frequency and intensity are exacerbated by climate change. While national frameworks set broad objectives, the translation of these goals into localized and actionable measures is often inconsistent. Decades of urban expansion into vulnerable areas, including floodplains, have increased the exposure and susceptibility of populations and infrastructure to extreme weather events. These historical decisions often limit the efficacy of current adaptation efforts. Despite national frameworks, local infrastructures, particularly in urban areas, often lack the capacity to manage extreme rainfall events, such as vulnerabilities in urban drainage systems and land-use planning, such as developments in flood-prone zones. Coordination gaps between national, regional, and municipal levels hinder the effectiveness of CCA strategies in addressing specific vulnerabilities like those exposed by the recent DANA. While Spain has a strong policy framework, the pace of implementation can lag behind the urgency of climate risks. Efforts to enhance infrastructure, update regulations, and integrate climate data into planning processes may not be sufficient to prevent or mitigate the impacts of extreme phenomena.

Suggested below are potential pathways for enhancing the adoption of a transformative climate adaptation approach, aligned with each of the seven key transformative innovation features.

Directionality. Set clear, measurable CCA targets and prioritize innovative adaptation approaches. Build a strong base of expertise in CCA, across national, regional, and municipal administrations, with a focus on cross-collaboration. Leverage insights gained from other EU regions to refine and enhance adaptation strategies.

Articulation. Clarify the responsibilities of local, regional, and national governments in adaptation projects to minimize overlaps and ensure accountability at each level. Develop incentives to encourage private sector participation in CCA initiatives. Introduce green certifications or awards recognizing businesses that adopt and implement adaptation practices. Encourage public-private partnerships that can leverage private sector innovation and investment to complement public resources. Establish a dedicated funding mechanism tailored to smaller municipalities, offering straightforward application processes and providing technical assistance to support project development and management.

Ensuring cross domain synergies. Provide increased support to multi/inter/trans disciplinary CCA research. Identify and address any strategic silos that may hinder collaborative efforts across sectors. Engage communities in CCA initiatives, including in research projects, with a focus on responsible research practices. Leverage the potential of a “climate adaptation economy” by incorporating business-oriented innovation tools into the adaptation project portfolio.

Increasing breadth and depth of stakeholder involvement. Continue and expand the stakeholders engagement efforts already established. Design detailed recommendations for involving distinct groups, including vulnerable, marginalized, and underrepresented communities. Ensure that stakeholder involvement is not limited to the initial stages of planning but includes regular feedback loops throughout implementation. Establish channels for continuous input from diverse groups to refine CCA strategies over time. Encourage greater business participation in CCA.

Setting up effective multi-level governance models. Define clear roles and responsibilities of each coordinating body within the local-regional-national framework. Develop a digital platform to facilitate information sharing, decision-making, and responsibility tracking among these bodies, enhancing accountability, clarity of information and decision making flow.

Making room for experimentation. Introduce policy "labs" that serve as change agents and innovation catalysts within governance structures. These policy labs are particularly well-suited to address complex issues, such as CCA, through innovative approaches**.** Establish a centralized, accessible database that documents and showcases successful adaptation practices and experimentation initiatives. Foster a culture of innovation.

Awareness and understanding of CCA. Use surveys and public consultations to assess public understanding and misconceptions regularly. Provide enhanced support for the organisation of workshops and seminars to explain climate change causes, impacts, and necessary actions. Develop educational materials tailored to local contexts. Produce mini-documentaries featuring stories of people affected by climate change. Partner with influencers and public figures to broaden the campaign’s reach. Establish funding opportunities and technical assistance for small municipalities to help them actively participate in climate awareness initiatives. Set up regional “training of trainers” programs where municipal staff and local volunteers learn to lead climate awareness activities within their communities.

Knowledge base for CCA. Constantly update the dedicated platforms with information regarding the implementation of the CCA plans, relevant projects, programmes etc. Ensure budgetary resources and timely update of the monitoring platforms. Collect and incorporate granular, locally relevant data that can inform regional adaptation strategies. Develop mechanisms for integrating region-specific data into national climate risk reports, ensuring they address unique local vulnerabilities and conditions. Provide funding and technical support to municipalities for installing data collection infrastructure.

Strategic capacity. Establish a technical assistance programme and dedicated funds for training workshops to enhance local officials' expertise. A centralized platform is essential for sharing information about training opportunities, while enhanced collaboration between regional and local authorities can ensure standardized processes meet local needs. Create a database of relevant CCA good practices for the national, regional, local context. Tailored training programmes for regions, municipalitioes like Granada should address specific climate risks. Financial and technical support for smaller municipalities and regular evaluations of training impact will further enhance local strategic capacity and climate resilience.

1 Introduction to the case study territory

1.1 Profile of the territory

1.1.1 Spain

Spain, the second-largest country in the European Union, encompasses a total land area of 506,994[1] square kilometres. It shares the Iberian Peninsula with Portugal. Spain's mainland is primarily surrounded by the Mediterranean Sea to the south and east, with a minor land boundary shared with Gibraltar. To the north and northeast, it is bordered by France, Andorra, and the Bay of Biscay, and to the west and northwest, it abuts Portugal and the Atlantic Ocean. Beyond the Spanish mainland, the country also includes the Canary and the Balearic Islands archipelagos, in addition to the autonomous cities of Ceuta and Melilla. According to the data provided by the National Statistics Institute (INE), as of January 1, 2022, Spain's resident population stands at 47,432,893 inhabitants. This figure represents a substantial growth of 16% since 2002.

Spain's geographical location exposes it to the influences of two different bodies of water: the expansive and open Atlantic Ocean, and the Mediterranean Sea, which connects to the Atlantic through the narrow Strait of Gibraltar. The strait facilitates the exchange of waters with distinct salinity and temperature characteristics. The Spanish coastline, stretching over 7,876 kilometres, is distributed across the mainland, the Balearic Islands, and the Canary Islands. Spain is one of the most biologically diverse countries in the European Union and belongs to an area designated as one of the 25 biodiversity hotspots on the planet. The Natura 2000 network in Spain has around 1500 protected sites and is one of the largest national networks in the EU [2] and comprise in total the area of more than 222,000 km^2. Of this total area, more than 138,000 km^2 correspond to land surface, which represents approximately 27.35% of the Spanish territory, and about 84,300 km^2, to marine surface. These sites protect a wide range of habitats, including wetlands, coastal dunes, forests, grasslands, and mountain areas.

Given its topography and geographical position, the country experiences a wide range of climatic conditions, from humid Atlantic regions with annual rainfall exceeding 2,000 millimetres to vast semi-arid areas characterized by severe hydrological stress. Additionally, isolated areas in Spain exhibit cold alpine climates. Spain's great **climatic diversity**, together with other morphological and geological aspects, explains the great hydrological contrasts that exist. The natural regime of rivers depends mainly on rainfall, either through surface runoff or through underground contributions.

1.1.2 Andalucia

Andalusia, autonomous community (comunidad autónoma) and historical region of Spain, encompasses the provinces (provincias) of Huelva, Cádiz, Sevilla, Málaga, Córdoba, Jaén, Granada and Almería. Covering 87,268 km^2, Andalusia is Spain's second largest Autonomous Region and accounts for 18% of the country's total population. Andalusia comprises a total of 778 municipalities and is distinguished by a dense network of diverse population centres. Slightly more than half of the population resides in 29 municipalities with over 50,000 inhabitants; the average density is around 100 inhabitants per square kilometre.

[1] wikipedia

[2] https://www.miteco.gob.es/es/biodiversidad/temas/espacios-protegidos/red-natura-2000/rn_espana.html

Figure 1. Andalusia Region

Andalusia borders at the north with the regions of Estremadura and Castilla-La Mancha with the Sierra Morena Mountain range forming the southern border of the “Meseta Central” plateau. Its main river system is the Guadalquivir River basin that stretches throughout the autonomous region. In the west, the Guadiana River acts as the dividing line between Andalusia and Portugal, in the province of Huelva. Along the southern coast, Andalusia is bordered by the Atlantic Ocean, and the Mediterranean Sea. The eastern boundaries are delineated by the Mediterranean coast of Almería and the Levante region in eastern Spain. Approximately half of Andalusia's terrain is mountainous, with over a third of its land situated at elevations surpassing 600 meters above sea level. The region boasts an expansive high plateau and is home to 46 peaks above 1,000 meters (Britannica).

In terms of GDP, Andalusia contributes 13.3% to the national GDP, making it the third-largest Autonomous Community in terms of GDP, and the 16th in GDP per capita. For the period 2021-2027, it has been classified as a "less developed region" under cohesion policies, as it falls below 75% of the EU GDP per capita. In 2021 (Q3) the unemployment rate rose to 22.4% and the region GDP contracted by 11.0% in 2020 (10.0% according to the INE Regional Accounting), being strongly affected by the COVID pandemics. The regional economy has already recovered pre-crisis employment levels, although the unemployment rate remains at 19% [BBVA, 2022].

Andalusia, while rich in agricultural output, is comparatively less developed and contributes a smaller share to Spain's overall gross domestic product (GDP). The GDP by sector is primarily concentrated in services and tourism (75.4% of the region's GDP, compared to the national average of 75.1%). The industry sector contributes 11.5% to Andalusia's regional GDP, which is lower than the 15.9% national average. Agriculture is a significant sector in Andalusia, accounting for 6.1% of the region's Gross Value Added (GVA), which is more than double the 2.8% contribution of agriculture to the national GVA. Andalusia contributes 29.1% to the national agriculture total [S4 Andalucia, 2021-2027]. The manufacturing sector in the region is relatively underdeveloped and is primarily centered on processing agricultural products, fishing, and mining. While Andalusia's mining industry has experienced a decline from its peak in the late 19th century, mines in the Sierra Morena still yield substantial quantities of coal, iron, copper, and lead. Despite abundant coal deposits in the Sierra Morena and the utilization of hydroelectric resources along the upper reaches of the Guadalquivir River and the lower regions of the Baetic Cordillera, Andalusia faces an energy deficit. To-

wards the end of the 20th century, the region turned to solar and wind power plants as an alternative energy source. Andalusia's service sector has benefited from tourism, with visitors attracted to the hotels along the Mediterranean coast as well as the architecturally rich cities of Granada, Córdoba, and Sevilla.

The agricultural landscape in Andalusia is dominated by large estates known as "latifundios," which have become increasingly mechanized over time. However, the region still lags behind the national average in terms of the adoption of modern agricultural practices such as the use of tractors, irrigation, and fertilizers. Oranges are cultivated throughout the region, while mountainous areas are dedicated to the cultivation of cork trees. Andalusia is renowned for its wine and brandy production, with notable centers in Jerez, Niebla, Montilla, and Málaga. The provinces of Sevilla, Córdoba, and Jaén are significant producers of olive oil and collectively account for about two-thirds of Spain's total olive oil production.

The **Natura 2000 Network in Andalusia** covers, within the jurisdiction of the Government of Andalusia, 2.67 million hectares, of which 2.59 million are terrestrial and 0.07 million are marine. It is one of the richest and diverse of the European Union. For its management and conservation, it is fully included in the Network of Protected Natural Spaces of Andalusia (RENPA), by virtue of Decree 95/2003, of April 8. It is made up of 197 protected spaces: (a) 63 Special Protection Areas for Birds (ZEPA); (b) 190 Places of Community Interest (SCI), of which 176 are declared Special Areas of Conservation (Natura2000). Among these are the Doñana National Park declared Ramsar Wetland (1982) and a UNESCO World Heritage Site (1994) and Sierra Nevada National Park, two of the most important and extensive national parks in Spain.

Most of lowland Andalusia experiences a Mediterranean climate characterized by mild, rainy winters and hot, dry summers. Annual precipitation levels vary, ranging from approximately 80 inches (2,000 mm) in the Sierra Nevada and the Grazalema Mountains to as little as 8 inches (200 mm) in the arid Andalusian steppes. The coastal and lowland areas of Andalusia enjoy approximately 3,000 hours of sunshine per year. While the lower part of the Guadalquivir River basin features fertile soil, the relatively low rainfall necessitates irrigation in certain areas. Temperature averages in different cities throughout the region vary, with some as low as 15.1 °C. Along the Guadalquivir valley and the Mediterranean coast, the average temperature hovers around 18 °C. January is the coldest month, with Granada at the base of the Sierra Nevada experiencing an average temperature of 6.4 °C. The hottest months are July and August. Córdoba ranks as the hottest provincial capital, closely followed by Seville. The Guadalquivir valley has witnessed some of the highest temperatures ever recorded in Europe, the mountains of Granada and Jaén experience the coldest temperatures in southern Iberia, although they do not reach continental extremes and are surpassed by certain mountains in northern Spain.

1.1.3 Granada

Granada is the capital city of the province of Granada, located in the autonomous community of Andalusia, Spain. Positioned at the base of the Sierra Nevada mountains, Granada sits at the confluence of four rivers: the Darro, the Genil, the Monachil, and the Beiro. It is situated at an average elevation of 738 meters above sea level. As of the 2021 national census, the population of Granada city was 227,383, while the estimated population of the entire municipal area was 231,775, ranking it as the 20th largest urban area in Spain.

Granada experiences a hot-summer Mediterranean climate, with distinct seasons. In the summer the temperatures are high and the conditions are arid, with daily averages reaching around 34°C in July, and temperatures often exceeding 40°C. Winters in Granada are characterized by cooler and

wetter conditions, marked by annual rainfall concentrated between November and January. Frost is a regular occurrence, while snowfall is a rare event in the city, typically happening once every few years. Granada's spring and autumn seasons are characterized by unpredictability. In the recent years, the city has witnessed extreme heatwaves during the summer. In 2017, Granada experienced two significant heatwaves. In 2023, Granada faced yet another July heatwave.

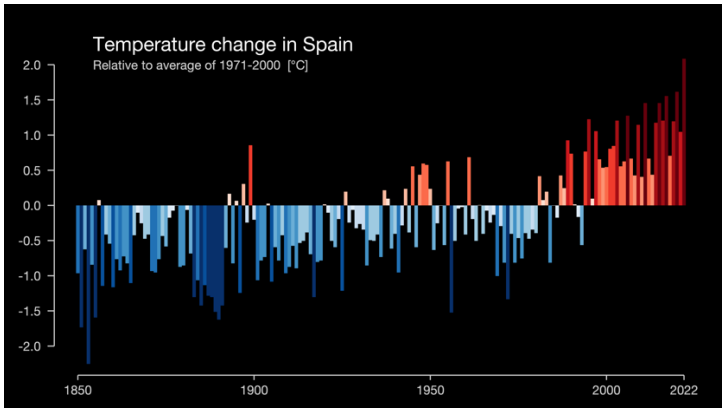
1.2 Climate change risks and vulnerabilities

A summary of the climate change impacts and vulnerabilities are listed below, as highlighted by the National Climate Change Adaptation Plan, 2021 · 2030, the GreenPeace report, 2023 and other relevant academic studies.

1.2.1 Temperature increase and heatwaves

- According to the Greenpeace report, "*The Mediterranean, which includes Spain, is heating faster than many other world regions and has already experienced climate change impacts such as drought, floods, heatwaves, temperature extremes and increased forest fire risk* [Greepenpeace Report, Miller K, Santillo D, 2023]". On a global scale, the average annual temperature has increased by approximately 1.15 degrees C compared to the nineteenth century (data comparison between the years 2011– 2020 with the years 1850–1900 (IPCC, 2023)). Since the 1980s, the rate of atmospheric warming in the Mediterranean has outpaced the global average. The projection is that the Mediterranean region will experience a warming of 2 degrees Celsius within the coming two decades, unless there are rapid and substantial reductions in global greenhouse gas emissions [Zittis et al., 2019]. This has been evidenced through events like the unusual spring heatwave in southern Spain in 2023, where temperatures at Córdoba airport reached 38.8°C on April 27, making it the hottest April day ever recorded in the country (McGrath & Hedgecoe, 2023).
- Length of summers has increased by an average of nine days per decade (AEMET).
- Increase of the number of heat wave days: since 1984, the number of days per year in which heat wave temperature thresholds are exceeded has doubled (AEMET).

Figure 2. Temperature change in Spain, relative to average 1971-2000.



Source: https://showyourstripes.info/c/europe/spain/all (accessed October 2023)

1.2.2 Droughts and floods

- Decrease in annual rainfall/ Decrease in the average flow of rivers/ Decrease in water resources. Spain has been witnessing a decline in annual rainfall, with a decrease of approximately 3 to 11 millimeters per decade since the 1950s [Cherif et al., 2020]. This trend has led to significant water stress in several regions. In particular, the south and central regions of Spain have seen a decline in the amount of annual precipitation, including both rain and snow. A 2019 study shows that 11 out of Spain's 15 river basin districts were experiencing water stress [Vargas, J. & Paneque, P., 2019]. While changing weather patterns played a role, the primary factors contributing to this stress were the increased demand for water in agriculture (approximately 80%), urban water consumption (16%), and industrial use (4%). In 2023, the three districts facing the most severe water stress are Guadiana, Gualdalquivir, and the interior basins of Catalonia [Greenpeace, 2023]. In 2023, during the heatwave, the fight over who gets Spain's water in Donana Park has even become a matter of national political dispute. Water police was searching for illegal wells in Donana Park.[3]
- **Expansion of semi-arid climate**. When comparing Spanish climate maps for the periods 1961-1990 and 1981-2010, it becomes evident that semi-arid areas have expanded. Approximately 30,000 square kilometers, which constitute around 6% of Spain's total surface area, transitioned to a semi-arid climate. This change is particularly notable in the southeast of the Iberian Peninsula. [Magrama, 2016]
- **Decrease in the recharge of aquifers**: the recharge of aquifers would be worth 15% of the amount of water that is extracted annually for irrigation from rivers and aquifers estimates that, for a global warming of 2 °C [Bisselink, B. et al. 2018].
- **Increased fire danger**: increased soil dryness or elevated temperatures, in turn, increase the danger of forest fires.
- **Torrential rains and floods**: an increase in episodes of torrential rains and flooding is expected in some areas. **DANAs** (Depresión Aislada en Niveles Altos)**,** also known as "cold drops (la gota fria)," are feared meteorological phenomena in Spain, particularly in the Mediterranean region, due to their history of causing severe flooding. A DANA occurs when a pocket of cold air becomes isolated at high altitudes, contrasting with warm surface temperatures, especially over a warm Mediterranean Sea. This temperature gradient creates atmospheric instability, leading to intense storms and torrential rains that often result in flooding. While these events are most frequent in summer and autumn, they can occur year-round, though with less intensity. Climate change is believed to exacerbate their severity. Studies suggest that rainfall is now less frequent but more extreme, aligning with higher levels of precipitable water in the atmosphere. Notably, the 1973 DANA in Almería, Granada, and Murcia was among the most destructive, with record rainfall and significant loss of life. In autumn 2024, heavy rainfall has caused 150 liters of water per square meter to fall in just a few hours. The DANA caused devastating floods in Valencia, resulting in over 200 deaths and the destruction of thousands of vehicles and homes

[3] https://www.bloomberg.com/news/features/2023-07-22/spanish-climate-election-what-s-at-stake-as-country-suffers-heat-drought#xj4y7vzkg

1.2.3 State of surface waters and marine waters

- **Increase of seawater temperature**: The surface water temperature has risen in all Spanish marine regions. Sea surface temperature shows warming rates between 0.2 and 0.7°C per decade, with an average of 0.34°C per decade since the 1980s for the Mediterranean.
- **Salinity changes in surface waters**/acidification of marine waters show high spatio-temporal variability, with an increasing trend in salinity in intermediate and deep waters. During the last century ocean pH has decreased ~0.1 units; acidification is more noticeable in surface waters in direct contact with the atmosphere.
- **Rise in average sea level** has been especially notable since 1993. The mean sea level rise along the Atlantic-Cantabrian coast has generally followed the global average trend. Between 1900 and 2010, it rose at a rate of 1.5 to 1.9 millimeters per year and increased to 2.8 to 3.6 millimeters per year from 1993. In the Mediterranean Sea, sea level changes have displayed variable trends. From the 1960s to the 1990s, there were periods of negative or decreasing trends in sea levels. From the 1990s onwards, the sea level rates increased from 2 to 10 millimeters per year.

1.2.4 Impacts on fauna and flora

Changes in the distribution of terrestrial and aquatic species, which move towards habitats with a more favourable climate. Climate change also enhances the colonization by invasive exotic species that act as vectors of disease transmission, impacts on fauna and flora and other elements of the natural heritage. For example a study showed that “Andalusian oak forest” and the “Corylus wet forest” types were the most vulnerable to climate change. High-elevation forest types and those with high moisture requirements were more vulnerable to climate change. [Hidalgo-Triana N, et al 2023].

