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DESERTIFICATION IN SPAIN

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Introduction

This report is on the issue of Desertification in Spain. Over the past several decades it has become apparent that significant parts of Spain are at risk of desertification, which is the process by which arable and useful land become desert land. This poses a considerable risk to the Spanish people and economy. Desertification causes huge damage to agriculture, which is a vital part of the Spanish and wider European economy, with Spain sometimes being considered one of the 'Breadbaskets of Europe.' It is also associated with growing risk of forest fires, droughts and other natural catastrophes which could cause significant harm to the Spanish people.

The problem of desertification has several causes. The ongoing global process of rising temperatures has had a significant impact, a longer hotter summer and more extreme heat waves contributes to desertification. On the national level, agricultural practices are unsustainable, leading to degradation of soil quality, the destruction of vegetation and the overexploitation of water resources. Water has also been mismanaged, with many sources being contaminated whilst droughts and overexploitation pushes water resources to the brink of drying up. Finally the actions of stakeholders, including the European Union, federal government, autonomous communities, river basin agencies and private companies have all contributed by advocating damaging practices and failing to coordinate a proper response to these issues.

Considering the significant risk and multi-faceted nature of the problem we advocate for numerous changes to aid in the prevention of desertification. In regards to stakeholders we suggest that changes could be made to enable greater cooperation between them, such as reform to River Basin Agencies, and changes to the Common Agricultural Policy so that it no longer encourages damaging practices. In regards to agriculture we also advocate for the adoption of newer practices, which would both protect and renew soil, and prevent the process of desertification.

In short we seek to understand the causes and implications of this crisis, and recommend various policy changes that we believe would have a positive impact.

Energy & Environment briefing note

Overview

This section discusses how the geography of Spain is changing, more precisely how the country is at high risk of desertification.

Spain is increasingly being afflicted by rising temperatures. Temperature records are now consistently being broken and the average temperature is expected to continue to climb. Hot Spells are also becoming more common and more intense as the summer season lasts longer, whilst the winter is more moderate and shorter than in previous years

Spain's underground aquifers are coming under threat as a source of water. Heavy exploitation is beginning to deplete them heavily, an increase in temperatures leads to further depletion, meanwhile they are becoming increasingly contaminated. Furthermore, the inconsistent rainfall patterns and increased cases of drought have led populations to become more dependent on aquifers.

The risk of radical desertification across Spain presents a unique challenge to the Spanish government and the European Union that it is obliged to confront. However a series of stakeholders must be appeased to do so, and it remains unclear whether the Spanish government is willing to make the economic and political sacrifices necessary for change.

The quality of Spain's soil is under threat. Human actions, such as urban development and agriculture makes soil increasingly vulnerable to becoming desert and eroding away. Moreover, wildfires and development have destroyed huge amounts of vegetation, further increasing the risk of desertification.

Temperature:

Temperatures in Spain have increased, reaching unprecedented levels.

- In 2022, the highest temperature in Spain was registered in Montoro, Córdoba at 47.4 degrees, being the hottest summer in the last 700 years.[1] In 2017, the same location registered the maximum temperature at 46.9 degrees.[2]
- The average temperature of Spain has increased by 1.3 degrees in 70 years. Additionally, according to the Mediterranean Experts on Climate and Environmental Change (MedECC), the temperature in Spain could increase by 2.2 degrees in 2040 and 3.8 degrees in 2100.[3]
- The temperatures of marine waters surrounding Spain in 2020 were 0.5 degrees higher than normal.[4] Additionally, in 2023 the sea temperature in the Balearic Islands exceeded 28 degrees, which is between 3-4 degrees higher than average.[5]

The periods of extreme heat in the country are now longer and more intense.

- Spain suffered from three heatwaves and registered 41 days of heatwave in 2022 (the highest number since 1975).[6] Two of the three heatwaves lasted more than 15 days. One of the heatwaves had an impact in 44 out of 50 provinces.[7]
- In 2023, Spain suffered from 88 tropical nights (term used to refer to those nights in which the minimum temperature is not lower than 20 degrees) out of the 92 days of summer.[8]
- According to the State Meteorological Agency (AEMET), summers will be nine days longer on average per decade. This trend is already visible, the current summer season in Spain is five weeks longer than what it was in the 80s.[9]

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[1] Notivoli et al., 2023, Unprecedented warmth: A look at Spain´s exceptional summer of 2022.
[2] Albert, M., 2022, *¿Cuál es el récord de temperatura Máxima Alcanzado en España?*
[3] MedECC, 2020, Climate and Environmental Change in the Mediterranean Basin – Current Situation and Risks for the Future. First Mediterranean Assessment Report
[4] AEMET, 2020, Informe sobre el estado del clima de España 2020.
[5] RTVE, 2023, La temperatura del mar en España registra valores máximos sin precedentes en 83 años.
[6] Data, N., 2022, Esta década ya es la segunda con más días de ola de calor (y apenas van tres años). Newtral
[7] Ibid.
[8] Belver, J., 2023, Las noches tórridas de mas de 25ºC se multiplican por cinco
[9] Hodgson, C., 2023, AEMET warns of a sultry summer ahead in Spain

The cold season is becoming warmer every year.

