Report: Links between agricultural practices and biodiversity in Mediterranean Landscapes

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Striving for positive social and economic impact on the lives of those dealing with environmental challenges
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Abstract

Extensive agricultural systems have contributed to livelihood subsistence in the Mediterranean basin for centuries as well as playing an important role in shaping the Mediterranean biodiversity. It has contributed to shape landscapes, culture and society through often complex and multidirectional relations. However, the relationship between cultural practices in extensive agricultural systems and biodiversity has not been well studied. This study has thus explored the relationships and feedbacks between cultural practices (agriculture, grazing, silviculture etc.) and biodiversity in the Mediterranean basin where it is documented and justified. To achieve this a combination of structured interviews held with experts on the nexus between biodiversity and cultural practices from 9 case studies in the Mediterranean, as well as a literature review was undertaken. Through the study it has been evidenced that a large amount of cultural practices related to biodiversity exist. This relationship is however less evidenced regarding water infrastructure and drystone walls. Literature exploring the nexus between cultural practices and biodiversity also presents a bias towards European countries, especially Spain and Italy. It is recommended that in the future studies should explore the nexus between cultural practices and biodiversity with efforts focused on field work and under a Mediterranean cooperation approach to assess differences and similarities between countries.

The literature review evidenced that, only 11 out of 26 papers (less than half) have undertaken field work to assess biodiversity. The studies that have undertaken field work are in European countries. Of these studies, 7 analyse plant species, 2 analyse a combination of plant and other taxonomic groups, while one study analyses amphibians and another soil biodiversity. Only 2 out of the 13 studies undertaking an explicit socio-ecological approach use field work. The remaining papers are mainly related to landscape diversity and are studied using a combination of GIS data and socio-economic information. The studies that analyse biodiversity without field work are mainly found in Italy, Greece and Spain, and to a lesser extent in France, Morocco and Turkey.

Through the interviews held with local experts and the associated assessment of the case studies, several features can be highlighted.

In the Levante region of Liguria (Italy) the most distinct cultural practice is the local Cabannina cattle breed, which through its capacity to digest lignin and grazing, avoids secondary succession and thus contributes to pasture and landscape diversity. The breed spends its first six years in the mountain regions following which it is moved to the coast of Liguria. However, this system is not well studied. Silvicultural management of trees and secondary agricultural elements such as drystone walls are suspected to have a relationship with biodiversity.
In the Anti-atlas Réserve de biosphère de l’arganerie (Morocco) the most distinctive cultural practice is how the traditional Agdal communal governance prohibitions can contribute to preserve the wild pollinators, pasture and shrub diversity as well as the subsistence of *Argania spinosa* as long as overstocking is avoided. However, this system is not well evidenced in the literature.

**Morocco – Anti-atlas Réserve de biosphère de l’arganerie**

<table>
<thead>
<tr>
<th>Agricultural practice</th>
<th>The silviculture is the center of the system. Argan forests are managed through a traditional governance system called Agdals with rules and norms to secure livelihoods. The system through its norms and rules preserves biodiversity. The co-evolution of nature and cultural practices have increased the resilience of the system.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend</td>
<td>Negative trend</td>
</tr>
<tr>
<td>• Lack of appropriate institutional national support</td>
<td></td>
</tr>
<tr>
<td>• Decreasing generational takeover</td>
<td></td>
</tr>
<tr>
<td>• Migration processes</td>
<td></td>
</tr>
<tr>
<td>Highlights</td>
<td>• The system is in a process of transformation</td>
</tr>
<tr>
<td></td>
<td>• Resilient system at local scale to external drivers</td>
</tr>
<tr>
<td></td>
<td>• Flexible governance system with a co-evolution between the natural and social system.</td>
</tr>
</tbody>
</table>

In Ait M’hamed, Imegdale and Oukeimden (High Atlas, Morocco) the principal cultural practice is the Agdal governance of the communal land with specific norms and rules. By prohibiting access to the Agdals while plants are undergoing the phenological phases of flowering and fructification can secure the reproductive success of these plans while at the same time providing an important resource for butterflies and birds (which feed on insects). Scientific evidences for these relationships need to be further assessed.

**Liguria - Italy**

<table>
<thead>
<tr>
<th>Agricultural practice</th>
<th>Autochthonous Cabanina cattle herding in two distinct regions. Mountain regions until the age of 5-6 and then at the coastline afterwards. Cabanina cattle maintain the natural landscape. The region is characterized by dry stone walls and silvicultural management of chestnut trees.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trend</td>
<td>Unknown trend</td>
</tr>
<tr>
<td>• Lack of adequate governance to support young people willing to enter the agricultural sector.</td>
<td></td>
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<tr>
<td>• Industrialization and tourism are competing economic activities.</td>
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<tr>
<td>• In the last 5 years livestock numbers have increased</td>
<td></td>
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<tr>
<td>Highlights</td>
<td>• Autochthonous Cabanina cattle herding</td>
</tr>
<tr>
<td></td>
<td>• U Cabanin cheese production</td>
</tr>
<tr>
<td></td>
<td>• Dry stone wall landscape</td>
</tr>
<tr>
<td></td>
<td>• Chestnut silvicultural management</td>
</tr>
</tbody>
</table>
In Santiago de la Espada, Pontones and Castril (Spain), the principal cultural practice is livestock herding that contributes to landscape diversity by avoiding secondary succession and hence maintaining habitats. Communal lands are under a governance mechanism with specific norms and rules. The relationships between biodiversity and pastoral activity and governance is currently being studied in the region.

In Menorca (Spain), the principal cultural practice is the landscape mosaic which is accomplished through the practice of traditional agriculture as wine or olive tree orchards and its integration with the silvicultural management of small forests and grazing of livestock. Within the agropastoral system, crop rotation contributes to an increased diversity of annual plants while securing soil fertility. The fertility of the soil is assured through herding (and avoidance of overstocking) of local cattle and sheep breeds. These relationships are well evidenced in the literature.
<table>
<thead>
<tr>
<th>Spain - Menorca</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural practice</strong></td>
</tr>
<tr>
<td>Agricultural and pastoral activities co-exist in a unique landscape mosaic characterised by dry stone walls and underground water tanks. The dominant livestock breed is the Menorcan cattle and sheep and important agricultural activities are vineyards. Within the livestock system rotational grazing and crop rotation is practiced.</td>
</tr>
<tr>
<td><strong>Trend</strong></td>
</tr>
<tr>
<td>Positive trend</td>
</tr>
<tr>
<td>• Livestock systems transform from dairy production and non local breeds to semi-extensive local cattle breed for meat production.</td>
</tr>
<tr>
<td>• Local institutions are supporting extensive production systems.</td>
</tr>
<tr>
<td>• New agricultural holdings are dedicated to traditional activities.</td>
</tr>
<tr>
<td><strong>Highlights</strong></td>
</tr>
<tr>
<td>• Recovery of the autochthonous cattle breed.</td>
</tr>
<tr>
<td>• Use rotational grazing and crop rotation to preserve soil fertility.</td>
</tr>
<tr>
<td>• Dry stone walls as distinct landscape elements.</td>
</tr>
<tr>
<td>• Recovery of traditional agricultural activities as wine orchards and olive trees.</td>
</tr>
</tbody>
</table>
In the Central System (Spain) the principal cultural practice is herding. Pastoralism is essential to maintain the plant communities in alpine pastures and the hay meadows. The maintenance of these landscapes in turn is favorable for bird biodiversity especially in farmland birds. Furthermore, grazing and browsing of livestock is important to avoid secondary succession of pastures and thus maintains the landscape diversity. Several studies acknowledge these relationships between cultural practices and biodiversity.

### Spain – Central System

**Agricultural practice**

Agrosilvopastoral system of goat farming characterized by a complex cycle of transhumance, herding and rotational crop rotation. Grazing and browsing contributes to landscape diversity, decreases fire risk and enhances biodiversity. Secondary farming elements such as silvicultural management or dry stone walls are central for biodiversity.

**Trend**

Negative trend

- Bovine tuberculosis of wild ungulates affects domestic livestock.
- The institutional system of sanitary controls are eradicating extensive livestock farms.
- Lack of institutional support.

**Highlights**

- Complex interactions between pastoralism, silvicultural management enhances biodiversity while securing pasture productivity.
- Secondary elements of the agropastoral system such as dry stone walls and water ditches are important factors for biodiversity.

### Spain and Portugal – Dehesas/Montados

**Agricultural practice**

Dehesas are agrosilvopastoral systems and the product of the co-evolution of humans, pasture and trees. Traditionally Dehesas were mixed systems that combined sheep, goat and some cattle but today are substituted by cattle only. Transhumance is being substituted by rotational grazing. Montados are characterized by cork trees.

**Trend**

Negative trend

- Unsuitable policies at national and international level e.g. CAP
- Market pressure with a lack of recognition for extensivity.
- The image of the media is projecting on intensive agriculture in the region.

**Highlights**

- Agrosilvopastoral systems that traditionally combined different autochthonous livestock breeds.
- Transhumance was the center of its activity.
- Silvicultural management of trees is central to sustain landscape structure.
- Secondary structures as drystone walls contribute to biodiversity.
In Lemnos (Greece), the principal cultural activity are the Mandras which are the shepherd’s houses with their associated drystone structures. These drystone structures constitute habitats for birds, reptiles and insects. Around the Mandras rotational grading and cropping is practiced allowing the recovery of soil and contributing to its fertility and diversity.

In Al Shouf (Lebanon) the principal cultural activities include local seed cultivation which contributes to the horticultural diversity. Likewise, crop diversification increases plant diversity. Rotational grazing by local livestock breeds avoids secondary succession and thereby increases the landscape diversity. More detailed studies in this region are needed to demonstrate this connection.

The evidence from the literature and the case studies analysed show that there is a decreasing trend of cultural practice use in the Mediterranean. This decreasing use of cultural practices can negatively affect biodiversity as shown through the examples of the abandonment of transumance and transfermitance in the Central System in Spain, abandonment of herding in Dehesas or the abandonment of traditional breeds such as the Cabannina cattle in Liguria. Although there is a strong link between cultural practices and biodiversity there are certain examples that have been harder to evidence this fact such as habitats in drystone walls or dry stone walls.
water ditches, governance mechanisms and plant diversity, or herding and landscape diversity. Other cultural practices are contrasted to have a positive effect on biodiversity such as silvicultural management for tree species diversity, herding of livestock for the maintenance of *Nardus stricta* communities, alpine pastures or hay meadows, and the selection of traditional livestock breeds which add genetic diversity to the livestock species and allow traditional management as these breeds are adapted to local climatic and environmental conditions. Also, some practices as governance norms and rules have contrasted information on their relevance for biodiversity, but in some others this information is missing. That claims for further research in this respect. Finally, we can state that if cultural practices continue to decrease across the Mediterranean landscapes this will negatively affect biodiversity.
Glossary of terms

Glossary of terms for cultural practices

- **Dry-stone walls**: are constructed without any kind of concrete and constitute a central element of extensive agriculture around the Mediterranean basin. They create habitat for cultivation or natural grasslands, increase land surface, avoid soil erosion, contribute to water retention and are an important habitat for insects, reptiles, birds and some small mammals. Sometimes they can as well constitute a habitat for amphibians. Dry-stone walls can be considered an ecosystem in itself. In other cases they were as well used to separate land tenure or to manage livestock.

- **Local Food**: locally characteristic food products which results from the extensive agricultural activity and is considered a cultural output of an extensive agricultural activity.
  - **Flour**: locally characteristic food product based on flour as main ingredient.
  - **Diary**: locally characteristic food product based on milk.
  - **Meat**: locally characteristic food product based on meat.
  - **Fruit**: traditionally characteristic food products based on the cultivation of a tree and the harvesting of its fruits.

- **Landscape mosaic**: local extensive agriculture contributes to create a fragmented landscape with different habitats and land use systems which is characteristic of a region. It can for example be triggered by livestock management or a specific characteristic of livestock, dry-stone wall constructions, cultivation, crop rotation or diversification, silvicultural management or any combination of the above-mentioned practices. These activities usually avoid secondary succession. The landscape mosaic often triggers increased landscape biodiversity.

- **Mandras**: pastoral shelter house which until the end of the 20th century, served as a place of production and residence, playing an important role in the formation of the socio-economic relations. Mandras were surrounded by an orchard and dry-stone walls.

- **Nomadism**: movement of animal and people between same areas but without a fixed habitation.

- **Pastoral hut**: shelter for pastoralist often constructed out of dry-stone structures.

- **Pastoralism**: pastoralism with a shepherd in natural grasslands, crops or forests. Can as well take the form of rotative grazing.

- **Plant collection**: collection of edible, aromatic and medicinal plants.

- **Religious beliefs**: it can contribute to a certain degree to the retention local identity and activities such as pastoralism, its traditional lifestyle and its associated benefits for biodiversity.

- **Redileo**: Livestock was traditionally closed up during nights at different sites each certain time periods. This was a way to shelter livestock at nights, fertilize soils and control vegetation growth. Nowadays this practice has declined severely.

- **Traditional agricultural system**: culturally distinct forms to manage agricultural lands.
  - **Gardens and crops**: associated to the livelihood as an element for subsistence. They can as well denote land tenure. They constitute an element of landscape heterogeneity which adds biodiversity.
  - **Local seeds**: local varieties of seeds adapted to local environmental conditions and extensive land practices. Often they are kept in families and are not shared.
  - **Traditional crop recovery**: recovery of formerly used crops and trees in agricultural systems.
  - **Crop cultivation**: has the traditional function to serve as fodder for livestock and to avoid shrub encroachment.
  - **Crop rotation**: rotation of different types of crop to ensure soil fertility. This is a central activity in many agropastoral systems.
  - **Fallow land practice**: allows the recovery of soil after cultivation for some years by not growing crops.
  - **Apiiculture**: beekeeping as agricultural activity which feeds on local flowering resources, i.e. in Argan forests they feed on Argan flowers when other flowering resources are not present.
• **Traditional governance systems**: management of a natural resource (can be water or land) through norms and rules in a communal management system.
  - **Communal Amassing Water governance**: is distributed between users in a circular manner depending on land size.
  - **Communal Agdal governance**: A communal governance system with an assembly and specific norms and rules of access and use of the Agdals exists to manage the system in a multifunctional manner i.e. During the flowering period access is prohibited, when fruits are fallen from the trees collection is allowed, after that livestock entrance is allowed. This structure is flexible depending on natural conditions.
  - **Berber land use rights**: During more than 20 years the Berbers in the Agdal system have more land use rights than other areas which contributes through their identity to the subsistence of the Agdal governance system.
  - **Pastoral governance**: Norms and rules as for example access dates, stocking rates of communal natural grasslands and is linked to social community imaginary as this system is contested.
  - **Dehesas Boyales**: communally owned Dehesas with individual use norms and rules.
  - **Hamas governance**: A community-based governance approach established in the VI Century to manage natural resources.

• **Silvicultural management**: tree management which sustains or contributes to the maintenance of extensive agricultural system.
  - **Quercus pyrenaica pruning**: serves as browsing fodder for livestock and as fire wood.
  - **Pruning**
    - *Q. ilex pruning*: serves as fodder for livestock and is central to sustain Dehesa structures.
    - *Ash tree pruning*: pruning in summer is a source to overcome nutritional shortage in grasslands for livestock.
  - **Fig tree plantation**: it's plantation and harvesting is a cultural activity in some Mediterranean regions.
  - **Tree plantation**
    - *Adler tree plantation*: planted next to orchards and gardens as they contribute to nitrogen fixation.
    - *Chestnut tree plantation*: grazing structure for livestock and element to prevent wild fires and create landscape heterogeneity.
    - *Pine tree pasture*: livestock pastures under pines as fodder source. This increases biodiversity of a monospecific plantation and avoid complete shrub encroachment.
  - **Q. suber harvesting**: bark harvesting of the cork tree is central to the activity of Montados and Dehesas.
  - **Shrub growth**: allows the regeneration of trees.
  - **Dry hedgerows**: are used to separate land tenure.
  - **Olive trees secondary products**: humus and wood as heating source.

• **Transhumance**: seasonal movement of livestock depending on landscape productivity. Usually two fixed and differentiated regions can be distinguished: summer regions and winter regions. Movement distance uses to be long. It as well has an important function of soil regeneration and biodiversity. It can be practiced by all type of livestock but usually each livestock specie has a specific management.

• **Transstermitance**: is short distance movement between usually two regions: summer regions and wintering regions. It can be practiced by all kind of species. It as well has an important function of soil regeneration and biodiversity. It can be practiced by all type of livestock but usually each livestock specie has a specific management.

• **Local livestock breed**: local livestock breeds are adapted to environmental and climatic conditions and to the local topography and due to that they often require fewer external inputs and less attention by the farmer. Local breeds are often required to manage the land in a distinct manner which is impossible with other breeds.
  - **Menorcan cattle**: meat oriented but can as well produce milk
  - **Alvileña Negra cattle**
  - **Brown Retinta cattle**
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- Blanca Cacereña cattle
- Morucha cattle
- Cabanina cattle: This breed is adapted to the abrupt topography and is able to digest lignin making this species a crucial element for the landscape mosaic and biodiversity. Formerly this cattle breed was a crucial element for the local food security and local economy.
- Fighting bulls
- Segureña sheep: meat oriented.
- Brigasca sheep
- Menorcan sheep: meat oriented
- Merino sheep
- Black Merino sheep
- Tree climbing goat
- Chablie goat: milk oriented
- Bardi goat: milk oriented
- Murciano-Granadina goat
- Florida blanca goat
- Guadarrama goat
- Iberian Pig
- Vara Valley Black Cock
- Non recognized local livestock breed: local breed which is not yet officially recognized.