1.3 Impact

1.3.1 Spain

Climate change has far-reaching impacts on various aspects of society and the environment. Here are some of the key impacts in different sectors:

Health. Climate change affects health directly through extreme weather events and indirectly through increased air pollution, aeroallergens, changes in disease-transmitting vectors' distribution, and water and food quality loss. Human exposure to elevated environmental temperatures can cause an insufficient response of the thermoregulatory system. Specific age groups, such as the elderly population and young children are more vulnerable, due to greater difficulty in controlling temperature regulation mechanisms. The World Health Organization (WHO) estimated that heat stress contributed to over 4,000 excess deaths in Spain in 2022.

Agriculture, Livestock, and Forestry. These sectors are highly dependent on climate and soil conditions. An analysis showed that the water cost in ES, is the most determinant factor in shaping agricultural land, offsetting the impact of the driver of water availability. In contrast, irrigation water use is driven not only by water cost but also by irrigation efficiency. The magnitude of the sensitivity to these drivers differs significantly across crops. [Martinez, P. Blanco et al 2023]

Tourism. Climate change impacts the tourism industry, with changes in weather patterns affecting travel destinations and tourism-related activities.

Coastal Resources. Rising sea levels and more powerful coastal storms lead to coastal retreat, alterations in sedimentary and erosions, and impacts on coastal ecosystems.

Energy Production and Consumption. Climate change affects various components of the energy system, from changes in the availability of renewable resources (e.g., wind, solar, and water) to the generation, transportation, distribution, and storage of energy.

Cultural Heritage. Many properties, particularly those near coastlines, are at risk due to rising sea levels and the need for adaptation measures.

Infrastructure Operability. Climate change can disrupt the operability of transport and social infrastructure systems. It affects not only these systems directly but also the adaptation measures required to mitigate these impacts.

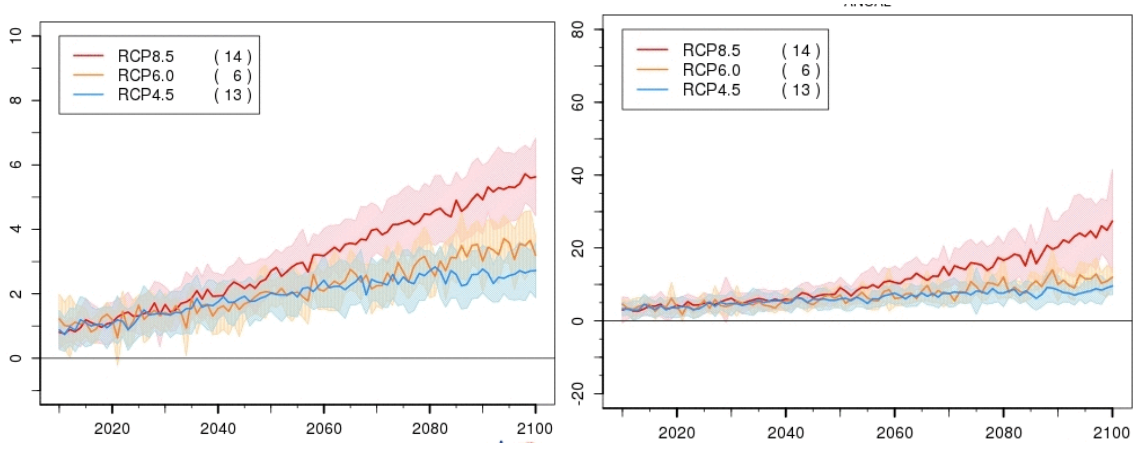
1.3.2 Andalucia

The analysis of the impact of the climate change in region of Andalucia, using various scenarios, foresees uneven warming, more noticeable in the interior, off the coast and more pronounced in mountain areas, especially in the Betic mountains. The projections performed with distinct scenarios, during the ex-ante phase of the elaboration of the Andalucia Plan for CCA identify similar vulnerabilities as those at national level (as detailed above), but some with higher impacts.

1.3.2.1 Temperature

By mid-century (2041-2070) the most sustainable scenarios foresee a rise of between 2 and 4.5°C, while those with highest emissions (SSP3-7.0 and SSP5-8.5) show increases of between 2.5°C in the area around the Strait to 5.5°C in the Betic mountain.

Figure 3. Prediction of (a) the increase of the average annual maximum temperature; (b) change of the heatwaves length using various greenhouse gas emission.



Source: AEMET[4], accessed on 21 October 2023

[4] https://www.aemet.es/es/serviciosclimaticos/cambio_climat/result_graficos?w=0&opc1=and&opc2=Tx&opc4=0&opc6=0&opc3=Anual

By the end of the century (2071-2100) the most optimistic scenarios show increases of between 2 and 5.5°C, while those with highest emissions show increases between 4 and 9°C. This corresponds to a maximum average temperature higher than 25°C on the coast (with a high humidity index) and higher than 30°C in the Guadalquivir plains. [Analysis of Future Evolution under Climate Change Scenarios of Climate Variables and Derived Variables][5]

The most probable scenarios predict average annual maximum temperatures of 24 to 26°C for the end of the century in the Guadalquivir area, 22 to 24°C on the coast, while in the interior depends strongly on the altitude, going from a range of 10-18°C to 15-24°C. The most pessimistic scenario raises these averages to 25-28°C (Guadalquivir area), 23-25°C (coast), 16-25°C (interior) for the aforementioned regions.

1.3.2.2 Precipitation

For the middle of the century (2040-2070), in the first emissions scenario (SSP1-2.6) moderate relative increases are estimated, between 0 to 5% in localized regions, while in the rest of the Andalusian territory a decrease is observed between 0 to 5%. In the other scenarios (SSP2-4.5 -> SSP5-8.5) a generalized estimate of declines is observed that gradually intensifies as the future scenario becomes more pessimistic. A very similar situation is obtained in the two most pessimistic future scenarios, with a decrease from -1% to -15%, and can even reach -15 to -20% very locally in SSP5-8.5.

1.3.3 Granada

The main risks identified using various emissions scenarios are: higher temperatures, longer lasting heat waves, decrease of in rainfall, more intense periods of drought, increase in the concentration of precipitation, and greater frequency of downpours [PLAN PROVINCIAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO DE GRANADA, 2019].

In Granada province, the temperature increase is greater in the interior area of the province, especially in those more arid territories and with less vegetation cover.

[5] https://www.ficlima.org/intercambio/indexed/Escenarios_Andalucia/Entrega_03/00_Documentacion/Entrega-03-1_Análisis_Futuros_Variables.pdf

2 State-of-play of CCA and innovation strategies

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) serves as Spain's foundational framework for climate adaptation efforts, promoting coordinated action across sectors like water, biodiversity, energy, and urban planning. Approved in 2020, it outlines two work programs (2021-2025 and 2026-2030) that assign responsibilities to various entities and establish mechanisms for monitoring and evaluation. Additional national plans complement the PNACC, including strategies for energy, health, sustainable finance, and coastal protection, each integrating climate mitigation and adaptation goals. Spain's 2030 Sustainable Development Strategy and sector-specific frameworks like the Circular Economy and Industrial Strategies also align with climate objectives. Notably, Spain achieved significant EU recognition in climate action, with five of its cities labeled as EU Mission Climate-Neutral and Smart Cities in 2023.

In **Andalucía,** the *Andalusian Climate Action Plan (PAAC)*, established under Law 8/2018, aims to incorporate climate adaptation into regional and local planning, aligning with national and EU frameworks, and contributing to the 2030 Agenda. Approved in October 2021, the PAAC provides the legal and strategic structure for climate action in the region.

In **Granada**, the *Adapta Granada Plan* (PLAN PROVINCIAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO DE GRANADA, 2019), approved in April 2023, was developed using a unique methodology that combines scientific data analysis with climate vulnerability assessment and coordination among local stakeholders. The plan, initiated in 2018 with support from the Biodiversity Foundation, is designed to address the adaptation needs of supra-municipal entities in the province.

2.1 Spain

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) has been, since 2006, the reference framework for public efforts at national level, for the generation of knowledge and design of measures for adaptive responses. The National Plan for Adaptation to Climate Change (PNACC 2021-2030) constitutes the basic planning instrument to promote coordinated and coherent action against the effects of climate change in Spain.

After going through a period of public consultation, the Council of Ministers, at the proposal of the Ministry for the Ecological Transition and the Demographic Challenge, approved on September 22, 2020 the second National Plan for Adaptation to Climate Change for the period 2021-2030.

The PNACC 2021-2030 will be implemented through two main programming instruments:

- **The 2021-2025 Work Programme** of the **National Climate Change Adaptation Plan (PNACC)** details the actions to be implemented during the first five years of the plan and the Second Programme will cover the period 2026-2030. The Working assigns responsibilities to various entities for executing these actions and establishes mechanisms for information sharing, monitoring, and evaluation of the plan's progress. Developed with input from 18 ministries, along with several state agencies and autonomous organizations, the programme underwent a period of public consultation to ensure broad stakeholder engagement in shaping its goals and actions.
  The PNACC-2 Work Programmes will:
  - Detail the planned measures,
  - Identify, where appropriate, priority measures, taking into account the level of risk associated and potential benefits of the proposed adapta- tion measures.

    - Identify the organisations responsible for the development of the measures and collaborating organisations.
    - Include compliance indicators with the defined measures in order to facilitate monitoring and evaluation.
- **Sectoral and Territorial Adaptation Plans.** These plans are instruments for detailed adaptation planning in specific areas of work or territories. The plans:
    - Include a diagnosis of the main risks posed in the sectoral or territorial area in question
    - Define objectives to be met in order to respond to the described risks
    - Detail a set of measures to meet the defined objectives
    - Identify the organisations responsible for the development of the measures and collaborating organisations
    - Include compliance indicators with the defined measures in order to facilitate monitoring and evaluation.

Other important Strategies and Plans defined at national level, which integrate actions relevant for climate change mitigation and adaptation are:

- National Integrated Energy and Climate Plan 2021-2030: Defines national goals for greenhouse gas emission reductions, renewable energy integration, and energy efficiency improvements.
- Long-Term Strategy for a Modern, Competitive, and Climate-Neutral Spanish Economy by 2050: Analyzes options for decarbonizing the economy and proposes a trajectory to achieve climate neutrality based on available technology and scientific knowledge.
- Sustainable development Strategy 2030: The strategy, shaped as a long-term national plan, fosters political and social consensus to drive the structural transformations required for the 2030 Agenda, aiming to position Spain as an international leader in its implementation.
- National Health and Environment Plan (Plan Estratégico de Salud y Medio Ambiente (PESMA) 2022-2026): The plan aims to reduce the impact of environmental factors on public health by promoting healthy and sustainable environments. Aligned with the Agenda 2030 and the European Green Deal, the plan focuses on areas like air quality, water, climate change, and chemical management.
- Environmental Education Action Plan for Sustainability (2021-2025) (Plan de Acción de Educación Ambiental para la Sostenibilidad (PAEAS) 2021-2025): Focuses on education for sustainability.
- Spanish Strategy for Science, Technology, and Innovation 2021-2027 (english version) (Estrategia Española de Ciencia, Tecnología e Innovación 2021-2027 (EECTI 2021-2027): Incorporates climate change objectives into science and technology policies.
- Desertification Strategy, National Forest Strategy, and Demographic Challenge Strategy (Estrategia Nacional de Lucha contra la Desertificación (ENLD). Approved in June 2022, the ENLD updates the 2008 National Action Program against Desertification. Its objective is to establish a framework for policies and initiatives related to desertification in Spain, ensuring compliance with international commitments.

- Circular Economy Strategy (España Circular (EEEC) 2030 y Planes de Acción): Approved on June 2, 2020, it establishes the foundation for transitioning from a linear economy to a circular model, aiming to retain the value of products, materials, and resources within the economy for as long as possible, minimize waste generation, and maximize the utilization of unavoidable waste Integrates climate objectives into circular and industrial economic processes.
- Industrial Strategy (Política Industrial Española 2030): Supports sustainable and decarbonized industrial progress, accompanied by a new Industrial Law.
- Sustainable Tourism Strategy of Spain 2030 (Estrategia de Sostenibilidad Turística en Destinos): Addresses the relationship between climate change and tourism.
- Spanish Coastal Protection Strategy against Climate Change (Plan Estratégico Nacional para la Protección de la Costa Española considerando los Efectos del Cambio Climático - PEN). This strategy aims to increase the resilience of the Spanish coastline to climate variability and change, integrating adaptation measures into coastal planning and management. It provides a framework for assessing vulnerabilities and implementing actions to mitigate adverse effects on coastal ecosystems and communities.
- National Strategy for Green Infrastructure, Connectivity, and Ecological Restoration. Spain's strategic framework for implementing and developing green infrastructure across its territory, including its maritime waters. Approved on July, 2021.

Given the significant impact of climate change in Spain, five out of ten cities that received the label EU Mission for Climate-Neutral and Smart Cities on October 2023 are from Spain: Madrid, Valencia, Valladolid, Vitoria-Gasteiz and Zaragoza (Spain), together with Klagenfurt (Austria), Cluj-Napoca (Romania) and Stockholm (Sweden), Sønderborg (Denmark), Mannheim (Germany).[6]

2.2 Andalusia

In Spain, although there is no national requirement to create regional plans, all autonomous communities have developed their own strategic frameworks, plans and/or programs regarding adaptation to climate change. Some autonomous communities, such as Catalonia, the Balearic Islands and Andalusia, have reinforced the legal framework by approving their own climate change laws [Law 16/2017 of August 1 (Catalonia), Law 8/2018 of October 8 (Andalusia) and Law 10/2019 of February 22 (Balearic Islands). The majority of large Spanish cities have approved their own strategies or plans to combat climate change that include, in many cases, objectives and lines of work on adaptation.

The **Andalusian Climate Action Plan** (PAAC) is the general strategic planning instrument in Andalusia for the fight against climate change, and is derived from Law 8/2018 on climate change of Andalusia. It has the aim to integrate climate change into regional and local planning, align them with the national strategic plans, the European Green Deal and the Paris Agreement, contributing to achieving the Sustainable Development Goals set by the 2030 Agenda.

The PAAC was approved by the Government Council on October 13, 2021 and published by Decree 234/2021, of October 13, which approved the Andalusian Climate Action Plan Climate in BOJA number 87 of October 23, 2021.

2.3 Granada

Given that there were no methodologies for the preparation of Climate Change Adaptation Plans for supra-municipal entities, the Granada Provincial Council has designed its own methodology, which

[6] https://ec.europa.eu/commission/presscorner/detail/en/ip_23_4879

combines, on one hand, the scientific analysis of climatic data in each territory, and the evaluation of its vulnerability to climate change, according to the climatic scenarios, and on the other hand, the necessary institutional coordination and participation of the territory's agents in the process of proposing and selecting adaptation actions. The Plan ADAPTA GRANADA (PPACCGr) was approved on 27 /4/2023). The work undertaken for the design of the Plan was carried out through the ADAPTA Granada Project between the months of September/2018 and June/2019, and had the support of the Ministry for the Ecological Transition through the Biodiversity Foundation.[7]

[7] http://www.adaptagranada.es/gallery/resumen%20ejecutivo%20ppaccgr%20adapta-granada-una%20pagina.pdf

Table 1: Status of the relevant strategic documents and actions

National level		
item	**Status**	**Link**
Climate Law (including adaptation)	adopted	▪ Law 7/2021, of 20 May, on Climate Change and Energy Transition
National Adaptation Strategy (NAS)		▪ National Climate Change Adaptation Plan 2021-2030 ▪ National Climate Change Adaptation Plan
National Adaptation Plan (NAP)	adopted	▪ Climate Change Adaptation: Work Programme 2021-2025 ▪ Climate Change Adaptation: 3º Work Programme ▪ Climate Change Adaptation: 2º Work Programme ▪ Climate Change Adaptation: 1º Work Programme
Sectoral Adaptation Plan (SAP)	adopted	▪ Adaptation Strategy for the Spanish Coast ▪ Strategic Guidelines on water and climate change ▪ Climate Change Plan 2018-2030 of ADIF (Administrator of Railway Infrastructures)
Climate Risk Assessment (CRA)	Finalised	▪ A preliminary General Assessment of the Impacts in Spain Due to the Effects of Climate Change ▪ Impacts and risks derived from climate change in Spain
Meteorological observations	Established	State Meteorological Agency (AEMET)
Climate projections and services	Established	▪ Climate projections for the XXI Century (AEMET) ▪ The AdapteCCa Climate Change Scenario Viewer ▪ "Climate Change on the Spanish Coast" (C3E) - WEB viewer ▪ Assessment of the impact of climate change on water resources and droughts in Spain - CAMREC ▪ Spanish Autonomous Communities viewers of climate change in coastal areas
Adaptation portals and platforms	Established	▪ Spanish Climate Change Platform AdapteCCa ▪ The AdapteCCa Climate Change Scenario Viewer
Monitoring, reporting & evaluation indicators & methodologies	Established	▪ Executive Summary of the Evaluation Report of the PNACC (2019)
Governance regulation adaptation reporting		▪ 2021 Art. 19 (1) reporting ▪ 2023 Art. 17 (2)(d) reporting ▪ 2023 Art. 19 (1) reporting
ANDALUSIA		
Andalusian Climate Action Plan	Adopted 2021	▪ https://www.juntadeandalucia.es/medioambiente/portal/documents/20151/27181420/PAAC.pdf/e4761b37-e5ea-1204-9364-3f25bbd39be3?t=1635167310439
Climate projections and Scenarious for Climate Change Andalusia	done	▪ https://www.juntadeandalucia.es/medioambiente/portal/areas-tematicas/cambio-climatico-y-clima/escenarios-locales-de-cambio-climatico/que-son-los-escenarios-locales-de-cambio-climatico ▪ https://www.juntadeandalucia.es/medioambiente/portal/areas-tematicas/cambio-climatico-y-clima/escenarios-locales-de-cambio-climatico/escenarios-locales-de-cambio-climatico-actualizados-6-informe-ipcc ▪ https://andalucia.sicma.red/
Adaptation portals and platforms	Established	▪ https://www.juntadeandalucia.es/medioambiente/portal/web/cambio-climatico
GRANADA		
Plan ADAPTA GRANADA. Plan Provincial de Adaptación al Cambio Climático de Granada (PPACCGr)	adopted	▪ http://www.adaptagranada.es/gallery/resumen%20ejecutivo%20ppac-cgr%20adapta-granada-una%20pagina.pdf
Adaptation portals and platforms		▪ http://www.adaptagranada.es

Source : Author compilation

3 Analysis against conceptual framework: Transformative Innovation for better Climate Change Adaptation

A previous report on this subject for the European Commission JRC had defined an analytical framework identifying seven key features of Transformative Innovation as essential conditions for the design and implementation of CCA strategies with high ambition level (European Commission, 2024). These features can be summarised as follows:

Directionality: defining goals and scope of strategic action, as well as articulating impacts, in a way which reflects societal challenges with wide appeal, formalised through endorsement at highest political level to secure engagement of all relevant authorities and stakeholders.

Articulating instrument portfolios and defining synergies between funding sources: establishing all-encompassing instrument portfolios addressing the whole innovation cycle and the various aspects of CCA, paired with adequate funding resources.

Ensuring cross domain synergies: favouring whole-of-government approaches to ensure greater horizontal coherence between various thematic policy areas (R&I, agriculture, environment, mobility, health etc.), resulting in coordinated mixes of instruments of different types.

Increasing breadth and depth of stakeholder involvement: working towards social acceptance of new solutions and shaping of innovative developments, as well as improving public trust, opening up public debates, managing diverse and sometimes conflicting views over alternative pathways.

Setting up effective multi-level governance models: maximising potential of vertical synergies, recognising complementary roles for various governance levels - local, regional, national and EU;

Making room for experimentation: providing adequate spaces for risk-taking and creativity - ensuring a risk-tolerant environment to facilitate development of new and/or radical solutions.

Securing high levels of policy intelligence, learning and strategic capacity: building strong evidence-based policy learning capacities, based on a solid knowledge base and special skills to manage transitions, as necessary companions to the transformative innovation approach.

The analysis below follows this framework. The key characteristics of the territory's approach to CCA strategy development and implementation and their linkages with innovation policies and strategies, as revealed by the case study research, are explored in turn, in relation to the above seven features. Each feature constitutes a core section of the Report.

