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CASE STUDY

Dehesa silvopastoral system for soil protection and ecosystem management (Spain)



Project full title: Enhancing Technical and Vocational Skills for Implementing Nature-Based Solutions (NbS) to Combat Land Degradation

Project acronym: NbS4LD

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1. INTRODUCTION

This case study has been analysed by [MIXTURA AMBIENTAL](#), a partner organisation of the NbS4LD project. It is a Spanish non-profit association composed of 20 renowned natural and social science researchers, artists, and local agents (particularly women and vulnerable groups) that promotes sustainable transitions, especially in rural areas and the Global South. Mixtura aims to contribute to sustainable development by combining natural and social sciences, traditional knowledge, and cultural expressions. The association works to create conditions that allow communities and vulnerable populations to find solutions to current socio-environmental challenges, such as desertification and land degradation. It promotes the preservation of cultural diversity, which is associated with higher biological diversity.

The Dehesa Silvopastoral System is a traditional Nature-based Solution developed in southwestern Spain and Portugal since the Middle Ages (10th-15th centuries) and still actively managed today. It covers extensive areas including the UNESCO Biosphere Reserve Dehesas de Sierra Morena and the Sierra de Aracena y Picos de Aroche Natural Park. This landscape combines scattered oak trees, pastures, and extensive livestock grazing, providing soil protection, water regulation, biodiversity conservation, carbon storage, and rural livelihoods.

The intervention addresses land degradation challenges including soil erosion, poor regeneration, climate change, drought, wildfire risk, and oak decline (La Seca). Sustainable practices include rotational grazing, controlled stocking rates, oak regeneration, vegetation management, soil conservation measures, and restoration of traditional barriers. The system supports local economies through Iberian ham production, livestock, cork, forestry products, hunting, mushrooms, and ecotourism.

The Dehesa demonstrates strong environmental and socioeconomic outcomes, improving ecosystem resilience while preserving cultural heritage. Its replication potential is high for Mediterranean silvopastoral landscapes, although long-term sustainability requires continued adaptation, institutional support, and measures against climate change and oak decline.

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[Dehesa landscape in Cortegana, Huelva, Spain - Author: Juliana Chaves-Chaparro, Mixtura Ambiental]



[Tree affected by La Seca disease - Author: Juliana Chaves-Chaparro, Mixtura Ambiental]

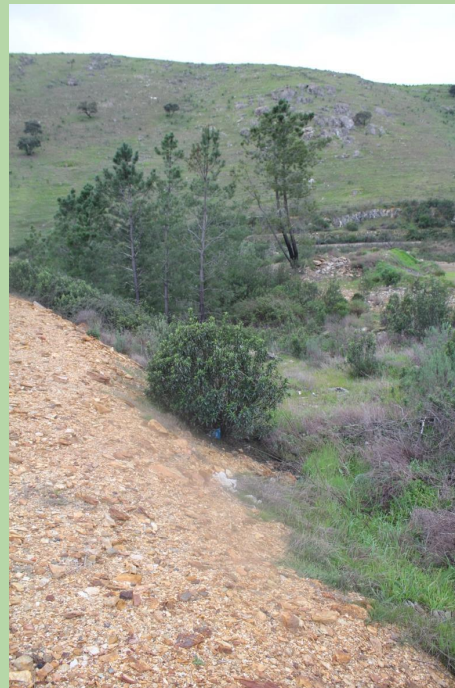
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[Cortegana village, Huelva, Spain - Author: Juliana Chaves-Chaparro, Mixtura Ambiental]



[Degraded habitat and eroded land after the loss of Dehesa ecosystems - Author: Juliana Chaves-Chaparro, Mixtura Ambiental]