- Spain's average temperature in 2020 was 14.7 degrees, even when including the colder months.[10]
- On the 29th of January 2021, thermometers in Alicante, a province in the southeast of Spain, measured at almost 30 degrees becoming the highest temperature ever recorded in January.[11]
- Places that snow are at risk of lack of snow during the winter. A study focusing on the Aneto, a glacier in the Pyrenees, illustrates this concern by pointing out that in the last 41 years, "the total glacierized area has decreased by 64.7%, and the ice thickness has decreased, on average, by 30.5 m".[12]

[10] AEMET, 2020, Resumen Anual Climatológico 2020
[11] Benayas., V, 2021, Is this winter's crazy weather in Spain a taste of things to come?
[12] Vidaller et al., 2023, The Aneto glacier's (Central Pyrenees) evolution from 1981 to 2022: ice loss observed from historic aerial image photogrammetry and remote sensing techniques

Water Exploitation & Scarcity:

Groundwater bodies are becoming polluted as a result of human activities.

- Increased content of chlorine (>14%) in some aquifers due to the dumping of 70 million tonnes of salt waste from potash extraction.[13]
- 84.2% of tested aquifers in rural areas of Catalonia showed a positive presence of pesticides, of which 23.7% exceed the EU drinking water directive requirement.[14]
- In 2013, 41% of the observed Spanish groundwater bodies were in bad status due to pollution and excessive levels of extraction, 4% of the groundwater bodies had not been studied.[15]
- Samples taken in important biodiversity areas detected pharmaceuticals in 84% of samples and lifestyle compounds in 76% of samples between 0.5 to 41,083 ng/L concentrations.[16]

Increase in groundwater extraction has increased depletion.

- In the Jucar Basin of Spain, groundwater extraction rose from 310 to 730 km^3 per year, pushing depletion up to 150 km^3 increasing water scarcity.[17]
- Spain is projected to face decreasing water availability due to increased temperatures; 2 degrees would lead to a loss of 3272 Mm^3/year. This is equivalent to 15% of the reported annual amount of water used for irrigation hence forcing responsibility on groundwater extraction to fulfil these needs.[18]
- Groundwater use in Spain increased by 4500 Mm^3/year from 1960 (2000 Mm^3/year) to 2000 (6500 Mm^3/year).[19]
- Reservoirs in Catalonia have shrunk to 27% of their capacity, while in the Guadalquivir river basin, reservoirs have shrunk to 26% of its capacity in southern Andalusia. This has led to restrictions of permissible water consumption in Catalonia.[20]

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[13] Stefano et al., 2014, Groundwater use in Spain: An overview in light of the EU Water Framework directive
[14] Ibid.
[15] Stefano, L.D. and Llamas, R., 2017, Water, agriculture and the environment in Spain: Can we square the circle?
[16] Dulsat-Masvidal et al., 2023, Water pollution threats in important bird and biodiversity areas from Spain
[17] Kahil et al., 2016, Improving the Performance of Water Policies: Evidence from Drought in Spain
[18] Bisselink et al., 2018, Impact of a changing climate, land use and water usage on Europe's water resources
[19] Molinero et al., 2011, Groundwater in Spain: Legal framework and management issues
[20] Euronews, 2023, Barcelona is heading for a 'drought emergency' as water shortage worsens

Drought suffering.

- Inconsistent rainfall patterns in Catalonia have been recorded since the 1920s and have led to episodes of severe droughts in 1973, 1985 and 1988, leading to supply restrictions that are still seen today.
- More recently, Catalonia was affected by a drought episode from 2004-2008 with different severity stages. During 2007-2008 Barcelona faced the most severe drought of the last century, before an extreme rainfall ended this episode. [21]
- In 2023, Cordoba received 30% of the expected rainfall, compared to the rainfall records from 1981 to 2010. This caused a decrease in the health of vegetation in Cordoba as well as parts of Andalusia, affecting olive tree vegetation.[22]
- Since the 1950s, different regions across Spain have experienced increased droughts, as well as increased extreme rainfall events. As a result of climate change, average rainfall is predicted to decrease between 5% to 15% from 2040 to 2100.[23]

[21] Martin-Ortega, J. and Markandya, A., 2009, The costs of drought: the exceptional 2007-2008 case of Barcelona
[22] Cassidy, E., 2023, Spain Browned by Drought
[23] Martin-Ortega, J. and Markandya, A., 2009, The costs of drought: the exceptional 2007-2008 case of Barcelona

Stakeholder Action:

Stakeholder roles.

- Any government policy in this area is difficult because the creation of more sustainable agriculture, land usage and water usage policy, would require a slowdown in economic growth in agriculture which stakeholders in the government and industry do not desire.[24] This has been referred to as 'Mediterranean syndrome.'[25]
- The decentralisation of agricultural policy to regional agricultural ministries since the passage of the 1978 constitution has led to poor coordination between the regions, central government and the European level.[26]
- Meanwhile farmers and private enterprises continue to engage in unsustainable practices like the expansion of irrigation, as EU subsidies and government failings means that this remains their best economic interest.[27]

Governmental role in ending desertification.