3.1 Directionality: defining goals and expected impacts for society

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) (PNACC-2) aims to minimize current and future climate change damages and build resilience through coordinated efforts. It continues PNACC 2006-2020, incorporating new international commitments and recent climate risk knowledge. PNACC-2 sets nine objectives, including enhancing climate observation, generating knowledge, building capacity, identifying risks, integrating adaptation into public policies, involving stakeholders, coordinating administratively, fulfilling international commitments, and monitoring and evaluating policies. It outlines 81 action lines across various sectors, organized into 18 work areas.

The **Andalusian Climate Action Plan (PAAC)** serves as the primary strategic framework for addressing climate change in the region and is based on Andalusia's Law 8/2018 on climate change. The plan includes 44 adaptation strategies within a 2021-2030 timeframe, divided into three operational phases. Law 8/2018 marked a key environmental milestone, creating the Andalusian Office of Climate Change to support efforts in mitigation, adaptation, and communication. However, challenges remain in fully engaging the private sector and ensuring the effective implementation of adaptation measures.

The PAAC identifies knowledge gaps in adaptation and highlights the importance of fostering applied research and knowledge management. It includes a section called "dimensions of adaptation," which provides the rationale for selecting the strategic adaptation lines.

The **Plan Provincial de Adaptación al Cambio Climático de Granada (PPACCGr)** focuses on identifying climate threats, assessing impacts, evaluating municipal and territorial vulnerabilities, proposing mitigation measures, and encouraging stakeholder participation.

Bottleneck. At the supra-municipal and municipal levels, there was no predefined methodology for designing Climate Change Adaptation (CCA) Plans. In this context, Granada developed tailored approaches. This gap could lead to inconsistencies in how adaptation is implemented at these levels. The plan aims to monitor implementation. The operationalisation plans include various source for funding.

3.1.1 Spain

The PNACC 2021-2030 (PNACC-2) main objective is to avoid or reduce present and future damages derived from climate change and build a more resilient economy and society, through coordinated, coherent and consistent efforts. The PNACC-2 is the continuation of the previous PNACC 2006-2020, coordinated by the Spanish Office of Climate Change (OECC), which was implemented through three successive work programs. PNACC-2 incorporates the new international commitments and the most recent knowledge on the risks derived from climate change, taking advantage of the experience obtained in the development of the first PNACC.[8]

PNACC 2021-2030 defines objectives, criteria, areas of work and lines of action to promote adaptation and resilience to climate change. Nine specific objectives have been outlined to complement the overarching goal.

[8] https://adaptecca.es/nacional

- Enhanced Climate Observation: Strengthen the systematic observation of climate patterns and improve the production and updating of region-specific climate change projections for Spain. Develop climate services to provide valuable information.
- Knowledge Generation: Promote a continuous process of knowledge generation on climate change impacts, risks, and adaptation in Spain. Develop methodologies and tools for analyzing potential climate change impacts.
- Capacity Building: Enhance capacities for adaptation by supporting the acquisition and development of expertise in climate change adaptation.
- Risk Identification: Identify the primary climate change risks in Spain, considering their nature, urgency, and magnitude. Support the formulation and implementation of appropriate adaptation measures.
- Integration into Public Policies: Integrate adaptation into public policies to ensure that climate change considerations are embedded in governmental actions.
- Stakeholder Involvement: Encourage the active participation of all stakeholders, including various levels of government, the private sector, social organizations, and the general public, in shaping responses to climate change risks.
- Administrative Coordination: Ensure administrative coordination and strengthen governance related to adaptation to climate change.
- European and International Commitments: Fulfill and expand Spain's commitments in the European and international context regarding climate change adaptation.
- Monitoring and Evaluation: Promote the monitoring and evaluation of adaptation policies and measures to assess their effectiveness and make necessary improvement

PNACC defines and describes **81 lines of action** to be developed in the different natural systems and socioeconomic sectors of the country, organized in **18 work areas**, including human health, water and water resources, natural heritage, biodiversity and protected areas, coasts. and marine environment, forest protection, fight against desertification, or agriculture, livestock and food security. In addition to the sectoral guidelines, the plan proposes seven key lines of work to be integrated transversally into all areas.

3.1.2 Andalucia

"It should be noted that policies concerning CC in Andalusia are defined for all territorial units as a whole, this meaning that they apply equally on the regional, provincial, and municipal level, defining the framework for Climate Action. Support to smaller territorial units is provided by the central services of Andalusia ministry and territorial/provincial delegations." (interview with staff of Junta de Andalucia).

The Andalusian Climate Action Plan (PAAC) defines the strategic objective in terms of adaptation as" *Reducing the risk of the impacts of climate change, minimizing its effects*" within the framework of a vision of change and transformation of society directed towards "*sustainable development and climate neutrality in 2050 in Andalusia through shared responsibility of Public Administrations, companies and citizens* " in line with the path taken by Europe in the European Green Deal.

The achievement of the objectives of the PAAC is addressed from the delimitation of a series of strategic lines, up to a total of 44 in the case of adaptation, distributed among the set of strategic areas stipulated by Law 8/2018, art 11.

This social transformation is framed within a time horizon of the PAAC between 2021 and 2030, which will be divided into three operational programs covering the periods 2021-2022, 2023-2026. and 2027-2030.

Adaptation Programme. The Adaptation Programme aims to reduce the economic, environmental, and social risks derived from climate change through the incorporation of adaptation measures in the autonomous provincies and local planning instruments:

- Guide and establish the programming of actions to adapt to the climate change of the Andalusian society, the Andalusian business, the Administration of the Junta de Andalucía and the local entities, according to an evaluation of risks based on a common scenario.
- Expand the knowledge base about the impacts of climate change in the territory of the Autonomous Community.
- Incentive for the participation of private sectors in the identification of opportunities and threats.

In the fight against climate change, municipalities play a very important role as local authorities are in an ideal position to satisfy citizen needs and preserve public goods. Being aware of the above, Law 8/2018 positions local entities in a central place in its strategic design, establishing as another planning instrument the **Municipal Plans against Climate Change (PMCC)** and defining, through the PAAC, a planning system that connects the regional level with the local level to address the fight against climate change.

'The PAAC acknowledges the presence of knowledge gaps in adaptation and emphasizes the need to promote applied research and knowledge management. It dedicates a specific section, "dimensions of adaptation" to address these gaps, providing the foundation for selecting the strategic adaptation lines'. (interview with staff of Junta de Andalucia).

3.1.3 Granada

"Municipalities play a very important role as local authorities are in an ideal position to satisfy citizen needs and preserve public goods. Being aware of the above, Law 8/2018 places local entities in a central place in its strategic design, establishing as another planning instrument the Municipal Plans against Climate Change and defining, through the PAAC, a planning system that connects the regional level with the local level to address the fight against climate change." (interview with staff of Junta de Andalucia)

The objectives of the **Provincial Plan for Adaptation to Climate Change of Granada (PPAC-CGr)** are:

- Identify climate threats in the territory.
- Know the potential impacts that may occur in the provincial territory according to the proposed scenario.
- Evaluate the response capacity or vulnerability of municipalities and Territorial Management Units to potential threats and impacts.

- Propose lines of work and measures aimed at reducing/alleviating the detected threats, both supralocal and local, as well as sectoral.
- Encourage the participation of experts and social agents so that a document agreed upon by all is formed and that adjusts to reality.
- Monitor the implementation of the project and its actions.

3.2 Articulating instrument portfolios and defining synergies between funding sources

The funding landscape for climate adaptation in Spain is supported by various EU financial instruments, with Spain being a significant recipient of Horizon Europe funding. Initiatives like the PIMA Adapta plans, implemented under the National Plan for Adaptation to Climate Change (PNACC) since 2015, aim to reduce vulnerability to climate impacts. Additionally, synergies between national and regional plans through the PNRR Complementary Plans focus on strategic areas such as energy, green hydrogen, biodiversity, and marine science. In Andalusia, the Andalusian Climate Action Plan (PAAC) and the Smart Specialization Strategy for the Sustainability of Andalusia (S4Andalucia) 2021-2027 are crucial in guiding climate change mitigation and adaptation efforts. These initiatives promote cooperation across regional and national levels, as well as with European programs like Horizon Europe, LIFE, and Interreg.

Bottlenecks

- Despite available funding, several bottlenecks may hinder the effective implementation of climate adaptation projects.
- One challenge is the limited involvement of the private sector, where more incentives are needed to encourage business participation in adaptation measures.
- There is also a need for better alignment and coordination between national, regional, local, and sectoral policies, which may to fragmented efforts and inadequate responses to the scale of climate risks. For instance, smaller municipalities often face difficulties in implementing complex funding mechanisms due to the complexity of application processes.
- Furthermore, the PAAC, while applicable across various levels of government, does not fully address the unique challenges smaller municipalities face, leading to potential inefficiencies.
- Other bottlenecks include knowledge gaps related to climate impacts, particularly region-specific data, and coordination challenges between regional and local governments, which can result in fragmented actions.

3.2.1 Spain

Among the European funds and other instruments associated with the Multi-Financial Framework 2021- 2027, that include climate change adaptation actions in their scope, the following, as described below, are highlighted by the PNACC 2021-2027 as complementary EU funding sources for its implementation.

EUROPEAN SOCIAL FUND PLUS (ESF+) 2021-2027 includes climate change as a transversal element. MITERD will collaborate with the Ministry of Labour and Social Economy in defining measure for climate change adaptation in the strategic documents, especially those related to training and capacity building for technical and professional performance with adaptive criteria, including the possibility of specific financing programmes such as **Empleaverde**.

The **Empleaverde Programme** of the Ministry for the Ecological Transition and the Demographic Challenge is the initiative of the Biodiversity Foundation to promote and improve employment, entrepreneurship and the environment. Through the Empleaverde Program, the Biodiversity Foundation acts as a bridge between employment policy and environmental policy with a double objective: (1) the environment and sustainability becomes the basis for better jobs and more competitive companies; (2) employees and companies are key actors in improving the environment. The programme is an example of social innovation.
Source: https://www.empleaverde.es/programa-empleaverde

Source: https://www.empleaverde.es/programa-empleaverde

EUROPEAN REGIONAL DEVELOPMENT FUND (ERDF). At least 30% of ERDF reources in Spain must be invested in Policy Objective 2: Greener Europe, which includes Specific Objective IV, aimed at promoting climate change adaptation, risk prevention and disaster resilience. At least 6% of ERDF resources will have to be dedicated to sustainable urban development, and part of these ac-tions are climate-related.

EUROPEAN AGRICULTURAL GUARANTEE FUND GUARANTEE FUND (EAGF) AND EUROPEAN AGRICULTURAL FUND FOR RURAL DEVELOPMENT (EAFRD). EAGF and EAFRD are the funds that finance the Common Agricultural Policy (CAP) through direct payments to farmers. At least 40% of the overall financial envelope should be dedicated to environmental and climate change objectives. The introduction of 'eco-schemes' can be used to incentivise additional practices that promote greater adaptation to climate change.

To date, the Climate Change strand has co-financed 72 projects in Spain with a total funding of €224 million, of which the EU has contributed €122 million. These projects have addressed key areas such as greenhouse gas reduction, renewable energy development, management of natural resources, resilient communities, carbon sequestration, and the mitigation of natural risks.

Source:https://cinea.ec.europa.eu/system/files/2023-04/Spain_Update_EN_Final_March23.pdf

EUROPEAN MARITIME AND FISHERIES FUND (EMFF). EMFF can contribute to climate change adaptation through diversification of traditional fisheries, reducing the impact of fishing on vulnerable marine ecosystems, or supporting aquaculture to diversify its production and protect itself against climate-induced risks. At the regional and local level, the EMFF can support community-led development in fishing villages, which can involve local approaches to adaptation. The implementation of a similar plan to Pleamar is sought. Pleamar is one of the programme funded by EMFF during the cycle 2014-2020.

tions and R&D&I. and thus reinforce the involvement with the protection and conservation of the marine environment in which they carry out their activity.

Source: https://www.programapleamar.es/resultados-del-programa-pleamar-periodo-2014-2020

LIFE Programme funds climate change mitigation, adaptation, governance and information projects. The LIFE Climate change mitigation and adaptation strand will support actions which help implement the 2030 energy and climate policy framework and meet the European Union's commitments under the Paris Agreement on Climate Change. The budget for the period 2021–2027 is set at €5.4 billion.

Horizon Europe 2021-2027 includes, within Pillar II Global Challenges and European Industrial Competitiveness, a cluster dedicated to "Climate, Energy and Mobility". In addition, Horizon Europe also incorporates several "missions", one of which is specifically dedicated to climate change adaptation and social transformation. The allocation against climate change has been allocated a budget target of 35% of the total programme budget out of an agreed total of EUR 75.billion for 2021-2027.

A search on the Horizon Europe Dashboard using the keyword "climate adaptation" reveals that Spain has participated in 1,462 projects related to climate adaptation.

Source: Horizon Europe Dashboard (accessed 23 October 2023)

The **European Investment Bank (EIB)** finances climate action, mitigation and adaptation, measures. Technical and financial advice and contributes, together with other sources, to the financing of projects on renewable ene-gies, rational use of energy, technological efficiency, sustainable transport, efficient water supply and management. Support for projects is mainly provided through loans.

NATIONAL FUNDING INSTRUMENTS

Sectoral budgets. A significant part of the efforts dedicated to adaptation involves adjusting or rethinking existing lines of action so that they incorporate climate change. Hence, these will be implemented largely through the budgets of the department involved.

The PIMA Adapta plans contribute to the improvement of the environment, encouraging low-carbon economic activity and strengthening the resilience of the systems where they intervene.

Box 1. PIMA Adapta Programme

The PIMA programme has two general lines of work:
Mitigation PIMA, which promote measures to reduce greenhouse gas emissions into the atmosphere in different sectors
PIMA Adapta, which are framed within the National Plan for Adaptation to Climate Change (PNACC) and aim to implement projects that reduce vulnerability to the effects of climate change, anticipating the expected impacts. PIMA Adapta has been in operation since 2015 in order to support the fulfilment of the objectives of the PNACC. PIMA Adapta funds may be allocated to units within the Central Government or distributed to Autonomous Communities for project management purposes. PIMA Adapta initiative contemplates actions in different areas:
- PIMA Adapta Agua: Water resources and public hydraulic domain
- PIMA Adapta Costas
- PIMA Adapts National Parks
- PIMA Adapts Ecosystems
- PIMA Adapta Biodiversity

Source: PIMA Adapta. Knowledge and action against the risks derived from climate change (2020)

MOBILISING PRIVATE FUNDING. Actions envisaged include the integration of adaptation to climate change into lines of public funding that involve the leverage of private financing and the creation of incentives for adaptation in companies.

Both the Spanish Science and Technology and Innovation Strategy (EECTI) and the State Plan for Scientific and Technical Research and Innovation, are aligned with the European objectives. The national strategic lines follow the Horizon Europe themes, hence among the six themes, there are two targeting explicitly CCA:

- Climate, energy and mobility: climate change, decarbonization, mobility and sustainability
- Food, bioeconomy, natural resources and the environment: from biodiversity to use of food of the land and seas.

In Andalucia, the following two plans were identified:

- Pablo de Olavide University. The 'Biodiversity' plan focuses on the exploration, analysis and foresight of biodiversity, as well as possible responses to the 2030 sustainable development strategy in a scenario of global change.
- University of Cádiz (UCA) The 'Marine Sciences' plan has the objective of promoting the development of a research and innovation strategy that will address new challenges in marine-maritime monitoring and observation, climate change, aquaculture and other sectors of the blue economy.

The **National Plan for Resilience and Recovery package**, NPRR and the NextGenerationEU temporary instrument designed to promote recovery have investements of more than **3.4 billion** euros aimed to strengthen the Spanish Science, Technology and Innovation System (SECTI), through nine investment programmes. The PNRR Complementary Plans, in which common priorities of the state and regional plans converge, allow synergies in strategic areas reflected both in the state and regional Smart Specialisation Strategy (RIS3). Among the 8 scientific areas identified, the following have direct relevance for CCA: Energy and Green Hydrogen, Agrifood, Biodiversity, Marine Science. In order to build territorial synergies, the Complementary Plans envisage the participation of several Autonomous Regions in a programme, with the possibility of participating in several projects.
While all the programmes must align to the SDG, some explicitly target climate change mitigation and adaptation.
Investment 7 Environment, climate change and energy[9]. This PNRR investment develops measures linked to environmental protection, the fight against climate change, research on new energy sources and technologies, and key materials for the energy transition. The following research projects will be implemented:

- Sustainable plastics for a circular economy;
- Climate change and impact on water reserves;
- Renewable energies;
- Development and integration of key high-tech components in the transition in the energy cycle towards a green and resilient economy:
- Favourable areas for the environmentally sustainable exploitation of raw materials of mineral origin critical for the energy transition both on land and at sea

The **Strategy for Science, Technology and Innovation 2021-2027** and its implementing **National Plan** recognize the importance of addressing climate change and promoting the efficient use of resources and raw materials. This is evident in the inclusion among the six challenges, two which are focused on:

[9] https://www.ciencia.gob.es/en/Estrategias-y-Planes/Plan-de-Recuperacion-Transformacion-y-Resiliencia-PRTR/Medio-ambiente--Cambio-climatico-y-energia.html

- climate, energy and mobility:
    - climate change, decarbonization
    - sustainable mobility
    - sustainable cities and ecosystems
- food, bioecnomy, natural resources and enviroment.
    - Exploration, analysis and forecast of biodiversity
    - Sustainable and smart food chain

Spain and Portugal collaborated on the topic CCA, in the framework of the LIFE SHARA project (Sharing awareness and governance of adaptation to climate change). The project took place between September 2016 and October 2021 with the aims to strengthen the governance of climate change adaptation and increase resilience in Spain and Portugal.

Moreover, R&D&I actions in the field of climate change mitigation are regarded as horizontal in nature, meaning they have broad relevance across various sectors of economic activity. These sectors encompass transportation, residential, commercial, institutional, waste management, forestry, energy, agriculture, and livestock, among others. The goal is to align R&D&I activities and sectoral policies to facilitate the transition to a low-carbon economy, thereby promoting progress towards sustainable development.

3.2.2 Andalusia

Law 8/2018, art. 8 states that the Andalusian Climate Action Plan (PAAC) as the general planning instrument of the Autonomous Community of Andalusia for the fight against climate change. This is approved by the Government Council on October 13, 2021. Monitoring and climate action reports are published on the Andalusian Climate Change Portal. This law considers as "other planning instruments" the Municipal Plans against Climate Change and collaboration with the General Administration of the State on climate change.

Box 2. Andalucia extra-regional cooperation

The PAAC promotes interterritorial cooperation between different regions and/or countries in a space of collaboration and synergy. For Andalusia, extra-regional cooperation is fundamentally focused on the European Union space as a collaborative territory. These collaborations are set with different cooperation tools and financial instruments. Through these associations, cooperation projects can develop, design and apply joint solutions to common problems and challenges inherent to a large part of their international cooperation space, sharing experiences, good practices, ways of working and a wide dissemination of the results obtained.In the field of climate action, Andalusia mainly participates in European projects and initiatives (Interreg; Horizon 2020, LIFE, etc.), cooperation networks (EIT Climate -KIC Spain, Conference of Peripheral and Maritime Regions of Europe, European Committee of the Regions or Global Pact of Mayors for Climate and Energy) and Andalusian development cooperation (Union for the Mediterranean).

In the risk assessment exercise carried out within the framework of preparing the PAAC, the impacts related to the alteration in the rainfall regime as a consequence of climate change stood out floods, droughts, availability of water resources.

NACAO Interreg Project

The Ministry of Sustainability, Environment and Blue Economy of the Government of Andalusia through the Andalusian Office of Climate Change of the General Directorate of Environmental Sustainability and Climate Change, leads the Interreg Europe NACAO (Nature-based Carbon Offsets) project, approved in the 1st call of the new Interreg Europe 2021-2027 programme. The consortium consists of five European public administrations: the Regional Government of Marche (Italy), the Regional Government of Świętokrzyskie (Poland), the Regional Government of Central Finland, the City Council of Bremen (Germany) and the Environment and Energy Agency of the Auvergne-Rhône-Alpes region (France). Good practices on the topic of the project will be shared and integrated in the knowledge for public policies formulation. The NACAO project aims to support these regional governments by promoting nature-based solutions for carbon offsetting. These solutions focus on preserving, restoring, and enhancing natural sites, such as forests, wetlands, and mires, which can act as carbon sinks and help offset greenhouse gas emissions. Throughout the project, partner regions will exchange experiences related to carbon credits, emissions markets, and relevant policies, all with the goal of fostering nature-based approaches to reduce carbon emissions and combat climate change.