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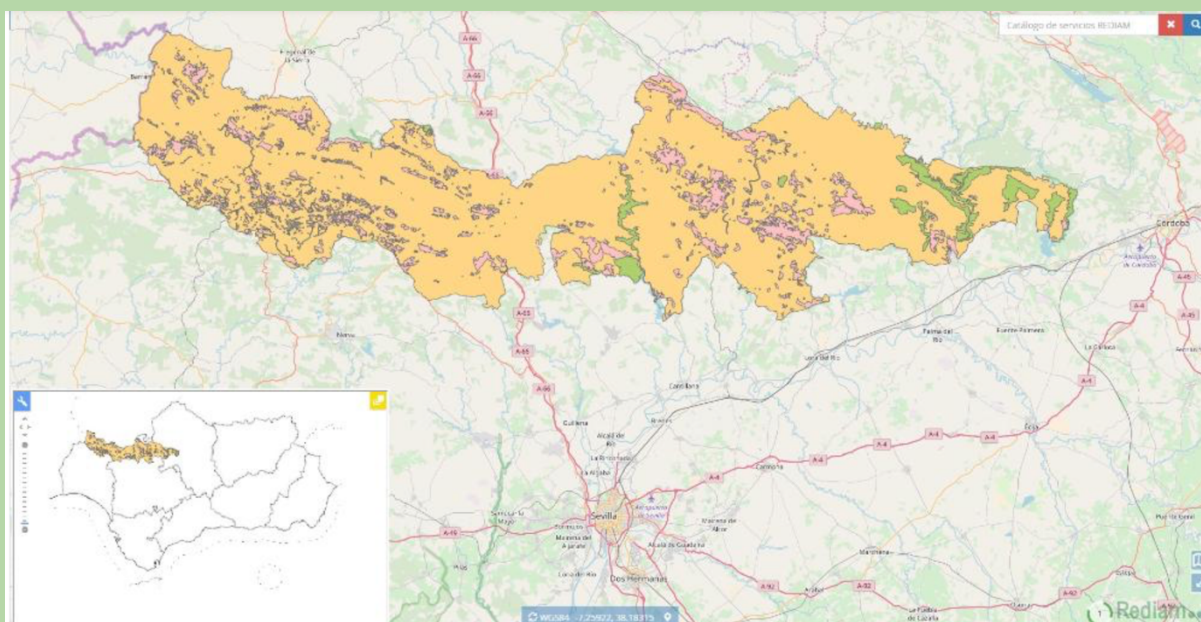


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2. CONTEXT

2.1 LOCATION

Country: Spain and Portugal. Regions: Andalusia (Andalucía), Extremadura, Castilla-La Mancha (Spain); Alentejo (Portugal). Sites: Protected Area of Dehesas de Sierra Morena Biosphere Reserve (424,400 ha); Sierra de Aracena y Picos de Aroche Natural Park. Approximate GPS coordinates: Latitude 38.0° N - Longitude 6.5° W.



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2.3 LANDSCAPE TYPE

Silvopastoral system.

2.4 LAND DEGRADATION CHALLENGE

Soil erosion. Poor land management. Climate change. Deforestation

2.5 BASELINE DATA

Land condition	• Site: Dehesa silvopastoral landscapes of southwestern Spain (Extremadura, Andalusia, Castilla-La Mancha) and Alentejo (Portugal), including the UNESCO Biosphere Reserve Dehesas de Sierra Morena and the Sierra de Aracena y Picos de Aroche Natural Park (Huelva, Andalusia). • Soil: Mediterranean soils supporting silvopastoral systems. Generally fertile under sustainable management, but vulnerable to compaction, reduced infiltration, and degradation from overgrazing, drought, and oak decline (La Seca). • Vegetation cover: open woodland dominated by holm oak (<i>Quercus ilex</i>), cork oak (<i>Quercus suber</i>), and locally Pyrenean oak (<i>Quercus pyrenaica</i>), with herbaceous pasture and scattered shrubs. • Erosion status: moderate risk of soil erosion in degraded areas. Tree cover and herbaceous vegetation traditionally protect soils, but erosion increases where oak mortality, overgrazing, land abandonment, or poor regeneration occur.
Environmental context	• Climate: Mediterranean climate characterized by hot dry summers, irregular rainfall, recurrent droughts, and increasing climate change impacts. • Hydrology: water availability is limited and strongly dependent on seasonal rainfall. Tree cover and grasslands improve infiltration, groundwater recharge, and water retention, while degraded areas experience increased runoff and lower soil moisture. • Biodiversity: high-biodiversity silvopastoral ecosystem supporting endemic flora and fauna, including endangered species such as the Iberian lynx (<i>Lynx pardinus</i>), Spanish imperial eagle (<i>Aquila adalberti</i>), and black stork (<i>Ciconia nigra</i>). • Environmental pressures: climate change, drought, soil erosion, soil compaction, poor oak regeneration, land abandonment, wildfire risk, overgrazing in some areas, and the spread of the oak decline disease “La Seca” caused primarily by <i>Phytophthora cinnamomi</i>.