- Water infrastructure: traditionally constructed water infrastructures which are crucial for livestock or agricultural activity.
  - Underground water tanks: Water tanks have been dug and pastoralist and agriculturalist use impermeable stone structures to channel rain water. These structures are crucial to water livestock and collateral increases biodiversity in the surroundings.
  - Water ditches: are traditionally formed by a wide water ditch with lateral exits to flood the pasture or gardens.
  - Semi-permanent ponds: ponds constructed to water livestock.
  - Stone water tanks: water tanks constructed of stone to collect rain water.

Glossary of terms for drivers affecting cultural practices

**Negative drivers**

- **Agricultural intensification**: is triggered to compete with intensive agricultural systems or to seek a more stable income. An important trigger is mechanization and increased land tenure.
- **Climate constraints**: climate change is affecting extensive agriculture through increased unpredictability, increasing presence of droughts, changes in rainfall regime. This can for example trigger reduced productivity, access to water, tree regeneration or increase uncertainty upon norms and rules of governance systems.
- **Lack of governance**:
  - Transhumance governance: overgrazing of communal managed systems by high intensity livestock systems under a transhumance structure.
  - Neo-rural movement: difficulty to enter into the agricultural sector for neo-rurals due to increased land fragmentation which can't be managed, and ageing population which does not comprehend needs of neo-rurals.
  - Communal management degradation: migration and depopulation trigger a degradation of traditional communal governance systems. In some cases subsidies have transformed communal management systems from a communal management of pastures to a communal management of subsidies.
  - Urban-rural divide: contradictory cosmovision upon nature are found between rural and urban habitants and a lack of valorization of products and its benefits.
  - Lack of support: absence of institutional support or attention to extensive agriculture and their infrastructure or products, in some cases favoring nature conservation over pastoral needs.
  - Syrian crisis: Syrian refugees see themselves as forced to compete with Lebanese pastoralist for very low salaries.
  - Sedentarization policies: policies which restrict animal movement.

- **Land abandonment and depopulation**: people emigrate from rural areas abandoning traditional agricultural practices, land management or governance systems. It is characterized by a lack of generational takeover. Often it triggers secondary succession which increases risks of hazards such as wild fires. In some cases only certain regions are abandoned which usually
are more difficult to mechanize or certain practices which imply greater working force (i.e. transhumance, redileo, dry-stone wall maintenance). Abandonment has a consequence an increasing difficulty to access land and degrading extensive agricultural infrastructures. In regions where people migrate to they often search for alternative economic opportunities to extensive agriculture.

- **Market pressure**: triggers increased competitiveness (in contrast to cooperative and mutual help systems) which can bring with its intensification, reduction of product prices, or a degradation of traditional management practices to search for an increased profitability undermining the sustainability of the resource base system. Market structure is mainly price oriented disregarding positive externalities of extensive agricultural products.
  - **Syrian crisis**: Syrian refugees see themselves as forced to compete with Lebanese pastoralists for very low salaries.
- **Media**: changing consumer behavior of local population or urban regions which are ill-informed upon products and incentive consumption of products from intensive agriculture.
- **Pastoralism**: Goats eating from the Argan tree are considered a threat.
- **Pests**: which affect livestock, crops, orchards or trees.
- **Returnees**: people returning to rural areas who have lost traditional knowledge or apply inadequate agricultural management practices or claim for land use rights. These factors can harm traditional practices and associated biodiversity.
- **Tourism and urbanization**: they compete for land use and are sectors to which some farmers switch to seek alternative employments.

- **Unsuitable policies**
  - **Common Agricultural Policy (CAP)**: has favored intensive agriculture over extensive agriculture for many years through inadequate subsidies. This has affected cultural practices which are not subsidized, lead to afforestation of agricultural lands or the prohibition of grazing under trees.
  - **Land privatization**: land privatization is incentivized which increases land fragmentation. This can avoid mechanization and simultaneously increase management costs.
  - **Commercial seeds**: subsidies for commercial seeds in detriment to local seed varieties.
  - **Policy lack and enforcement**: lack of policies for extensive agriculture and of enforcement of those in place.
  - **Cereal policies**: Salazar regime implemented cereal policies substituting traditional Montado systems. This has effects on the landscape structure until today.
  - **Health regulations**: to control infectious diseases such as the Bovine Tuberculosis do not distinguish between extensive and intensive systems, reducing animal movement or inadequate compensations.
  - **Subsidy delay**: subsidies are payed late creating a vicious cycle of indebtedness of extensive agricultural farmers.
- **Wild fauna - ungulates**: wild ungulate species which compete for fodder or are an important vector of infectious diseases such as the Bovine Tuberculosis. This constitutes an important sanitary risk and increases mistrust in institutions and between farmers with different livestock species.
- **Wild fauna – carnivore**: wolves and bears which can hunt livestock.

**Positive drivers**

- **Extensive agricultural sector market orientation**: orientation of extensive agriculture to added value products.
- **Eco-tourism**: as dynamization factor for rural development.
- **Land prices**: decreasing land prices which are easier to rent.
- **Market niche**: increasing interest for local, organic or ecological products.
- **Media**: recognition and awareness raise of the problematics of rural abandonment.
- **Governance**:
  - **Local associations**: local associations that defend interests of farmers.
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- **Institutional recognition**: increasing recognition of the value of extensive agriculture for nature conservation.
- **EU movement for extensive agriculture**: academia and NGOs who claim for a CAP that acknowledges extensive agriculture and its value or which implement local projects to favor extensive agriculture.

- **Knowledge transmission**: cultural practice knowledge is transmitted.
- **Local subsidies**: local subsidies for extensive agriculture and traditional cultural practices.
- **Mainland distance**: distance to mainland decreases transformation of primary sector to other economic activities.
- **Private advisors**: agricultural sector advisors which sometimes favor extensive production but in some cases as well intensive production systems.
- **Reducing insensitivity**: decreasing intensive production systems in favor of extensive systems.
- **Recovery of traditional agriculture**: recovery of formerly used agricultural systems, practices or local breeds.
- **Returnees and neo-rurals**: people recognize extensive agriculture as an employment sector.
- **Soil fertility**: is a constant supply for extensive agricultural systems.
1. Introduction and Scope of the Agricultural Practices in the Mediterranean Landscape

The motivation for this study is to explore the relationships and feedbacks between cultural practices (agriculture, grazing, silviculture etc.) and biodiversity in the Mediterranean basin where it is well understood, documented and justified. The current report provides firstly a general introduction giving a state of the art for this subject. Followed by a focus on the relationships between cultural practices and biodiversity, as well as, the drivers and trends that are influencing cultural practices to comprehend the mechanisms of biodiversity loss due to the loss of cultural practices.

Extensive agricultural systems have contributed to the subsistence of households in the Mediterranean basin for centuries. In such it has contributed to shaping the landscapes, culture and society through often complex and multidirectional relations. The multifunctional relationship allowed to manage landscapes and territories of the Mediterranean basin while being related to local culture and knowledge. Thus, it has contributed to shape the unique biodiversity of the region. In fact, the Mediterranean basin is recognized as a biodiversity hotspot harboring between 15,000 to 25,000 species, 60% of which are unique to the Mediterranean and one third is endemic, making the Mediterranean basin a system of great conservation value (IUCN, 2008). Extensive agriculture has been defined by Beaufoy, (1994) as referring to low-intensity farming. Given this definition extensive farming is characterised by a low amount of external inputs per hectare, specifically related to fertilizer usage and other external nutrients, irrigation water and agrochemicals coupled with exploitation of land on a large scale. Regarding livestock, stocking densities are considered as a measure of intensity. These low intensity systems can comprise of crops (permanent or not), livestock or a combination of both. To further differentiate extensive agriculture, the marginal use of external manufactured inputs has traditionally been an important difference between modern and traditional agriculture. On the contrary, labour can be intensive, and usually the systems are limited by natural conditions and factors while taking advantage of the diversity of local resources (Beaufoy, 2008).

According to Lomba et al., (2014) traditional agricultural landscapes are predominantly found in eastern and southern Europe including habitat types such as semi-natural grasslands, Dehesas and Montados steppe grasslands, permanent crops, and arable crops in dryland areas (Beaufoy, 2008; Plieninger & Bieling, 2013). This depicts the importance of a careful assessment of extensive agricultural practices in the Mediterranean due to the higher presence of traditional agricultural landscapes in this region compared with other European areas.

Related to the concept of traditional agriculture is what Andersen, Baldock, Bennett, & Beaufoy, (2003) defined as high natural value farmland (HNVf). These HNVf’s area in the EU is where agriculture is a major or dominant land use and is associated with a high species and habitat diversity, or the presence of species of European conservation concern, or both. In fact approximately over 30% of EU farmlands are High Nature Value farmlands. It is estimated that ca. 50% off all species and 63 out of 231 habitat types of European conservation interest rely on the persistence of specific agricultural practices, associated with HNV farming systems (Andersen et al., 2003; Lomba, 2018). Therefore, according to previous definitions HNVf can be classified into 3 principal categories (Andersen et al., 2003):

- Type 1 - Farmland with a high proportion of semi-natural vegetation.
Type 2 - Farmland with a mosaic of low-intensity agriculture and natural and structural elements, such as field margins, hedgerows, stone walls, patches of woodland or scrub, small rivers etc.

Type 3 - Farmland supporting rare species or a high proportion of European or World populations.

In the following figure the relationship between farming intensity and types of HNVf is depicted:

Figure 1. HNVf in relation to the intensity of farming systems. HNVf is presented in relation to the intensity of farming features, and features underlying the classification of the three broad types as proposed by Andersen et al. (2003). HNVf are extensively managed farmlands with a high proportion of semi-natural vegetation. HNVf are farmlands with low intensive inputs associated with mosaics of semi-natural and cultivated land, on a mosaic with small scale landscape. HNVf farmlands support rare species or high proportions of European or world populations even if coincident with more intensively farmed landscapes (indicator species). Figure reproduced and adapted from Lombada et al. 2014.

In fact, within HNVf the idea is that natural values, environmental qualities and cultural heritage are linked or depend on farming which provides multiple benefits beyond food. Extensive agriculture in the Mediterranean is characterized by multifunctionality, in which there exists a long-term extraction of goods including accommodating livelihoods to landscapes and territories while being related to local culture and knowledge. Nature-culture integration permits the emergence of local identities constructed through complex relationships between land use types in rural areas. These systems are shaped and maintained through human use and value concepts in order to satisfy the cultural and economic needs in the context of adverse policies. In short, extensive agriculture can be understood as socioecological systems in which
vegetation and culture co-evolves in relation to practices, rules and perceptions anchored in local livelihoods, history and ecology.

Extensive farming practices provide multiple goods and services while producing high-quality products for human consumption with low environmental impacts. The production of these goods and services matches a social demand of goods and Nature’s Contribution to People (NCPs) from extensive farming that until recently were poorly acknowledged. Concrete examples are recreational opportunities, fire prevention or maintenance of landscape heterogeneity through practices such as grazing and browsing that maintains biodiversity. This evidences how the Mediterranean basin plays a crucial role for extensive agriculture.

Nowadays, extensive agricultural systems are facing enormous challenges due to socio-ecological and economic trends (Beaufoy, 2008; Plieninger & Bieling, 2013) which can broadly be divided into three categories: agro-ecological, governance weakness and economic viability:

- **Agro-ecological challenges:**
  - Scrub encroachment is the consequence of a simplified management of grazing areas or their abandonment leading to the natural succession of pastures. The succession of pastures in Mediterranean areas without human influence follows the ecological stages of scrub and tree regeneration (Bernués et al., 2005; Rigueir-Rodríguez, McAdam, & Mosquera-Losada, 2009).
  - The ecological succession and scrub encroachment increases biomass leading to a higher flammability and combustibility increasing fire virulence (Mancilla-Leytón & Martín Vicente, 2012).
  - Climate change leads to increasing climatic variability and extreme events making livestock management even more unpredictable (Fernández-Giménez & Estaque, 2012).

- **Challenges related to governance weakness**
  - A concrete example of the negative effect of international policies on extensive agricultural systems is the integration of Spain in the EU and the Common Agricultural Policy (CAP), there have been successions of counterproductive reforms negatively impacting silvopastoral systems. Two examples are: i) the payments on per-head basis of subsidies which lead to livestock intensification; and ii) the admissibility coefficient which exclude Dehesas from subsidies by not considering these as pastures for livestock (Caraveli, 2000; Plieninger, 2006).
  - Abandonment of farming practices resulting in complex transformations related to: i) agro-ecological degradation through the simplification of forage and pasture practices; ii) economic restructuring, reflected by a high opportunity cost for all assets devoted to farming; and iii) social recomposition, evidenced by a changing role of extensive farming and mountain areas as a marginalized space with a lack of empowerment and social-economic perspective by institutions (López-i-Gelats, 2013).
  - Agroforestry has often been marginalized in EU as the administrative structures within national governments have only considered as legitimate forestry or agriculture. Furthermore, agroforestry falls between the EU definitions of forestry and agriculture impoverishing agroforestry systems (Rigueir-Rodríguez et al., 2009).
  - Rural areas, such as the Pallars Sobirà, are increasingly oriented towards tourism and hence the tertiarization of the rural economies. This can contribute to the simplification of farm management or its abandonment (López-i-Gelats, Milán, & Bartolomé, 2011).

- **Challenges with regards to the economic viability:**

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1. Nature contribution to people allows to identify services provided by ecosystems for society and is the common framework used by the IPBES where it has been used to assess worldwide state of biodiversity. Consequently it is an ideal approach for the present study.
Due to increasing farm input costs and labor costs with constant or decreasing meat and dairy product prices the gross margin of farms decreased to the point that some farms are only viable through subsidies (Bernués, Ruiz, Olaizola, Villalba, & Casasús, 2011). This combined with a lack of generational turnover and the ageing of pastoralists (Aldanondo-Ochoa et al. 2007) threatens their socio-economic continuity of traditional farming into more profitable intensive agriculture which is provoking the loss of the associated biodiversity. This process of intensification can as well reduce the resilience of agricultural systems, and adaptation to external and internal drivers and cause instability and increase the risk of collapse of the entire extensive agricultural system.

As a consequence of the increasing pressures on extensive farming a simplification of the management systems traditionally found has occurred which threatens their subsistence and hence the goods and services they provide to society (Dong et al., 2011; López-i-Gelats et al., 2011). During the last few decades, many extensive farms have been lost due to the aforementioned drivers which have led to land abandonment, depopulation or intensification of former extensive agricultural systems. To overcome this vulnerability it is crucial for farms to adapt, combine experiences and knowledge, innovate and adjust responses and institutions to change. These properties are often stored in Traditional Ecological Knowledge (TEK).

TEK is regarded as the cumulative knowledge, practices and beliefs that evolve through adaptive processes and is handed down through generations. TEK can include different levels of analysis such as local knowledge of animals, land and resource management systems, social institutions and a particular world view. TEK is fundamental to promote adaptation for rural communities and contributes to sustaining biodiversity and ecosystems services, hence contributing to sustainable pathways. TEK is a crucial component of adaptation, and skills, knowledge and learning pathways are often dependent on a small geographical context. In short, as TEK is the result of the coevolution of social and ecological systems, TEK can increase the ability of communities to deal with disturbances while securing ecosystem services under conditions of uncertainty and change. To stop the loss of these valuable practices, it is imperative to enhance the knowledge of linkages between biodiversity and agricultural practices that maintain them.

Within this framework, the objective of this study was to address the nature of the relationship between cultural practices and biodiversity. This study focused on the drivers and trends that are influencing cultural practices in order to contribute to understanding the mechanisms to stop the loss of these valuable practices. Through that, it aimed to enhance the knowledge on linkages between biodiversity and agricultural practices that maintain extensive agricultural systems. In the study several case study regions have been assessed based on an initial sample of case study locations provided by IUCN: Al Shouf (Lebanon), Lemnos (Greece), High Atlas (Morocco), Deheasas/Montados (Spain/Portugal) and Menorca (Spain) and a subsequent literature review and snow-ball interview process.

The study was financed by IUCN through a terms of reference under the umbrella of the MAVA foundation.

In the following sections this study will present the methodology describing how a literature review and an interview process has been carried out while ensuring cross-referencing. After that the main results of the study are described. This is followed by a brief discussion, recommendations and future steps. Finally the cited references and annexes are listed.
2. Methodological Approach to explore the link between agricultural practices and biodiversity

The relationship and feedback loops between biodiversity and cultural practices was assessed based on a literature review and semi-structured interviews of local experts (Figure 2). To achieve this, extensive agriculture, pastoralism and silvicultural practices have been defined based on reports and peer-reviewed articles.