- After the 1977 UN conference on desertification, Mediterranean countries, including Spain, launched an ongoing project to combat desertification. This project has encouraged and funded more research and studies focusing on potential methods to mitigate the impact of desertification.[28]
- One of the national strategies tackling desertification consists of improving the tools to analyse the risk of desertification. More precisely, strengthening the integrated surveillance system for the evaluation and monitoring of desertification. The same strategy also includes the creation of a national inventory of soils.[29]
- The government is expected to give economic aid to the industries affected by desertification. Between 2023 and 2027, it will give 211.5 million euros in coupled payments to affected industries such as oil, raisin, and dried fruits. It will also give over 310 million euros to the fruit, vegetables and wine sector. [30]

[24] Valderrama et al., 2022, Desertification in Spain: A Sound Diagnosis without Solutions and New Scenarios
[25] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[26] Ibid.
[27] Ibid.
[28] Ministerio para la Transición Ecológica y el Reto Demográfico, n.d., Proyecto LUCDEME
[29] Ministerio para la Transición Ecológica y el Reto Demográfico, 2022, Estrategia Nacional de Lucha contra la Desertificación.
[30] Ibid.

- The Spanish government also unveiled the National Strategy for the Battle against Desertification (ENLD) as an updated strategy.[31]

International policy.

- Since Joining the European Economic Community (later the European Union), parts of Southern Spain have transformed into the 'breadbaskets' of Europe but this has come at the cost of unsustainable farming practices.[32]
- Spain as a member of the European Union contributes to the Common Agricultural policy and this does offer a degree of support available in times of crisis such as droughts.[33] However the Common Agricultural Policy has also been accused of encouraging the overgrazing of livestock[34] and other bad agricultural practices.[35]
- The United Nations Convention to Combat Desertification was adopted in 1994. Spain was one of the first to sign, on the 14 of October of 1994, and has had accession since 1996.[36]

[31] DeAndreis, P., 2022, Spain launches a new strategy against desertification
[32] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[33] Bolongaro, K., 2019, Farmer vs. sand: Spain's fight against desertification
[34] Valderrama et al., 2022, Desertification in Spain: A Sound Diagnosis without Solutions and New Scenarios
[35] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[36] United Nations, 1994, United Nations Convention to Combat Desertification in those Countries Experiencing Serious Drought and/or Desertification, Particularly in Africa

Soil Quality Degradation:

The quality of soil is increasingly degrading due to human actions.

- Spain is one of the countries with the highest soil degradation rates with 12.5% of Spanish territory being impacted by loss of vegetation.
- Between 2000 and 2006, Spain's productive soil loss due to soil sealing increased by 15%. 'Soil sealing' is an irreversible process used to describe the soil losing its productive capability due to being covered by artificial materials.[37]
- According to the European Soil Data Center (ESDAC), soil salinity affects an estimated 3% of 3.5 million hectares of irrigated land in Spain.[38]

Spanish soil is increasingly at risk of erosion.

- Soil erosion has increased from 1 to 3% in Spain between 2010 and 2016. [39] According to data from the National Inventory of Soil Erosion (INES), the average annual soil loss in Spain is around 14.2 tons per hectare per year. [40] (>10 tonnes per hectare per year is severe). [41]
- The most affected communities by soil erosion are Cantabria, Andalusia and Catalonia.[42] This is worrying as, for instance, Andalusia is an autonomous community with more land used for agricultural purposes. The Andalusian agricultural gross value added represented 7.2% of Andalusia's GDP in 2020.[43]
- The Data from the Ministerio para la Transición Ecológica y el Reto Demográfico (Ministry for Ecological Transition and Demographic challenge) revealed that 50% of agricultural land in Spain is at high-medium risk of erosion.[44]

The amount of vegetation is declining.

- Between 2001 and 2022, 377 kha of tree cover were lost due to fires and another 1.18 mha due to other factors.[45]

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[37] European Commission, 2012, The State of Soil in Europe
[38] European Commission, 2008, Saline and Sodic Soil in European Union.
[39] Panagos et al., 2020, A soil erosion indicator for supporting agricultural, environmental and climate policies in the European Union
[40] Rodríguez-Berbel et al., 2022, Impact on Agriculture on Soil Degradation II
[41] Eurostat, 2020, Agri-environmental indicator - soil erosion
[42] Ibid.
[43] Junta de Andalucía, 2021, El sector agrario y pesquero
[44] Europa Press, 2021, La erosión del suelo provocará una reducción del 10% de la producción de alimentos en 2050
[45] Global Forest Watch, n.d., Spain Deforestation Rates & Statistics

- Different biomes in Spain showed different trends from 1996 to 2006, where biomes that had smaller water requirements (shrubs and pastures) saw a decrease in area, while forest areas increased (biomes which required more water).
- Forest figures increased by approximately 1.5 Mha, leading to a rise in precipitation annually consumed by Spanish forests, from 35% to 39% in 2006.[46]
- Spanish soil is generally considered to have a low content of organic matter; this is associated with a lower ability to support vegetation and a higher chance of desertification.[47]

[46] Stefano, L.D. and Llamas, R., 2017, Water, agriculture and the environment in Spain: Can we square the circle?
[47] Bolongaro, K., 2019, Farmer vs. sand: Spain's fight against desertification

Insights

Overview

Having exposed how the impact of desertification is visible in Spain, the following section expands on it and explains three key causes that have contributed to the situation. While some causes have been natural, for example, climate change, others have been the result of human action, in particular the agricultural sector and the inadequate response of stakeholders.