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Socioeconomic context	• Population: predominantly rural communities distributed across low-density agricultural and livestock landscapes. • Livelihoods: extensive livestock production (Iberian pigs, cattle, bulls, and sheep), cork production, forestry products, hunting, mushroom collection, ecotourism, and traditional cultural activities. • Land management: traditional silvopastoral management based on extensive grazing, rotational stocking, tree pruning, pasture management, and conservation of multifunctional landscapes. • Resource dependency: local communities depend heavily on ecosystem services and natural resources provided by the dehesa, including livestock production, cork, timber, non-timber forest products, biodiversity, and tourism.
Policy and governance	• Institutional framework: management is based on private and public land ownership, traditional stewardship systems, regional and national environmental policies, EU conservation and rural development programmes, and UNESCO Biosphere Reserve recognition. Governance involves landowners, local communities, regional administrations, environmental organizations, and research institutions.

3. INTERVENTION

3.1 TIMEFRAME

Middle Ages (10th-15th centuries) - present (ongoing). The intervention refers to the traditional Dehesa silvopastoral management system, continuously implemented and adapted over centuries. Current adaptive management measures addressing climate change, soil degradation, wildfire risk, and oak decline (La Seca) remain ongoing.

3.2 TYPE OF INTERVENTION

Afforestation. Silvopastoral ecosystem restoration and sustainable land management.

3.3 IMPLEMENTING ORGANISATIONS

Private and public landowners, local communities, livestock producers, regional governments, research institutions, and environmental organizations. Together they manage and conserve the Dehesa silvopastoral landscape through traditional practices and adaptive measures for climate change, biodiversity, and soil protection.

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3.4 FUNDING SOURCES

The system is mainly self-financed by local communities and private landowners through livestock revenues, with additional support from regional (Andalusian environmental authorities) and national (Ministry of Environment) institutions for the conservation of its biocultural values within the UNESCO Biosphere Reserve.

3.5 IMPLEMENTATION ACTIONS AND MEASURES

The Dehesa is a human-created system derived from Mediterranean forests, shaped over centuries through grazing, clearing, and land management practices. The term “dehesa” comes from the Latin *defensa* (“fenced land”) and originally referred to protected grazing areas in medieval Spain. Scientific studies show that dehesas existed in some form since the Middle Ages (approximately 10th–15th centuries) as managed grazing landscapes. The modern structure, characterized by open oak parklands, developed mainly during the 18th-19th centuries, particularly after land privatization and agricultural reforms. Its current form as a silvopastoral system combining trees, pasture, and livestock became widespread during the 19th-20th centuries (M. Vicente & F. Alés, 2006).

The Dehesa system is an integrated silvopastoral landscape where scattered oak trees, herbaceous understory, and extensive livestock grazing interact to create a multifunctional ecosystem. Soil protection results from several ecological processes: tree canopies reduce raindrop impact and improve microclimatic conditions; roots enhance soil structure and organic matter accumulation; and the herbaceous layer protects soil from erosion while promoting water infiltration. Livestock grazing plays a central role by cycling nutrients through manure deposition and controlling shrub encroachment, maintaining open grasslands and reducing wildfire risk. Sustainable management practices include rotational grazing, controlled stocking rates, and periodic pruning of holm oaks to maintain productivity. Together, these practices form a nature-based system that has evolved over centuries and provides significant ecological, cultural, and economic benefits, including cork production, livestock farming, Iberian pig production, traditional bull breeding, mushroom collection, and wood resources.