Figure 2. Methodology overview. Description of the main methodological steps of the literature review and interview process.

2.1. Literature review

To obtain the data necessary to achieve and expand on the knowledge of cultural practices and biodiversity in the Mediterranean, Figure 3 gives a schematic overview of the literature review process that was followed:

Figure 3. Literature review process

To gather the information key publications have been collected from peer-reviewed journals available through Scopus (using a search string) and expert recommendation. After the identification of the information and information gaps from the initial 136 collected articles, 26 have been analyzed once excluded those without feedback loop between cultural practices
and NCP’s, reviews, and meta-analysis. Then the information was collected and cataloged across 8 categories: country, region, taxonomic groups, NCPs (18 subgroups), specific cultural practices, drivers of cultural loss and trend direction (see annex 1). The last step of the literature review process consisted in the quantitative descriptive analysis of the information collected. For a detailed description of the literature review methodology see annex 2.

2.2. Interviews

Interview process
To achieve and expand the knowledge of cultural practices and biodiversity in the Mediterranean and gain a complementary view upon the findings of the literature review, the process depicted in figure 4 was undertaken:

![Figure 4. Interview process](image)

First interviews were defined based on the five project sites of the MAVA funded and IUCN implemented project: Al Shouf (Lebanon), Lemnos (Greece), High Atlas (Morocco), Deheasas/Montados (Spain/Portugal) and Menorca (Spain). Then a snow-ball sampling process was undertaken to get a representative view of the nexus between cultural practices and biodiversity in the Mediterranean basin. This process was stopped when information gathered started to be repetitive, or when recommended actors started to repeat. Key informants were always experts of specific regions. Interviews were held after interviewed actors signed a consent sheet to comply with EU legislation on data policy and protection (see annex 3). Interviews followed a semi-structured format (see annex 4). The interviews where then transcribed to then catalogue information into cultural practices, functional ecological group, NCPs, trends or drivers. Through the categorization of data following the standard data format the same data structure as the literature review was ensured, allowing data comparison (figure 5).
Figure 5. Key dimensions of the standard data form. Basic elements are the type of practice, the cultural activity the affected taxonomic group and the trend and the driver of that trend.

The last step of the interview process consisted in the analysis of the information collected using grounded theory (Corbin & Strauss, 1990) based on the initial domains of cultural practices, functional ecological group, NCPs, trends or drivers. To complete the analysis the feedback between literature review and the interviews was ensured that the core information is consistent between sampling methodologies. For a detailed description of the interview methodology see annex 5.
3. Results and analysis of the literature and interview process. Evidences of cultural practices and biodiversity links

3.1. Literature review

The case studies analyzed within the literature were found not to be evenly distributed geographically. European Mediterranean countries represented the majority of cases found (figure 6). A possible explanation for that is that European countries are much more studied than non-European countries. The limitation to English and peer-reviewed studies can be a factor that also contributes to this overrepresentation of European case studies.

<table>
<thead>
<tr>
<th>CASE STUDY LOCATION</th>
<th>NO OF CASES</th>
<th>PERCENTAGE</th>
</tr>
</thead>
<tbody>
<tr>
<td>ITALY</td>
<td>10</td>
<td>38</td>
</tr>
<tr>
<td>SPAIN</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>GREECE</td>
<td>4</td>
<td>15</td>
</tr>
<tr>
<td>FRANCE</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>MOROCCO</td>
<td>2</td>
<td>8</td>
</tr>
<tr>
<td>PORTUGAL</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>TURKEY</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL</td>
<td>26</td>
<td>100</td>
</tr>
</tbody>
</table>

Figure 6. Case studies of the literature review, an overview. The number of studies their percentage and distribution is depicted.

There were many different types of agricultural systems found in the literature review, but the most common systems identified were agrosilvopastoralism, silvopastoralism and others (other refers to agriculture which has not been specifically defined but is referred to as traditional or extensive) (figure 7).
The main biodiversity elements related to extensive agriculture in the Mediterranean basin can be classified into flora and fauna. Most studies were focused on livestock diversity of sheep, goat and cows and its socio-ecologic relevance. This is not surprising as sheep and goat are the traditional livestock species used in extensive pastoral systems in the Mediterranean basin. (figure 8)
Interestingly, only 11 out of the 26 papers (less than half) that were analysed have undertaken field work to assess the biodiversity. The studies that have undertaken the field work are found in Italy, Spain, and one study respectively in France and Portugal. Of these, studies, 7 analyse plant diversity (of which 3 are ethnobotanical studies), 2 analyse a combination of plant and other taxonomic groups, such as insects or birds while one study analyses amphibians and another soil biodiversity. Furthermore, only 2 out of the 13 studies undertaking an explicit socio-ecological approach use field work. The remaining papers are in their vast majority related to landscape diversity and are studied using a combination of GIS data and socio-economic information. The studies that analyse biodiversity without field work are mainly found in Italy, Greece and Spain, and to a lesser extent in France, Morocco or Turkey.

The feedback loop found between cultural practices and biodiversity in extensive agriculture was best expressed in the NCP’s habitat creation and maintenance, supporting identities, and learning and inspiration (figure 9).

The most important drivers of cultural loss are seen to be socio-demographic with ageing, depopulation and land-abandonment are seen as the most important drivers of cultural loss found in the literature (figure 10). Cultural practices are being slowly lost as an ageing population and depopulation stop the creation and transfer of TEK. While our results cannot show one example of an increase in cultural practices, it consistently shows a clear picture of industrialization and urbanization processes combining with depopulation and an ageing
agricultural community to undercut the cultural values, traditional knowledge and sense of identity once held in all the regions studied.

![Bar chart showing major drivers of cultural practice loss](chart.png)

**Figure 10. Major drivers of cultural practice loss.** The most important drivers of cultural practice loss stated in case studies is depicted.

3.2. **Interviews**

The objective of the interview process was to complement the information gained in the literature review and deepen into the knowledge of particular connections between cultural practices and biodiversity in specific Mediterranean regions. Based on snowball sampling a total of nine case studies were analyzed (figure 11). These were distributed across Spain and Portugal (4 case studies) with one shared case (Dehesas/Montados), Morocco (2 case studies), Italy (1 case study), Greece (1 Case study) and Lebanon (1 case study).

![Map showing interview case study distribution](map.png)

**Figure 11. Interview case study distribution.** Map of the distribution of interview case studies. Italy (1 case study), Morocco (2 case studies), Spain and Portugal (4 case studies) with one shared case (Dehesas/Montados), Greece (1 Case study) and Lebanon (1 case study).
1. Italy – Levante Liguria: pastoral system based on the autochthonous cattle breed Cabanina and its particular management.
5. Spain – Menorca: rotational livestock management of autochthonous cattle breed and traditional agriculture of olive and wine orchards surrounded by dry stone walls.
7. Spain and Portugal – Dehesas/Montados: agrosilvopastoral system based on the interaction of pasture with livestock and trees and its co-evolution to local socio-economic conditions.
9. Lebanon – Al Shouf: pastoral system with ancient governance system and diverse a large agricultural diversity.

The analyzed extensive agricultural systems are characterized by the combination of agricultural practices and pastoralism in the same or different land bases. This contributes to the creation of specific Mediterranean cultural landscapes and its associated biodiversity.

The distinct characteristic of the Italian case study is its local breed and management, while for the Moroccan cases the particularity is the traditional governance system. In Sierra Nevada transhumance is the most distinguishable practice. Menorca on the contrary is unique due to its landscape mosaic and the relevance of dry stone walls. The extensive goat system of the Central System in Spain is characterized by the prevalence of transtermitance and the relevance of the synchronization between pastoralism, crop cultivation and rotation, and browsing in shrublands or forests. Dehesas and Montados are distinguished by the interaction between livestock with pastures and trees to create a savanna like ecosystem. In Lemnos, Mandras are unique and the central element of agropastoral activity. Finally, in Al Shouf, the combination of ancient governance and crop diversity distinguishes it from the other case study region. All case studies are facing a negative or very negative trend with the exception to Menorca where the trend is positive.

In short, a large diversity of agricultural and pastoral systems is central for the maintenance of biodiversity. However these are in its majority under threat due to multiple negative drivers. The following sub-sections elaborate in detail the description of each of the selected case studies. Additionally, each sub-section entails an overview figure of the main highlights of the case studies.
The region of Liguria is characterized by an abrupt topography with mountainous regions that extend to the Mediterranean Sea in which agricultural mechanization of many land areas is extremely difficult. The extensive agricultural practice that is characteristic of the region is agrosilvopastoralism. According to the interviews, this system is characterized by the presence of the *Cabanina* cattle breed which formerly was of great socio-economic importance in the region with more than 20,000 animals which suffered a dramatic decline of almost 100% where nowadays there are approximately 1500 animals. Through the interview process it emerged that this breed is famous for producing a local cheese called *U Cabanin* and formerly was a crucial element for food security in the region. The landscape management and creation of a cultural landscape through this species is characteristic as the *Cabanina* cattle is present in the mountainous region until reaching an age of 6 years. After the age of 6 years the cattle are driven to the coastal area. Of crucial importance, is that the *Cabanina* cattle are able to digest lignin and hence are able to maintain grasslands intact and avoid secondary succession, thereby increasing landscape heterogeneity and biodiversity. The cultural landscape of the Levante region of Liguria is also well characterized by dry stone wall structures which contribute to biodiversity as they constitute a refugia for small mammals and are a natural habitat for insects and reptiles. These dry-stone walls are an important element for the functionality of the agrosilvopastoral systems as they avoid erosion and increase water infiltration. However, these structures are currently being abandoned and afforestation is taking place. This abandonment in turn can have negative effects for biodiversity and increase hazards such as flooding. Within this system it is characteristic to find planted alder trees to increase nitrogen fixation for small gardens and orchards. Finally, traditionally the system was characterized by the traditional silvicultural management of chestnut forests which consisted of favoring chestnuts in detriment to other tree species increasing the landscape heterogeneity. Chestnuts were collected to produce flour to bake bread in a traditional and artisanal way.

The interviewed expert stated that this traditional system is nowadays facing several threats such as demographic processes of migration of local population to coastal areas and an increased age structure of the rural areas. This rural system also lacks adequate governance systems which can train young people that are willing to enter the agricultural sector. Another important governance aspect is the increased vision of urban society of wilderness which is contrary to the traditional agrosilvopastoral management of the cultural landscape in a system which is already facing problems due to wild ungulates. Simultaneously processes of industrialization and tourism are transforming the socio-economic structure of the region. All
this is contributing to land abandonment which can contribute negatively to biodiversity. However, SlowFood\(^2\) has recently contributed to the creation of a local association of *Cabannina* cattle breeders and in the last 5 years there has been a positive increasing trend of livestock numbers from 500 to 1500. The trend of this region is uncertain due to the numerous negative pressures the extensive agricultural system is facing, combined with a recent increase in livestock numbers.

This traditional agrosilvopastoral system is also contributing to the creation of several NCP’s such as local food and feed, medicinal, biochemical and genetic diversity, the formation and protection of soils and most importantly the creation and maintenance of habitats. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

**Italy – The Levante region in Liguria: evidences of the nexus between biodiversity and cultural practices**

According to the interviewee the most distinct cultural practice in the Levante region of Liguria is the breeding of the local *Cabannina* cattle breed, which through its capacity to digest lignin and grazing avoids secondary succession and contributes to pasture and landscape diversity. In Liguria the Brigasca sheep and the Vara Valley Black Cock contribute to livestock genetic diversity of the region. In the same line, in the interview it is suspected that a large diversity of local seeds exists which can potentially increase the genetic diversity of horticultural plants. From the silvicultural perspective, the planting of *Alnus glutinosa* contributes to the fixation of nitrogen in the soil and hence increases agricultural productivity while at the same time being an added biodiversity species to the region. The management of competitive trees with *Castanea spp.* has been important to preserve its habitat and pastures associated to it. Finally, through the interview it is suspected that drystone walls are important refugia for insects, reptiles and small mammals. But at the same time drystone walls play a key function to avoid soil erosion, contribute to water retention and increase agricultural land surface. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 2.

**Table 2. Liguria - nexus between biodiversity and cultural practices.** Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for the Levante region in Liguria.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local livestock breeds</td>
<td><em>Cabannina</em></td>
<td><em>Cabannina</em> increase the genetic diversity of cattle breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by Matassino et al (2008) and Ricardo et al (2013)(^3),(^4)</td>
</tr>
</tbody>
</table>

\(^2\) Slow Food is a global, grassroots organization, founded in 1989 to prevent the disappearance of local food cultures and traditions, counteract the rise of fast life and combat people’s dwindling interest in the food they eat, where it comes from and how our food choices affect the world around us.


<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastoralism</td>
<td>Landscape diversity</td>
<td>Pastoralism of Cabannina cattle (able to digest lignin) avoids secondary succession and contributes to landscape heterogeneity and diversity. This is achieved through a local breed with a unique management system.</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Pastoralism</td>
<td>Pastures</td>
<td>Grazing of natural pastures avoids the dominance of certain grass species over others thereby increasing the overall diversity. This is done by a local breed with a unique management system.</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Local livestock breeds</td>
<td>Brigasca sheep</td>
<td>Brigasca sheep increase genetic diversity of sheep breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by Bittante (2011)⁵</td>
</tr>
<tr>
<td>Local livestock breeds</td>
<td>Vara Valley Black Cock</td>
<td>Vara Valley Black Cock increase genetic diversity of cock breeds</td>
<td>Interviewee provided the suggested link. This is supported by SlowFood⁶</td>
</tr>
<tr>
<td>Agro-silvicultural</td>
<td><em>Alnus glutinosa</em></td>
<td><em>Alnus glutinosa</em> was traditionally planted next to gardens for nitrogen fixation and to increase soil fertility and productivity. This increased tree biodiversity</td>
<td>Interviewee provided the suggested link. This is supported by Molinari et al. (2015)⁷</td>
</tr>
<tr>
<td>Silvicultural management</td>
<td><em>Castanea spp.</em></td>
<td>Competing trees with <em>Castanea spp.</em> were cut to secure the preservation of <em>Castanea spp.</em> The flour is used in traditional dishes as well as associated pastures to <em>Castanea spp.</em></td>
<td>Interviewee provided the suggested link. This is supported by Sebastiani et al. (2009)⁸</td>
</tr>
<tr>
<td>Local seeds</td>
<td>Horticultural diversity</td>
<td>Preservation and planting of local seeds can preserve genetic diversity of agricultural production plants</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

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<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drystone walls</td>
<td>Insect, reptile and mammal diversity</td>
<td>Drystone walls constitute a natural refuge for insects, reptiles and some mammals and thus enhancing biodiversity. Drystone walls have important roles for water retention and help to improve soil erosion</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>
### Morocco – Anti-atlas Réserve de biosphère de l’arganeraie

| Agricultural practice | The silviculture is the center of the system. Argan forests are managed through a traditional governance system called Agdals with rules and norms to secure livelihoods. The system through its norms and rules preserves biodiversity. The co-evolution of nature and cultural practices have increased the resilience of the system. |
| Trend | **Negative trend** |
| • Lack of appropriate institutional national support |
| • Decreasing generational takeover |
| • Migration processes |
| Highlights | **The system is in a process of transformation** |
| • Resilient system at local scale to external drivers |
| • Flexible governance system with a co-evolution between the natural and social system. |

In the Réserve de biosphère de l’arganeraie there is large heterogeneity of the socio-ecological system which sits at the distributional limit of the trees at the edge of the Sahara dessert. According to the interviewed expert, the characteristic feature of this Mediterranean landscape is the argan forest and its traditional communal governance management. The traditional and principal product extracted from this agrosilvopastoral system is the argan fruit which is used in multiple ways. The management of the system follows the agdal communal governance. This governance system possesses concrete rules and norms to secure the productivity of the system. Examples of the management rules prohibits entry into the agdal when the argan tree is flowering. Once the argan fruits fall from the tree access is granted to collect the fruits. This practice is traditionally carried out by woman. After the fruits are collected, the tree climbing goats are then given access. As a byproduct of this multifunctional management, biodiversity is assured at the flora and fauna level. For example, the agran trees have an associated biodiversity and can potentially contribute to a larger diversity of wild bees as the argan trees flowers later in the season when many other floral resources have overcome the phenological flowering phase. Traditionally, woman collect aromatic and edible herbs and grasses within this system. Where private land is present, hedgerows of dry shrubs denote land tenure and consequently can potentially be a habitat for local reptiles.

As could be derived from the interviews, currently, the agdal system and the argan trees are in a process of transformation in which there are regions with a positive trend as well as regions with a negative trend. The principal drivers for this are attributed to the demographic processes of migration which took place in the last third of the XX century and have degraded the governance system. According to the interviewed actor, an increasing proportion of people prefer to live in peri-urban areas as working conditions in the traditional system are harsh. However, there are locals which emigrated and now are returning and have little traditional knowledge are claiming land tenure rights and sometimes bring new agricultural management systems into the agdal which are not adapted to the needs of the current system threatening its existence. An incentive for people which are returning to the region is the increasing marked boom of argan products such as argan oil, argan soap or food products with argan as a basic ingredient. However this market could in the near future reach saturation in its growth. Added to that is the increasing problem of large camel herds which disrupt argan fruit production and thus the subsistence of the traditional system and its governance. This has subsequently led to human fatalities. Other drivers in the region is the increasing willingness of parents to school their children which could potentially reduce the knowledge transfer. The schooling of children
has caused a decreased availability of herdsmen as traditionally this was a task used to be carried out by children whereas nowadays herdsmen carry out this task who require salaries. This system has in general terms a negative trend regarding its persistence due to the cumulative effect of all negative which hamper the system and degrade its functioning.