The first theme addressed is the excessive use of groundwater for irrigation purposes. The agriculture industry is a large contributor to the Spanish economy hence why the economic profitability is often prioritised over the environmental implications. As discussed in the briefing, building on from worsening weather conditions, the second theme will explore the role of climate change in heightening the risk of desertification. Finally, we will discuss how stakeholder response, in particular government agencies and policy makers, have not taken the appropriate steps and precautions to limit the vulnerability to desertification.

Agriculture and the excessive use of groundwater.

Spain's agricultural sector has been for the past few decades linked to irrigated crop production. Given the natural heat and light conditions of the country, this type of crop production was introduced as a tool to provide Spain with a comparative advantage over other European countries, and nowadays, it is fundamental for the country's economy. In 2021, 65% of the final plant production was obtained from irrigation, which makes Spain the EU country with the most land used for irrigation agriculture.[48] The country is the biggest exporter of fruit and vegetables in the EU, and is well-known as "the vegetable garden of Europe."[49]

Firstly, irrigated land on average is more profitable than non-irrigated land. An irrigated hectare of land produces six times more than a non-irrigated land.[50] Moreover, in terms of income, the former generates four times more income.[51] Secondly, irrigated land is more beneficial in terms of employment, as it requires more workers.[52] Consequently, this type of crop has been used as a tool to tackle depopulation in rural areas. It follows that the existence of water for irrigation purposes increases the attractiveness and likelihood of development in the area.

The use of groundwater strategic reserves located in areas where rainfall is scarce has allowed the development of irrigation agriculture across Spain. Nevertheless, the large quantities of water this type of agriculture needs is becoming a growing problem in the context where droughts are becoming more common. According to WFF, in Spain 80% of water resources are used for the agricultural sector, especially for irrigating crops.[53] The latter are estimated to consume 100 times more water in a year than the 3 millions citizens living in the capital.[54] Consequently, while irrigated crops contribute to the economy, they also represent a threat to water supply.

In the last couple of years, given the lack of rainfall, illegal extractions of water have increased for agricultural purposes. For instance, it has been claimed that 4,700 ha of water were illegally extracted from Doñana, the largest wetland in Europe. This quantity is the equivalent of more than 5,700 football fields.[55] Another example is the consumption of illegally extracted water from the Tablas de Daimiel National Park in

[48] Ministerio de Agricultura, Pesca y Alimentación, 2021, Encuesta Sobre Superficies y Rendimientos de Cultivos en España
[49] Garriga, J.M., 2022, The use of water in agriculture: making progress in modernising irrigation and efficient water management
[50] Ministerio de Agricultura, Pesca y Alimentación, 2008, Plan Nacional de Regadíos Horizonte 2008
[51] Ibid.
[52] Ibid.
[53] WWF, n.d., Agua: Sequía
[54] Ibid.
[55] Martínez, et al., 2021, El robo del agua

the autonomous community of Castilla-La Mancha. This wetland, although protected, has been used to irrigate 51,465 ha of crops.[56]

Acknowledging the situation, in 2021, the Court of Justice of the European Union denounced that "Spain did not take into account the illegal water extractions (...) and did not provide any preventative measures regarding alterations of protected ecosystems".[57] The Court of Justice also expressed their discontent on Spain's lack of effort to deal with the overexploitation of water for agricultural purposes in the province of Huelva.[58] It is worth-mentioning that Huelva is amongst the biggest European producers of red fruits, and the province concentrates around 98% of national production.[59]

From a legal perspective, an administrative concession is necessary in order to be able to extract groundwater. However, in the cases mentioned before and in other similar situations, water is being used without authorization and full immunity.[60] This is because the administration either lacks the capacity to surveille extractions, or the willingness to prioritise environmental concerns over economic and social profitability.

In some cases it has been the own administration who has contributed to the situation by granting more farmers the rights, or by allowing them to extract more water than recommended.[61] As suggested previously, irrigating agriculture is economically and socially important for Spain. As a result, the public administration has for decades encouraged irrigated crops without taking into account the fact that water is limited.

[56] Ibid.
[57] CURIA, 2021, España debería haber tenido en cuenta las extracciones de agua ilegales y las destinadas al abastecimiento urbano en la estimación de las extracciones de agua subterránea de la comarca de Doñana
[58] Abril, G., 2021, La justicia europea condena a España por no tener en cuenta las extracciones ilegales de agua subterránea en Doñana
[59] Interfresa, 2023, La Provincia de Huelva Produce el 98% de los berries de España y Cerca del 30% de la Unión Europea
[60] Martínez, et al., 2021, El robo del agua
[61] Ibid.

Climate Change.

Although human actions contribute to the aggravation of Spain's desertification, the effect and role of climate change cannot be denied. As mentioned in the briefing, there is clear evidence that Spain's weather is changing from the increasing frequency of high temperatures and decreasing rates of rainfall.

The Centre for Studies and Public Works Experimentation (CEDEX in Spanish) conducted Hydrographic Studies which showed that droughts will become more frequent in Spain and that rainfall will decrease between 2 and 4% between now and 2040.[62] Furthermore, there is a clear link between low water resources, frequent droughts, and the impacts produced by climate change. This makes Spain an area with higher vulnerability to increased water stress, runoff, and temperature increase.[63] All of these factors have led to a much higher risk of desertification in semi-arid areas.