'*In line with this, the Junta de Andalucía participates as a partner in the Horizon Europe project, Climepower along with 13 others partners from 6 different countries. The objective of this project is to identify and test tools for modeling the impact/effect of possible adaptation measures related to the water environment (drought and floods).' (interview with staff of Junta de Andalucia).*

The General Directorate of Environmental Quality and Climate Change (DGCACC) is participating in two climate adaptation projects funded by Climate KIC:.

- **DEEP DEMONSTRATION IN REGIONS: FORGING RESILIENCE** – Focused on building resilience in Andalucía. The project offers specialized participatory processes in adaptation, potentially enhancing the content of the Andalusian Climate Action Plan (PAAC) and its public information processes. The final output will be a Project Portfolio, comprising a selection of pilot adaptation projects that integrate into Andalusian policies.
- **CRISI-ADAPT-II** – Provides climate risk information to support adaptive planning. The project finalised in 2022 and focused on the impact of drought in Andalucía and other regions. FIC is working on simulating drought effects using various variables and conducting simulations to understand potential outcomes.

The Andalucian Government also implemented PIM projects:

- The *PIMA Adapta Costas* project, extended to 2021, provided input for Spain's National Climate Change Adaptation Plan (PNACC) and the Strategy for Adapting Spain's Coastline to Climate Change. It focused on conducting detailed regional studies along the Spanish coast, ensuring a consistent methodology for data collection and vulnerability assessment. The work of the Andalucian Directorate was focused on: (1) A cartographic viewer to integrate collected data with climate change projections for coastal risk assessment; (2) A coastal risk study to assess the vulnerability and exposure of natural and socio-economic assets. (3) A Climate Change Adaptation Plan for public maritime-terrestrial areas in Andalucía, primarily focused on ports.

- PIMA *PIMA Climate Change* The goal of *PIMA Climate Change* is to promote and support climate adaptation in urban and peri-urban areas, enhancing synergies between adaptation and mitigation strategies. In Andalucía, after the Andalusian Climate Action Plan is approved, grants will be made available to support municipal climate initiatives.

The LIFE programme in Andalucia. *Blue Natura Andalucía* is part of the Climate Action subprogramme within LIFE, focusing on climate change mitigation. The spanish partners in the project are the **Environment and Water Agency of Andalusia (AMAYA)**, which is a public agency attached to the Government of Andalusia, which provides essential services in environmental and water matters in the Andalusia territory. Another partner is the **SPANISH NATIONAL RESEARCH COUNCIL (CSIC)**, specifically the Group of Aquatic Macrophytes Ecology (GAME) from the **Centre for Advanced Studies of Blanes (CEAB)**, a research centre belonging to the CSIC, and the association *Man and Territory (Asociación Hombre y Territorio HYT) which* has a wide experience in conservation, research, dissemination, and citizen participation.

The project aims to quantify carbon storage and sequestration rates in Andalucía's seagrass meadows and salt marshes, analyze their long-term CO_2 capture potential, and assess their role in climate change mitigation. The project also supports funding for blue carbon habitat restoration, promotes stakeholder engagement through training and outreach, and develop tools, including carbon credit verification standards and project models, to integrate these efforts into international carbon markets.The **Smart Specialization Strategy for the Sustainability of Andalusia, S4Andalucia 2021-2027**, approved in July 2023, will benefit of 498,042,287 euros from ERDF Andalusia 2021-2027 Programme. S4Andalucia is the evolution of RIS3Andalucía for the period 2021-2027 and represents the regional instrument for planning, execution, development and evaluation of public actions in research, innovation and industrial transition, digitalization, training, entrepreneurship and cooperation for specialization with a transversal perspective of sustainability and fight against Climate Change. It places sustainability as a central element of its actions and incorporates a new industrial policy guided by the framework of the European Green Deal.

The S4 areas are listed below.

- E.1. Intelligent, resilient and healthy society
  - E1.S1. Health and social well-being
  - E1.S2. Tourism and culture
  - E1.S3. ICTCE sector.
- E2. Agrotechnology
  - E2.S1. Green and blue economy
  - E2.S2. Agri-Food Industry – Functional Food
- E.3. Natural resources: Mining and the water cycle
  - E3.S1. Mining resources
  - E3.S2. The water cycle
- E.4. Transportation industries
  - E4.S1. Advanced transportation and mobility systems industry
  - E4.S2. Industrialized construction
- E.5. Ecological Transition
  - E5.S1. Energy Transition
  - E5.S2. Industries linked to mitigation and adaptation to climate change

A transversal axis is the sustainability and circularity. The actions that are incorporated into S4Andalucia through this axis respond to the challenges aimed at supporting the sustainability of processes, products and services in a general framework of commitment to a circular economy, activities that contribute to increasing the culture of sustainability and circularity in the Andalusian innovation ecosystem, to generating innovative developments in companies and public services, and especially to the protection of biodiversity, environmental quality and the sustainable use of resources.

The modification of Law 10/2021 will allow companies registered in the community environmental management and audit system (EMAS) and those registered in the Registry of the Andalusian Emissions Compensation System (SACE) to benefit from a 30% reduction in the fee for the prevention and control of pollution as of January 1, 2023.

The S4 provides support for collaborative public-private actions.

The Andalusian Research, Development, and Innovation Strategy (EIDIA) 2021-2027 highlights key elements related to climate change. Among the identified **weaknesses** is the limited number of research, technological development, and testing centers in Andalucía, particularly in critical areas like energy and climate change. Andalucía's strong potential for renewable energy presents a major **strength**, offering opportunities to attract industrial and RDI investments related to climate and energy. The Andalusian government has prioritized climate change and the energy transition through its "Green Revolution," establishing a cross-sectoral commission under the Presidency to stimulate RDI activities. This initiative aims to attract investment and improve coordination among regional departments and public companies. **Social innovation** is also seen as a vital opportunity, complementing technological innovation as a driver for developing the social and collaborative economy, particularly in areas such as energy transition and climate action.

Box 3. The Andalusian Climate Change Observatory Network Programme

The Andalusian Climate Change Observatory Network Programme (CAGPDS02), with a budget of €17.6 million, is dedicated to enhancing data availability for studying and monitoring biodiversity and its adaptation to global changes. This goal is supported by developing a strong scientific and technical infrastructure to improve biodiversity management.

The programme's core actions include:
- Developing the LifeWatch-ERIC e-infrastructure, which will serve as a platform for virtual laboratories and services.
- Establishing a regional infrastructure to support a distributed work environment, enabling effective monitoring of global change impacts on biodiversity.
- Research organizations will operate as observatories, while the regional administration will provide the necessary infrastructure to ensure that knowledge generated is available in formats suited for integration into public administration processes and environmental policies.
- The programme aligns with other strategic initiatives, such as the Andalusian Sustainable Development Strategy 2030, the Air Quality Strategy, the Environmental Employment Generation Strategy 2030, S4 Andalucía, and the Rural Development Program 2014-2022.

Key initiatives within the program include:
- Launching a knowledge transfer node within the REDIAM network.
- Converting public administration data into FAIR (findable, accessible, interoperable, and reusable) formats for R&D centers.
- Developing projects that comply with EU environmental information access directives.
- Managing biodiversity and ecosystem data repositories.
- Generating information to support climate adaptation, mitigation policies, and risk management.
- Creating a prototype e-infrastructure for environmental data.

Overall, these efforts aim to improve climate data management and support effective climate action in Andalucía.

Source: *https://www.juntadeandalucia.es/sites/default/files/2021-11/EIDIA%202021-2027%20Borrador%20%281%29_2.pdf*

3.2.3 Granada

Provincial Climate Change Adaptation Plan for the Province of Granada (Plan Provincial de Adaptación al Cambio Climático de Granada (PPACCGr)) proposes also a Catalogue of Adaptation Measures for the Province of Granada, clustered on eleven thematic areas. The Plan clearly distinguishes between (1) measures that are under the **Exclusive Competence** of the Provincial Council/City Councils, (2) Measures under **Shared Competence** between the Provincial Council/City Councils and other administrations, (3) Measures **Outside the Competence** of the Provincial Council/City Councils, which fall under the responsibility of other administrations. Thus the Provincial Climate Change Adaptation Plan for the Province of Granada consists exclusively of the measures that, within each thematic area, fall under the Exclusive Competence of the Provincial Council/City Councils, along with those under Shared Competence between the Provincial Council and other administrations.

3.3 Ensuring cross domain synergies

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) emphasizes coordinated and transparent actions across multiple domains, advocating for collaboration between institutions, consistency in sectoral policies, and public access to climate information. Strategic areas identified for climate adaptation include water, biodiversity, energy, agriculture, urban planning, infrastructure, tourism, and coastal management, among others. The plan integrates interdisciplinary approaches aligned with the Strategy for Science, Technology, and Innovation (EECTI) 2021-2027, fostering high-impact research and collaboration with Horizon Europe.

In Andalucía, Andalusian Climate Action Plan (PAAC) and Law 8/2018 reinforce these principles by requiring regional and local adaptation plans to align with climate change policies. The Andalusian Climate Change Office oversees coherence across policies, while intersectoral working groups foster collaboration in climate adaptation.

Granada's Provincial Council has adopted eleven thematic areas from the PNACC, focusing on sectors such as agriculture, biodiversity, energy, and tourism, as part of its Adapta Granada Plan. The Council's catalog of projects supports the implementation of these areas, involving both provincial and municipal responsibilities.

Bottlenecks

Although all the relevant plans, at national, regional and local levels, emphasize cross-domain collaboration, achieving effective coordination between sectors like water, energy, and infrastructure may be difficult due to varied objectives and priorities within each domain.

While the PAAC and Law 8/2018 call for alignment in adaptation plans, differences in resources and capacities between regional, provincial, and municipal levels can lead to inconsistent policy application, potentially reducing overall adaptation effectiveness.

Although intersectoral working groups are established, true integration across diverse areas remains challenging. These sectors may operate in silos, limiting the impact of coordinated adaptation strategies.

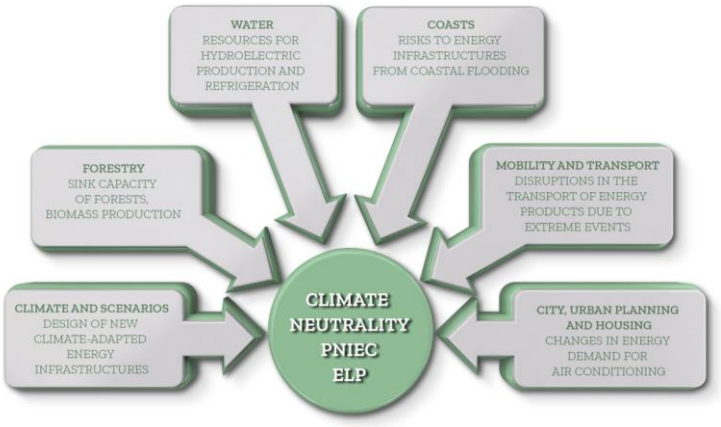
Granada's focus on specific sectors within the PNACC through the Adapta Granada Plan is promising, but the complexity of aligning local initiatives with broader regional and national strategies can hinder cohesive implementation.

Municipalities, may face constraints in implementing complex adaptation projects due to limited technical or financial resources, slowing progress in key adaptation areas such as urban planning and tourism.

3.3.1 Spain

- PNACC 2021-2030, acknowledging the need for coherent actions across distinct domains, sets as guiding principles, among others:
- Collaboration among institutions: acknowledging that efforts to adapt to climate change should occur across various scales and sectors, strategic cooperation between institutions is seen as essential for effective and coordinated responses.
- Consistency in sectoral policies: all policies should integrate climate change adaptation, working towards the common objective.
- Transparency: Information related to climate change impacts, vulnerability, and adaptation policies and actions should be disseminated to relevant individuals and organizations.

Figure 4. Coordinated actions for in PNACC



Source: PNACC 2021-2030, pag 50.

The following strategic areas will be considered for adaptation: 1. Water resources; 2. Flood prevention; 3. Agriculture, livestock, aquaculture, fishing and forestry; 4. Biodiversity and ecosystem services; 5. Energy; 6. Urbanism and territorial planning; 7. Buildings and housing; 8. Mobility and road, railway, port and airport infrastructures; 9. Commerce; 10. Tourism; 11. Coastline; 12. Migrations associated with climate change.

The **Strategy for Science, Technology and Innovation 2021-2027 EECTI 2021-2027** (EECTI 2021-2027) explicitly encourages inter-disciplinarity that generates high-impact science and knowledge and multi-disciplinarity to allow the development of scientifc missions.

The implementation of the EECTI promotes the alignment with Horizon Europe, and support for participation in international projects and joint programming actions of Horizon Europe and international facilities, favouring, for this purpose, the use of adequate, agile and effcient instruments, as well as the availability of specifc funding.

3.3.2 Andalucia

The Andalusian government (Junta de Andalucía) has set governance structures aimed to ensure coordination and collaboration between the different Ministries within the framework of the **Andalusian Climate Action Plan** (PAAC) . On the other hand, Law 8/2018 states that regional and local planning activities related to strategic areas for adaptation to climate change require the inclusion of content that ensures the full coherence with CC policies. Based on this, the Andalusian Climate Change Office develops a line of work aimed at ensuring full coherence with the PAAC of regulations, plans and other materials submitted to the public information process.

The PAAC in terms of adaptation, promotes the creation of intersectoral work groups to enhance synergies in terms of adaptation of different strategic areas that develop interrelated policies, in order to favor solutions that maximize the needs raised and minimize the resulting conflicts. The PAAC, on the other hand, in terms of adaptation recognizes the existence of knowledge gaps, urging the promotion of applied research and knowledge management, to which it dedicates a section: "dimensions of adaptation", which serves as a basis of reasoning for the choice of the package of strategic lines regarding adaptation.

Andalusia has a research, Development and Innovation Strategy (Estrategia de Investigación, Desarrollo e Innovación de Andalucía (EIDIA) 2021-2027), with a time horizon 2027, approved by Government Council Agreement dated June 14, 2022, fully aligned with the criteria and approaches included in the Horizon Europe programme.

3.3.3 Granada

The Provincial Council of Granada has selected eleven thematic areas from the thirteen proposed by the National Climate Change Adaptation Plan. These areas are (1) Agriculture, covering Livestock, Fishing, and Aquaculture; (2) Water; (3) Biodiversity; (4) Energy, including Industry; (5) Infrastructure; (6) Health and Social Aspects; (7) Soils and Coastal Areas; (8) Cross-cutting Issues; (9) Tourism; (10) Urban Planning, including Housing; and (11) Forestry. This selection aims to guide the region's efforts in adapting to climate change across a wide range of sectors. (Proyecto Adapta Granada).
The Catalog of Projects for the Development of the Adapta Granada Plan includes a portofolio of projects with various themes. These projects aim to facilitate the implementation of actions outlined in the Adapta Granada Plan that fall under the exclusive responsibility of the Provincial Council of Granada's Delegations, as well as those involving the City Councils within the province. Additionally, the catalog addresses actions that are a shared responsibility between the Provincial Council, City Councils, and other administrations.
Author analysis of these projects reveals that some are primarily focused on mitigation, other on adaptation actions, while certain projects have objectives addressing both mitigation and adaptation to climate change, as indicated below.

Adaptation

Incorporation of permeable pavements (SUDS) in green areas. The project aims finding solutions to manage the runoff water generated by the impermeability of urban pavements, and if possible, capture this rainwater for reuse in various municipal services. As part of the AdaptaGranada Plan, *Installation of Sustainable Urban Drainage Systems (SUDS)*, has been incorporated as a solution for adaptation in the urban planning area.

Incorporation of species better adapted to climatic conditions in Municipal Gardens. The design and planning of vegetation adapted to the new conditions generated by climate change.

Design of the Prevention and Management Plan for invasive species. Due to the increasing threats posed by climate change, particularly rising temperatures, decreased rainfall, and intense droughts, there is a loss of biodiversity, a disconnection between urban and natural green spaces, and the introduction of invasive species that displace native ones. These invasive species often have water and land resource needs that are not suitable for the region's climatic conditions. The aim is to provide municipalities with a set of guidelines and tools to address this issue, laying the foundation for the management of invasive exotic species within each locality.

Bioclimatization actions for spaces, itineraries and tourist resources: Measures required to adapt municipalities to new climate conditions, ensure citizens' comfort and protect vulnerable sectors such as tourism.

Comprehensive water cycle management plan in small municipalities: inventory and evaluation of the state of infrastructure. This project aims to implemet tools for optimizing water use and improving the efficiency of supply networks to prevent losses, in the context of ongoing decrease in rainfall and resulting water shortages. These tools include monitoring and awareness campaigns in the context of increased water consumption, especially for domestic use due to rising temperatures.

Incorporation of rainwater use systems in municipal buildings and facilities: In the context of drop of the rainfall, the project aims the implementation of water collection systems designed to store and maintain water quality at a level suitable for reuse in various urban applications that do not require potable water, such as garden irrigation, street cleaning, or use in ornamental fountains and ponds. Any uncontaminated water that is not utilized to be returned to the natural environment or directed into the ground

Mitigation

Municipal electricity microgeneration plan. The plan involves producing electricity through numerous small sources located near consumption points, operating in cooperation with conventional power plants, creating in this way a more balanced energy system and reducing reliance on large power stations. This approach often uses renewable energy, helping to lower CO2 emissions.

Design of local strategies for smart territories (Smart Villages): Action plan for the use of smart systems applied to urban management.

Creation of a local/regional energy community. Implementation of measures aimed at building resilience in local energy management, ensuring a reduced impact from potential climate change effects while also contributing to decarbonization efforts. In this context, local energy communities can engage in a variety of activities, including producing, consuming, storing, sharing, or selling energy.

Mitigation and adaptation to Climate Change

Design of green corridors as a tourist resource at the municipal level : The design and planning of green corridors aiming to connect municipality green spaces, to create new tree-covered areas, and provide shaded zones.

Design and preparation of a Tourism Sustainability Plan: The objectives of this plan include the introduction of actions aimed at mitigating the effects of climate change, focusing on the renaturalization and protection of ecosystems, as well as improving urban areas to enhance comfort for tourists in the face of heat waves, rising average maximum summer temperatures, and other extreme weather events.

Training and awareness in extensive farming with less impact on climate change: **Adaptation.** This initiative aims to adapt extensive livestock farming to climate change by addressing expected changes in temperature, rainfall, and other atmospheric phenomena. The goal is to make the livestock industry more resilient by efficiently utilizing resources and ensuring the sustainable management of pastures, animals, and farms to cope with shifting climate conditions. **Mitigation**: In addition to adaptation, the initiative seeks to reduce greenhouse gas emissions from livestock farming. By minimizing waste and fostering agricultural-livestock synergies, the project aims to contribute to climate change mitigation through more sustainable farming practices.

Good agricultural practices to improve soil conservation and carbon sequestration: Training and raising awareness in sustainable agricultural practices with lower environmental impact, which increase carbon sequestration, and adaption of soils to climate change.

Catalog of technical solutions for aquifer recharge: Measures to adapt to the effects of climate change on water availability, Establishing strategic water reserves, intentional aquifer storage to address potential shortages caused by climate change and ensure long-term water security. This measure is particularly relevant in the province of Granada, which heavily depends on groundwater for its drinking water supply.

Response, communication and citizen participation plan in health matters for adaptation to climate change: Design of a Local Health and Emergency Plan that includes mechanisms for raising awareness and responding to climate emergencies, with a strong focus on preventive measures aimed at the most vulnerable groups identified in the municipality.

Creation of friendly spaces in urban environments: incorporation of resilient infrastructure: The Urban Green Infrastructure project aims to address flooding in urban areas by creating green spaces that temporarily store rainwater, thereby reducing flood risks. A key component is the creation of a network of peri-urban parks with significant ecological and landscape value, connected by eco-recreational corridors. Additionally, the project involves planting native herbaceous species in tree pits and parks to attract fauna for the biological control of pests, reducing the need for chemical pesticides. The initiative also includes remodeling avenues and public spaces to improve both ecological and social connectivity, with a focus on prioritizing pedestrians and increasing accessibility.

Recovery of degraded non-agricultural soils through organic amendments from organic waste: Local actions are proposed along riverbanks, streams, urban road embankments, unpaved streets, and even vacant spaces to mitigate the risks of flooding and erosion. Additionally, these measures are intended for other non-agricultural landscapes to combat desertification, improve soil stabilization and restoration, and enhance ecosystem services.