Despite the aforementioned situation, in recent years, the Amassing and Berber people are increasingly reclaiming their cultural and language rights which has some positive effects but some negative impacts as well on the argan silvopastoral system. A positive trend in the region is the occurrence of successful agdals where a recovery of traditional practices is incentivized by NGOs and national and international organizations. A particular important characteristic of the system is its capacity to adapt to local conditions making the system resilient and in a continuous process of transformation.

This traditional agricultural system contributes substantially to the production of NCP’s as it supports identities, creates food and feed, while creating medicinal, biochemical and genetic diversity as well as contributing to pollination and habitat creation. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Morocco – Anti-Atlas Réserve de biosphère de l’arganeraie: evidences of the nexus between biodiversity and cultural practices

Through the interviews specific links between biodiversity and cultural practices have been suggested. Most importantly the local experts have highlighted that fact that the traditional Agdal communal governance prohibitions can contribute to preserve wild pollinators, pasture and shrub diversity as well as the subsistence of *Argania spinosa* as long as overstocking is avoided. It was also suggested that *Argania spinosa* has a particular flora associated to it and thus its habitat is only preserved when governance rules and mechanisms are functioning (i.e. goats are not allowed to browse *Argania spinosa* until fruits have been collected). The goats grazing and browsing in Argan forests are from the local livestock breed called “haha”. This local livestock breed adds genetic diversity to the goat species and is adapted to the local environment. The local expert highlighted how dry shrub hedgerows are used to separate private land property and that this can be a favorable habitat for snakes. Finally, the collection of aromatic, edible and medicinal plants can have an indirect link to biodiversity however, how this can operate is not very clear. A possible mechanism could be the ancestral nurturing of these plants which in some cases have naturalized. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 3.
Table 3. Anti-atlas Réserve de biosphère de l'arganeraie - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for the Anti-atlas Réserve de biosphère de l'arganeraie.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agdal communal governance with norms and rules: prohibits access during the flowering season</td>
<td>Wild pollinators</td>
<td>Tree flowering phenology is posterior to pasture phenology which can potentially ensure nutrients for wild pollinators</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Agdal communal governance with norms and rules: prohibition of access to livestock until Argan fruits are collected</td>
<td>Pasture and shrubs</td>
<td>If overstocking is avoided, grazing and browsing can contribute to a higher heterogeneity of pastures and shrubs avoiding the dominance of a few dominant species</td>
<td>Interviewee provided the suggested link. This is supported by Domínguez (2019)⁹</td>
</tr>
<tr>
<td>Agdal communal governance with norms and rules: prohibition of access to livestock until Argan fruits are collected</td>
<td>Argania spinosa</td>
<td>If browsing intensity on Argania spinosa is kept moderate the competition of the phenology of the tree is ensured</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Silvicultural management of Argan trees through governance norms and rules</td>
<td>Plant diversity</td>
<td>Through the adequate management of Argania spinosa and if overexploitation is avoided, Argan trees provide habitats for herbs and annual plants</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Local livestock breeds</td>
<td>Goats</td>
<td>&quot;Haha&quot; goats increase genetic diversity of goat breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by Aïch et al. (2008)¹⁰</td>
</tr>
<tr>
<td>Dry hedgerow maintenance</td>
<td>Snakes</td>
<td>Dry hedgerows are used to separate land tenure and contribute to a habitat for reptiles such as snakes</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>


<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant collection</td>
<td>Plant diversity</td>
<td>Nurturing and adequate collection of plants as food or for medicinal purposes could ensure their naturalisation</td>
<td>Interviewee provided the suggested link. This is supported by Teixidor-Toneu et al. (2016) \textsuperscript{11}</td>
</tr>
</tbody>
</table>

The areas of Ait M’hamed, Imegdale and Oukeimden have been assessed during the interview process. Pastoral activities in high mountain altitudes take place mainly in degraded shrubland and meadows while in Imegdale they occur in degraded forested areas. Different Amazigh tribes live in these areas, belonging to different clans.

In the interview, it has been stated that the extensive agricultural practice that dominates is pastoralism with different kinds of rights of usage (including agdals) followed by small-scale traditional agriculture (valleys) with different degrees of intensification and transformation. The most common livestock found are goats and sheep, followed by cows. Camels are present in some family groups, especially those semi-nomadic from the south. Local varieties of goats and sheep are being substituted by more productive breeds but less adapted to the local topography. Within the system different activities occur simultaneously, for example after cereal collection, animals feed on the terraces or collection by woman of medicinal and aromatic plants for sale occurs.

According to the interviewed expert view, within the traditional agricultural system many cultural practices persist. A paradigmatic example are the different types of prohibitions and restrictions from tagdalt and azzayn to agdals, which allow for critical parts of the life cycles of plants (and associated fauna) to be respected and can enhance biodiversity at all trophic levels. This in turn contributes to the maintenance of the landscape mosaic and is even enhanced between tribe heterogeneity in governance mechanisms. Local institutions and actors contribute to the multifunctional governance of the system by managing different resources such as water, pasture or seeds.

This is a central element for the preservation of the local biocultural diversity. For example, water ditches allow the growth of edible and ruderal plants which are collected by woman. Nomadism with adequate stocking rates can have an important function for biodiversity in their routes. Within this multifunctional system medicinal and edible plant collection has the role for livelihood subsistence and can have a potential positive effect on biodiversity.

This traditional and highly valuable system is in a slow but constant process of abandonment of extensive pastoral activity, mainly due to population increase, sedentarization, a
diversification of the economy and greater dependence upon urban centers. According to the interview analysis, negative drivers can be grouped into governance weakness, unsuitable policies, climate constrains, agricultural intensification, market pressure and demographic processes. Governance weakness has multiple causes as agdals systems are contested systems with conflicts over water and land access that can lead to privatization if it is not adequately managed. Sedentarization is increasing in the former nomadic tribes where children are also now going to school. The schooling of children is taking a traditional work force away from the system. Children through school gain other aspirations through schooling which is to a certain degree impeding cultural transmission. Another element which is weakening traditional institutional systems are changes in religious cosmovision are affecting traditional governance belief structures of Berbers. Added to the governance problems, policy elements such as land privatization, incentives of commercial seeds and top-down implemented associations are impacting negatively upon the pastoral system and its associated biodiversity. There is a feedback between market pressure and agricultural intensification as the market incentives sedentarization and hence intensive agriculture is perceived as a more stable economic activity. In parallel to that land abandonment takes place due to the migration towards cities. Climate change is impacting upon the system through increasing droughts. In Ait H’Amed the negative trends have increased conflict in the area. The general trend of the region is negative because of the summed effect of many individual negative drivers.

Despite these negative drivers, according to the interviewed expert, some positive elements can be highlighted such as an incipient revalorization of local livestock breeds as they require fewer external inputs, the resilience of the system to the top-down implementation of associations by the government and that traditional knowledge even if it is somewhat reduced is still being transferred through the generations. This system contributes to the maintenance of important NCP’s such as habitat maintenance, the formation and protection of soils, providing local food and feed and these tribal systems can contribute to the creation of a self-identity. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Morocco – High Atlas, Ait M’hamed, Imegdale and Oukeimden: evidences of the nexus between biodiversity and cultural practices

The analysis of the interview highlights several relationships between biodiversity and cultural practices in the High Atlas region of Morocco. The most important factors to distinguish amongst in the High Atlas region is the Agdal governance of communal land with specific norms and rules. It was mentioned that by prohibiting access to the Agdals while plants are undergoing the phenological phases of flowering and fructification can secure the reproductive success of these plans while at the same time being an important resource for butterflies and birds (which feed on the butterflies). By providing access to goats after this process it contributes to manure the pastures and enrich the soil. Governance practices of the Agdal systems are locally adapted to the environmental and social context. This according to the interview can contribute to an increased landscape diversity. Regarding agriculture a diversity of practices are highlighted that can have a connection to biodiversity. Therefore, a nexus which is harder to evidence is suspected by the interviewee between edible and medicinal plant collections and plant diversity, as the naturalization of species can make it almost impossible to prove these relationships. Alternatively it is easier to evidence the relationship between water ditches and ruderal and edible plants, where crop rotation can secure soils sustainability or subsistence agriculture contributes to landscape diversity. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 4.
Table 4. High Atlas, Ait M’hamed, Imegdale and Oukeimden - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for the High Atlas, Ait M’hamed, Imegdale and Oukeimden.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agdal governance norms and rules:</td>
<td>Plant, butterfly and</td>
<td>Securing the phenological phases of flowering and fructification can potentially allow the</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>inhibition of access during the</td>
<td>bird diversity</td>
<td>reproductive success for plants and serve as nutrient for butterflies which in turn can be a</td>
<td></td>
</tr>
<tr>
<td>flowering season</td>
<td></td>
<td>prey for bird. Manure of goats then feedback into the soil ecosystem.</td>
<td></td>
</tr>
<tr>
<td>Agdal governance norms and rules:</td>
<td>Landscape diversity</td>
<td>Norms and rules of Agdal governance mechanisms are adapted in each Tribe to local conditions</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>local adaptation</td>
<td></td>
<td>potentially increasing landscape heterogeneity</td>
<td></td>
</tr>
<tr>
<td>Plant collection</td>
<td>Plant diversity</td>
<td>Collection of edible, medicinal and aromatic plants can potentially favor biodiversity if</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Water ditches used under Agdal</td>
<td>Edible and ruderal plants</td>
<td>intensity is not too high and when a process of nurturing or naturalization takes place.</td>
<td></td>
</tr>
<tr>
<td>Water ditches under Agdal governance</td>
<td></td>
<td>Water ditches which are not impermeable are natural habitats for ruderal and edible plants</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Crop rotation</td>
<td>Soil biodiversity</td>
<td>Rotation of crops and norms and rules that avoid overstocking can prevent a loss of soil</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Traditional subsistence agriculture</td>
<td>Landscape heterogeneity</td>
<td>Traditional agriculture such as potatoes, onions or edible plants add landscape diversity to the region</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>
Spain – Sierra Nevada – The villages of Santiago de la Espada, Pontones and Castril

The three villages are traditional ancient pastoral villages where the presence of the local Segureña sheep breeds dominates over goats, cattle and horses. According to the interviewed expert, in the region approximately 200 shepherds persist. The pastoral activity takes place in Dehesas dominated by pine trees and agricultural lands at heights of up to 1,600m. Within this system there are pastoral governance institutions with specific norms and rules for the access of high mountain pastoral lands and Dehesas boyales. Concrete examples of the governance rules are access dates and stocking rates. The governance structure has been handed down for centuries through the generations and thus it is currently linked to the social community imaginary of a contested pastoral system. From an anthropological perspective pastoralist see themselves reinforced by religion (belief structures) around romerías, Virgen de Fatima and Easter amongst others, which contributes to the retention of local identity and through the activities such as pastoralism, it preserves the traditional lifestyle and thus the associated benefits for biodiversity. For example, a plant formerly used against witches by religious orders of Santiago de Compostela who occupied the region, has currently evolved as a plant used to bring "good luck" distributing this species beyond its biogeographic domain. Within the system activities of plant collection, dry-stone walls and irrigation ditches management are present and contribute positively to local biodiversity through the creation of grasslands and habitats for amphibians in the irrigation diches. Transhumance takes place from Santiago de la Espada, Pontones and Castril to Sierra Morena characterized by a milder climate and pasture availability during winter. Pastoralist gather from the Mountains of Segura, Santiago de la Espada, Pontones and Castril. All these aforementioned activities create a characteristic Mediterranean cultural landscape which is a heritage of pastoral activity and is an important element for local biodiversity. For instance, the transhumant activity is an important vector for seed dispersal.

In the region significant negative drivers exist as stated by the interviewee. Important factors include governance weakness and the lack of adequate policies. In the view of the interviews, in the region for example there is a significant lack of services and infrastructure for pastoral activity which is an added burden in a region in which little care is taken by government structures over pastoralism in a region with a very high unemployment rate which creates a depressive atmosphere. An example given by the interviewees to highlight the lack of support is the periodization of environmental elements over pastoralist to preserve nature when ecosystems have been co-created by nature-human interactions. In the same line, health
inspections dedicate little attention to pastoral circumstances and needs. From a policy perspective, the CAP has favored intensive agriculture, subsidies are delayed which creates a vicious cycle of debt. Furthermore, the interviews mention that there is a lack of a specifically targeted policies for pastoralism at European and Spanish level. Added to that they mention that pastoral governance systems dedicated formerly exclusively to pastoral land management are now largely dedicated to splitting subsidies between herdsmen who have access to communal land. Simultaneously agricultural intensification is taking place in lowlands towards which the population is slowly but constantly migrating. This in turn decreases the intergenerational turnover of pastoral activity. Due to all these drivers the general trend of the system is negative.

In spite of these negative aspects, positive drivers include the appreciation for the Segureña breed and the presence of the association of the Segureña sheep called ANCOS. Authorities and natural park managers are slowly starting to understand the importance of pastoralism for nature conservation in the region. The pastoral system of the region has an important contribution to NCP’s by supporting the creation of local identity, creating a positive cognitive and physiological benefits due to nature experience for tourism while increasing medicinal, biochemical and genetic diversity through local breeds. This socio-ecological system creates and maintains habitats which otherwise would not exist such as for example dry-stone walls which create pasture for livestock and simultaneously forms and protects the soil. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Spain – Sierra Nevada – The villages of Santiago de la Espada, Pontones and Castril: evidences of the nexus between biodiversity and cultural practices

In the region of Santiago de la Espada, Pontones and Castril livestock herding is the main activity which according to the expert interviewed is providing important contributions to biodiversity. Specially as it maintains landscape diversity by avoiding secondary succession and hence maintaining habitats. In this line pastoralism under pine forests according to the interview could contribute to maintain pollinator diversity and plant diversity by avoiding secondary succession of the pine forest. Likewise, the communal pastoral governance norms and rules can contribute to avoid overstocking in alpine pastures, while at the same time it can avoid secondary succession. The principal livestock breed in the region is the Segureña Sheep which increases the overall genetic diversity of sheep. Transhumance, according to the interviewee, can have an important function for seed dispersal and hence contribute to genetic plant diversity. Other secondary elements of the livestock system such as drystone walls can potentially contribute to the creation of natural pastures through soil retention and water ditches creating a potentially important habitat for amphibians. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 5.
### Table 5. Sierra Nevada – The villages of Santiago de la Espada, Pontones and Castril - nexus between biodiversity and cultural practices.

Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for the Sierra Nevada – The villages of Santiago de la Espada, Pontones and Castril.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Religious beliefs: Romerías, Virgen de Fatima</td>
<td>Landscape diversity</td>
<td>Belief structures can contribute indirectly, to a certain extent, to biodiversity by contributing to sustaining a traditional pastoral society (identity) which supports a certain landscape heterogeneity</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Plant collection</td>
<td>Plant diversity</td>
<td>Ethnobotanical plant use (to “prevent bad luck”) has naturalized plant species that otherwise would not be present in the territory</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Pastoral governance norms and rules: livestock numbers assigned to each stockman</td>
<td>Plant diversity</td>
<td>Adequate stocking rates can contribute to increased plant diversity by avoiding secondary succession and dominance of certain plant species</td>
<td>Interviewee provided the suggested link. This is supported by Sanosa i Cols (2017) and Peña (2019)12,13</td>
</tr>
<tr>
<td>Pastoralism under pine forest</td>
<td>Plants and pollinators</td>
<td>Grazing and browsing of livestock in pine forests contribute to create heterogeneity within forests</td>
<td>Interviewee proposes relationship and currently under study</td>
</tr>
<tr>
<td>Pastoralism</td>
<td>Landscape diversity</td>
<td>Grazing and browsing of livestock creates a heterogeneous landscape which is characteristic of alpine landscapes in Sierra Nevada and a cultural element</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Segureña sheep</td>
<td>Segureña sheep increase genetic diversity of sheep breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by the toros bravos web site14</td>
</tr>
<tr>
<td>Bull fighting tradition</td>
<td>Spanish Bull Fighting</td>
<td>Extensive tradition of bull fighting which adds livestock diversity and is culturally imbedded in the region. The presence of bulls in the region is strange as natural conditions are not optimal but cultural factors have contributed to their presence.</td>
<td>Interviewee provided the suggested link. This is supported by García-Fernández et al. (2019)15</td>
</tr>
</tbody>
</table>

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12 Pau Sanosa i Cols. 2017. Decisiones y cosmovisiones. Entre la gobernanza ambiental y la dimensión simbólica. TFM. UAB.
13 Adrià Peña Enguix. 2019. la gobernanza de sistemas comunales el comunal pastoril de Castril de la Peña. TFM. UAB
14 http://www.ancos.org/
15 https://torosbravos.es/loro/origenes/
# Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transhumance</td>
<td>Plant diversity</td>
<td>Takes place in the Sierra Morena with milder climatic and greater pasture availability. Through this process plant seeds are dispersed.</td>
<td>Interviewee provided the suggested link. This is supported by García-Fernández et al. (2019) and Manzano et al (2006).</td>
</tr>
<tr>
<td>Drystone walls</td>
<td>Natural grasslands and landscape diversity</td>
<td>Dry stone walls contribute to soil retention and to the creation of natural grasslands and hence an increased landscape diversity</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Water ditches</td>
<td>Amphibians</td>
<td>Irrigation ditches can harbour an associated amphibian fauna</td>
<td>Interviewee provided the suggested link. This is supported by Gozález (2014).</td>
</tr>
</tbody>
</table>

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Spain – Menorca

Menorca is an island in the Mediterranean Sea characterized by its extensive agriculture production of wine and olive, and agropastoral management by the Menorcan local breeds of cattle and sheep. The formerly existing intensive system of cattle breeding for the local production of cheese is being transformed to an extensive meat-based system. Currently, the agropastoral system is characterized by rotational cultivation of crops and rotational grazing of cattle. This increases local plant diversity and allows the natural recovery of soils as well as increasing the insect diversity through cattle manure. This activity creates a cultural landscape which is characteristic of Menorca. Important for the livestock system are the subterranean water tanks which were dug with little mechanization up until 1950. These structures are important for drinking water for livestock and wildlife. The agricultural activities which are taking place in Menorca are mainly olive tree plantation and wine plantations which have an increasing trend due to the interest in its ecological and traditional management by foreign and new land owners. Likewise, fig trees are being recovered due to their increased marked value. The agricultural and agropastoral activities create a heterogeneous landscape of forest, agriculture and livestock which reduces the risk of pests. Central to the extensive agricultural and agropastoral activities are the dry-stone walls which not only crucial to the animal management or shelter for the fig trees, but are equally important habitats for small mammals, reptiles and insects.