Turbulent weather conditions have led to the thinning of topsoil, which puts Spain's soil at risk of erosion, with three quarters of it already facing desertification.[64] This high risk of desertification in Spain, is further shown by the measured desertification sensitivity, which the European court of auditors registered to be at an index of 1.4-1.6 in the centre of Spain, whereas neighbouring countries such as France had an index of up to 1.3.[65] These trends correlate with high temperature changes throughout seasons, as well as low seasonal precipitation. Both of these measured influences are directly correlated to climate change's impacts on the environment. These bio-physical changes are recognized by the World Atlas of Desertification (WAD) as some of the 14 global change issues used to identify ongoing desertification.[66] Along with a surveillance system for assessing and monitoring desertification (SURMODES), Spain has faced worsening conditions of a desertification situation detected 20+ years ago and has shown this to be in part due to global warming.[67]

Climate change and the increase of temperatures has also led to a loss of vegetation and biodiversity. The fluctuating conditions may not be suitable for the current vegetation to grow, and therefore leading to a reduction in productivity, often even cases of death. This decline leads to an increase of erosion as the soil loses structure and support that vegetation provides. Erosion is principally controlled by vegetation

[62] Madrid, J., 2017, Evaluación del impacto del Cambio Climático en los Recursos Hídricos y Sequías en España
[63] Estrela et al., 2012, Impacts of climate change on water resources in Spain
[64] Bolongaro, K., 2019, Farmer vs. sand: Spain's fight against desertification
[65] Cerdà, A., 1997, Soil erosion after land abandonment in a semiarid environment of southeastern Spain
[66] Martínez-Valderrama et al., 2022, Desertification in Spain: A sound diagnosis without solutions and new scenarios
[67] Ibid.

as it protects and covers the soil surface, increases fertility through an exchange of minerals and improves water-retention capacity by providing porosity and texture to the soil.[68]

Loss of vegetation has had a higher impact on abandoned land, which has been a result of migration from rural to urban areas. The bare soil combined with the high temperature and inconsistent precipitation patterns makes it timely for vegetation to recover, especially in drought periods, which as the briefing points out have been occurring more often. Abandoned territories showed runoff to occur sooner than soil with growing vegetation, even if this had only recently been introduced to the area. It took even longer for runoff to occur in cases where vegetation was more complex and had been there longer. Stone cover also offered a protection, which enhanced infiltration from irrigation and rapid runoff.[69] Although land abandonment leads to ecosystem degradation, this is shown to only be the case for the first years, when vegetation is recovering. In the past 10 years, it has been shown that soil quality increased if it had not been impacted by desertification.

Overall, climate change has taken a toll on Spain's soil vulnerability to desertification. Along with the increase of temperature and decrease of precipitation being inadequate conditions for healthy soil, these have also impacted vegetation in the southeast areas of Spain. This loss of vegetation caused by climate change and exacerbated by an increase of rural to urban migration, has been the reason for rapid runoff as well as soil erosion.

[68] Cerdà, A., 1997, Soil erosion after land abandonment in a semiarid environment of southeastern Spain
[69] Cerdà, A., 1997, Soil erosion after land abandonment in a semiarid environment of southeastern Spain

Inadequate stakeholder response.

The process of desertification in Spain is not only a result of natural processes. It is also a result of the actions of farmers and other organisations, the difficulty for stakeholders to coordinate the management of resources and the issues with promoting a version of agriculture that is more environmentally sustainable. The origins of these issues go back decades, but remain an ongoing challenge.

Much of this originates in policies from the Franco Era (1939-1975). The Franco dictatorship promoted development plans, under these the South-East of Spain was given a privileged position in agriculture that allowed a massive expansion of irrigation. However, the government failed to control this expansion, in the 1970s for instance people ploughed more than their allowance of water allowed, leading to the exploitation of aquifers.[70]

This was aggravated later with the devolution of responsibilities to various organisations. The 1978 Spanish constitution devolved significant powers to regional governments (autonomous communities), this included agricultural policy, and limited the national government to simply liaison between the regional and European levels on agriculture.[71]

A further example of the devolution of responsibilities is on the management of water. Since the 1985 Water Act, Spain has treated groundwater (such as rivers, lakes etc.) as a 'public resource.' These groundwater sources under the act became the responsibility of 'River Basin Agencies'. Water management has since proved a challenge in Spain, in part because of this organisational set-up. For one, the river basin agencies struggle to perform their existing objectives such as monitoring water management because of a lack of human and financial resources. Furthermore, the European Water Framework Directive (WFD) in 2000 placed greater strain on them, asking that the agencies perform more complex objectives in maintaining water quality (possibly stopping certain developments that place groundwater sources at risk), rather than bog-standard water management.[72] Additionally the WFD is arguably more focused on the problems of North European water management (water quality), than issues in Southern Europe (water scarcity).[73]

River basin agencies have been further placed under strain by political disputes. Their internal structures have been altered, adding 'public authorities committees.' These