The dehesa also plays an important cultural role, hosting traditional events such as *romerías* (religious and cultural festivals in southern Spanish villages) and supporting species with high ecological and cultural value, including cattle breeds, Merino sheep, and Iberian pigs linked to *jamón de bellota* production. It is recognized as a biodiversity hotspot supporting endangered species such as the Iberian lynx (*Lynx pardinus*), the Spanish imperial eagle (*Aquila adalberti*), and the black stork (*Ciconia nigra*).

However, the native oak species dominating these landscapes (*Quercus ilex*, *Quercus suber*, and *Quercus pyrenaica*) face increasing survival challenges due to climate change, poor natural regeneration, land abandonment, increased wildfire risk, and the spread of oak decline syndrome known as “La Seca” (“drying”).

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“La Seca” is a multifactorial decline syndrome affecting Mediterranean oak ecosystems, primarily associated with the soil-borne pathogen *Phytophthora cinnamomi*. Its impacts are intensified by drought, soil degradation, and land-use pressures. The disease affects large areas of dehesa ecosystems in southwestern Europe and has caused significant tree mortality, threatening biodiversity, soil stability, and traditional rural livelihoods. Current research focuses on integrated management strategies, including the selection of resistant trees, biological soil treatments, and adaptive land management practices.

Since soil erosion, soil compaction caused by overgrazing, and poor drainage conditions can accelerate disease development, a combination of Nature-based Solutions (NbS) and adaptive management techniques is required to address these challenges. Measures include:

- **Soil treatments:** calcium amendments, phosphorus fertilization, improving drainage conditions, avoiding waterlogging (which favors pathogen spread), and maintaining vegetation cover.
- **Biological measures:** use of beneficial microorganisms such as *Trichoderma* to reduce pathogen presence, vegetation management, grazing control, promotion of natural regeneration, reforestation, and maintenance of mixed-age tree populations and resistant genotypes.
- **Physical measures:** restoration of traditional stone barriers, which reduce erosion and also function as biodiversity corridors.

4. IMPACT

4.1 ENVIRONMENTAL IMPACT

☑ Improved soil health or reduced soil erosion. Increased vegetation cover or habitat restoration. ☑ Improved water quality or water availability. ☑ Increased carbon sequestration or storage. ☑ Improved ecosystem services.

Dehesas in good ecological condition significantly improve soil structure, increase organic carbon, and enhance water retention. Studies show higher infiltration rates and reduced erosion under tree cover. Manure deposition increases nutrient availability, supporting soil fertility and plant productivity. Biodiversity is high, with habitats supporting endemic herbaceous and tree species, as well as endangered species such as the Iberian lynx and black stork. Fire risk is reduced through grazing management and landscape-scale practices.

In particular, livestock in dehesa systems (sheep, cattle/bulls, and Iberian pigs) play a central ecological role in soil biofertilization through nutrient cycling, organic matter inputs, and microbial activation. Manure and urine deposition contribute nitrogen (N), phosphorus (P),

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potassium (K), and micronutrients, enhancing soil fertility and supporting vegetation growth. Grazing stimulates plant regeneration and increases root exudates that support soil microbial communities.

Scientific studies show that extensive grazing can increase soil organic carbon and microbial biomass, improving soil aggregation and water retention (Joffre et al., 1999; Plieninger et al., 2001). Manure patches create spatial heterogeneity, forming “hotspots” of biological activity where nutrient mineralization rates are higher (Rodríguez-Rojo et al., 2022). Iberian pigs, through their rooting behaviour, incorporate organic material into the soil layers, improving aeration but potentially causing localized disturbance if not properly managed.

Sheep grazing tends to be more homogeneous, contributing to a more even distribution of nutrients, while cattle and bulls create concentrated nutrient zones due to dung deposition patterns. This spatial variability supports plant diversity and ecosystem resilience. Studies also indicate that dung beetles and soil macrofauna accelerate manure decomposition, integrating nutrients into the soil profile and reducing nutrient losses.