The Menorcan extensive primary sector is facing negative drivers such as unsuitable CAP policies which favor intensive agriculture over extensive agriculture and some exploitations are opting for intensification to increase economic returns. Increasing changes in the rainfall regime are impacting negatively upon wine production. Despite these negative factors in Menorca a series of positive drivers are observed. Intensive milk production has decreased since 1980 due to decreasing milk prices. The local administration is trying to incentivize traditional practices by subsiding the recovery of subterranean water tanks, dry stone walls and the pruning of small forest structures. In Menorca generally the extensive agriculture sector is producing products with an added value rather than intensifying production. Because of these drivers Menorca has a general positive trend in the activity of extensive agriculture.

Menorcan extensive agricultural systems deliver important NCP’s as a medicinal, biochemical and genetic diversity of local breeds, traditional food and feed, regulates detrimental organisms that can cause pests through a heterogeneous landscape. Crop rotation and cattle manure contribute to the formation and protection of soils and an increased potential for pollination.
Finally, this system is central to the creation and maintenance of a highly valuable landscape. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Spain – Menorca: evidences of the nexus between biodiversity and cultural practices

Analysis from the interview shows several relationships between cultural practices and biodiversity in Menorca. The most distinct feature is the increased landscape diversity which is accomplished through the practice of traditional agriculture such as wine or olive tree orchards and its integration with the silvicultural management of small forests and grazing of livestock. Within the agropastoral system, crop rotation contributes to an increased diversity of annual plants while securing soil fertility. The fertility of the soil is assured through the herding (and avoidance of overstocking) of local cattle and sheep breeds that while contributing to insect diversity through manure are in itself a contribution to genetic diversity of livestock. Other secondary elements of the agricultural system are drystone walls which are potential habitats for mammals, reptiles and insects, or subterranean water tanks which during summer are an important source for water for the wild fauna. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 6.

Table 6. Menorca - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for Menorca.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop rotation</td>
<td>Annual plant diversity</td>
<td>Crop rotation which is at the core of traditional agropastoralism contributes to annual plant biodiversity and soil fertility</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Traditional agricultural recovery</td>
<td><em>Ficus carica</em></td>
<td>Fig trees which traditionally have been planted are being recovered due to its market value adding tree diversity to the island</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Traditional agricultural heterogeneity</td>
<td>Agricultural and landscape diversity</td>
<td>Menorca is characterized by a landscape mosaic composed of different agricultural activities (i.e. olive and wine orchards or <em>fabacea</em>) which adds diversity to agriculture and landscape</td>
<td>Interviewee provided the suggested link. This is supported by De Cet et al. (2013) 19</td>
</tr>
<tr>
<td>Pastoralism</td>
<td>Landscape diversity</td>
<td>Pastoral activity contributes to creation of a natural landscape mosaic characteristic of Menorca and avoids secondary succession</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Livestock manure management</td>
<td>Insect diversity</td>
<td>Cattle manure can increase insect diversity while livestock grazes on the pastures</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

## Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local livestock breed</td>
<td>Menorcan Cattle</td>
<td>Menorcan cattle increase genetic diversity of cattle breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by the vaca menorquina Website[^20]</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Menorcan Sheep</td>
<td>Menorcan sheep increase genetic diversity of sheep breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by CAIB[^21]</td>
</tr>
<tr>
<td>Silvicultural forest small forest management</td>
<td>Landscape diversity</td>
<td>Small forest structures shelter cattle during summer heat and contribute to landscape diversity</td>
<td>Interviewee provided the suggested link. This is supported by Biosfera Menorca[^22][^23]</td>
</tr>
<tr>
<td>Subterranean water tanks</td>
<td>Wild fauna</td>
<td>Water tanks have been dug with little mechanization until 1950 approximately. These structures are crucial to water livestock and are an important resource for wild fauna during summer</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Drystone walls</td>
<td>Mammals, reptiles and insects</td>
<td>Dry stone walls are an ecosystem in itself and in Menorca have a size of approximately 12,000 km as they constitute the basic element to separate land structures. They are important to manage livestock and at landscape level constitute a refuge for mammals, reptiles and insects</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

[^20]: http://vacamenorquina.org/
[^21]: https://www.caib.es/sites/racesautoctones/ca/ovella_menorquina-4094/
The interview centered around the Central Spanish System and specifically extensive agrosilvopastoral goat farming. But within the wider landscape, in the lowland Dehesas cattle dominates with the presence of numerous local breeds such as the Aliviñeña Negra, Morucha or fighting bulls. At the hilly mountain slopes, sheep and goat systems become more prominent. Important local goat breeds are the Murciano-granadina and Florida breeds which are livestock for meat production and adapted to the local ecosystem. According to the interviewed actors, the high mountain zones are then characterized by mountain pastures to which transmigrance and transhumance takes place. Pastoralism in natural habitats is the principal cultural element that needs to be protected in the region as this is the basic element that sustains a cultural landscape and is defined by the interviewed actors as a cultural practice in itself. The landscape of the Central System and specifically HNV areas such as alpine pastures and meadows are sustained by pastoralism and are central to biodiversity. Hay meadows were used to feed animals in winter while after mowing, livestock grazed the fields and, through manure, fertilized the fields. This closed the nutrient cycle and increased the overall biodiversity. *Quercus pyrenaica*, ash and chestnut trees have been the central elements to the pastoral systems as pruned materials served as browsing material for livestock while providing wood (i.e. for construction) and fire wood. The associated pastures to these trees provided large productivity and a positive effect on biodiversity. For example ash trees surrounding grassland in the regions between Sierra de Vejar up to Puerto del Pico traditionally were pruned in summer to serve as feed when pastures had low nutritional capacity. Secondary elements of the pastoral system were irrigation ditches in the area of Sierra de Vejar with a pre-Arabic origin. These are traditionally formed by a wide water ditch with lateral exits to flood pasture. This contributed to the high productivity of meadows, fodder for winter and pasture after mowing while sheltering a high biodiversity as for example water ditches are used by trout as breeding areas and are a common habitat for *Salvelinus fontinalis*, *Lacerta schreiberi* and *Triturus pygmaeus*.

Through the interviews it emerged that other important elements for local biodiversity are semi-permanent water ponds which represent an interesting habitat for birds. Of course, insects are abundant in natural grasslands and pastures used in different ways by the livestock. Another secondary characteristic of the systems were dry stone structures as dry-stone walls which are an important habitat for reptiles. However, dry-stone walls are being abandoned because it is a labor and time consuming activity which in a system of decreasing work force is a scarce asset. Characteristic of the system was formerly transhumance which contributed to seed
dispersal, but now transhumance is very rare. Transtermitance is important for the production cycle of cattle, sheep and goats and contributes to seed dispersal and the maintenance of natural high mountain grasslands. For example, the Cattle do not require the continuous presence of herdsman. Cattle go to the mountain pastures during summer until autumn where they feed exclusively on the open pastures. This was traditionally complemented by the goat system of which the flocks stayed in the mountainous system from spring to winter. These goats were traditionally herded and contributed to the generation of pasture for cattle. The overall functioning of this socio-ecosystem with its central activity of grazing and browsing by the different livestock species, contributes to avoidance of secondary succession (shrub encroachment and afforestation) and maintained a landscape mosaic with high biodiversity.

The majority of traditional practices, including herding of goats is in serious decline due to several severe negative drivers. For instance, wild fauna represents an important threat to the domestic livestock as increasing wolf populations can increase conflicts in the area. More over the proliferation of Capra pyrenaica is an important vector for bovine tuberculosis. In fact, health regulations on bovine tuberculosis is causing the shutdown of many farms at Gata, North of Cáceres and partially Sierra Norte Madrid. It constitutes one of the main drivers for the disappearance of extensive livestock systems. Furthermore, health regulations on bovine tuberculosis is disincentivizing the mixt pasture between cattle, goat and sheep. National and international policies (CAP) are designed for intensive production systems and not for extensive pastoral activities and when that is added to the administrations that have not given enough attention to the importance of the disappearance of extensive pastoralism in the region, continuity of the activity is hampered severely. This increasing droughts episodes are reducing the productivity of pastures and increasing the dependence on irrigation. All this combined with market pressure leads to agricultural intensification where possible and the abandonment and migration where intensification is not possible. This abandonment then reduces land access and infrastructure maintenance which brings with it processes of afforestation and increased risks of fire.

The negative trend of this system is seriously compromising the provisioning of NCP’s such as medicinal, biochemical and genetic diversity, the creation and maintenance of important and highly diverse habitats, the production of food and feed and the supporting of the pastoral identity. In fact, the lack of pastoralism is decreasing the capacity of the system to regulate hazards and extreme events and creating and maintaining soils or the dispersion of seeds. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Spain – Central System: evidences of the nexus between biodiversity and cultural practices

Through the interview with local experts it emerged that the principal cultural activity of the region is that of pastoralism. Pastoralism is essential to maintain plant communities in alpine pastures and hay meadows. The maintenance of these landscapes in turn is favorable for bird biodiversity specially in farmland birds. Furthermore grazing and browsing of livestock is important to avoid secondary succession of pastures and thus maintains the landscape diversity. Within this system transtermitance and transhumance are mechanisms that contribute to landscape and plant diversity by maintaining open landscapes and dispersing seeds. Livestock breed diversity in this region is high and thus contributes to the genetic diversity of livestock. Silvicultural management is important to preserve Castanea spp. and Fraxinus spp within the landscape mosaic. Finally, water ditches and ponds are creating habitats for fish, reptiles, amphibians and insects which increases habitat diversity and through that increases species richness in the ecosystem. Each cultural practice, its associated biodiversity element and the evidence is detailed in the following table 7.
Table 7. Central System - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for the Central System.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silvicultural management of <em>Castanea</em> spp.</td>
<td><em>Castanea</em> spp.</td>
<td>Chestnut plantations create landscape mosaic, prevent fire and increase tree biodiversity</td>
<td>Interviewee provided the suggested link. This is supported by Silla et al (2018)²⁴</td>
</tr>
<tr>
<td>Silvicultural management of <em>Fraxinus</em> spp.</td>
<td><em>Fraxinus</em> spp.</td>
<td>Ash trees in the surrounding grassland in regions between Sierra de Vejar up to Puerto del Pico traditionally were pruned and fed when pastures had low nutritional capacity. This contributes to close the natural cycle and adds to tree biodiversity</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Silvicultural management of <em>Quercus pyrenaica</em></td>
<td>Landscape diversity</td>
<td>Pruning, thinning and browsing of <em>Q. pyrenaica</em> contributes to creating a particular landscape element that aids in increasing the overall landscape diversity</td>
<td>Interviewee provided the suggested link. This is supported by Nuñez et al (2012)²⁵</td>
</tr>
<tr>
<td>Pastoralism</td>
<td><em>Nardus stricta</em> communities, hay meadows, alpine pastures</td>
<td>Pastoralism in natural habitats is the principal cultural element to protect. The landscape and specifically HNV areas such as <em>Nardus stricta</em> communities, hay meadows and alpine pastures are sustained by pastoralism.</td>
<td>Interviewee provided the suggested link. This is supported by Bendia et al. (2013) and Reine et al. (2014)²⁶,²⁷</td>
</tr>
<tr>
<td>Pastoralism</td>
<td>Birds (i.e. <em>Turdus</em> philomelos, <em>Coturnix coturnix</em>, <em>Stereoptelia turtur</em>) and insects (i.e. lepidoptera, coleoptera or coprophagous insects)</td>
<td>Birds prey on an increased insect biodiversity (i.e. lepidoptera, coleoptera or coprophagous insects) of natural grasslands flooded by water ditches</td>
<td>Interviewee provided the suggested link. This is supported by Salaverri et al (2019)²⁸</td>
</tr>
</tbody>
</table>

²⁸ Salaverri, Luis; Guiltan, Jos; Munilla, Ignacio; et al. 2019. Bird richness decreases with the abandonment of agriculture in a rural region of SW Europe. Regional Environmental Change. Vol: 19(1). pp: 245-250
<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastoralism</td>
<td>Landscape diversity</td>
<td>Grazing and browsing by the different livestock species contribute to avoid secondary succession and maintain a landscape mosaic</td>
<td>Interviewee provided the suggested link. This is supported by Riedel et al. (2013)&lt;sup&gt;29&lt;/sup&gt;</td>
</tr>
<tr>
<td>Transtermitance</td>
<td>Plant diversity</td>
<td>Short distance movement of livestock to mountain areas in the summer months. Grazing and browsing contributes to sustain habitats such as <em>Nardus stricta</em> communities and alpine pastures. It also contributes to seed dispersal and soil fertility</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Transtermitance</td>
<td>Landscape diversity</td>
<td>Through grazing and browsing livestock avoids secondary succession (i.e. of <em>Cytisus oromediterraneus</em>) thereby increasing landscape diversity</td>
<td>Interviewee provided the suggested link. This is supported by Azcarte et al. (2013)&lt;sup&gt;30&lt;/sup&gt;</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Murciano-Granadina, Florida, Guadarrama and Verata Goat</td>
<td>The Murciano-Granadina, Florida, Guadarrama and Verata goat increase genetic diversity of goat breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by ARCA&lt;sup&gt;31, 32, 33, 34&lt;/sup&gt;</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Alvileña Negra, Morucha and the Spanish Fighting Bull cattle</td>
<td>The Alvileña Negra, Morucha and Spanish Bull Fighting cattle increase genetic diversity of cattle breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by ARCA&lt;sup&gt;35, 36, 37&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>30</sup> Azcarate, Francisco M.; Robleño, Irene; Seoane, Javier; et al. 2013. Drove roads as local biodiversity reservoirs: effects on landscape pattern and plant communities in a Mediterranean region. Applied Vegetation Science. Vol.: 16(3): pp 480-490
## Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water ditches</td>
<td>Salvelinus fontinalis, <em>Triturus pygmaeus</em>, <em>Salamandra salamandra</em>, <em>Scincidae</em>, <em>Lacerta schreiberi</em>, <em>Natrix maura</em>, <em>Natrix natrix</em> and trouts</td>
<td>Water ditches are used by trout as breeding areas and together with associated pastures are common habitats for Salvelinus fontinalis, <em>Salamandra Salamandra</em>, <em>Lacerta schreiberi</em>, <em>Natrix maura</em>, <em>Natrix natrix</em>, <em>Scincidae</em>, <em>Triturus pygmaeus</em>, Odonata</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Semi-permanent water ponds</td>
<td>Birds and reptiles (i.e. <em>Lacerta schreiberi</em>), amphibians and fishes</td>
<td>Important for livestock and habitat for some bird species, reptiles such as <em>Lacerta schreiberi</em>, and for amphibians and fish.</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>
Dehesas and Montados are an extended traditional agrosilvopastoral system widely extended through the whole Iberian Peninsula. According to the interviewed actors, this system is characterised by its multifunctional nature and interaction between livestock, forest and pasture management. Due to its large extent it is very difficult create a general picture of the system. However, in general Dehesas and Montados are characterised by the multifunctional activity of silviculture such as cork harvesting every nine years in many Montados of Portugal or pruning of *Q. ilex* trees. Under the Dehesa trees (which can also be *Q. pyrenaica*, *Castanea* sp. or other species) livestock graze and feed on natural grasslands. On the other hand, in Montados usually grazing under regenerating trees after cork extraction is prohibited. In Dehesas traditionally the so called “redileo” was practiced, which consist of closing the animals into a specific land area during night to shelter them, fertilize naturally the soil and manage the shrubs. This was complemented with the practice of transhumance in summer to high alpine regions in order to guarantee the recovery of soils and its associated flora and fauna. Of course, transhumance and transtermitance had an important effect of seed dispersal. The so called Dehesas boyales are communally owned Dehesas which have rules and norms for its use. These can harbor a higher diversity due to the larger amount of practices taking place within the system.