[70] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[71] Ibid.
[72] Molinero et al., 2011, Groundwater in Spain: Legal framework and management issues
[73] Albiac et al., 2012, River basin governance and water policies in Spain

are only consultative bodies, however they have allowed for the autonomous communities to unduly influence water policy and attempt to exert greater control over water resources in their territory, which has in turn led to more inefficient water policy.[74] In fact political disputes on water management between the autonomous communities is not unheard of - following the 2001 Hydrological Plan, the 'Ebro transfer' was proposed which caused a dispute between Valencia and Murcia (receiving states) and Catalonia and Aragon (donating states).[75]

Additionally, entry to the European Economic Community (EEC, later the European Unions) meant entry into the Common Agricultural Policy (CAP). This meant that the national government had little power over agriculture, and the national agricultural ministry was confined to simply liaising in between the regional and European level.[76] Spain's entry to the EEC, in 1986, and the 'European Single Market' in 1992 had negative consequences. The entry into this huge European market meant that demand for certain crops increased, these crops more often than not required irrigation, unlike dryland crops such as cereals hence increasing water usage even further.[77]

As part of the EEC Spain also joined the Common Agricultural Policy. The CAP is a complex and enormous European wide policy, but in essence it gives aid to farmers, traditionally this was based on the amount that they produced, though more recently it has been changed to be essentially income support for farmers.[78] However, this policy has historically had several negative environmental impacts: the aid given increased farm productivity leading to greater irrigation and more water strain, additionally it incentivised farming in higher elevation and drier areas, furthering the problem of soil erosion.[79]

Government actions to respond to desertification have been plagued by the issue of monitoring desertification. The National Action Program for Desertification (PAND-2008) project sought to accurately map this process out. However, it fell short of this in part of the methodology used, which involved the mapping of biophysical indicators, but did not include socio-economic indicators, such as increased agriculture which can allow for better long-term indications of where it is at risk of desertification.[80]

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[74] Ibid.
[75] Ibid.
[76] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[77] Ibid.
[78] European Commission, n.d. , The common agricultural policy at a glance
[79] Oñate, J.J. & Peco, B., 2005, Policy impact on desertification: stakeholders' perceptions in southeast Spain
[80] Martínez-Valderrama et al., 2022, Desertification in Spain: A sound diagnosis without solutions and new scenarios

Overall, the existing and historical institutional set-up of Spain limited the actions that stakeholders could take to respond to desertification. The decentralisation of water management and agricultural policy to regional governments, and the influence of the EU on agricultural policy, created an environment where policies that harmed the environment were passed. Furthermore, this decentralisation limited the ability of stakeholders to properly respond, thus playing an important part in desertification.

Conclusion:

- The agriculture sector is one of the biggest contributors of desertification in Spain as 80% of water resources are used for agricultural purposes. The large production coupled with overexploitation from illegal extraction and lack of rainfall are critical factors that pose the biggest threat to water supply.
- Spain's prevailing risk of desertification further intensifies through the effects of climate change on precipitation trends, temperature increases and vegetation loss. Migration movements from rural to urban land has increased the soil's vulnerability to climate change's impacts.
- The process of desertification has been exacerbated by the long running issues of stakeholders management of agriculture, water and land. The highly decentralised system has inhibited stakeholders, such as the regional and national governments, the European Union and other agencies, ability to properly respond.

Policy Recommendations

Overview

Considering that desertification is a process that cannot be easily reversed, this final section provides three policy recommendations aiming at mitigating and slowing down the impact of desertification.

Action 1: Use conditioners such as polyacrylamide and gypsum in the soil when employing furrow irrigation systems.

Action 2: Set up educational workshops and accessible mentoring programs on soil regenerative agricultural practices.

Action 3: Reform of the Common Agricultural Policy & River Basin Agencies.

Action 1: Use conditioners such as polyacrylamide and gypsum in the soil when employing furrow irrigation systems.

Furrow irrigation system is one of the oldest methods for irrigation practices. It is mainly used to grow cereals such as rice or corn, horticultural crops. Before the existence of water pumps, all irrigation crops used furrow irrigation. Nowadays, this practice is still used thanks to their low-cost, easy implementation and their little or no energy needs.[81] Nevertheless, the Spanish government is making significant efforts to replace this irrigation system with more modern techniques that allow better water management. This is owing to the fact that the furrow irrigation system is the irrigation system that uses the most water.[82] The reason behind is its low efficiency compared to other irrigation systems. For example, while dry and localised irrigation have an efficiency of around 95%, that of furrow irrigation is around 50%.[83] This translates into a greater amount of water needed. As a result, in Spain, in the last ten years this system has decreased by 16.2%, thus, it is only used for 22.3% of the total irrigation land.[84]

However, given certain geographical conditions or the type of crop, using more efficient irrigation systems might not be available. While the implementation of localised systems would significantly help alleviate water stress, it can only be applied in flat and uniform terrain.[85]

Consequently, on terrain where other irrigation methods cannot be used - mainly terrain with steep slopes or topographic irregularities, the use of conditioners, including polyacrylamide and gypsum is suggested. Their use is not new in agriculture, in the past it was mainly used to improve soil physical and chemical properties. For instance, they can reduce the toxicity of heavy metals, reduce soil acidity, and stimulate microbial activity, which entails greater availability of nutrients.[86] Nonetheless, this report suggests that conditioners can also be employed as a way to make furrow irrigation more efficient at water management.