Adaptation measures for outdoor areas of schools to enable them as climate shelters: Measures to improve climate change adaptation in schools, particularly in outdoor spaces. Additionally these measures go beyond specific actions by integrating them into the overall functioning of the school

and are linked to the school's educational project through a collaborative process involving administrations, organizations, and schools. Pedagogical projects engage students in deciding the specific actions to be taken.

Project for the implementation of measures for bioclimatization of educational centers: Various measures to improve climate change adaptation in schools focus on indoor space; the measures are also linked to energy savings, thereby contributing to the reduction of greenhouse gas emissions.

Forestation of Monte Público: The primary goal of creating a CO2 absorption zone is to reduce carbon dioxide emissions. In addition to this, the presence of the forested area will bring indirect social benefits by enhancing the landscape value, making the area more visually appealing with tree cover replacing the current barren land. Furthermore, the increased tree structure and plant diversity will improve soil infiltration and reduce runoff speed, thereby decreasing erosion and soil loss

Design of parks and gardens. The main goal of this project is to create new parks in peri-urban areas, to serve as CO2 sinks, reduce the urban heat island effect, mitigate noise pollution, act as filters to reduce air pollution, and enhance biodiversity. The project proposes a plan for the creation and environmental management of ornamental tree-lined avenues, considering geographic location, climate, soil, and other biotic and abiotic factors to ensure the successful implementation of these green spaces.

Trees in playgrounds and municipal parking lots : The purpose of the project is to plant trees in public play and recreational areas for children, as well as in uncovered municipal parking lots. The main objective is to achieve greater CO_2 sequestration, leading to a reduction of carbon footprint. Additionally, the aim is to lower urban temperatures by creating more shaded area

Creation of green walls and roofs: The primary objective of this project is to cover municipal public buildings with vegetation. The creation of new green spaces enhances CO2 absorption in urban areas, reducing heat islands by purifying the air, minimizing dust swirls, stabilizing temperature fluctuations, and regulating humidity levels. Additionally, the project will help lower energy demand in the buildings where it is implemented.

Recovery of degraded channels: The recovery of degraded channels aims to address significant alterations in river ecosystems, which greatly impact the biotic communities within them. This project plan is applicable to any degraded watercourse in Granada that requires restoration. A traditional method being used involves public or private entities financing ecosystem management projects that provide CO_2 sink services.

Maintenance of crop land and pastures: The goal of this project is to restore grasslands and agricultural lands, leveraging their high potential for CO_2 sequestration, as well as the soil microorganisms associated with them. The restoration plan considers environmental factors such as soil, climate, and topography, and selects vegetation that can adapt to the local conditions without the need for harmful chemicals or herbicides. The aim is to create healthy crop and pasture areas

Carbon dioxide sequestration in wetlands and peatlands: The project aims to create new, environmentally high-quality aquatic spaces while improving the conservation of existing wetlands and peatlands. Key considerations for the project include biodiversity indicators, balance in trophic chains, and monitoring the quality of aquatic systems and soil. Special attention will be given to

public or private water bodies at risk of degradation due to natural or human factors, with a focus on enhancing their CO2 absorption capacity.

Rooftop gardens: Provide support to encourage new rooftop greenhouse projects. These green rooftops act as CO2 sinks and help absorb pollutants, contributing to improved environmental quality.

Heat Networks: This project focuses on the implementation of district heating networks in urban areas. These underground systems provide heating and hot water to cities by integrating renewable or residual energy sources. The primary goal is to reduce carbon dioxide emissions associated with electricity generation and fossil fuel consumption. The project involves installing a large-scale heat distribution infrastructure that serves an entire neighborhood or urban area, similar to the smaller systems already in place for individual buildings or homes.

Incentive for carbon sequestration in the olive grove. This project aims to transition existing olive groves to align with the new environmental policies under the PAC 2023-2027. Olive groves are highly effective at capturing organic carbon from the atmosphere, making them a key player in carbon sequestration efforts. A central part of the project is the maintenance of live vegetation (cover crops) cover in olive groves. By preserving or planting herbaceous species in the olive fields, the project seeks to boost the groves' ability to capture CO_2. This live plant cover, whether naturally growing or deliberately introduced, improves soil health and increases the overall carbon sequestration capacity of the olive groves, helping to combat climate change more effectively.

Regeneration of poplar groves : This project aims to restore poplar groves, not only as effective carbon sinks but also as sources of biodiversity and drivers of the local economy through sustainable timber extraction. The initiative encourages participation from local entities and private landowners in regenerating poplar plantations, whether on public or private land, with the primary function of serving as carbon sinks.

Recovery of degraded areas: This project aims to create a forest cover in degraded mountainous areas affected by erosion, desertification, and forest fires. A restoration plan for the vegetation will be developed, taking into account the environmental factors of the area (such as soil, climate, and topography) and the recommended vegetation

3.4 Increasing breadth and depth of stakeholder involvement

Spain. The The National Plan for Adaptation to Climate Change (PNACC 2021-2030) was developed through an inclusive process, gathering input from experts and key figures in climate adaptation. Methods included deliberative workshops, online expert submissions, surveys, and interviews, involving stakeholders from public administrations, the private sector, and civil society. This participatory approach aligns with UNFCCC guidelines, ensuring representation across diverse groups. The PNACC promotes collaboration among sectors through forums, support for self-assessments by key actors, and establishment of collaborative working groups. The Spanish Strategy of Science, Technology and Innovation (EECTI) 2021-2027 also followed a participatory co-design process involving business, research, public administration, and civil society stakeholders.

Andalucía. The Andalusian Climate Action Plan (PAAC) emphasizes public participation and transparency, established through *Law 8/2018* and structured with participatory frameworks. The preparation process included public workshops, technical assessments, and consultations with stakeholders, resulting in a plan developed collaboratively with economic, social, and administrative entities. Two commissions—the Interdepartmental Commission on Climate Change and the Climate Change Monitoring Commission—oversee coordination, governance, and monitoring of the PAAC. Another notable example of participatory policymaking in Andalucía is the *Smart Specialisation Strategy for Sustainability (*ESTRATEGIA DE ESPECIALIZACIÓN INTELIGENTE PARA LA SOSTENIBILIDAD DE ANDALUCÍA 2021-2027, *S4ANDALUCIA)*, which involved a multi-phase engagement process.

Granada. Without existing methodologies for Climate Change Adaptation Plans at the supramunicipal level, the *Provincial Council of Granada* created its own approach, integrating scientific climate data analysis with local stakeholder participation. Granada was divided into nine *Territorial Management Units (UTGs)*, each with a Territorial Committee involving representatives from the Provincial Council, municipalities, and social groups. These committees participate in the design, development, monitoring, and evaluation phases of the *Provincial Climate Change Adaptation Plan (PPACCGr)* (PLAN PROVINCIAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO DE GRANADA, 2019)

Bottlenecks

While the national and Andalusian CCA policy design processes emphasized stakeholder involvement, there is a lack of specific guidance on how to incorporate distinct groups effectively. This can result in certain voices being underrepresented in adaptation planning.

Overlapping responsibilities among national, regional, and local authorities lead to delays in decision-making and implementation. Public involvement in disaster preparedness and climate adaptation remains limited. While in theory actions are taken, there is often limited contribution to policy discussions or action plans.

Although a rigorous co-creation process was followed at both national and Andalusian levels, ensuring structured consultation and engagement, the absence of a unified framework for stakeholder involvement at local and regional levels could hinder the depth of stakeholder integration, particularly for smaller municipalities.

Financial and technical resource constraints limit the capacity of smaller municipalities, especially in rural Andalusia, to engage in broad-scale climate adaptation measures.

Stakeholders often lack the technical knowledge or data needed to participate effectively in climate adaptation and disaster mitigation.

Private sector involvement, such as businesses and developers, is often inconsistent, particularly when short-term economic interests conflict with long-term sustainability goals. In Granada, urban expansion projects often disregard flood-prone zones, exacerbating risks during heavy rainfall events.

Existing infrastructure and governance systems are not sufficiently resilient to handle extreme weather events. The recent DANA phonemenon in Valancia revealed vulnerabilities in urban drainage systems and disaster response mechanisms.

3.4.1 Spain

According to the information provided by The National Plan for Adaptation to Climate Change (PNACC 2021-2030), the document has been developed through a collaborative process.[10]

Before the initial drafting of the PNACC, preliminary concepts and suggestions were collected from experts and influential figures in the field of adaptation. Several consultation were employed:

- Expert input via an online form: Subsequent to the workshops, all attendees were given the chance to submit additional reflections and recommendations through an online submission form.
- Deliberative workshops**:** Four workshops were conducted, allowing participants to communicate, compare viewpoints, discuss critical elements, and prioritize proposals related to the various aspects of the Plan.
- Supplementary inputs, such as the insights, appraisals, and recommendations of individuals actively engaged in the field of adaptation in Spain, were gathered through surveys and in-depth interviews. In the second phase aimed at formulating the new Plan, input from experts and stakeholders in the field of adaptation was collected through various means, including workshops, online forums, and one-on-one consultations with major public administrations tasked with implementing adaptation policies and measures.

The adoption of a participatory approach in climate change adaptation planning and development has ensured the involvement of stakeholders from various sectors, including the private sector, civil society, local communities, migrants, children, youth, persons with disabilities, and vulnerable populations. The participation process ensures the inclusion of women, gender-focused organizations, people with disabilities.

To encourage the active involvement of societal actors within the framework of the PNACC, several measures have been implemented. Key actors, including businesses, trade unions, and social organizations, will receive support to carry out self-assessments on climate change risks, impacts, and adaptation. Sector-specific and cross-sectoral forums have been established to facilitate discussions and exchanges. Collaborative bodies and working groups are being maintained and promoted to strengthen cooperation. Additionally, collaboration agreements are being encouraged to enable coordinated efforts between public and private organizations. The PNACC-2 continues to focus on promoting information dissemination, capacity building, research, innovation, and social participation to enhance overall engagement and effectiveness.

Preparation process of the Spanish Strategy of Science, Technology and Innovation (Estrategia Española de Ciencia y Tecnología y de Innovación – **EECTI**) 2021-2027: Another example of co-design was the preparation of the EECTI, which followed an open and inclusive process, involving the main RDI actors, through the constitution of interest groups that respond to a quadruple helix model (Businesses, Research and Public Administration, Civil Society and Innovation Users). Prior to the preparation of the EECTI, bilateral meetings were held with the ministerial departments with sectoral actions in R&D&I.

[10] Programa de Trabajo 2021-2025 del PNACC. Informe de participación pública

3.4.2 Andalucia

"The Andalusian government (Junta de Andalucía) is committed to fostering participatory processes in policy development and planning" (Interview with staff Junta de Andalucia)

Box 4. Stakeholders involvement in the preparation of PAAC

To ensure alignment with public interests, the Andalusian government introduced the **Citizen Participation Law (Law 7/2017)** and established organizations like the **Andalusian Institute of Public Administration (IAAP)**. This framework promotes integrating citizen participation, transparency, and accountability into planning processes. Notably, within the participatory development of the Andalusian Climate Action Plan (PAAC), the Workshop on the Diagnosis and Scope Document of the PAAC exemplifies an innovative approach. Law 8/2018 emphasizes public participation, citizen information, and governance as core principles, requiring diverse channels to encourage civil society's involvement in shaping climate policies. To enhance coordination and cooperation, it mandates the formation of two key structures: the Interdepartmental Commission on Climate Change of Andalusia and the Climate Change Monitoring Commission, both of which play vital roles in participation, governance, and monitoring of the PAAC. Similarly, the approbation of Municipal Plans against Climate Change **(PMCC)** makes it compulsory to inform the public, as well as the organization of workshops in many municipalities

The actions undertaken in the co-design process are described in the *Annex III of PACC – results of the participatory actions process*. The Annex includes:
- Report on the Public Participation workshop (June/July 2020)
- Technical Assessment of the Prior Public Consultation procedure (02/04-05/22/2020)
- Technical Assessment of the Public Consultation procedure within the framework of the PAAC Strategic Environmental Assessment procedure (06/08-08/12/2020)
- Technical Assessment of the Hearing and Public Information Processing procedure of the draft Decree approving the Andalusian Climate Action Plan and its Strategic Environmental Assessment Study (12/04/2020 - 02/11/2021).

During the first stage, from the approval of Law 8/2018 to beginning the drafting of the PAAC, various participation, coordination and governance actions related to the areas of the affected administrations were carried out, with experts in different areas related to the contents developed in the PAAC, JASPERS (Joint Assistance to Support Projects in Europe Regions) and innovative participatory tools were implemented for the generation and improvement of content, highlighting the holding of sectoral Workshops on the Diagnosis and Scope Document with the participation of more than a hundred representatives from 79 entities, with the support of the European Innovation and Knowledge Community, Climate -KIC.

Another relevant example of the participative involvement in the policy making, is the design of the Smart Specialisation Strategy for Sustainability *(*ESTRATEGIA DE ESPECIALIZACIÓN INTELIGENTE PARA LA SOSTENIBILIDAD DE ANDALUCÍA 2021-2027, *S4ANDALUCIA)* strategy which has required a process in phases, involving participation, social dialogue and, ultimately, seeking maximum consensus.

3.4.3 Granada

Since no existing methodologies for Climate Change Adaptation Plans for supramunicipal (neither municipalities) entities) were available, the Provincial Council of Granada developed a tailored methodology. This method combines scientific analysis of each municipality's climate data and vulnerability assessment based on global scenarios with institutional coordination and local stakeholder participation in proposing and selecting adaptation actions. The plan's design is based on *Convocatoria Comités Territoriales*. Granada was divided into nine *Territorial Management Units (UTGs)*. For each UTG, a Territorial Committee was established to serve as a participatory body throughout the design, development, monitoring, and evaluation phases of the PPACCGr. These committees include representatives from the Provincial Council of Granada, municipal representatives within the UTG, and identified social groups and stakeholders.

3.5 Setting up effective multi-level governance models

In theory, coordination mechanisms and organizational structures are well-established, ensuring both vertical and horizontal coordination for climate adaptation efforts across all levels. National, regional, and local entities are aligned through structured committees, commissions, and offices, facilitating cross-sectoral collaboration and integration of local insights into broader climate strategies. These entities aim to ensure inter-institutional coordination, foster cross-sectoral cooperation, and support participation from civil society, alongside active involvement in European and international climate platforms.

Spain

The *Spanish Climate Change Office* within MITERD coordinates the *National Climate Change Adaptation Plan (PNACC) 2021-2030*, overseeing information, monitoring, and evaluation. Key national bodies supporting climate action include:

- **Spanish Climate Change Office** (General Directorate level)
- **National Climate Council**: Advises on climate policies and strategies.
- **Climate Change Policy Coordination Commission (CCPCC)**: Coordinates between state and autonomous communities, comprising technical groups focused on emissions trading, mitigation, and adaptation.
- **Interministerial Commission for Climate Change and Energy Transition**: Monitors and proposes public policies for ecological and climate objectives.

Andalucía

Effective climate adaptation governance in Andalucía involves coordination between local, regional, and national authorities, facilitated through mechanisms such as:

- **Andalusian Office of Climate Change**: Established by Law 8/2018 to support adaptation and communication on climate policies.
- **Interdepartmental Commission on Climate Change**: Created to ensure collaboration across Andalusian government departments (Decree 44/2020).
- **Municipal Plans Against Climate Change**: Connect local efforts with regional strategies, with Provincial Councils supporting municipalities under Law 8/2018.
- **Coordination with National and Autonomous Entities**: Andalucía participates in various national structures, including the CCPCC, ensuring alignment with broader state policies and initiatives.

Granada

Granada ensures vertical and horizontal coordination for climate adaptation through two main committees:

- **Technical Committee**: Comprising experts from relevant provincial and regional bodies, this committee addresses adaptation needs, challenges, and solutions, contributing specialized knowledge.
- **Territorial Committees**: Established across nine *Territorial Management Units (UTGs)*, these committees gather local data, fill information gaps, and represent diverse stakeholders, including municipal representatives, social groups, environmental technicians, and regional entities.

Bottlenecks

Complexity of Coordination Across Multiple Levels: While coordination structures exist, the involvement of numerous bodies (e.g., the Spanish Climate Change Office, National Climate Council, CCPCC, and Interministerial Commission) can create complexity, potentially leading to overlapping responsibilities and communication delays.

The lack of established methodologies for supramunicipal and municipal levels (e.g., in Granada) requires local entities to develop their own approaches, which can lead to inconsistencies in adaptation planning and implementation across regions.

Smaller municipalities may lack the technical and financial resources needed to actively participate in multi-level governance structures, leading to uneven engagement and potential gaps in local adaptation measures.

During the recent floods events in Spain (autumn 2024), the lack of coordination between municipalities and regional bodies slowed emergency response efforts and complicated resource allocation.

3.5.1 Spain

The Spanish Climate Change Office of the MITERD, as co- ordinator of the PNACC 2021-2030, is responsible for organising the information, monitoring and evaluation actions .
Among other organizations that, at the national level, perform different functions in the fight against climate change, the main are:

- Spanish Climate Change Office (Oficina Española de Cambio Climático)
- The National Climate Council (El Consejo Nacional del Clima – CNC)
- The Climate Change Policy Coordination Commission (CCPCC) (La Comisión de Coordinación de Políticas de Cambio Climático - CCPCC)
- Interministerial Commission for Climate Change and Energy Transition (Comisión Interministerial para el Cambio Climático y la Transición Energética)

Spanish Climate Change Office (Oficina Española de Cambio Climático) was established by Royal Decree (Real Decreto 376/2001). Its subsequent revisions Article 4.2 of Royal Decree 500/2020 establishes that the following management bodies depend on the Secretary of State for the Environment:

- The General Directorate of Water.
- The Spanish Office of Climate Change, with the rank of general directorate.
- The General Directorate of Quality and Environmental Assessment.
- The General Directorate of the Coast and the Sea.
- The General Directorate of Biodiversity, Forests and Desertification
- **The National Climate Council** (El Consejo Nacional del Clima (**CNC**). This Council is attached to the Ministry of Public Works, Transport and Environment, and had the objective to coolaborate in the development of the National Climate Program, advising the Government on policy regarding climate change and response strategies.

Box 5 Climate Change Policy Coordination Commission

Law 1/2005, of March 9, creates the Climate Change Policy Coordination Commission (CCPCC), (La Comisión de Coordinación de Políticas de Cambio Climático - CCPCC), as a coordination and collaboration body between the General Administration of the State and the Autonomous it.

The CCPCC is made up of seventeen members, representing the General Administration of the State, one member designated by each Autonomous Community, one member designated by each of the cities of Ceuta and Melilla and one member representing the local entities.

This Commission comprises three Technical Groups: one dedicated to the Emission Rights Trading Regime, another to Mitigation and Inventory, and a third to Impacts and Adaptation. Subgroups, stemming from these Technical Groups, include representatives from Autonomous Communities with a particular interest in specific topics within these areas, such as the evaluation of climate risks. This structure of Technical Groups and the Commission operates effectively in terms of institutional coordination at both the managerial and technical levels.

Interministerial Commission for Climate Change and Energy Transition (Comisión Interministerial para el Cambio Climático y la Transición Energética) was established with the aim to achieve

the best treatment of public policies regarding the transition towards a more ecological productive and social model, and is assigned a wide variety of functions, which correspond to the monitoring and formulation of proposals that serve as a basis for decision-making related to climate change and energy policies, and among others:

The coordination, advisory, and participation forums outlined in the plan are important components of its governance system, aiming to achieve the following key objectives:

- Enhance inter-institutional coordination, encompassing both cross-sectoral collaboration (involving various thematic departments) and territorial coordination (with a focus on linking the Central Administration, autonomous communities, and local administrations).
- Foster participation and cooperation with various stakeholders from civil society.
- Facilitate technical and scientific guidance and promote the exchange of knowledge and insights.

Active involvement in European forums and other international platforms, particularly those with neighboring nations and Latin American countries, are also supported by PNACC.

3.5.2 Andalucia

Effective multi-level governance for climate change adaptation involves coordinated efforts across different levels of government.

Box 6. Multi level coordination governance

A clear **coordination mechanism** between different levels of government, including local, regional, and national authorities, with specific roles and responsibilities to avoid overlaps and ensure a smooth flow of information. At regional and local levels, climate action plans that align with national strategies were developed. The plans consider specific vulnerabilities and capacities of each region or locality.

At the regional level, through the Interdepartmental Commission on Climate Change, created and regulated by Decree 44/2020, of March 2, as a collegiate body of the Administration of the Government of Andalusia for coordination and collaboration on climate change.