However, the migration of people and the abandonment of practices in increasing the vulnerability of these systems which in some cases are overexploited or the management has been transferred to the local council.

Through the interviews it emerged that within the Dehesas traditionally crops were planted as fodder for livestock during the winter months. Livestock fed on the acorns of trees to complement its fodder. Traditionally Dehesas were mixed livestock systems which combined sheep with goat and some cattle. However, currently cattle are predominant and sheep presence have decreased while goats have almost completely disappeared. Between the local breeds local cattle breeds such as the Alvileña Negra, Brown Retinta and Blanca Cacereña can be highlighted. The traditional sheep breed is the Merina breed and a local variety can be found, the Black Merina. These breeds are adapted to the local environmental conditions and in general they require fewer external inputs as other livestock breeds. The adaptation of these breeds to the local environment is crucial to maintain the landscape of the Dehesa.
In the interviews it was stated that Dehesa and Montado systems have many important secondary elements which support local biodiversity such as dry stones walls and ponds and wells habitats for birds, reptiles, amphibians and insects. Traditionally within certain regions of the Montado or Dehesa shrub grow and this favors the growth of young trees which is an important habitat for birds. Nowadays, shrub encroachment takes place due to the abandonment or due to the intensification of the activity on smaller land areas.

All these activities create a unique landscape which, from a landscape perspective at first sight, seems homogeneous, but due to the presence of all these cultural practices a large associated biodiversity depends on the multifunctionality of the system. Hence the human-nature interaction which manages livestock, pastures and trees is pivotal for the diversity in this ecosystem which encompasses soil microbiota of plants, birds and livestock species.

Interviewed actors mentioned that Dehesa and Montado systems are facing several negative drivers of which the three most important drivers are: (i) unsuitable policies, (ii) market pressure and (iii) the image media is projecting on intensive agriculture in the region. The CAP has subsidised commercial seeds which has completely dominated local seeds and varieties. Furthermore, CAP has led to the intensification of livestock production on Dehesas and Montados with negative effects for tree regeneration. The market is principally price-oriented disregarding all positive externalities generated by Dehesas and Montados. Market competitiveness has also favored individual perspectives on land management and the abandonment of cooperation and mutual help. This in combination with media which is ill-informing consumers is deeply affecting the Dehesa and Montado continuity. A particular negative driver for cork Dehesas and Montados is Corebus undatus which is an insect nesting in the bark of cork trees reducing their quality and economic revenue. Climate change is also a driver as it negatively affects tree regeneration. These drivers are leading to the abandonment of traditional activities such as transhumance, redileo, directed grazing by a herdsmen or tree pruning. In fact, Dehesas in hilly areas are being completely abandoned. The abandonment also affects the governance systems and degrades the communally owned Dehesas boyales. Due to these negative pressures people have been migrating to cities since the 1960s in Spain to search for other economic opportunities. Due to that there is a general negative trend of the Dehesas in Spain, conversely in Portugal the Montados are on a constant trend.

Some positive effects however have been detailed, such as in Portugal Montado owners are increasingly organising themselves in associations to defend their interests. An at international level associations and scientists are increasingly defending a change of the PAC to recognising its value and importance. Some consumers are also acknowledging local products and some media outlets are slowly recognising the threats that rural depopulation is bringing with it. Finally, and most interestingly, in academia worldwide there is an increasing interest for agroforestry systems and Dehesas and Montados are the role model in Europe.

The recognition of Dehesas and Montados may be due to the numerous NCP’s they provide. Livestock breeds are an important genetic diversity contribution. These systems provide important food and feed for animals and humans. While they of course support a particular identity which is related to a landscape which is enjoyed by society. This enjoyment brings with it physical and psychological experiences and learning and inspiration. The system can be important to prevent hazards such as wild fires while it contributes to the formation of soil and in fact to the creation and maintenance of a whole habitat and characteristic ecosystem. A glossary can be found in the introduction and cross-case comparison can be found in table 1.
Spain and Portugal – Dehesas/Montados: evidences of the nexus between biodiversity and cultural practices

Through the analysis of the interview it has been highlighted that Dehesas and Montados constitute to a unique savanna like ecosystem in the Iberian Peninsula. The principal characteristic of Dehesas are livestock and more recently a large diversity of local livestock breeds exists that add genetic diversity to the general species pool. If overstocking is avoided, the livestock manure can contribute to soil fertility and diversity. This is characteristic of the traditional practice called redileo. Grazing and browsing in Dehesas contributes to maintain an open landscape habitat for bird species. Furthermore, the maintenance of this habitat can contribute to landscape diversity. Livestock practices of transhumance and transtermitance are important to providing a diversity of mountain pastures and the regeneration of Q. ilex. Silvicultural management of Q. ilex and Q. suber are important to maintain the habitat of these species, while shrub management was traditionally used to increase the recruitment of Q. ilex seedlings. Secondary elements of this particular ecosystems such as drystone walls, water ditches and semi-permanent ponds are habitats for birds, reptiles and amphibians. Without these habitats species likely would not be present in the landscape. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 8.

Table 8. Dehesas/Montados - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for Dehesas and Montados.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Redileo</td>
<td>Soil microbiota</td>
<td>Livestock was traditionally closed up during nights at different sites within certain time periods. This was a way to shelter livestock at nights, fertilize soils and control vegetation growth while increasing soil microbiota diversity</td>
<td>Interviewee provided the suggested link and currently under study</td>
</tr>
<tr>
<td>Governance of dehesas boyales</td>
<td>Plant diversity</td>
<td>Dehesas boyales are communally owned and managed under traditional rules and norms. If correctly implemented these rules and norms are important to preserve the activity and to increase the biodiversity due to the heterogeneity of practices</td>
<td>Interviewee provided the suggested link. This is supported by Hernando et al (2010)\textsuperscript{38}</td>
</tr>
<tr>
<td>Crop cultivation</td>
<td>Landscape diversity</td>
<td>Crop cultivation had the traditional function to serve as fodder for livestock, avoid shrub encroachment and hence increase landscape diversity</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

\textsuperscript{38} Hernando, A., Tejera, R., Velázquez, J., Núñez, M.V. 2010. Quantitatively defining the conservation status of Natura 2000 forest habitats and improving management options for enhancing biodiversity. Biodiversity and Conservation 19(8), pp. 2221-2233
<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow cropping in Montados</td>
<td>Soil diversity</td>
<td>Fallow cropping allows soil recovery and can contribute to soil diversity</td>
<td>Interviewee provided the suggested link. This is supported by Barrico et al. (2010)³⁹</td>
</tr>
<tr>
<td>Silvicultural management of Q. <em>ilex</em></td>
<td><em>Q. ilex</em></td>
<td>Pruning and thinning of Q. <em>ilex</em> contributes to ensuring its presence on the landscape</td>
<td>Interviewee provided the suggested link. This is supported by Martín et al. (2015)⁴⁰</td>
</tr>
<tr>
<td>Silvicultural management of Q. <em>suber</em></td>
<td><em>Q. suber</em></td>
<td>Pruning, thinning, grazing avoidance and harvesting of Q. <em>suber</em> contributes to ensuring its presence on the landscape</td>
<td>Interviewee provided the suggested link. This is supported by Pulido et al. (2010) and Plieninger et al. (2004)⁴¹,⁴²</td>
</tr>
<tr>
<td>Silvicultural management of shrubs</td>
<td>Birds and Q. <em>ilex</em></td>
<td>Areas were grazing is not so intense, shrubs can increase the landscape heterogeneity. This formerly was actively managed and now occurs due to land abandonment. The shrub cover can be important for tree regeneration and is a habitat for birds</td>
<td>Interviewee provided the suggested link. This is supported by Pulido et al. (2010) and Plieninger et al. (2004)⁴¹,⁴²</td>
</tr>
<tr>
<td>Dehesa landscape</td>
<td>Landscape diversity</td>
<td>The integrated management of trees, livestock and pasture contributes to landscape diversity</td>
<td>Interviewee provided the suggested link. This is supported by Plieninger et al (2007) and Moreno et al⁴³,⁴⁴</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pastoralism</td>
<td>Soil diversity, insects and birds</td>
<td>Adequate livestock pressure, redileo or rotational grazing contributes in allowing the soil regeneration by manure which contributes to soil insect diversity. The maintenance of open landscapes is also favorable for birds</td>
<td>Interviewee provided the suggested link. This is supported by Hevia et al (2016)45</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Alvilleña Negra and Blanca Cacereña cattle</td>
<td>The Alvilleña Negra and Blanca Cacereña cattle increase genetic diversity of cattle breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by ARCA46</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Merina sheep</td>
<td>Merina sheep increase genetic diversity of sheep breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by ARCA47</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>Iberian pig</td>
<td>Iberian pig increases genetic diversity of pigs breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link. This is supported by ARCA48</td>
</tr>
<tr>
<td>Transtermitance and Transhumance</td>
<td>High mountain grassland diversity and Q. ilex</td>
<td>The practice had an important function in allowing the regeneration of the soil and trees. During the summer months livestock are at the high alpine natural grasslands where through grazing it contributes to grassland diversity and in winter months are moved to the dehesas</td>
<td>Interviewee provided the suggested link. This is supported by Carmona et al. (2013)49</td>
</tr>
<tr>
<td>Drystone walls</td>
<td>Birds and reptiles</td>
<td>Drystone walls are important habitats for birds and reptiles</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Water ditches</td>
<td>Natural grasslands</td>
<td>Water ditches were important to water orchards and for some natural grasslands of dryer dehesas</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Semi-permanent water ponds</td>
<td>Reptiles and amphibians</td>
<td>Temporary wells in Montados are habitats for reptiles and amphibians</td>
<td>Interviewee provided the suggested link. This is supported by Gutiérrez-Rodríguez et al. (2017) [50]</td>
</tr>
</tbody>
</table>

The entire island has been analysed based on its agropastoral activity. The agriculture that dominates is mainly arable land for livestock fodder. The pastoral activity takes place in natural phrygana, grasslands/meadows and in farmlands. On the whole island around 60,000 sheep and 10,000 goats are raised. Cattle breeding appears at significantly lower numbers with approximately 1,500 bovines. A local breed of sheep still survives on the island today despite imports of foreign breeds. The average size of Lemnos' farms is around 15.8 ha. The dominant farm type is mixed (i.e. both land farming and livestock breeding), reaching a figure that is much higher compared to the national average. In fact, this complementarity is what characterises the agricultural system of Lemnos, which is based on the traditional 'Mandras'. The three main farm types are distinguish as: (I) small-to-medium-sized mixed farms (in terms of Utilized Agricultural Area and/or herd size), which present a balanced portion of cultivated land and natural grasslands; (II) large mixed farms, which depend more on natural grasslands and purchase of feeds, and (III) crop farms, characterised by a diversified crop production (including cereals, legumes and vineyards).

All cultural aspects and traditions are linked to the mixed crop-livestock land use system organised around the traditional Mandras of Lemnos. In fact, Lemnos' Mandra system could be considered as the end result of the island's environmental, socio-economic and cultural characteristics, which in turn plays a pivotal role for the organisation and sustainability of the rural landscape. The dry stone structures of the Mandras play an important role as habitats for some species of biodiversity (especially reptiles, birds and insects), while the mosaic of arable fields extending around the Mandras, with the patches of semi natural vegetation including scattered trees and field boundaries ('trafoi') are the main habitat for local agrobiodiversity, from the micro-organisms of the soil, to the wild herbs, insects and farmlands birds. The dense presence of Mandra in Lemnos has created a continuous system, allowing humans to establish their presence in the fields and pastures across the whole island. This renders the Mandra not only a distinct visual feature of the Lemnian landscape, but the core functional element around which the traditional, extensive, agropastoral practices of the island are being organized. The two main characteristics of this traditional 'Mandra system' are diversification and complementarity. Diversification occurs as a result of this land use mosaic, but also as a result of specific practices that extend across the island (i.e. significant crop diversity, crop rotation between cereals and legumes and fallow land practice). Complementarity corresponds to the mixed system of cultivation and stockbreeding, where farmers have tried to get the most out of their land, eventually creating a complex system that incorporated livestock farming into the
main agricultural practices of crop rotation and fallowing. This can be described as a semi-extensive stockbreeding practice, where livestock are foraging inside arable fields that are left fallow, thus combining feeding with soil fertilizing (green manure); whereas additional livestock feeding needs are covered through grazing at nearby grasslands.

Most agropastoral practices and even the production of goods is based on traditional knowledge; this relates specifically to the production of food (mainly cheese but also wine and bread), the main agricultural practices (e.g. crop rotation, fallow land practice, intercropping, rain fed crops, own production of fodder, maintenance of semi-natural vegetation and field boundaries, etc.), but also harvesting and the use of medicinal plants.

Another significant element of agricultural biodiversity on Lemnos is crop landraces (i.e. local populations, traditional cultivars or heirloom varieties, which have evolved under natural and farmers’ selection in low-input agricultural systems); despite commercialisation of seeds in the post-CAP period, many landraces are still cultivated on Lemnos. The pastoral activity which takes place in shrublands (phrygana) dominated by Sarcopoterium spinosum, low-growing dense-sward formation of perennial and annual grasses and herbs (meadows) dominated by Trifolium sp and in forage crops directly grazed by the animals (not harvested for grain), usually in the vicinity of the Mandra (farms); and fodder crops, where animals are left to graze after harvest (sometimes also in-between) is a traditional activity that adds landscape heterogeneity and biodiversity.

Lemnos Island has been –and still is– characterised by a particular land ownership status, where most of the land is rented by the farmers; this has always hindered their efforts to manage their land more efficiently and made their profession less profitable, but on the other hand it accounts for preserving some practices today, such as field boundary conservation. Mechanisation (which started in the 1950s-1960s in Lemnos) has resulted in the loss of traditional farming practices and the neglect of terraced cultivations, etc. Mass emigration in the post-World War 2 period has probably played the most important part in the abandonment of traditional Mandra and the gradual shift to a less extensive agropastoral system, characterised by intensification in some parts and abandonment in others. In contrast, recent trends in population increase (and especially of youth returning to their homeland due to reduced employment opportunities in the urban centers) has given a new impetus to the farming system of Lemnos. Finally, policy changes, especially after 1980 with the accession of Greece to the EU and the implementation of the CAP have been the cornerstone to the loss of the most traditional practices (intensification of farming practices, commercialization of seeds, imports of farmed animals, etc.).

These drivers have caused throughout the last five decades a significant decreasing trend regarding number of agricultural holdings on Lemnos, while at the same time there is a significant growth in the average farm size. These facts, in a way, reflect the decrease in extensive agropastoral farms on the island in the past 50 years. Intensification of agriculture in Lemnos takes place in terms of infrastructures, inputs and herd sizes; however, this trend is milder compared to other Greek rural areas. In parallel, farmland abandonment is also taking place, especially in the eastern part of the island. Hence agropastoral holdings are increasingly dependent on inputs (feeds and fertilizers). Despite these changes, the very essence of the semi-extensive agropastoral Mandra system is still apparent on Lemnos, and the island retains its agricultural character today.

Despite these trends the farming profession on Lemnos retains its family-based character up to today. Kehayiades (a local word, meaning herder and carer of the land) are managing the
Mandras of Lemnos and are iconic symbols of the Lemnian culture, as depicted through the local songs, dances and paintings. This family structure has ensured traditional practices being handed down through generations. The traditional agropastoral Mandra system contributes to secure NCP’s as medicinal, biochemical and genetic diversity through local livestock breeds and plant landraces which provide food and feed for animals and humans. The Mandras system supports the local identity of pastoralist. The pastoral activity is important for the formation of soils and the creation and maintenance of habitats. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

Greece – Lemnos: evidences of the nexus between biodiversity and cultural practices

According to the interview, central to the agrosivlopastoral activity in Lemnos are the Mandras which are the shepherd’s houses with their associated drystone structures. These drystone structures constitute habitats for birds, reptiles and insects. Around the Mandras rotational grading and cropping is practiced allowing the recovery of soil and contributing to its fertility and diversity. The fertility and diversity of soils is assured through fallow land practices. Within the region seed diversity exists which in turn increases the horticultural diversity. Land tenure margins are denoted through small orchards which are habitats for birds, insects and plants. Another element to demark land tenure is the maintenance of certain trees next to roads which contributes to increasing the landscape diversity. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 9.