This recommendation follows the results by Carlos Chávez, Carlos Fuentes and Eusebio Ventura Ramos.[87] In their study they showed that water efficiency might be reduced due to surface sealing. The latter would be when the soil surface disintegrates and then entrained by water creating a low permeability layer, which

[81] Ministerio de Agricultura, Pesca y Alimentación, n.d., Riego por Gravedad
[82] Calvo, P.A., 2021, Cultivos de regadío en España: todo lo que necesitas saber
[83] Martorell, S.D., 2022, Tipos de riego. ¿Cuál es más eficiente?
[84] Goixart, I.S., 2022, Los datos del regadío en España (2021)
[85] Ibid.
[86] Bhattacharjee et al., 2020, Gypsum in Agriculture: A Brief Discussion
[87] Chávez et al., 2010, Uso Eficiente del Agua de Riego por Gravedad Utilizando Yeso y Poliacrilamida

obstructs the passage of water. In this case, the properties of 'polyacrylamide' would improve soil stabilisation and the use of 'gypsum' would increase the permeability of the soil by substituting Na+ for Ca2+.

The final remarks conclude that not only do the use of conditioners imply a better water efficiency, but also that the plants grow faster and accumulate more grains when using polyacrylamide and gypsum than when not. It is worth mentioning that the study focused only on oats, and therefore, that the results might be slightly different when growing other crops. It is further suggested that the Spanish government should conduct further studies to determine the impact and quantity of conditioners on each crop.

Moreover, the type of soil used in the study was clay soil, but it is argued that other types of soil such as semi-arid or arid can also benefit from conditioner application that leads to higher infiltration.[88] This is significantly relevant considering that 74% of the Spanish territory is at risk of desertification. Within that 74%, 55.9% of the territory is semi-arid and 0.5% is arid.[89]

It follows that if the land of Spain is becoming increasingly arid, then the government should invest in irrigation practices that can be used on this type of land. Given that modern and efficient agricultural techniques such as dry or localised irrigation are not always available, improving traditional techniques such as furrow irrigation might be another solution to reduce water stress levels.

[88] Graber et al., 2006, Soil Stabilization in Semiarid and Arid Land Agriculture
[89] Sanjuán et al., 2013, Mapa de la Condición de la Tierra en España: 2000-2010

Action 2: Set up educational workshops and accessible mentoring programs on soil regenerative agricultural practices.

The high levels of soil erosion that emerge from vegetation loss, overgrazing and migration to urban areas lead to further soil vulnerability which is then heightened by changes in temperature and precipitation. As a means of mitigating these instances, and preventing the increased chance of soil erosion, farmers and those living in rural areas can take part in sustainable agricultural practices. Between these would be 'crop rotation', 'sheep grazing' and 'planting crop covers', actions which have been put in practice throughout history and shown to be effective, but have more recently been lost or replaced by technology intensive practices.

Crop rotation involves the alternation between the crops grown in a patch of soil. This is to prevent the excessive intake of singular nutrients, rather than distributing seasons in which crops with different nutrient requirements are planted on the same soil. This would involve the comprehension of the appropriate crops that can coexist in such an area as well as which nutrients they require. Beyond the prevention of loss of soil quality, and therefore increased vulnerability to erosion, this technique also permits farmers to no longer need additional fertilisers, as the soil provides necessary qualities for the altering crops being grown there. The use of legumes to act as nitrogen fixators has shown to replace the need for additional fertilisers, demonstrating how the use of crop rotation is beneficial to the quality of the soil and undoing the impacts that monoculture may have on the soil. A further example of crop rotation, considering Spain's biome and growing conditions, would be the rotation from potatoes to wheat to Galician wheat in three years. Overall, the practice of altering what was farmed has shown to have higher yields, lower environmental impacts (such as a decrease in the application of fertilisers) and of course a decrease in soil erosion.[90]

Along with crop rotation, use of cover crops is necessary to ensure decrease in soil erosion and reduce vulnerability of the top soil. Crops such as barley or vetch are planted along the land and as the name indicates, cover the soil from direct exposure. This not only reduces runoff and soil erosion, but has also been shown to increase soil health and quality.[91] Although most forms of cover crops are beneficial to decrease soil's vulnerability to desertification, different vegetation results in different qualities added into the soil. For instance, although vetch covers crops faster and showed higher improvement to the soil nitrate, it also provided less protection than

[90] Câmara-Salim et al., 2021, Environmental consequences of wheat-based crop rotation in potato farming systems in galicia, Spain

[91] Repullo et al., 2021, Cover Crop Contributions to Improve the Soil Nitrogen and Carbon Sequestration in Almond Orchards (SW Spain)

barley during the decomposition period.[92] Due to these differences it would be recommendable to educate farmers on the different roads they could take, and which ones are more suitable to the type of crops they already plant and therefore what qualities of their soil they should improve. Grapes and traditional vineyard management in Spain has shown to have substantial water erosion and exposed calcium carbonate-rich subsoil layers - due to the use of surface tillage- which degrades the soil surface. In this case inter-row crop covers would permit the continued traditional management, controlling the vigour of the vines and reducing erosion and runoff.[93]

Agroforestry and grazing are additional tools that farmers can implement for vegetation management. The combination of crops and livestock within a farming system, known as agroforestry, is a sustainable, natural approach to land management.[94] The relationship built between livestock and crops becomes a circular exchange, where waste from one is taken up by the other. Dead or dying crops are consumed by the sheep or cattle, which is a form of vegetation cutting that replaces use of prescribed fire to get rid of this waste. In 2019, soil samples were taken before extensive grazing took place and after as well as comparing it with mechanical clearing techniques and the use of both. The study found that extensive grazing increased soil's organic matter, showing better results than in the treatment with mechanical clearing. This is due to animal manure, whereas mechanical clearing's increase in organic matter was due to the vegetal components' humification incorporated into the surface layer.[95] Therefore, the use of agroforestry and vegetation control increases the quality of the soil and reduces its vulnerability to desertification, and this is shown to be a far more successful practice than the technology intensive alternatives.