Law 8/2018 art. 7 stipulates the creation of the **Andalusian Office of Climate Change**, as an administrative unit to support and promote mitigation, adaptation and communication policies on climate change

The Municipal Plans against Climate Change (stipulated by Law 8/2018) connects the regional level with the local level to address the fight against climate change. In this exercise, the Law itself has the Provincial Councils, as a governance structure with the responsibility to provide the necessary support in this task.

The Andalucian Government (Junta de Andalucía) actively participates in the coordination of the climate change policies with the General State Administration (AGE) and other Autonomous Governments, within governance structures, such Commission of Coordination of Climate Change Policies, its Technical Groups for Mitigation and Adaptation, as well as in the ad hoc working groups created for the coordinated development of specific topics.

3.5.3 Granada

Two distinct types of committees, set at the level of Granada province, aim to ensure the horizontal and vertical coordination.

The **Technical Committee** provides specific expert knowledge on the themes of the Plan, both in the needs and problems and in the proposal of adaptation solutions. The committee is made up of technical-experts from all the organizations involved in the province such as the different Delegations and Services of the Provincial Council of Granada, Provincial Energy Agency of Granada, Departments of the Government of Andalusia (Agriculture, Livestock, Fisheries and Sustainable Development, Health and Families), Ministry of Ecological Transition (Provincial Coastal Service, Guadalquivir Hydrographic Confederation), University of Granada, Motril Port Authority, IGME (Geological and Mining Institute of Spain), IFAPA (Agrarian and Fisheries Research and Training Institute) , Sierra Nevada National Park, etc.

Territorial committees: Nine Territorial Committees were created, one for each Territorial Management Unit (UTG). The committee has the responsibility to assess and provide information, quantitative data, covering and better defining the lack of official data for each Technical Management Unit. Representatives of the Provincial Council of Granada and the municipalities that make up the corresponding UTG, municipal environmental technicians, as well as members of the social fabric and identified interest groups such as the GDR (Rural Development Group), social inclusion technicians, Seprona - Civil Guard, technical staff of protected natural spaces, Protection Agents of the Andalusian Health Service, technicians of the Regional Agrarian Offices (OCAs), Andalusian Entrepreneurship Centers (CADEs), associations of the territory, etc.

3.6 Making room for experimentation

Spain. The Spanish National Climate Adaptation Plan (PNACC) lacks a strong focus on experimentation. The PNACC's platform, AdapteCCa, serves as a national tool for sharing data and experiences, facilitating knowledge exchange that could potentially encourage more experimental climate adaptation projects.

Andalusia. The interviews identified little about experimentation. An innovative risk management model is being implemented by the Government of Andalucía. Some projects may exist, yet they are not very visible. For example. the CartujaQanat in Seville project highlights an innovative approach to addressing urban heat while creating socially inclusive, adaptable urban spaces.

Granada. Granada's Provincial Climate Adaptation Plan (Adapta Granada) identifies opportunities for experimentation within several adaptation projects. These experimental approaches allow Granada to gather data and insights for refining adaptation measures that are sustainable, scalable, and tailored to local needs.

Bottlenecks

There is a certain degree of interest and willingness for experimentation in climate change adaptation initiatives. However, the absence of visible examples and a publicly accessible database of these good practices limits their broader impact and scalability.

Legal and administrative frameworks are often inflexible, making it difficult to test and scale innovative solutions in climate adaptation.

Rigid frameworks conflict with the need for localized adaptation strategies tailored to local unique climate risks.

Experimentation often requires additional funding that municipalities or regions lack, particularly in rural Andalusia.

Experimental projects often lack community involvement, reducing public acceptance of innovative measures. Residents may resist changes like floodplain restoration if they are not engaged in the planning process.

Given the transversal nature of the fight against climate change, the operational development of the PAAC requires the need to integrate adaptation into society as a whole, for this it requires a necessary sectorization exercise in order to facilitate the implementation of adaptation policies in each of the different strategic areas.

3.6.1 Andalusia

Interviewes with the Junta de Andalucia evidentiate little about experimentation. The interviews identify as a novel solution in the field of adaptation, « *its own risk management model, which involves the coordination of all its strategic areas* » (interviews with Junta de Andalucia). To facilitate this work, the Ministry of Sustainability, Environment and Blue Economy (CSMAEA) has developed a climate risk assessment methodology, which together with its support tool also aims to normalize this process throughout the Andalusian Administration.

Box 7. CartujaQanat – Recovering the street life in a climate changing world

CartujaQanat is essentially an innovative urban climate governance project that can be described as a co-creational leadership project for urban climate transformation.

Context: Seville faces extreme summer temperatures that can surpass 50ºC, and future projections indicate a 4.5ºC increase in average temperature and a 20% reduction in rainfall. The Isla de la Cartuja, where the project is located, initially showcased innovative bioclimatic architecture and temperature control solutions during Expo'92. Nowadays, the University and the Cartuja Technology Park coexist in this space, grouping public entities such as JRC Sevilla, 442 companies, 10,000 university students and other activities (leisure spaces, museums, etc.). People is attending this area for working or studying, but there are no spaces with good conditions for street life, especially in summer.

RESULTS

Spaces

- The Thomas Alva Edison Avenue, in the Cartuja Technology Park, has been renovated and transformed through the combination of historic climate control technologies (the qanat) with cotemporary technologies targeting NetZero energy consumption. Innovative components as variable solar control, nocturnal dissipation towards the sky, dissipation towards the ground with nocturnal evaporative regeneration, thermal storage in qanats and solar electricity production are used throughout this area. An open air amphitheatre
- A semi-underground events area
- A technology demonstration area
- Open-space recreation area. A 10°C reduction of the temperature in open spaces.

Social innovation

- A new model of public-private-social partnerships is being developed to enhance local climate change resilience and adaptation. This initiative explores co-management approaches to ensure the newly transformed spaces are actively rediscovered and utilized by citizens and stakeholders. Partnerships have been established between the Seville City Council, PCT Cartuja, the University of Seville, and EMASESA, designating them as co-managers to oversee this process.
- Additionally, innovative collaborations with private companies and other stakeholders have been formed to expand the application of the cooling model. These partnerships aim to implement the model in other spaces, such as outdoor gym areas and playgrounds, broadening its impact and utility.
- Developed new partnerships with private companies and other stakeholders interested to apply the new cooling model to additional spaces such as outdoor gym areas or playgrounds.

Innovation

- Experimentating with new materials
- Re-inventing an ancient old water cooling technique, the Qanat, which derives from the Persian empire.

Programme Scalability. Number of public spaces where the new cooling techniques will be scaled: Already during the project lifecycle, there have been indications that the solution will be replicated to at least two new locations in the city, including bus-stops and open-air gyms. playgrounds.

3.6.2 Granada

The analysis of the projects implemented within Adapta Granada Plan (PLAN PROVINCIAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO DE GRANADA, 2019) identifies opportunities for experimentation within the listed projects, particularly in integrating innovative practices, testing alternative solutions, and refining methodologies for climate adaptation and mitigation. Here are some examples:

- **Permeable Pavements and Sustainable Urban Drainage Systems (SUDS)**: Experiment with different materials and designs for permeable pavements and SUDS in green areas to optimize rainwater capture, storage, and reuse. Testing various types of soil

and vegetation cover in SUDS could help determine the best combinations for stormwater management in diverse urban environments.

- **Adaptation of Plant Species in Municipal Gardens**: Conduct trials with different climate-resilient plant species to identify the most suitable options for local climates. Experimenting with diverse vegetation mixes in municipal gardens can provide data on water needs, growth rates, and overall resilience.
- **Invasive Species Management**: Pilot test preventive and control measures for managing invasive species, focusing on species-specific strategies and assessing their impact on local biodiversity and resources. This could involve exploring bio-control methods or natural deterrents to evaluate their effectiveness in diverse municipal settings.
- **Bioclimatization for Tourist and Public Spaces**: Experiment with various bioclimatic measures in different types of public spaces (e.g., parks, tourist sites, walkways) to evaluate how they impact comfort levels, energy efficiency, and cooling effects. Testing these measures in various configurations could yield insights for broader urban adaptation planning.
- **Water Cycle Management in Small Municipalities**: Trial the use of different water management technologies and awareness campaigns tailored to smaller municipalities. Experiments could focus on the integration of advanced monitoring systems to track water consumption patterns and assess their effectiveness in reducing waste and improving water conservation.
- **Smart Village and Microgeneration Initiatives**: Pilot different configurations of local energy production, storage, and consumption models within "smart villages" to evaluate how these systems enhance resilience and reduce emissions. Experimenting with small-scale microgeneration systems and community energy-sharing models could help optimize local energy grids.
- **Agricultural Practices for Soil Conservation and Carbon Sequestration**: Test various sustainable farming techniques, such as cover cropping, no-till farming, and rotational grazing, to determine the most effective practices for enhancing soil health and carbon storage in different soil types and climates.
- **Green Corridors and Urban Green Infrastructure**: Experiment with different tree species, layout designs, and maintenance approaches in green corridors to improve air quality, reduce heat, and support biodiversity. Testing the ecological and social connectivity of these corridors could help refine green infrastructure strategies.
- **Carbon Sequestration in Olive Groves and Poplar Groves**: Test the impact of different cover crops and tree planting densities in olive and poplar groves to maximize carbon capture. Experimenting with combinations of natural vegetation and low-impact management techniques could also support biodiversity while enhancing soil quality.
- **Rooftop Gardens and Green Walls**: Experiment with various plant species and soil substrates in rooftop gardens and green walls to optimize CO_2 absorption, urban cooling, and energy savings. Testing different irrigation and maintenance methods could also improve sustainability and reduce costs.

By implementing pilot projects and experimental approaches within these areas, valuable data and insights can be gathered to refine adaptation and mitigation strategies, making them more effective, sustainable, and scalable.

3.7 Securing high levels of policy intelligence, learning and strategic capacity

3.7.1 Awareness and understanding of CCA

At national level, The *National Climate Change Adaptation Plan (PNACC) 2021-2030* emphasizes stakeholder engagement across sectors, including vulnerable groups, private businesses, and civil society, aligning with UNFCCC guidance. Key actions include:

- Public Engagement and Education. The PNACC aims to monitor public perception, knowledge, and attitudes toward climate change and identify social barriers. It also aims to develop resources like guides, exhibitions, and audiovisual materials to improve climate change awareness.

- Institutional Initiatives: Programmess by the National Center for Environmental Education (CENEAM) and Institute for Energy Diversification and Saving (IDAE) provide educational materials, awareness programs, and promote renewable energy use.

- Platforms and Tools: Multi-actor platforms like #PorElClima and the Cero CO2 initiative engage diverse stakeholders in climate action, offering resources to reduce emissions and raise awareness.

- Action Plan for Environmental Education for Sustainability (2021-2025): Supports integrating climate education across all levels and sectors.

Andalucía. The Junta de Andalucía operates a dedicated climate change portal, Portal Andaluz de Cambio Climático, providing information, practical tips, and examples of sustainable practices for citizens.

Granada. The *AdaptaGranada Plan* includes a specific objective to increase local climate awareness. The "Campaign for Raising Awareness about Climate Change" offers some public resources, although limited information is currently available.

BOTTLENECKS

Insufficient Information on Local Campaigns: The AdaptaGranada Plan's awareness campaign provides limited publicly available information, potentially reducing its effectiveness in engaging the community.

Resource Constraints for Municipalities: Municipalities may lack the resources or capacity to participate fully engage and deploy climate awareness campaigns, resulting in variable levels of climate knowledge.

Lack of Tailored Local Outreach: While some awareness materials exist, there may be a need for more locally relevant, culturally adapted content that directly addresses the unique climate risks faced by Granada's communities.

Disparities in Access to Information. Rural or underserved areas may have less access to awareness campaigns and materials, exacerbating knowledge gaps and leaving some communities more vulnerable to climate risks than others.

3.7.1.1 SPAIN

The PNACC 2021-2030 contributes to the dissemination by elaboration of communication resources in different formats (informative guides, exhibitions, audiovisual materials and others), continuing the work already initiated into understandable and meaningful forms for the general public. The *National Climate Change Adaptation Plan* includes specific objectives and work lines under "Education and Society," with a dedicated action line focused on integrating climate change adaptation into the *Environmental Education Action Plan for Sustainability.*

As part of the PNACC, assistance will be provided to facilitate the development of social studies aimed at recognising several critical aspects, including:

- Monitoring the changes in social perceptions related to the risks associated with climate change.
- Assessing the level of understanding and awareness of climate change, its impacts, and the need for adaptation, while identifying any misconceptions and misunderstandings.
- Evaluating the traditional knowledge, skills, and capacities that communities possess for coping with change and uncertainty, considering how these cultural heritage elements can be leveraged to develop innovative adaptation strategies and actions.
- Analysing public attitudes toward adaptation and identifying potential social barriers that may hinder effective action.

Various initiatives are underway in public awareness and education, including the creation of educational materials and awareness programmes targeting institutions and the general public. On January 21, 2020, the Spanish Council of Ministers adopted the *Government Declaration on the Climate and Environmental Emergency*, which commits to achieving climate neutrality by 2050. Point 19 of the declaration calls for strengthening climate change content in the education system and approving an Action Plan for Environmental Education for Sustainability (2021-2025). Annual Working Programmes outline actions scheduled to be implemented or initiated, many of the actions directly targeting climate change mitigation and adaptation.

The National Center for Environmental Education (CENEAM) offers a mini-portal with extensive resources for climate change communication and education. The Institute for Energy Diversification and Saving (IDAE) *(Instituto para la Diversificación y el Ahorro de la Energia)*, under the Ministry of Energy, Tourism, and Digital Agenda, contributes with publications, audiovisual materials, thematic websites, exhibitions, and communication campaigns.

The work is complemented by the regional and local energy agencies which focus on social empowerment, promoting energy-saving technologies and renewable energy to support climate change mitigation. Spanish NGOs are increasingly active in climate awareness, with major environmental groups providing information and resources on their websites. Additionally, trade unions are involved in awareness efforts, targeting workers as the primary audience for climate education.

In addition to these actions important complementary actions are :

- The Platform *#PorElClima Community* , is a multi-actor platform, a hub aimed to raise awareness regarding the climate emergency. It serves as a space to connect those advancing climate action, offering a place to learn from best practices, gain inspiration from innovative initiatives, and access tools to reduce greenh ouse gas emissions.
- The National Center for Environmental Education (CENEAM) supports educational initiatives to raise environmental awareness and promote sustainability, engaging diverse audiences such as national park staff, biosphere reserve personnel, local communities near national parks, environmental educators, and the general public. It also facilitates inter-institutional training programs. To further enhance public participation, CENEAM organizes and supports seminars, working groups, and forums that provide a platform for environmental and education professionals to reflect, debate, and collaborate.

- The *Climate Change Exhibition* prepared by the *National Center for Environmental Education (CENEAM)* under the scientific guidance of the Spanish Climate Change Office, aims to educate the public on climate change, its causes, and the proposed responses. Originally created in 2005 and fully updated in 2012, the exhibition is available in a self-editable format, allowing educational institutions, cultural associations, municipalities, and other organizations to create their own versions for public display.
- *Cero CO2* is a climate initiative by the Fundación Ecología y Desarrollo aimed at businesses, governments, nonprofits, and individuals. It provides practical tools for addressing climate change mitigation actions through greenhouse gas emission accounting, reduction, and offsetting actions.
- The Climate Assembly (Asamblea ciudadana del cambio climatico) was established to reinforce citizens' participation in a social dialogue on the major issues involved in the ecological transition as one of the follow ups of the Declaration on the Climate Emergency. The Assembly ran from November 2021 through May 2022 and engaged a total of 110 citizens. The assembly offers a platform for citizens to bring fresh perspectives to climate policy, proposing innovative solutions that reflect public needs and priorities.

3.7.1.2 Andalucia

The Junta de Andalucia has a specific web portal (Portal Andaluz de Cambio Climático), dedicated to climate change. Here relevant activities (seminars, projects, reports and updates) are presented to the large public.

Box 8: Andalucia Web Portal for Climate Change

The Andalusian government has a specific web portal Portal Andaluz de Cambio Climático dedicated to climate change. The web portal offers information related to CCA, informing the relevant stakeholders and the society as large, about different types of relevant actions that are undertaken.

A special section is dedicated to the actions that can be taken by citizens at home, at the working and study place, and example of good practices in professional sectors.

Source:
https://www.juntadeandalucia.es/medioambiente/portal/web/cambio-climatico/cambio-climatico/actua

With the Blue Natura Life project, a Awareness and Communication plan was designed. The plan provides objectives and defines key messages, deducted from a SWOT analysis. It identifies target audiences and selects appropriate communication channels, ultimately shaping a cohesive communication strategy, aiming to raise awareness about the role of coastal wetlands and seagrass meadows as carbon sinks. These actions include organizing knowledge-sharing sessions for experts, training workshops for managers and technicians, and seminars for policymakers and the private sector to explore opportunities in blue carbon initiatives. Media events and field visits educate journalists on blue carbon's benefits, accompanied by a media kit for effective communication. An itinerant awareness campaign targets local populations through various events, informational posters, and youth-focused educational sessions. Temporary information points in selected towns are aimed to further engage the community, while a scientific monograph in *Chronica naturae* will highlight technical aspects of the project. Networking activities aim to connect with related projects to maximize transferability, and five information panels will be placed in notable natural areas. Finally, a Layman's report will summarize the project, its actions, and results for the general public.

The website of the Junta de Andalucía includes a portal titled *"Qué puedo hacer yo?"* (What can I do?), encouraging individuals to take action to reduce their energy consumption. It provides practical measures for daily life, including tips for saving water, managing waste, and conserving energy at home and within community spaces.

Another good example is the *CLIM-A International Congress on Climate Change* in Andalusia which gathered global leaders, experts, and professionals to discuss climate change challenges and opportunities in Andalusia, as well as the broader European and global contexts. Recognized by the European Commission as a complementary event for EURegionsWeek 2024, the congress emphasized the critical role of regions and cities in climate action.

3.7.1.3 Granada

A specific transversal objective of the Granada Plan is "Increased awareness among the population of the province of Granada about the effects of climate change" and the foreseen measure consists in awareness campaigns about the effects of climate change in the province of Granada. is dedicated to these awareness campaigns[11].

AdaptaGranada has a specific section dedicated to "Campaign for raising awareness about the Climate Change" (Campaña para la Concienciación sobre el Cambio Climático)**.** In 2022, the Granada Provincial Council has made a series of videos and infographics to raise awareness about climate change[12]. However, little information is available there.

3.7.2 Knowledge base for CCA

Spain.
The *National Climate Change Adaptation Plan (PNACC) 2021-2030* highlights the importance of data collection and monitoring to guide climate adaptation policy. PNACC mandates that adaptation actions rely on scientific data, emphasizing robust responses to extreme events, with a comprehensive evaluation scheduled for 2029. Key mechanisms include: **Climate Risk Reports** across Spain, **Sectoral Adaptation Reports**, **Monitoring Reports** and **AdapteCCa Platform**.

Andalusia. The *Andalusian Climate Action Plan (PAAC)* leverages updated Local Climate Change Scenarios (ELCCA) to guide regional adaptation efforts.

- **Portal Andaluz de Cambio Climático** provides publicly accessible climate adaptation information and actions undertaken across the region.
- **SICMA Platform**: An e-GIS-WEB tool offers a map-based projection of 80 climate-related variables, allowing stakeholders to explore future scenarios related to climate, water balance, biodiversity, and thermal comfort.
- **Localized Knowledge and Action**s offer regional climate projections that shape long-term adaptation measures, focusing on anticipated challenges in Andalucía over the 21st century.

Granada

- The *Provincial Plan for Adaptation to Climate Change of Granada (PPACCGr)* emphasizes monitoring and coordination for adaptation efforts.
- **Climate Change Adaptation Observatory**: A newly established observatory will oversee data collection, facilitate institutional coordination, and support data sharing

[11] http://www.adaptagranada.es/Campaña-de-Concienciación/

[12] https://www.dipgra.es/contenidos/plan-adaptacion-al-cambio-climatico/

- **Monitoring Committees**: Comprising representatives from each Territorial Management Unit, these committees track the execution of planned actions, reporting to the Provincial Council of Granada.
- **Regular Evaluation**: The Provincial Council conducts evaluations of adaptation effectiveness through annual, biannual, and triannual reviews to ensure progress tracking.