Table 9. Lemnos - nexus between biodiversity and cultural practices. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for Lemnos.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional small orchards</td>
<td>Birds, insects and plant diversity</td>
<td>Small orchards denote land tenure limits at elevated zones of 1-2 m adding heterogeneity to the landscape and have a mixture of arable and local plant species. This provides a habitat for birds and insects and thus increasing biodiversity</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Rotational grazing and cropping</td>
<td>Soil fertility and diversity</td>
<td>Through rotational grazing and cropping soil fertility and diversity is assured.</td>
<td>Interviewee proposes relationship and currently under study</td>
</tr>
<tr>
<td>Local seed diversity</td>
<td>Horticultural diversity</td>
<td>Natural and farmers’ selection of seeds in low-input agricultural systems increases genetic diversity of horticultural plants</td>
<td>Interviewee provided the suggested link. This is supported by Konstantinos et al. (2012)51</td>
</tr>
</tbody>
</table>

51 Thomas, Konstantinos; Thanopoulos, Ricos; Knuepffer, Helmut; et al. 2012. Plant genetic resources of Lemnos (Greece), an isolated island in the Northern Aegean Sea, with emphasis on landraces. Genetic Resources and Crop Evolution Vol: 59(7). pp: 1417-1440
<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow land practice</td>
<td>Soil diversity</td>
<td>Fallow land practice to allow the regeneration of soils is a traditional activity persistent in the region which contributes to soil diversity.</td>
<td>Interviewee provided the suggested link and currently under study</td>
</tr>
<tr>
<td>Silvicultural management</td>
<td>Tree diversity</td>
<td>Trees at field boundaries next to roads add landscape heterogeneity and biodiversity to the region</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Plant collection</td>
<td>Plant diversity</td>
<td>The collection of medicinal and edible plants as traditional knowledge of biodiversity. It can be that people maintain these plants to ensure their use.</td>
<td>Interviewee provided the suggested link. This is supported by Axiotis et al (2018)</td>
</tr>
<tr>
<td>Mandras</td>
<td>Birds, reptiles, insects</td>
<td>Madras are traditional pastoral houses with important elements of drystone and are habitats for birds, reptiles and insects.</td>
<td>Interviewee provided the suggested link</td>
</tr>
<tr>
<td>Traditional agrosilvopastoral management</td>
<td>Landscape diversity</td>
<td>Agropastoral systems integrate intercropping, rotational grazing, diversification of crops, small orchards and trees at land tenure limits. All this adds to overall landscape diversity.</td>
<td>Interviewee provided the suggested link and currently under study</td>
</tr>
</tbody>
</table>

The analyzed region is within the Bikar region. The top of the mountains above 1800 meters are open grasslands. This is followed by an altitude between 1800 and 1600 in which cedar forest occur and all agricultural activities are prohibited. Between 1600 and 1200 the landscape is dominated by pine and oak species where some agricultural activity starts to take place. Then between 1100 and 800 meters grazing and agricultural activity is dominant with the presence of terraces, some pine and oak trees and endemic trees and shrubs. In the region between 20 and 25 shepherds exists with 10,000 to 15,000 goats with a dairy and meat production. In the region two local livestock breeds are present: the chablie and bardi. In the region a traditional governance system called Hamas exists which is in place for over 1500 years. This community-based system is essential for adequate pastoralism and hence the maintenance of open corridors and a landscape mosaic. Within this system pastoralist practice rotational grazing and herding in mountain areas.

These activities are important for the local associated biodiversity. The crops which are planted are of endemic varieties and contribute to agricultural diversification where local seeds are favored. Within these crops aromatic plants are plated to avoid the appearance of pests. Olive trees of the region which are under extensive management produce olive oil, soap and humus meanwhile, the tree branches are used for heating. The system is characterised by the presence of water infrastructures as water tanks carved into stone which can be a source of water for wild flora and fauna. Dry stone walls present in the landscape are important to avoid soil erosion, prevent wild fires and contribute to local biodiversity such as birds, reptiles and insects. Within the pastoral system edible plants are collected for consumption.

This traditional system is pressured by several negative drivers. Climate change is increasing weather unpredictability. Increasing occurrence of pests. Lack of institutional and policy support. Due to the Syrian crisis, Syrian refugees see themselves forced to compete with milk prices in Lebanon, this is affecting in turn the profitability margins. There is also a lack of adequate policies and policy enforcement currently in the region. Finally, young people are abandoning rural areas and migrating to cities in search of other economic opportunities. Due to that an uncertain trend of pastoral activity in the region is occurring. Some positive drivers which are taking place is the increasing

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**Lebanon – Al Shouf**

<table>
<thead>
<tr>
<th><strong>Lebanon – Al Shouf</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agricultural practice</strong></td>
</tr>
<tr>
<td><strong>Trend</strong></td>
</tr>
<tr>
<td></td>
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<td></td>
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<tr>
<td></td>
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<tr>
<td><strong>Highlights</strong></td>
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</tbody>
</table>
acknowledgment of the importance of traditional practices to secure resilience and continuity of pastoral activities in the region.

The pastoral activity in the region is positively contributing to NCP’s through local livestock and crop breeds which add genetic diversity to the region. Dry stone walls are an important contributor to prevent hazards such as wild fires. Finally, pastoralism contributes to soil formation by the fertilization of soils and grazing is important for the creation and maintenance of habitats. A glossary can be found in the introduction and cross-case comparison can be found in table 1.

**Lebanon – Al Shouf: evidences of the nexus between biodiversity and cultural practices**

In the region an increased diversity of local seeds exists according to the interview. This contributes to the horticultural diversity. Likewise, crop diversification increases plant diversity. Rotational grazing by local livestock breeds avoids secondary succession and thereby increasing the landscape diversity. Local livestock breeds constitute to an added genetic diversity in the livestock species. Finally, secondary agricultural elements such as drystone walls are said to be habitats for birds, insects and plants. Each cultural practice, its associated biodiversity element and the evidence is explained in the following table 10.

**Table 10. Al-Shouf - nexus between biodiversity and cultural practices**. Cultural practices, biodiversity elements, nexus between cultural practice and biodiversity and evidences are provided for Al-Shouf.

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crop diversification</td>
<td>Plant diversity</td>
<td>Diversified crop plantations in small farms has been central to households and adds horticultural diversity</td>
<td>Interviewee provided the suggested link and currently under study</td>
</tr>
<tr>
<td>Local seed diversity</td>
<td>Horticultural diversity</td>
<td>Natural and farmers’ selection of seeds in low-input agricultural systems increases genetic diversity of horticultural plants</td>
<td>Interviewee provided the suggested link. This is supported by Mazid et al. (2014)53</td>
</tr>
<tr>
<td>Rotational grazing</td>
<td>Landscape heterogeneity</td>
<td>Rotational grazing as a traditional activity enhances landscape diversity by avoiding secondary succession</td>
<td>Interviewee provided the suggested link and currently under study</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>“Chablie” and “Bardi”</td>
<td>“Chablie” and “Bardi” goat increases genetic diversity of goat breeds and are adapted to the local ecosystem</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>

### Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Drystone walls</td>
<td>Birds, insects and plant diversity</td>
<td>Dry stone walls are an important landscape element which avoids erosion, prevents fires and is an important habitat for bird, insects and plants</td>
<td>Interviewee provided the suggested link</td>
</tr>
</tbody>
</table>
Table 1. Case study comparison. The table is elaborated based on the interviews and only depicts the presence of a certain practice, driver or contribution to biodiversity. The absence of a relationship does not indicate a positive, neutral or negative trend, but that the specific factor has not been stated during the interview. Arrows for each case study region depicts the overall: strong negative trend (red), negative trend (yellow) and positive trend (green). Crosses for cultural practices, drivers and biodiversity indicate if that element is present in the case study. Positive drivers are not depicted as they are unrepresentative compared to negative drivers.

<table>
<thead>
<tr>
<th>Analyzed variables</th>
<th>Dehesas/Montado</th>
<th>Sierra Nevada</th>
<th>Menorca</th>
<th>Sist. Central</th>
<th>Anti Atlas</th>
<th>High Atlas</th>
<th>Lemnos</th>
<th>Liguria</th>
<th>Al Shouf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural practice</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dry-stone walls</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Local Food</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Landscape mosaic</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Mandras</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Nomadism</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pastoral hut</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Pastoralism</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Plant collection</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Religious belief</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Redileo</td>
<td></td>
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<td></td>
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<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Silvicultural management</td>
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<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Traditional agriculture</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Traditional governance</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transhumance</td>
<td>X</td>
<td>X</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Transstermitance</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Local livestock breed</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Water infrastructure</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Agricultural intensification</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Climate constrains</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>
## Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

### Analyzed variables

<table>
<thead>
<tr>
<th>Analyzed variables</th>
<th>Dehesas/Montado</th>
<th>Sierra Nevada</th>
<th>Menorca</th>
<th>Sist. Central</th>
<th>Anti Atlas</th>
<th>High Atlas</th>
<th>Lemnos</th>
<th>Liguria</th>
<th>Al Shouf</th>
</tr>
</thead>
</table>

### Trend direction

- **Lack of governance:**
  - Dehesas/Montado: X
  - Sierra Nevada: X
  - Menorca: X
  - Sist. Central: X
  - Anti Atlas: X
  - High Atlas: X
  - Lemnos: X
  - Liguria: X
  - Al Shouf: X

- **Land abandonment and depopulation:**
  - Dehesas/Montado: X
  - Sierra Nevada: X
  - Menorca: X
  - Sist. Central: X
  - Anti Atlas: X
  - High Atlas: X
  - Lemnos: X
  - Liguria: X
  - Al Shouf: X

- **Market pressure:**
  - Dehesas/Montado: X
  - Sierra Nevada: X
  - Menorca: X
  - Sist. Central: X
  - Anti Atlas: X
  - High Atlas: X
  - Lemnos: X
  - Liguria: X
  - Al Shouf: X

- **Media:**
  - Dehesas/Montado: X
  - Sierra Nevada: X

- **Pastoralism:**
  - Dehesas/Montado: X

- **Pests:**
  - Dehesas/Montado: X

- **Refugees:**
  - Dehesas/Montado: X

- **Returnees:**
  - Dehesas/Montado: X

- **Tourism and urbanization:**
  - Dehesas/Montado: X

- **Unsuitable policies:**
  - Dehesas/Montado: X

- **Wild fauna:**
  - Dehesas/Montado: X

### Biodiversity

<table>
<thead>
<tr>
<th>Biodiversity</th>
<th>Dehesas/Montado</th>
<th>Sierra Nevada</th>
<th>Menorca</th>
<th>Sist. Central</th>
<th>Anti Atlas</th>
<th>High Atlas</th>
<th>Lemnos</th>
<th>Liguria</th>
<th>Al Shouf</th>
</tr>
</thead>
</table>

- **Flora:**
  - Dehesas/Montado: X

- **Natural grasslands:**
  - Dehesas/Montado: X

- **Agricultural plants:**
  - Dehesas/Montado: X

- **Shrubs:**
  - Dehesas/Montado: X

- **Trees:**
  - Dehesas/Montado: X

- **Fauna:**
  - Dehesas/Montado: X

- **Mammals:**
  - Dehesas/Montado: X

- **Birds:**
  - Dehesas/Montado: X

- **Amphibians:**
  - Dehesas/Montado: X

- **Reptiles:**
  - Dehesas/Montado: X

- **Insects:**
  - Dehesas/Montado: X
4. Discussion on the nexus between cultural practices in agriculture and biodiversity

Through the literature review and the interview process a total of 36 case studies have been analyzed in eight different countries: Portugal, Spain, France, Italy, Greece, Turkey, Lebanon and Morocco. Of these 35 case studies 26 correspond to the literature review and 9 to the interview process. This gives a good overview on the extensive Mediterranean agricultural systems and its relation to biodiversity.

Within the literature, the important point to emphasise is the multi-functionality of NCPs. While habitat creation is the most important aspect for biodiversity, it is also captured in the regulation of extreme events, soil protection, pollination and seed dispersal. But also in cultural practices such as the maintenance and creation of stone walls and hedgerows which are simultaneous cultural practices that affect biodiversity and are also a form of traditional ecological knowledge. However, these actions are for the vast majority an aspect related to farming, which is an act of self-identification and re-enforcing the identity of people in a geospatial sense. This sense of identity is embedded in the area and the products created there within. To the point where some studies concluded that people felt that lands that are 20km away were considered distant, as the knowledge of the people was so much more locally specific.

In the literature review the north of the Mediterranean is over-represented compared to the south, showing that the literature in English is highly biased towards European countries. Cultural practices and biodiversity are going to be highly interlinked in many African and middle eastern countries where traditional agricultural systems still have a much more prominent role in the daily lives of people when compared to Europe.

Furthermore the literature review shows that the major drivers of cultural practice loss can be seen as ageing, depopulation and land abandonment as direct competition with industrial agriculture. Due to the over representation of Europe, in the analysis it is impossible to say if these issues are prominent outside Europe, but it is clear that these issues are prominent drivers of cultural practice and biodiversity loss in the European Mediterranean.

The findings of the literature review are confirmed by the interview processes. The most important cultural practices that can be highlighted through the interview process are the creation and maintenance of a particular landscape which is shaped and created through agricultural, pastoral or silvicultural practices or any combination of the former.

Often the total or partial management of the system is under the structure of an institutional governance structure with particular normative resulting from the co-evolution of cultural practices and nature over generations. Many extensive agricultural systems take advantage of the adaptation of local breeds to environmental conditions while managing the land through the creation of dry-stone walls or water infrastructure such as water ditches, which is a cultural practice in itself. The interaction between humans and nature in the spheres of pasture, livestock, silvicultural and agricultural management has created unique landscapes which have an important value for biodiversity. In many case studies, insects and natural grasslands are the main biodiversity elements which are supported by traditional agricultural practices. The extensive agricultural systems are important sources of NCP’s. Being the most important are the creation and maintenance of habitats, regulation of hazards such as wild fires or the provisioning of food and feed related to a cultural activity.

Through the process of interviews, it emerged that most extensive agricultural systems are
under threat and facing a severe downward trend due to multiple negative drivers. The most important ones are the same found in the literature review: a combination between land abandonment and emigration. The triggers for that are related to market pressures which often bring with agricultural intensification, lack of governance and a lack of institutional and policy support. Climate change is also impacting on these systems and in some cases has severe consequences, but this is not seen as a generalized trend. The most important support structures identified are the institutional support to extensive agricultural and their cultural practices. Examples of this support structures are the incentives for the preservation of small forests in Menorca and the recognition of extensive agriculture as crucial for the preservation of landscapes and its associated biodiversity also found in Menorca. Another crucial aspect is the recognition of the local products provided by extensive agricultural systems such as the meat of the Segureña sheep breed.

In conclusion, there is a large diversity of cultural practices in extensive agricultural systems in the Mediterranean basin which directly and indirectly contribute to the creation of one of the most important biodiversity hot-spots worldwide and the creation of important NCP’s as highly demanded by society. However, these systems are under acute threats due to multiple socio-economic and political drivers. It is remarkable that climate change is not a consistent driver across regions. To counteract this trend, action is urgently needed at multiple institutional levels, this is not only a statement framed within this report, but a recent claim from the IPCC (Sanz & Cite, 2019).

Overview of the links between agricultural practices and biodiversity in Mediterranean Landscapes

In this study it has become evident that there is a mismatch between the scientific evidence of the link between cultural practices in agriculture and biodiversity and that which is “common knowledge” from the experts (interviewees) point of view. Following the interview process, the consultants verified a number of the interviewee highlighted relationships between cultural practices and biodiversity through a specific targeted literature research. This process provided further corroboration to the highlighted examples. The interviewed experts stated all the relationships that were found between biodiversity and cultural practices in the literature review. This reinforces the level of knowledge and adequacy of the interviewed expert.

A need for more ecological field studies evidencing the relationship between traditional agricultural activities and biodiversity is highlighted, and this is especially true for non-European Mediterranean countries. The lack of these studies represents an opportunity for new research and cross-border cooperation between Mediterranean countries to explore the similarities and differences of the effects of cultural practices on biodiversity.

Here we highlight the five principal mismatches between the suggested links expressed by interviewed actors and the peer reviewed scientific literature.

1. Drystone walls are mentioned as important habitats for plants, insects, birds or reptiles, but that could not be confirmed through the literature review.

2. Traditional water management systems are poorly analyzed in most of the Mediterranean countries. Water ditches and semi-permanent ponds are proposed by the interviewees as important habitats for amphibians or insects, however only few studies have been found that mention the relationship with traditional agricultural practices.
3. Regarding livestock management there are some studies on the effect of transhumance on seed dispersal or landscape diversity, but fewer studies on the relationship between practices such as rotational grazing or redileo conceived as cultural practice and plant or soil diversity.

4. Herding of livestock in semi-natural landscapes is often stated in interviews as an important contribution to landscape diversity, however studies that state pastoralism and herding activity as cultural practice and connect it to landscape diversity need further analysis since it is very frequently related to biodiversity by interviewed actors.

5. Governance of pastoral systems around the Mediterranean basin are often studied through socio-ecological or socio-economic studies and in interviews effective governance mechanisms are stated as crucial to sustain for example plant diversity. This relationship needs further study through specific field studies that connect biodiversity and governance as a cultural practice as some evidence exists, but it needs to be expanded since it is very often stated as driver for biodiversity in interviews to experts.