However, overgrazing may lead to soil compaction, reduced infiltration, and disruption of microbial communities. Adaptive management practices, such as rotational grazing and controlled stocking rates, maintain ecological balance by ensuring positive biofertilization effects while preventing degradation (FAO, 2017).

Key ecological processes:

- Nutrient cycling through manure and urine deposition
- Increase in soil organic matter and carbon sequestration
- Enhancement of microbial activity and enzymatic processes
- Improvement of soil structure and porosity
- Promotion of plant diversity and ecosystem productivity

4.2 COMMUNITY IMPACT

☑ Increased household income. ☑ Job creation or new livelihood opportunities. ☑ Improved food security. ☑ Strengthened community resilience. ☑ Increased local capacity or skills.

The system sustains rural livelihoods through high-value products such as Iberian ham (jamón de bellota from Iberian pigs), cattle (including bulls for traditional bullfighting and native sheep breeds), hunting, mushroom collection, and ecotourism. It supports cultural heritage, including the preservation of traditional jamón production practices dating back to Phoenician times, and provides socioeconomic resilience in rural areas by reducing land abandonment and associated

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wildfire risks. The UNESCO Biosphere Reserve of Dehesas de Sierra Morena recognizes and protects these ecological, cultural, and economic values. .

4.3 INSTITUTIONAL IMPACT

☑ Strengthened institutional coordination. ☑ Integration into local or national planning. ☑ Capacity building for institutions or communities. ☑ Establishment of new management structures or partnerships.

Dehesas are managed through traditional knowledge systems combined with modern policies. Governance includes land stewardship practices, grazing regulation, and conservation programmes supported by EU policies and UNESCO. Education and awareness among younger generations about conservation challenges and needs are essential to sustaining the biocultural values and traditional knowledge of Dehesas.



[School training on Dehesa conservation by the University of Huelva and Mixtura Ambiental in Cortegana
- Author: Juliana Chaves-Chaparro, Mixtura Ambiental]

4.4 SUSTAINABILITY OF THE RESULTS

☑ Integration into policies or development plans. ☑ Institutional support or partnerships. ☑ Strong local community ownership. ☑ Local technical capacity for maintenance. ☑ Monitoring and adaptive management systems.

Sustainability depends on measures addressing La Seca, including multiple land degradation prevention strategies such as balanced grazing, oak tree regeneration, and long-term policy

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support. Climate change increases risks related to drought and wildfires, but adaptive management practices can enhance ecosystem resilience. If dehesas are not properly managed due to disease impacts and insufficient funding for conservation, oak decline and vegetation changes (from native *Quercus* species to pine-dominated landscapes) may increase erosion risks and accelerate land degradation.

5. CONCLUSION

- **Community relevance:** fully.
The Dehesa system addresses real challenges affecting rural communities by sustaining traditional livelihoods, local products, cultural heritage, and resilience against land abandonment, wildfire risk, and climate impacts.
- **Technical effectiveness:** fully.
The intervention maintains ecosystem functions through silvopastoral management, improving soil protection, biodiversity conservation, water regulation, and habitat quality through long-term adaptive practices.
- **Economic efficiency:** fully.
The system is economically sustained through high-value products such as *jamón de bellota*, livestock, cork, hunting, and ecotourism, supporting rural economies while maintaining ecosystem services.
- **Institutional support:** mostly.
The system is supported by environmental policies, conservation frameworks, and partnerships between communities, landowners, and institutions. However, stronger support is needed to address *La Seca*, climate change impacts, and knowledge gaps.
- **Innovation:** partially.
The Dehesa is a traditional but adaptive Nature-based Solution. However, further innovation and investment are needed to improve responses to climate change, oak decline, and emerging ecosystem threats.
- **Replication & Scaling Potential:** mostly.
Dehesa management practices can be adapted and replicated in other Mediterranean silvopastoral landscapes, although successful implementation depends on local ecological and socioeconomic conditions..

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