The implementation of these agricultural practices would be mitigation approaches that should take place prior to desertification impacting an area. Therefore, organisations and communities, such as local farmer communities which already carry out these practices as well as specialised NGOs, should take the responsibility of educating farmers and land plot owners on the necessary conditions of soil to improve its quality, such as no water depletion, runoff, erosion or salinisation, as well as informing them of how to apply the techniques mentioned above. This can be done through bimonthly workshops which carry out the practices, permitting them to gain an understanding of how this would be done, as well as accessible mentoring plans

[92] Ibid.
[93] Ruiz-Colmenero et al., 2012, Vegetation cover reduces erosion and enhances soil organic carbon in a vineyard in the central Spain
[94] Woodland Trust, n.d., Agroforestry benefits nature, climate and farming
[95] Fonseca et al., 2023, Impacts of Extensive Sheep Grazing on Soil Physical and Chemical Quality in Open Mountain Forests, NE Portugal

which would relay debriefings of which crops are suitable and accessible to the community.

Action 3: Reform of the Common Agricultural Policy & River Basin Agencies.

As outlined in the insight, there are various issues in relation to how stakeholders are responding to the crisis of desertification. Namely, that the decentralised nature of Spanish agricultural and water policy has caused issues. Therefore we propose that greater coordination be encouraged in between stakeholders, to help respond to this issue.

In some areas progress can already be observed. As mentioned in the insight, River basin authorities/agencies (those in charge of water management in certain hydrographic regions) have struggled, being unable to meet the expectations placed upon them. In recent years the Spanish government's water policy has responded to this issue. There is a growing emphasis on drought risk management, which has led to plans to increase supply (such as by reusing water, and adding desalination plants), as well as storing more water and transferring it to areas of need.[96]

Despite these efforts the issues outlined previously have remained. River Basin Authorities are under-resourced and struggling with undue political influence. We recommend that the Federal government maintains its control of certain basins (those which cross state boundaries and so are under federal control) and does not cede these to autonomous communities. Water management should not become an object for internal political dispute between regions and the federal government and instead should remain depoliticised. This is difficult to achieve and would require that the various governments involved act cooperatively. One step could be reducing the influence of the public authority committees which have acted as a 'Trojan horse' for political influence in River Basin Authorities.

In regards to European level issues our recommendations come down to the Common Agricultural Policy (CAP). Entry into the Single Market and CAP, as mentioned in the insight, did likely encourage environmentally damaging agricultural practices. Nonetheless it has also brought significant prosperity to Spain, and should be accepted as a political reality.

Proposing reform to the CAP is difficult, both due to its complexity and politically contentious nature. However, as has been noted in various sections, there are numerous agricultural practices, such as the high elevation farming, or over-irrigation which were encouraged by the CAP and contribute towards desertification. In recent years there have already been reforms to make the CAP more environmentally friendly, which includes conditioning support for whether farmers reach certain

[96] La Moncloa, n.d., Environmental Policy

environmental targets (e.g. 3% of arable land must be dedicated to biodiversity).[97] We would recommend that the policy perhaps be altered so that aforementioned damaging agricultural practices are not as heavily subsidised by the CAP.

Overall, decentralisation and lack of coordination on water policy and agricultural policy, as discussed in the insight has limited the response to desertification. We recommend a greater degree of coordination and cooperation between stakeholders. More specifically we suggest that water policy should remain less political and more in the hands of the federal government, though still in consultation with other stakeholders. Additionally, European level policies such as the CAP reflect environmental priorities.

[97] European Commission, n.d., CAP 2023-27

Conclusion

In a context where the effects of climate change are visible worldwide, this report has focused on the increasing risk of desertification Spain is facing. Given its geographical location and the tardiness of proper responses to the issue, it was argued that Spain is in urgent need to implement more sustainable practices that find a balance between resource preservation and economic profitability. As highlighted, a continuation in current practices do not only pose a harm to the environment but to water supply which is crucial for the operation of the economy and wellbeing of society. The long-term implications of desertification may not necessarily be perceived as 'alarming' for now, but they are already starting to materialise, as evidenced by recent statistical data.

This report has provided an understanding of the current situation in Spain, an analysis into the underlying reasons that allow the problems to persist and several guidelines. Among the recommended policies are the improvement of irrigation techniques through the employment of conditioners, the education and increase of awareness around the use of soil regenerative agricultural practices and greater cooperation amongst stakeholders. Although reversing the process of desertification may pose an overwhelming challenge, it is still possible to invest efforts into preventing further damage. However, for this to happen, there needs to be a high degree of cooperation from all parts of society - from farmers and plot owners to government agencies and policy makers.

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