3.7.2.1 Spain

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) enhances the tools for collecting information and monitoring public adaptation policies and the Plan itself. Among the reporting and monitoring mechanisms are the following:

- **Climate Risk Reports:** The reports should synthesize and offer an up-to-date overview of the understanding of climate change-related risks in Spain.
- **Sectoral Adaptation** Reports analyze the status of various areas or sub-areas of work within the PNACC. They may be requested by the government or the Congress of Deputies.
- **PNACC Monitoring Reports**: These informative reviews, accessible to all, cover the actions carried out within the PNACC framework during a specific timeframe. They also include conclusions, challenges, and prospects for the future.

An initial set of indicators designed to provide an evolving perspective on the effects of climate change and the progress made in adaptation. This aims to facilitate ongoing policy improvement. Moreover, Climate Change Adaptation Platform (AdapteCCa), established in 2013 under the PNACC, should be improved, to solidify its role as a knowledge hub and ensure its full functionality.

Box 9. AdapteCCa national platform

The AdapteCCa platform is an online tool aimed to facilitate coordination and transfer of knowledge, experiences, information on impacts, vulnerability and adaptation to climate change, between the different Spanish administrations and the scientific community, planners and managers, both public and private, and other agents, allowing a multi-directional communication channel. It has been designed to maximize synergies with the European Climate-Adapt platform, the European Commission and the European Environment Agency having an important role in ensuring the complementarity between both platforms.
The platform has specific sections on:
- Thematic focus of CCA: energy, coast and marine enviroments etc
- TRANSVERSAL ASPECTS OF DE ADAPTATION: territorial and social vulnerability, cross-border etc
- Territorial approach: mountain, island, rural, other areas

« Adaptation decisions must be based on the best available science. However, the primary objective of these decisions will be to ensure a high level of environmental and health protection, even in cases where the available scientific data do not allow for a full risk assessment or evaluation ». (PNACC, pag 49).

Beside the requirments for data monitoring, and thorough data scientific and technical analyses, PNACC aligns to the principle that in the evidence based policy making, the design of actions should be done according to scientific scenarios, including the most unfavourable, especially in relation to responses to extreme events.

The PNACC 2021-2030 envisages an in-depth evaluation in 2029, in order to assess the progress, remaining challenges and lessons learned to date. The evaluation will include an analysis of the plan's relevance, effectiveness, efficiency, coherence and added value and should use a variety of sources, including factual information, but also the assessments of individuals and organisations active or interested in the field of adaptation.

3.7.2.2 Andalucia

The interviews with the relevant staff from Junta de Andalucia, highlights that *"Regardless of the existence of gaps and identified needs to deepen the knowledge of a specific sector, the* Andalusian Climate Action Plan (PAAC) *is based on the principle that with the current level of knowledge it is time to undertake, with the greatest possible intensity, action for adaptation to climate change. Along these lines, the Junta de Andalucía is making efforts to improve knowledge base related to the effects of climate change.* »

The *Andalusian Climate Action Plan (PAAC)* leverages updated Local Climate Change Scenarios (ELCCA) to guide regional adaptation efforts. The Portal Andaluz de Cambio Climático serves as a public platform providing accessible information on climate adaptation initiatives and actions across Andalucía.

The adaptation to climate change projections in Andalucia, according to the latest Intergovernmental Panel on Climate Change (IPCC) report (2021 and 2022) represents an important tool for the development of local impact and adaptation scenarios that help confront climate change in the region. All the information is publicly available on the Junta de Andalucia site[13]. To this end, the **Local Climate Change Scenarios of Andalusia** (Escenarios Locales de Cambio Climático de Andalucía ELCCA) have been updated. These scenarios will be taken as a reference in the planning of the Autonomous Community of Andalusia and will be updated according to the scientific advances that occur. The projection of each of the variables allows to explore, integrating local climate variability, the joint or individual output of 10 Coupled Model Intercomparison Projects (CMIP) global circulation models[14] on the 4 mandatory emissions scenarios established by the VI IPCC Report in different periods, throughout the 21st century. The results are simulations that try to illustrate, with current knowledge, the trend of various climate variables. Its objective is not to serve as a tool in the evaluation of the long-term climate, but to serve as a context and framework to reflect on some main challenges that Andalusia may face in relation to climate change throughout the 21st century and focus, consequently, measures that minimize its future impact.

The Committee of Regions of the European Union (EU) has recognized as "good practices" in environmental matters the preparation of the "*Climate Action Report of the Junta de Andalucía 2021-2022 in development of the Andalusian Climate Action Plan", the preparation of a "Protocol for calculating the Carbon Footprint of sustainable events",* and the preparation of an "Inventory of GHG emissions of Andalusia" on an annual basis. In this way, these new initiatives are now officially considered "good practices" recognized at the European level and become part of the 'European Green Deal map' ('EU Green Deal map').

Complementing this, the SICMA platform, an advanced e-GIS-WEB tool, offers map-based projections of 80 climate-related variables, enabling stakeholders to visualize future scenarios concerning

[13] https://www.juntadeandalucia.es/medioambiente/portal/areas-tematicas/cambio-climatico-y-clima/escenarios-locales-de-cambio-climatico

[14] Climate models are one of the primary means for scientists to understand how the climate has changed in the past and maychange in the future. The models simulate the physics, chemistry and biology of the atmosphere, land and oceans re constantly being updated, as different modelling groups around the world incorporate higher spatial resolution, new physical processes and biogeochemical cycles. CMIP6 will consist of the "runs" from around 100 distinct climate models being produced across 49 different modelling groups. (https://www.carbonbrief.org/cmip6-the-next-generation-of-climate-models-explained/)

climate, water balance, biodiversity, and thermal comfort. This localized approach is further supported by regional climate projections that inform long-term adaptation measures, addressing the anticipated challenges Andalucía will face throughout the 21st century.

Box 10. SICMA. Andalusia Platform for climate change scenarios

A publicly available e-GIS-WEB map viewer (https://andalucia.sicma.red/) has been enabled to facilitate geographical consultation of the results. This allows projecting future scenarios integrating 80 climate-related variables, grouped in 4 layers of information: Climate, Water Balance, Biodiversity and Thermal Comfort.

3.7.2.3 Granada

The Provincial Plan for Adaptation to Climate Change of Granada (PPACCGr) sets the following transversal objectives:

- **Monitoring and coordination for the execution of the** Adapta Granada Plan. The aim is to identify which planned actions within each measure have been implemented. This action should be performed every year by the Monitoring Committee, made up of the group identified in each UTG (who will act as representatives and will be in contact with the Provincial Council of Granada) and with the rest of the members of its Territorial Committees, Provincial Council of Granada.
- **Evaluation of CC Adaptation Lines**. The evaluation should be performed on an annual, biannual and triannual base (specified for each line). The responsible body is the Provincial Council of Granada. The Monitoring Indicator Sheets created for each Line of Action will be used, and included in the Monitoring and Evaluation Plan Document.
- **Creation of the Climate Change Adaptation Observatory in the province of Granada.**
- **Promotion of institutional coordination and the transfer of information and data between administrations.**

3.7.3 Strategic capacity

Spain. The PNACC 2021-2030 in Spain emphasizes strategic capacity building in climate adaptation, identifying essential skills and stakeholder needs while recommending diverse training formats such as workshops, experiential learning, and study visits.

In **Andalucia**, targeted *training programmes for technical staff within the regional administration who has expertise in climate change are organised, in the frame of the broader scope* standardized process within the framework of future operational activities within the Climate Adaptation Programme in Andalucia.

Granada. There is limited information regarding such training programmes.

Bottlenecks

- **Insufficient Training and Capacity Building at the local level**. While the PNACC 2021-2030 emphasizes strategic capacity building, there is limited implementation of targeted training programmes at the local level in Granada. This lack of capacity-building initiatives restricts the ability of local technical staff and stakeholders to effectively engage in climate adaptation planning and implementation.

- **Limited Availability of Information on Training Opportunities**. In Granada, there is minimal public information about training programmes, making it difficult for local technical staff and stakeholders to access or participate in capacity-building initiatives.
- **Uneven Implementation Across Regions**. Training programmes appear more concentrated at the regional level (e.g., Andalucia), with a lack of tailored initiatives specifically addressing the unique needs of smaller municipalities and local contexts like those in Granada.
- **Potential Gaps in Resources and Expertise** Local administrations in Granada may lack the resources or expertise to develop or sustain strategic training initiatives without additional support from regional or national authorities.

3.7.3.1 Spain

PNACC 2021-2030 addresses the need for strategic capacity building, the need to identify the emerging skills that are needed, the key stakeholders engaged in the process, and assess their specific capacity-building requirements. Various educational and training formats should be considered, such as study visits to exemplary projects, professional exchanges, experiential learning through practical initiatives, seminars, and workshops, among other methods. In the "Education and Society" domain, a range of action strategies is suggested to fulfill these objectives.

3.7.3.2 Andalusia – Granada

The Ministry of Sustainability, Environment, and Blue Economy (CSMAEA) is taking important steps to develop a new climate risk management model. According to the interviews, *"as part of this initiative, the Ministry is currently organizing training programs for technical staff within the regional administration who has expertise in climate change. The primary objectives of the training are to enhance their understanding of climate change, adaptation strategies, and to acquaint the staff with the methodologies for assessing climate risks and the tools associated with this assessment, all of which have been developed by the Ministry. »*

The ultimate goal of this training effort is to establish a standardized process within the framework of future operational activities within the Climate Adaptation Programme in Andalusia. This will enable the definition of clear objectives, the evaluation of actions, and the monitoring of relevant indicators related to climate change adaptation in the region. It is a significant step toward transparency and a structured approach to the risk assessment process, providing a solid foundation for decision-making related to climate adaptation.

Box 11 Participation in Climate Change KIC

The Directorate General for Environmental Quality and Climate Change (DGCACC) participated in two climate change adaptation projects promoted and financed by Climate KIC (Knowledge and Innovation Community), EIT (European Institute for Innovation and Technology) of the European Commission.

- DEEP DEMONSTRATIONS: FORGING RESILIENCE. REGION: ANDALUSIA. The project offers participatory processes specialized in adaptation, and can contribute to improving the content of the PAAC itself and its public information processes. The final product is the Project Portfolio, which will constitute a list of adaptation pilot projects that fit into Andalusian policies;
- RISI-ADAPT-II (until 2022) focused on the impact of the Drought in Andalusia and other regions, simulating the effects of the drought with different variables and carrying out simulations.

4 Conclusions

Spain is among the European Union (EU) countries already showing significant impacts from the climate crisis. Approximately 20% of mainland Spain has already suffered from desertification, primarily due to the combined effects of climate change and human activities, including the overuse of water resources, particularly the excessive extraction of groundwater. Additionally, 74% of the country is at risk of desertification.

The main conclusions for each of the seven key transformative innovation features in the analytical framework are summarized below. The analysis identifies good practices, bottlenecks and possible ways forward.

Good practices

- Strategies and implementing plans were developed at national, regional and local level. Spain has already some tradition in CCA strategies and planning. The National Plan for Adaptation to Climate Change (PNACC 2021-2030) is a continuation of the PNACC 1, 2006-2020. The National Plan complies fully to the conceptual framework used for analysis in this work, explicitly addressing all the relevant aspects.
- In a similar and complementary way, Andalusia developed the Andalusian Climate Action Plan (PAAC), derived from Law 8/2018 on climate change of Andalusia, and adopted it in 2021.
- Granada adopted *Adapta Granada Plan* (PLAN PROVINCIAL DE ADAPTACIÓN AL CAMBIO CLIMÁTICO DE GRANADA, 2019) on April 2023, plan which was developed based on unique methodology that combines scientific data analysis with climate vulnerability assessment and coordination among local stakeholders. The plan is designed to address the adaptation needs of supra-municipal entities in the province.
- All these plans, at national/ regional/local level, have specific objectives and implementing instruments. Given the complexity of the actions required by CCA, the objectives and action lines address different domains, as deemed relevant for Climate Change Mitigation and Adaptation.
- The strategic documents, for CCA and R&D&I were developed through a collaborative process, involving all actors of the quintuple innovation helix (university-industry-government-public-environment helix framework).
- Multi-level governance structures, at national, regional, municipality level, established through legal acts, ensure horizontal and vertical coordination and collaboration.
- The implementing plans allow for agile and flexible approach, as required by experimentation and social innovation.
- Transversal principles to which all the plans align, ensure coordination, transparency, public involvement in co-creation, and data monitoring for evidence base policy making. Specific training aimed to consolidate the strategic capacity is envisaged also in the plans. Dissemination events, awareness campaigns are also part of the process and advertised on the websites of the relevant authorities.
- Online platforms, publicly available, gather data related to climate, impact of climate change, using indicators established at international level.

For each dimension, suggested pathways are provided to help the adoption of a more traformative approach to climate change adaptation (CCA).

4.1 Directionality

The National Plan for Adaptation to Climate Change (PNACC 2021-2030) aims to reduce climate-related damages and enhance resilience, building on prior efforts and incorporating recent global commitments and climate risk insights. It defines nine objectives, including risk identification, public policy integration, stakeholder engagement, and monitoring, with 81 action lines spread across 18 work areas. However, challenges remain in translating these strategies effectively at local and regional levels. The Andalusian Climate Action Plan (PAAC), based on Andalusia's Law 8/2018, is the regional framework for climate action, aiming for climate neutrality by 2050. Granada's Provincial Climate Adaptation Plan (PPACCGr) targets climate threats, impacts, and municipal vulnerabilities, promoting local participation and proposing specific measures.

Bottlenecks.

In spite of the **Municipal Plans against Climate Change (PMCC)** defining, through the PAAC, a planning system **that connects the regional level with the local level**, there is room for improvement to fine tune methodologies for designing Climate Change Adaptation (CCA) Plans at the supra-municipal and municipal levels to avoid inconsistencies in how adaptation is implemented at these levels. Although strategic documents identify potential funding sources, given their competitive nature they may pose a challenge in operationalisation and achieving concrete outcomes.

Possible Ways Forward

- Define clear, measurable targets for climate change adaptation.
- Emphasize the importance of innovative approaches to climate adaptation.
- Establish a critical mass of essential Climate Change Adaptation (CCA)-related expertise within national, regional, municipal administrations, emphasizing cross- collaboration.
- Systematically leverage the lessons learned from various EU regions to inform and improve CCA efforts. Provide support and foster local climate adaptation innovation clusters

4.2 Articulating instrument portfolios and defining synergies between funding sources

Spain's climate adaptation funding relies on multiple EU financial instruments, with significant support from Cohesion Policy Funds and Horizon Europe. National efforts, like the PIMA Adapta plans under the PNACC, target vulnerability reduction, while complementary national and regional plans, including PNRR and Andalusia's PAAC and S4Andalucia strategy, emphasize areas like energy, biodiversity, and marine science. These initiatives aim to create synergies across funding sources, fostering collaboration between regional, national, and European programs, including LIFE and Interreg.

Bottlenecks

Despite the availability of funding (for instance PMCC support to local governments within the framework of the PIMA plan to support municipalities, or law 8/2018 supporting municipalities alongside other instruments), the effective implementation of climate adaptation projects remain challenging. Limited private sector involvement, due to insufficient incentives, hinders business participation in adaptation measures. Misalignment and poor coordination between national, regional, local, and sectoral policies may lead to fragmented efforts and inadequate responses to climate risks. Smaller municipalities, in particular, struggle with complex funding mechanisms and lack the

support needed to address their unique challenges, resulting in inefficiencies. Additionally, knowledge gaps, especially in region-specific climate impact data, and coordination issues between regional and local governments further disrupt cohesive and effective climate adaptation efforts.

Possible Ways Forward

- Develop a system that enables municipalities to share their experiences, challenges, and successes with regional and national bodies. This can inform adjustments to the PNAAC and PAAC, ensuring they remain responsive and relevant. It will also help the scaling -up of efficient instruments.
- Provide targeted guidance addressing the unique needs and challenges of municipalities. CCA guidelines should be context-specific, recognizing the diverse climate challenges across regions.
- Clarify the roles and responsibilities of local, regional, and national governments in adaptation projects to minimize overlaps and ensure accountability at each level.
- Develop incentives to encourage private sector participation in climate adaptation, including tax breaks, grants, or subsidies for companies investing in adaptation projects. Introduce green certifications or awards recognizing businesses that adopt and implement adaptation practices
- Encourage public-private partnerships to share resources and mitigate risks in high-impact areas such as infrastructure, water management, and renewable energy. These partnerships can leverage private sector innovation and investment to complement public resources.
- Establish a dedicated funding mechanism tailored to smaller municipalities, offering straightforward application processes and providing technical assistance to support project development and management.
- Facilitate the rapid entry of adaptation-focused startups and small to medium-sized enterprises (SMEs) into the market.
- Engage investors from the outset and establish robust policy signals to promote the long-term development of the local adaptation economy.
- Provide support to RDI projects focus on CCA solutions for specific regional, local specific challenges.
- Tailor policies and guidelines to be more inclusive and adaptable to varying local contexts; incorporate specific provisions for smaller municipalities, addressing their unique challenges and capacity constraints.

4.3 Ensuring cross-domains synergies

Spain emphasizes fostering collaboration between sectors to boost innovation, efficiency, and global competitiveness. Key areas of focus include integrating sustainability in urban planning, connecting research with industrial applications, promoting eco-tourism, and modernizing agriculture with technology. To achieve this, Spain employs integrated policies aligned with EU initiatives, encourages public-private partnerships, and coordinates efforts regionally. These synergies drive resource efficiency, innovation, economic growth, and societal well-being, positioning Spain as a leader in sustainable, cross-sector development.

The National Climate Change Adaptation Plan (NACC) 2021-2030 promotes coordinated, transparent climate adaptation across sectors like water, biodiversity, energy, and urban planning, fostering research and collaboration in line with the Strategy for Science, Technology, and Innovation (EECTI) and Horizon Europe. In Andalucía, the Andalusian Climate Action Plan (PAAC) and Law 8/2018 mandate alignment of regional and local adaptation plans with the Andalusian Climate

Change Office (OACC) ensuring policy coherence. One of OACC's line of activities is precisely to foster sectorial strategic planning in coherence with PAAC within the frame of Law 8/2018. Granada's Adapta Granada Plan adopts key NACC areas, focusing on agriculture, biodiversity, and energy.

Bottlenecks

Despite the emphasis on cross-domain collaboration in national, regional, and local plans, effective coordination across sectors like water, energy, and infrastructure is often hindered by differing objectives and priorities. While frameworks such as the PAAC and Law 8/2018 promote alignment in adaptation plans, disparities in resources and capacities between governance levels can lead to inconsistent implementation and reduced effectiveness.

Intersectoral working groups aim to foster integration, but sectors frequently operate in silos, limiting the impact of coordinated strategies. Initiatives like Granada's Adapta Granada Plan show promise in addressing sector-specific needs under the PNACC. However, aligning these local efforts with broader regional and national strategies remains a significant challenge.

Municipalities, particularly smaller ones, face additional barriers such as limited technical and financial resources, which hinder their ability to execute complex adaptation projects in critical areas like urban planning and tourism, ultimately slowing progress in achieving cohesive climate resilience. It remains to be seen whether ongoing initiatives such as financial support from the Andalusian Government or collaboration with Andalusian Federation of Municipalities and Provinces (FAMP) will overcome this bottleneck.

Possible ways forward

- Provide increased support to interdisciplinary CCA research. Design funding mechanisms that prioritize projects delivering both mitigation and adaptation benefits.
- Identify and address any strategic silos that may hinder collaborative efforts across sectors.
- Engage communities in climate initiatives, including research projects that address both adaptation and mitigation needs, with a focus on responsible research practices
- Leverage the potential of a "climate adaptation economy" by incorporating business-oriented innovation tools into the adaptation project portfolio.
- Establish centralized climate data platforms accessible to all sectors to support informed, cross-sector decision-making.

4.4 Increasing breadth and depth of stakeholder involvement

The National Climate Change Adaptation Plan (PNACC) 2021-2030 was developed through an inclusive process, gathering input from experts, public administrations, the private sector, and civil society via workshops, online submissions, surveys, and interviews. Similarly, the Spanish Strategy of Science, Technology and Innovation (EECTI) 2021-2027 was co-designed with input from business, research, public administration, and civil society. Similarly, the Andalusian Climate Action Plan (PAAC) was developed with input from public workshops, technical assessments, and consultations with stakeholders, involving economic, social, and administrative groups. The Smart Specialisation Strategy for Sustainability (S4ANDALUCIA) 2021-2027 was also developed with a multi-phase participatory process. The Provincial Council of Granada developed a unique approach

to Climate Change Adaptation Plans (CCAs) at the supramunicipal level, combining climate data analysis with local stakeholder engagement. The region was divided into nine Territorial Management Units (UTGs), each managed by a Territorial Committee with representatives from the Provincial Council, municipalities, and social groups. These committees participate across all stages of the Provincial Climate Change Adaptation Plan (PPACCGr).