The evidence from the literature and the case studies analysed show that there is a decreasing trend of cultural practice use in the Mediterranean. This decreasing use of cultural practices can negatively affect biodiversity as shown through the examples of the abandonment of transhumance and transtermitance in the Central System of Spain, abandonment of herding in Dehesas or the abandonment of traditional breeds such as the Cabannina cattle in Liguria. Although there is a strong link between cultural practices and biodiversity there are certain examples that are harder to evidence this fact such as habitats in drystone walls or water ditches, governance mechanisms and plant diversity, or herding and landscape diversity as detailed above. Finally, we can state that if cultural practices continue to decrease there will potentially be a significant negative effect on biodiversity in the Mediterranean landscapes.

Contrary to the aforementioned mismatches, there are several cultural practices which have a positive effect on biodiversity and are contrasted in more than one case study location. It has been found that local livestock breeds of cattle, sheep and goat add important genetic diversity to their species while they are also adapted to the local landscape and climatic conditions allowing traditional management of them. Related to that, pastoralism (through guided herding), transhumance and transtermitance are important practices that contribute to seed dispersal when seeds attach to wool or pass through the digestive tract. Guided herding, transhumance and transtermitance also avoid secondary succession of grasslands and maintain certain plant communities as for example \textit{Nardus stricta} communities or hay meadows. By sustaining these habitats, birds of open landscape can benefit as their natural habitat is maintained. While livestock is grazing and browsing in open landscapes, manure acts as a source for soil recovery, fertility, and diversity. So by one hand there exists a need to analyze effects of pastoralism on biodiversity, but on the other, there already several evidences which strongly support its relevance.

Often pastoral systems are ruled by governance systems, norms and rules and can increase plant diversity by avoiding secondary succession and dominance of certain plant species. Here again, these governance systems do have several evidences of their role for biodiversity, but at the same time the wide spread use of governance systems claim for more studies supporting this relationship.

Besides, silvicultural management of several tree species through pruning, thinning or planting contribute to tree and landscape diversity and are often a complementary or even central
activity of agrosilvopastoral systems. Finally, agricultural activities as plant collection and the use of local seeds for agriculture increase plant diversity and specifically, horticultural diversity. Details of each of the practices and the locations of the evidences are given in Table 11.

Table 11. Contrasted nexus between biodiversity and cultural practices. Evidences of the relationship between biodiversity and cultural practices which are contrasted in several case study locations (references can be found in previous section 3.2, interviews).

<table>
<thead>
<tr>
<th>Cultural practice$^{54}$</th>
<th>Biodiversity$^{55}$</th>
<th>Practice-Biodiversity nexus</th>
<th>Countries$^{56}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local livestock breeds</td>
<td>Livestock diversity i.e. Verata goat, Segureña Sheep or Alvileña Negra Cattle.</td>
<td>• Local livestock breeds being it cattle, goat or sheep are acknowledged to have a relationship with biodiversity by increasing genetic diversity of livestock species and are adapted these are adapted to local ecosystems.</td>
<td>Ligura (Italy), Morocco Anti-Atlas Réserve de biosphère de l’arganeraie, Sierra Nevada (Spain), Menorca (Spain), Central System (Spain) and Dehesas/Montados (Spain/Portugal)</td>
</tr>
<tr>
<td>Pastoralism, transhumance and transtermitance</td>
<td>Consolidated evidence on: Plant diversity, hay meadows, alpine pastures, <em>Nardus stricta</em> communities. Fragmented evidence on: landscape diversity, insect, bird and soil diversity</td>
<td>• Seed dispersal by transhumance. • Transtermitance avoids secondary succession increasing landscape diversity and grazing in summer areas contributes to high mountain grassland diversity. • Herding by shepherds contributes to sustain <em>Nardus stricta</em> communities, hay meadows, alpine pastures and bird and insect diversity. • Herding livestock fertilizes soils and can contribute to soil and insect diversity</td>
<td>Sierra Nevada (Spain), Central System (Spain) and Dehesas/Montados (Spain/Portugal)</td>
</tr>
<tr>
<td>Governance norms and rules in pastoral systems</td>
<td>Plant diversity like <em>Nardus stricta</em> communities</td>
<td>• If overstocking is avoided, stocking rates can increase plant diversity by avoiding secondary succession and dominance of certain plant species as i.e. <em>Cytisus oromediterraneus</em></td>
<td>Morocco Anti-Atlas Réserve de biosphère de l’arganeraie, Sierra Nevada (Spain) and Dehesas/Montados (Spain/Portugal)</td>
</tr>
</tbody>
</table>

$^{54}$ Traditional Ecological Knowledge (TEK) is regarded as the cumulative knowledge, practices and beliefs that evolve through adaptive processes and is handed down through generations. TEK can include different levels of analysis such as local knowledge of animals, land and resource management systems, social institutions and a particular world view.

$^{55}$ Biodiversity is understood in an ample sense including diversity of species, genes or landscapes.

$^{56}$ Regions in which case studies through interviews have been analysed.
## Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes

<table>
<thead>
<tr>
<th>Cultural practice</th>
<th>Biodiversity</th>
<th>Practice-Biodiversity nexus</th>
<th>Countries</th>
</tr>
</thead>
</table>
| Silvicultural management system | Q. ily, Q. pyrenaica, Castanea spp., Alnus glutinosa, shrubs and landscape diversity | - Pruning and thinning to maintain tree presence in the habitat and landscape diversity.  
- Shrub management to favor seedling recruitment.  
- Tree planting contributes to nitrogen fixation and increase soil fertility and productivity. | Ligura (Italy), Menorca (Spain), Central System (Spain) and Dehesas/Montados (Spain/Portugal) |

| Local seed diversity | Horticultural diversity | Natural and farmers’ selection of seeds in low-input agricultural systems increases genetic diversity of horticultural plants. | Lemnos (Greece) and Al Shouf (Lebanon) |
5. Recommendations

The consultants would like to bring attention to the following recommendations that have been derived for future studies and opportunities:

- Further case studies in the European and non-European region can be explored to depict unique characteristics of traditional agricultural practices.
- Undertake deliberative dialogues with local farmers, experts, the public administration and other stakeholders at each case study site to contrast information with the gained expert knowledge.
- Explore success stories and their drivers in extensive agricultural systems which are recovering or under a positive trend to assess possible cross-case knowledge exchange.
- Undertake scientific studies on the stated relationships between habitat suitability of drystone walls or water ponds and ditches for amphibians, reptiles or insects provided by the interviewees to scientifically support their claims.

These recommendations are especially important considering the following limitations of the study:

- The literature review and interviews are geographically biased towards the north due to the overrepresentation in research of these regions.
- The language of the search has been limited to English peer-reviewed studies excluding publications in grey literature and other national and local languages.
- The final sample size of the literature and interviews have been relatively small considering the size of the Mediterranean basin farming area.
- Interviews are based on the interpretation of the interviewer and the vision of the interviewed stakeholder.
6. Cited references


Plieninger, T. (2006). Habitat loss, fragmentation, and alteration - Quantifying the impact of land-use changes on a Spanish dehesa landscape by use of aerial photography and GIS.


7. Annex

7.1. Annex 1. Web-link to literature review database

The database generated during the literature review can be found by clicking here.

7.2. Annex 2. Literature review, detailed methodology

1. Information Gathering
The consultants have analyzed how the available information can contribute to the current knowledge on cultural practices and biodiversity. Key publications have been gathered from peer-reviewed journals available through Scopus and expert recommendation. The following search string was created using Scopus on the 27-05-2019:

```
TITLE-ABS-KEY (agricult* OR tradition* OR pastor* OR extensiv* AND ltk OR tek OR biodivers* AND cultur* AND mediterr* AND NOT intensiv*) AND (LIMIT-TO (DOCTYPE, "ar") ) AND (LIMIT-TO (LANGUAGE, "English")).
```

2. Identification of the information and information gaps
This search string resulted in a total of 136 articles that were to be examined. All reviews and meta-analysis were excluded as well as all papers which did not have a feedback loop between cultural practices and NCP’s as the objective of the study is to assess the feedbacks between cultural practices and biodiversity based on primary data sources. This resulted in a total of 21 articles being accepted with an additional 5 articles being added through personal recommendations from professionals working in the field of extensive agriculture. Leaving a total of 26 articles.

3. Cataloguing the information collected
These 26 articles were examined across 8 categories: country, region, taxonomic groups, NCPs (18 subgroups), specific cultural practices, drivers of cultural loss and trend direction. It is important to consider that due to the limited size, the analysis has been limited to a literature review and not to a meta-analysis as a larger sample size would be required to complete a meta-analysis. Nevertheless, the consultant team is confident that the state of extensive agricultural practices and their relationship with biodiversity has been accurately represented as in published articles sample size for literature reviews is similar.

4. Analyzing the information collected
The last step of the literature review process consisted in the analysis of the information collected. The information obtained from the literature has been subjected to analysis through quantitative descriptive statistical methods. Through this process the consultants were able to ensure that the data gathered and examples given are quoted with confidence and cross-referenced.
7.3. Annex 3. Consent sheet template

[Date, Place]

Dear [Name of stakeholder],

The links between agricultural practices and biodiversity in Mediterranean landscapes project, funded by MAVA and implemented by IUCN, proposes to identify how cultural practices in extensive agriculture contribute to biodiversity in Mediterranean landscapes. It assesses its drivers and trends under current conditions through a process of meta-analysis and semi-structured interviews. The aim of this document is to affirm your consent to participate in this interview in the framework of the links between agricultural practices and biodiversity in Mediterranean landscapes project. The information provided by you is voluntary and will be used for research purposes only. The provided information will be treated anonymously, which means it will be aggregated with other data and not used as individual data. This is in accordance with the data protection regulation from the European Commission: art. 5.1, “b”, of the Regulation (EU) 2016/679 of the European Parliament and of the Council, of 27th April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46/EC.

The results from the study will be stored in the database managed by WE&B. The results will be available to other collaborating researchers within the links between agricultural practices and biodiversity in Mediterranean landscapes project. Most participants will find the discussion interesting and thought-provoking. If, however, you feel uncomfortable in any way during the interview session, you can decline to answer any question or to end the interview.

If you want to receive a copy of the results of this study, please, identify yourself and contact us at:
Water, Environment and Business for Development
Mathias Brummer
Av. Corts Catalanes, 5
Sant Cugat del Vallès,
08173
Spain

Or via email:
mathias.brummer@weandb.org or david.smith@weandb.org

Yours truly,

Mathias Brummer
Environmental Consultant
Water, Environment and Business for Development,
mathias.brummer@weandb.org
Thank you again for your collaboration and time.

The present document includes the points we will discuss during our interview to explore the relationships between biodiversity and extensive agricultural practices. The present interview will have an approximate duration of 1 hour.

We would appreciate a lot if you could read the questions in advance and if you have time feel free to answer the questions and forward us your preliminary responses.

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Characterization of case study region</th>
</tr>
</thead>
<tbody>
<tr>
<td>General information</td>
<td>1. Which municipalities does your geographical area include?</td>
</tr>
<tr>
<td>General information</td>
<td>2. Do you know approximately the extension in hectares of the territory we are speaking of?</td>
</tr>
<tr>
<td>General information</td>
<td>3. Which type of extensive agriculture (pastoral, silvicultural, agricultural…) dominates in your territory? And which kind of animal breeds dominates (if there are any)?</td>
</tr>
<tr>
<td>General information</td>
<td>4. Based on your experience, is there an increasing or decreasing trend regarding extensive agriculture farms in the region? i.e. intensification or abandonment of farms</td>
</tr>
<tr>
<td>General information</td>
<td>5. To the best of your knowledge, how many acres are worked on average per farm? Are there different types of farms depending on the size?</td>
</tr>
</tbody>
</table>

Questions on silvi/agro pastoralism in the study region

<table>
<thead>
<tr>
<th>Dimensions</th>
<th>Institutional aspects</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cultural diversity in extensive farming</td>
<td>1. To the best of your knowledge, which traditions or cultural aspects of extensive agriculture persist in the region that can have a relationship with biodiversity preservation? i.e. maintenance of hedge rows which contribute to bird diversity etc.</td>
</tr>
<tr>
<td>Cultural diversity in extensive farming</td>
<td>2. To the best of your knowledge, what role do these specific traditional practices play for extensive agriculture?</td>
</tr>
</tbody>
</table>
| Cultural diversity and biodiversity nexus | 3. To the best of your knowledge, is there a dependence of biodiversity upon these practices? i.e. how have roads contributed to diffuse pollution or how pastoral fire
management contributes to landscape heterogeneity. Could you please cite any study evidencing this?

<table>
<thead>
<tr>
<th>Drivers of change</th>
<th>4. To the best of your knowledge, what are the main drivers that impact positively and negatively upon traditional practices in extensive agriculture? For instance governance, land access, demography, policy.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dimensions</td>
<td>Characteristics of the pastoral farms and of traditional agricultural or forest management</td>
</tr>
<tr>
<td>Extensive farming trends</td>
<td>1. In your opinion, in what way are traditional practices in extensive farms evolving or transforming?</td>
</tr>
<tr>
<td>Extensive farming and cultural practices trends</td>
<td>2. In your opinion, are traditional practices handed down through generations in successful farms or are they disappearing?</td>
</tr>
<tr>
<td>Dimensions</td>
<td>Environmental aspects</td>
</tr>
<tr>
<td>Climatic context and evolution</td>
<td>1. Can you summarize briefly how climate change has affected agriculture, silvicultural or pastoral activities in the last 10 years?</td>
</tr>
<tr>
<td>Vegetation context</td>
<td>2. What are the pastures/forests structure as in which extensive agricultural practices take place? i.e. shrubland, Dehesas dominated by a certain tree, Argan tree dominated landscapes, olive orchards</td>
</tr>
<tr>
<td>Dimensions</td>
<td>Temporal dimension of traditional practices in extensive agriculture, from past to present</td>
</tr>
<tr>
<td>Extensive farming context</td>
<td>1. Please briefly state, what are the main characteristics of extensive agriculture management in the region nowadays</td>
</tr>
<tr>
<td>Dimensions</td>
<td>Final points</td>
</tr>
<tr>
<td>General information</td>
<td>1. Are there any important points we have not talked about which you consider relevant for the study?</td>
</tr>
<tr>
<td>Social network</td>
<td>2. Are there any projects/experiences/initiatives in extensive agriculture which have linkages between cultural practices and biodiversity in similar ways than in your region which we could include in our analysis? If so please could you provide us with a contact name and e-mail?</td>
</tr>
</tbody>
</table>
7.5. Annex 5. Interviews, detailed methodology

1. Defining interviewees
The consultant team contacted the five MAVA funded and IUCN implemented project sites Al Shouf (Lebanon), Lemnos (Greece), High Atlas (Morocco), Deheasas/Montados (Spain/Portugal) and Menorca (Spain). From these initial actors, a snow-ball process was undertaken. Snow-ball sampling consists of inquiring and engaging with the initial actors for further contacts to interview which could evidence links between cultural practices and biodiversity.

The objective of the snow-ball sampling was to get a representative view of the nexus between cultural practices and biodiversity in four distinct Mediterranean regions: the Northern Mediterranean Basin, the Southern Mediterranean Basin, the Western Mediterranean Basin and the Eastern Mediterranean Basin. This process was stopped once actors mentioned that they had expertise in the same region and hence additional information that could be gained would be limited. Likewise, if actors did not mention further contacts to be addressed the contacting process was stopped. Key informants considered for interviews have been: researchers, field technicians or local administrations. Indispensable for the inclusion as key informant was a trajectory of activity related to cultural landscapes in each region.

2. Holding interviews
Before each interview actors were asked to sign a consent sheet to comply with EU legislation on data policy and protection (see annex 1). Interviews followed a semi-structured format with 15 questions grouped into: characterization of the study region, institutional aspects, systems characteristics and environmental and climatic aspects (see annex 2). The designed interview protocol allowed to assess the relationship between cultural practices and functional ecological groups and how this relationship contributes to provide services for society. The designed interview protocol also allowed to depict the driver of change of cultural practices and trends and their direction in each case. Interviews had a duration between 45 min and 1 hour and 30 minutes depending on the knowledge and idiosyncrasy of each interview. Interviews have been held in English or Spanish (the native languages of the consultant team) and in accordance to the languages of the interviewees.

3. Transcribing interviews
Based on the interviews (i), the desk analysis started with the transcription of interviews.

4. Cataloguing
The transcribed interview information was catalogued. The cataloguing takes the form of an Excel matrix table to allow for filtering and cross-referencing and to identify more easily the data gaps. The categorization depended on the information if it was: cultural practices, functional ecological group, NCPs, trends or drivers. The individual trends and drivers then allowed to assess the general trend direction. By categorizing data following the standard data format was ensured to follow the same data structure as the literature review and allow data comparison.

5. Analysis
The last step of the interview process consisted in the analysis of the information collected using grounded theory. This theory consists of the construction of a hypothesis through methodical gathering and analysis of data in an inductive manner. The results of this analysis were then put in context and analysed together with the literature review. The designed interview protocol allowed to assess the relationship between cultural practices and functional
ecological groups and how this relationship contributes to providing services for society. The designed interview protocol also allowed to depict the driver of change of cultural practices and trends and their direction in each case.
Links Between Agricultural Practices and Biodiversity in Mediterranean Landscapes