Bottlenecks

While the national and Andalusian climate change adaptation policy processes have emphasized stakeholder involvement, there is insufficient guidance on effectively integrating diverse groups, leading to the underrepresentation of certain voices in adaptation planning. Despite structured co-creation processes at the national and Andalusian levels, the absence of a unified framework for stakeholder engagement at regional and local levels weakens stakeholder integration, particularly in smaller municipalities. Financial and technical constraints further limit the capacity of rural Andalusian municipalities to implement large-scale adaptation measures.

Overlapping responsibilities among national, regional, and local authorities contribute to delays in decision-making and implementation, while public involvement in disaster preparedness and climate adaptation remains limited, often lacking meaningful input into policy or action plans.

Stakeholders often face barriers such as insufficient technical knowledge or access to relevant data, which undermines their ability to contribute effectively to climate adaptation and disaster mitigation efforts. Private sector participation is inconsistent, particularly when short-term economic interests clash with long-term sustainability goals. For instance, urban expansion in Granada frequently overlooks flood risks, increasing vulnerability during heavy rainfall.

Existing infrastructure and governance systems also lack resilience to extreme weather events. The recent DANA phenomenon in Valencia exposed significant weaknesses in urban drainage and disaster response systems, underscoring the need for more robust adaptation strategies.

Possible ways forward

- Continue and expand the positive stakeholder engagement efforts already established in the CCA strategy.
- Establish detailed recommendations for involving distinct groups, including vulnerable, marginalized, and underrepresented communities. These guidelines should outline best practices for reaching and integrating various stakeholders, ensuring that all voices are considered in adaptation planning.
- Ensure that stakeholder involvement is not limited to the initial stages of planning but includes regular feedback loops throughout implementation. Establish channels for continuous input from diverse groups to adaptively manage and improve CCA strategies over time.
- Continue to develop user-friendly platforms and tools to provide stakeholders with the necessary data and technical knowledge for effective participation. This could include localized climate projections, risk assessments, and best practices for adaptation.
- Encourage greater business participation in CCA: Organize stakeholder events focused on complex, slow-onset climate change impacts, showcasing examples of transformative innovation solutions from other countries to address CCA challenges.
- Invest in upgrading infrastructure to better handle extreme weather events, such as improving urban drainage systems. Enhance disaster response mechanisms through coordinated planning and simulation exercises involving all levels of government.

4.5 Setting up effective multi-level governance models

Coordination mechanisms and structures for climate adaptation are well-established across national, regional, and local levels, aiming to ensure both vertical and horizontal collaboration. National entities like the Spanish Climate Change Office, National Climate Council, CCPCC, and the Interministerial Committe support policy coherence and cross-sectoral cooperation, while Andalucía and Granada implement relevant frameworks at regional and provincial levels.

Bottlenecks

Despite coordination structures across national, regional, and local levels (including, inter alia methodologies and tools elaborated by the Andalucian office of climate change /OACC or the methodology used for the drafting of Municipal plans against climate change /PMCC), several challenges hinder the full effectiveness of climate adaptation governance. The involvement of numerous bodies, while intended to facilitate collaboration, can add complexity. This can lead to overlapping responsibilities and communication delays, which may impact timely decision-making and effective implementation. The absence of standardized methodologies for designing Climate Change Adaptation Plans at supramunicipal and municipal levels requires local entities, to develop their own approaches. This can result in uneven adaptation practices and a lack of coherence across different regions. Municipalities may lack the technical and financial resources needed to fully participate in multi-level governance structures. This may lead to potential gaps and a fragmented response to climate resilience and adaption.

Possible ways forward

- Clearly define the roles and responsibilities of each coordinating body within the local-regional-national framework to ensure accountability, efficient information flow and decision making process.
- Prioritize investments in resilient infrastructure, such as urban drainage systems, flood defenses, and early warning systems, to mitigate the impacts of intense rainfall and flooding. Incorporate climate risk into urban planning and development processes.
- Develop a digital platform to facilitate information sharing, and allow responsibility tracking among these bodies, enhancing response times and reducing communication delays.
- Involve local communities in adaptation planning through awareness campaigns and participatory processes. Equip municipal staff and local stakeholders with training on climate adaptation practices and governance.

4.6 Making room for experimentation

The PNACC shows limited focus on experimentation. In Andalusia, interviews also indicate little evidence of experimentation, though some projects are underway but not widely publicized. The Government of Andalucía is introducing an innovative risk management model, while Seville's Cartuja-Qanat project addresses urban heat through adaptable, socially inclusive spaces. Granada's Provincial Climate Adaptation Plan (Adapta Granada) explores experimental opportunities in various projects, allowing for the development of sustainable, scalable, and locally tailored adaptation measures. Although there is interest in experimentation within climate adaptation initiatives, the lack of visible examples and a public database of successful practices restricts their broader impact and scalability.

Possible ways forward

- Establish a centralized, accessible database to document and showcase successful adaptation practices and experimental projects. This platform could include case studies, project outcomes, and lessons learned, making it easier for municipalities and stakeholders to replicate effective strategies. Highlighting successful projects and innovative approaches can inspire further experimentation and build support within communities and government bodies.
- Introduce legal and administrative frameworks that allow for piloting innovative solutions without the constraints of rigid regulations. For instance, create temporary "experimental zones" or legal exemptions for climate adaptation projects, enabling testing and refinement before broader implementation.
- Design policies that empower municipalities to develop tailored solutions addressing their specific climate risks. Support this by providing flexible guidelines that accommodate regional and local variations, ensuring that projects are contextually appropriate and effective.
- Ensure that national and regional climate adaptation policies include provisions for experimental approaches. This integration can legitimize and prioritize experimentation as a key component of adaptation strategies, fostering a culture of innovation.
- Establish dedicated funding streams for experimentation in climate adaptation. These could include grants, subsidies, or public-private partnerships targeted at rural and resource-constrained areas. Incentivize innovation by rewarding municipalities and regions that successfully implement and scale transformative projects.
- Integrate participatory approaches into the design and implementation of experimental adaptation projects. Actively engage residents in planning processes through workshops, public consultations, and co-design sessions, ensuring their concerns and insights are incorporated. This can foster public acceptance and support for transformative measures, such as floodplain restoration or urban greening.
- Implement rigorous monitoring and evaluation mechanisms for experimental projects to assess their impact and scalability. Successful initiatives should be prioritized for broader implementation and integrated into mainstream climate adaptation policies.

4.7 Securing high levels of policy intelligence, learning and strategic capacity

4.7.1 Awareness and understanding of CCA

The PNACC 2021-2030 promotes extensive stakeholder involvement by engaging vulnerable groups, businesses, and civil society in climate initiatives, in line with UNFCCC guidance. Key measures include educational resources—guides, audiovisual materials, and monitoring tools to track public perceptions. The Action Plan for Environmental Education for Sustainability (2021-2025) encourages integrating climate education across sectors. In Andalucía, the Portal Andaluz de Cambio Climático delivers accessible information and sustainable practice tips. Meanwhile, Granada's AdaptaGranada Plan seeks to increase local climate awareness, although more public details on its campaign are needed.

Bottlenecks. Many municipalities, constrained by financial and technical resources, may struggle to execute effective campaigns, leading to uneven climate knowledge and preparedness across the regions. Existing outreach materials often lack local relevance, failing to address the unique cultural

and environmental contexts of Granada's communities. The absence of structured mechanisms for involving local populations limits public interest and participation in adaptation initiatives. Rural and underserved areas face further challenges due to disparities in access to information, leaving some communities more vulnerable to climate risks.

Possible ways forward

- Use surveys and public consultations to assess public understanding and misconceptions regularly, refining messaging based on community responses.
- Provide support for the organisation of **workshops and seminars** in schools and community centers to explain climate change causes, impacts, and necessary actions.
- Tailor educational materials for local contexts, addressing specific climate risks faced by communities in Andalucía and Granada. This could include producing region-specific videos and infographics for local campaigns like AdaptaGranada.
- Continue to develop **interactive materials** (infographics, videos, guides) to demonstrate practical ways to reduce carbon footprints.
- Facilitate **public dialogue forums** with citizens and experts to discuss local climate issues and solutions.
- **Organize sustainable community competitions** to encourage recycling, energy savings, and green transportation, rewarding communities for their efforts.
- Launch **social media campaigns**. Produce **mini-documentaries** featuring stories of people affected by climate change, emphasizing the impact of individual actions. Partner with **influencers and public figures** to broaden the campaign's reach.
- Establish funding opportunities and technical assistance for small municipalities to help them actively participate in climate awareness initiatives
- Set up regional "training of trainers" programmes where municipal staff and local volunteers learn to lead climate awareness activities within their communities.
- Implement feedback mechanisms to adjust strategies as needed, ensuring that all demographic groups are reached and engaged.
- Showcase Success Stories and Best Practices. Highlight successful local adaptation initiatives and their benefits to inspire and motivate broader community participation. This can foster a sense of ownership and urgency in addressing climate challenges.

4.7.2 Knowledge base for CCA

The *National Climate Change Adaptation Plan (PNACC) 2021-2030* in Spain prioritizes data-driven adaptation policy with tools for monitoring, including Climate Risk Reports, Sectoral Adaptation Reports, and Monitoring Reports to update on actions, challenges, and progress. The *AdapteCCa Platform* serves as a knowledge-sharing hub, aligning with the European Climate-Adapt platform.
In *Andalusia*, the *Portal Andaluz de Cambio Climático* provides open access to adaptation initiatives, while the *SICMA Platform*, an e-GIS-WEB tool, enables exploration of 80 climate-related variables for future planning. The Andalusian Office of Climate Change (OACC) also facilitates the processing of adaptation data derived from the Municipal plans against climate change (PMCC) templates to identify best practices.

Granada's *PPACCGr* emphasizes localized monitoring through a *Climate Change Adaptation Observatory* and *Monitoring Committees* across Territorial Management Units, with regular evaluations by the Provincial Council to track adaptation progress.

Bottlenecks

Integration of national, regional tools with localized initiatives in Granada, may lead to potential inefficiencies and data gaps. Smaller municipalities often struggle to utilize platforms due to limited technical capacity and awareness. Localized data specific to Granada's climate risks remains insufficient, hindering tailored adaptation planning, while the Climate Change Adaptation Observatory may face resource constraints in data collection and sharing. Monitoring and evaluation processes in Granada are complex and may lack consistency.

Possible ways forward

- Develop mechanisms for seamless integration of national, regional tools like SICMA with localized initiatives such as the Climate Change Adaptation Observatory. This could include shared platforms or collaborative frameworks.
- Provide training programmes for local stakeholders, including municipal staff, to effectively use relevant CC platforms. Ensure these tools are user-friendly and accessible to non-technical users.
- Allocate additional resources to the Climate Change Adaptation Observatory in Granada to enhance its capacity for collecting and sharing localized data. Foster collaboration with regional platforms to bridge any knowledge gaps.
- Use digital tools to facilitate efficient tracking and reporting of adaptation actions.
- Conduct sectoral studies focused on long-term climate risks and adaptation needs for key areas in Granada, such as agriculture, tourism, and urban development. Ensure these findings are integrated into broader regional strategies.
- Provide targeted technical and financial assistance to smaller municipalities in Granada to enhance their ability to contribute to data collection, sharing, and adaptation planning efforts.

4.7.3 Strategic capacity

The *PNACC 2021-2030* in Spain prioritizes building strategic capacity for climate adaptation by identifying emerging skill needs, involving key stakeholders, and assessing specific training requirements. It promotes diverse educational formats, including study visits, experiential learning, and workshops, to strengthen practical understanding of climate resilience across sectors. In Andalusia, the Ministry of Sustainability, Environment, and Blue Economy leads capacity-building initiatives, training regional technical staff in climate risk management and standardized assessment methodologies.

Bottlenecks

There is limited implementation targeted training programmes in Granada. restricts the ability of local technical staff and stakeholders to engage effectively in climate adaptation efforts. Public information about available training opportunities is minimal, further limiting access and participation.

Training initiatives are more concentrated at the regional level, with few tailored programs addressing the specific needs of smaller municipalities. Local administrations often face resource and expertise gaps, making it challenging to develop or sustain training efforts without external support.

Possible ways forward

- Create a database of relevant CCA good practices (i.e. heatwave etc) for the national, regional, local context
- Establish a technical assistance programme/dedicated fund offering training workshops and access to climate adaptation specialists to enhance local officials' expertise. Create a dedicated fund to support municipalities in obtaining the tools and training needed for effective local data collection and analysis.
- Design and implement training programs in Granada to build strategic capacity for climate adaptation. These programs should be tailored to address the specific climate risks and operational challenges faced by the local administration.
- Develop a centralized platform or regional communication strategy to disseminate detailed information about existing and upcoming training programs. This platform should include resources, schedules, and application processes to ensure accessibility.
- Facilitate collaboration between Andalucia's regional climate adaptation program and Granada's local authorities to ensure the standardized training process is extended and adapted to local needs.
- Expand training methodologies to include workshops, experiential learning, study visits, and simulations to enhance practical understanding and application of climate adaptation strategies at the local level.
- Provide financial and technical support specifically for smaller municipalities to ensure they can develop and sustain effective training initiatives. Dedicated funding from regional or national programs can address these gaps.
- Introduce a mechanism to assess the impact of training programs on local strategic capacity. Regular evaluations can help refine programs to ensure they meet the evolving needs of local stakeholders.

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List of abbreviations and definitions

AAPP	Public Administrations
AEI	State Investigation Agency
AEMET	State Agency for Meteorology
AGE	General State Administration
AI	Artificial Intelligence
BOJA	Official Journal of the Andalusian Government (Boletín Oficial de la Junta de Andalucía)
CACTI	Advisory Council for Science, Technology and Innovation
CCAA	Autonomous Communities
CCPCC	Climate Change Policy Coordination Commission
CDTI	Center for Technological and Industrial Development
CEH	Hydrographic Studies Center
CENEAM	National Center for Environmental Education
CIEMAT	Energy, Environmental and Technological Research Center
UNFCCC	United Nations Framework Convention on Climate Change
CNC	National Climate Council
CMIP6	Coupled Model Intercomparison Projects
COVID-19	Name given to the disease associated with the SARS-CoV-2 virus
CPCTI	Scientific, Technological and Innovation Policy Council
CPI	Public Purchase of Innovation
CRUE	Conference of Rectors of Spanish Universities
CSIC	Higher Council for Scientific Research
DANA	Depresión Aislada en Niveles Altos
DGA	General Directorate of Water
DGB	General Directorate for Biodiversity
DGC	General Directorate of Coasts
DGPI	General Directorate of Research Planning
ECCE	Assessment of climate change in Spain
EECTI	Spanish Science, Technology and Innovation Strategy
EMFF	European Maritime and Fisheries Fund
ERDF	European Regional Development Fund
ESEOO	Establishment of a Spanish Operational Oceanography System

FEMP	Spanish Federation of Municipalities and Provinces
ESF+	European Social Fund
FAMP	Andalusian Federation of Municipalities and Provinces
FECYT	Spanish Foundation for Science and Technology
GCOS	Global Climate Observing System
GDP	Gross Domestic Product
GEO	Earth Observation Group
GHG	Greenhouse gases
GICC	Interministerial Group on Climate Change
GOOS	Global Ocean Observing System
GTIA	Impacts and Adaptation Working Group
HE R&D&I	Framework Program. Horizon Europe.
INE	National Statistics Institute
INM	National Institute of Meteorology
IOC	Intergovernmental Oceanographic Commission
IPCC	Intergovernmental Group of Experts on Climate Change
IPSFL	Private non-profit institutions
ISCIII	Carlos III Health Institute
LCTI	Law 14/2011, of June 1, on Science, Technology and Innovation
MAEUEC	Ministry of Foreign Affairs, European Union and Cooperation
MAPA	Ministry of Agriculture, Fisheries and Food
MAP	Ministry of Agriculture, Fisheries and Food
MCIN	Ministry of Science and Innovation
MFF	Multiannual Financial Framework
MIMAM	Ministry of Environment
MINCOTUR	Ministry of Industry, Commerce and Tourism
MINCUL	Ministry of Culture
MINDEF	Ministry of Defense
MINECO	Ministry of Economy and Business
MINHA	Ministry of Finance
MINSAN	Ministry of Health
MITERD	Ministry for the Ecological Transition and the Demographic Challenge
MITMA	Ministry of Transport, Mobility and Urban Agenda
MUNI	Ministry of Universities

NMM	Mean Sea Level
OACC	Andalucian office of climate change *(Junta de Andalucia)*
OAPN	Autonomous Organization National Parks
OECC	Spanish Office of Climate Change
OECD	Organization for Economic Cooperation and Development
SDG	Sustainable Development Goals
PEICTI	State Plans for Scientific, Technical and Innovation Research
PIMA plans	Environmental promotion plans to support municipalities
PG	Expenditure Budget
PNACC	National Plan for Adaptation to Climate Change
PAAC	Andalusian Climate Action Plan
PGE	General State Budgets
PMCC	Municipal plans against climate change
PPACCGr	Plan ADAPTA GRANADA. Province Plan for Adaptation to Climate Change Granada
R+D+I	Research, development and innovation
RCM	Regional Climate Models
RIS3	Smart Specialization Strategy
S3	Smart Specialization Strategy
S4	Smart Specialization Strategy for Sustainability
SECTI	Spanish System of Science, Technology and Innovation
SMEs	small and medium enterprises
SRES	Special report on IPCC emissions scenarios
UN	United Nations
UNEP	United Nations Environment Program
WMO	World Meteorological Organization

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Annexes

Annex 1. Interviews

Interviews were conducted between September and November 2023, gathering consolidated opinions from staff members of the offices listed below. According to their expressed preferences, their names should remain confidential and their contribution should appear as indicated below:

- Andalusian Climate Change Office, Junta de Andalucia (led by Ms. Inmaculada Tola)
- DG for Environmental Sustainability and Climate Change, Junta de Andalucia (coordinated by Ms. María López Sanchís).

Annex 2. List of case studies

Case studies have been carried out to analyse to what extent and how enabling factors towards 'Transformative Climate Change Adaptation' strategies, as identified in the conceptual report (European Commission, 2024), are at play in reality, and what can be done to overcome barriers in various territorial contexts. The methodological framework described in the conceptual report essentially acts as a practical guide for undertaking cases studies on CCA strategies in different territories, in a uniform way. These case studies are listed below.

Table 2. Transformative innovation for better climate change adaptation – Case studies

Country	Territory	URL	DOI	JRC number
Belgium	Leuven	https://publications.jrc.ec.europa.eu/repository/handle/JRC137313	10.2760/58125	JRC137313
Finland	Espoo	https://publications.jrc.ec.europa.eu/repository/handle/JRC137316	10.2760/177322	JRC137316
Finland	Turku - Southwest Finland	https://publications.jrc.ec.europa.eu/repository/handle/JRC137315	10.2760/211155	JRC137315
France	Provence-Alpes-Côte d'Azur	https://publications.jrc.ec.europa.eu/repository/handle/JRC137314	10.2760/46893	JRC137314
Greece	Attica and North Aegean regions	https://publications.jrc.ec.europa.eu/repository/handle/JRC137322	10.2760/493562	JRC137322
Iceland		https://publications.jrc.ec.europa.eu/repository/handle/JRC137291	10.2760/305796	JRC137291
Italia	Emilia-Romagna	https://publications.jrc.ec.europa.eu/repository/handle/JRC137319	10.2760/790200	JRC137319
Netherlands	Northern Netherlands	https://publications.jrc.ec.europa.eu/repository/handle/JRC137312	10.2760/10862	JRC137312
Poland	Mazovia - Stare Babice	https://publications.jrc.ec.europa.eu/repository/handle/JRC137323	10.2760/58125	JRC137323
Portugal	Norte	https://publications.jrc.ec.europa.eu/repository/handle/JRC137321	10.2760/399394	JRC137321
Romania	Nord Vest - Cluj	https://publications.jrc.ec.europa.eu/repository/handle/JRC137317	10.2760/923916	JRC137317
Slovenia	Gorenjska	https://publications.jrc.ec.europa.eu/repository/handle/JRC137320	10.2760/502482	JRC137320
Spain	Andalucia - Granada	https://publications.jrc.ec.europa.eu/repository/handle/JRC137324	10.2760/104672	JRC137324.
Sweden	Blekinge and Värmland	https://publications.jrc.ec.europa.eu/repository/handle/JRC137318	10.2760/249067	JRC137318

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