Chair Agroecology and Food Systems for Social Transformation

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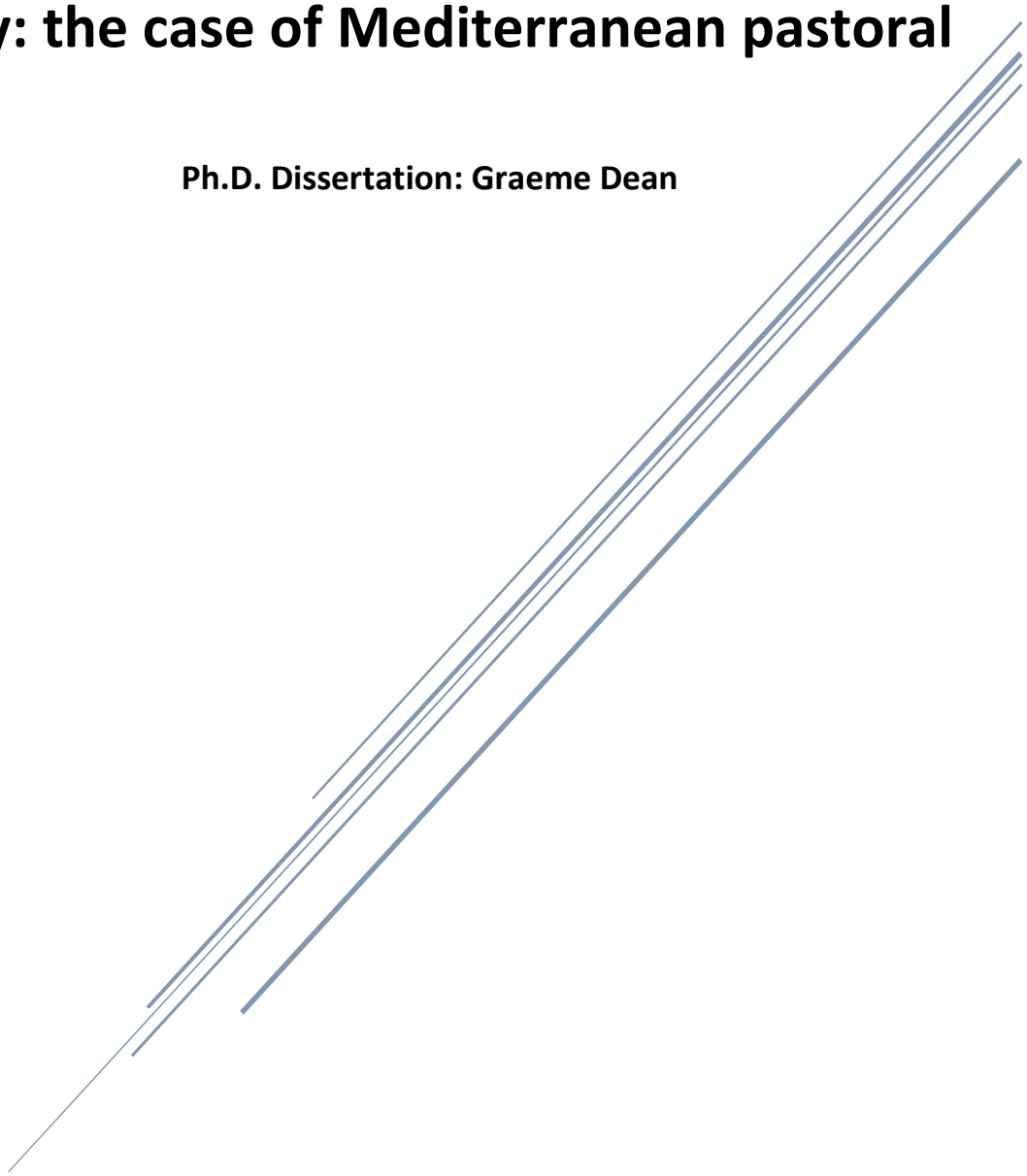
Understanding human-nature systems through complexity: the case of Mediterranean pastoral systems.

Ph.D. Dissertation: Graeme Dean



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I always considered that completing a doctorate would be a personal achievement. Now that I have submitted my doctoral thesis, I admit that it feels far less like a personal achievement and far more like a group effort. I have had cause to reflect on all the help I have had to help me reach this point, both professionally and personally.

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Chapter 1: Introduction

Human-Nature systems

Human-nature systems or socio-ecological systems are found all over the world and are defined by the complex and multifunctional adaptive interactions between people and their environment (Mcginnis and Ostrom, 2014). Examples of human nature systems include forestry systems, where people interact with forest landscapes, modifying and maintaining the forests while extracting resources such as fuel, food and other resources (Sharma et al., 2012; Westholm, 2016); or pastoral systems, where landscapes are modified by pastoralists to better suit the needs of their livestock and in doing so help create biological diversity, are also considered human-nature systems (Hobbs et al., 2014; Oteros-Rozas et al., 2012). These human systems, through their deep integration with nature, are relevant to the health and maintenance of many different biocultural landscapes, such as the Mediterranean basin in the case of pastoral systems (Ben Hounet et al., 2016; Oteros-Rozas et al., 2014), and many forests regions around the world (Carter et al., 2014). Some of the most relevant human-nature systems are managed by indigenous people through the use of traditional practices, including many global biodiversity hotspots (Hobbs et al., 2014; Oteros-Rozas et al., 2014; Stave et al., 2007). Indeed, in many parts of the world forests are maintained by indigenous people who use the forests to supply food, firewood and non-timber forest products through the use of traditional ecological knowledge (Paneque-Gálvez et al., 2018; Sharma et al., 2012; Westholm, 2016). The study of human-nature systems is characterised by an acknowledgement of the complexity of trade-offs and synergies between humans and nature. The connections linking humans and nature should be discussed, such as the modification or use of landscapes (Fernández-Giménez, 2015; Leister et al., 2019; Pineda-López et al., 2015). Despite their inherent complexity, human-nature systems suffer from a lack of interdisciplinary thinking, as natural and social sciences are rarely truly integrated. As researchers tend to focus on either the human or natural element of the systems through the use of biological, economic or social methodologies and narratives (Leister et al., 2019; Liu et al., 2007; Manzano et al., 2021), meaning that the multifunctional trade-offs and synergies of human-nature systems are not appreciated. In this thesis I will be using pastoral systems as an example of a human-nature system, adding to the debate on the role of human-nature systems, and examining what goods and services are provided by pastoral systems, as well as their drivers of change and their place in global debates.

Pastoral systems as an example of a human-nature system

Pastoral systems can be found in all continents excluding Antarctica (Dong et al., 2016). They are found in many different ecosystems, from desert landscapes (Hobbs et al., 2014), to tundra (Heikkinen et al., 2012) mountains (O'Rourke et al., 2016) and grasslands (Osano et al., 2013) and everything in between (Dong et al., 2016). They have existed for thousands of years, first due to their adaptability as well as their capacity to adapt to and modify the

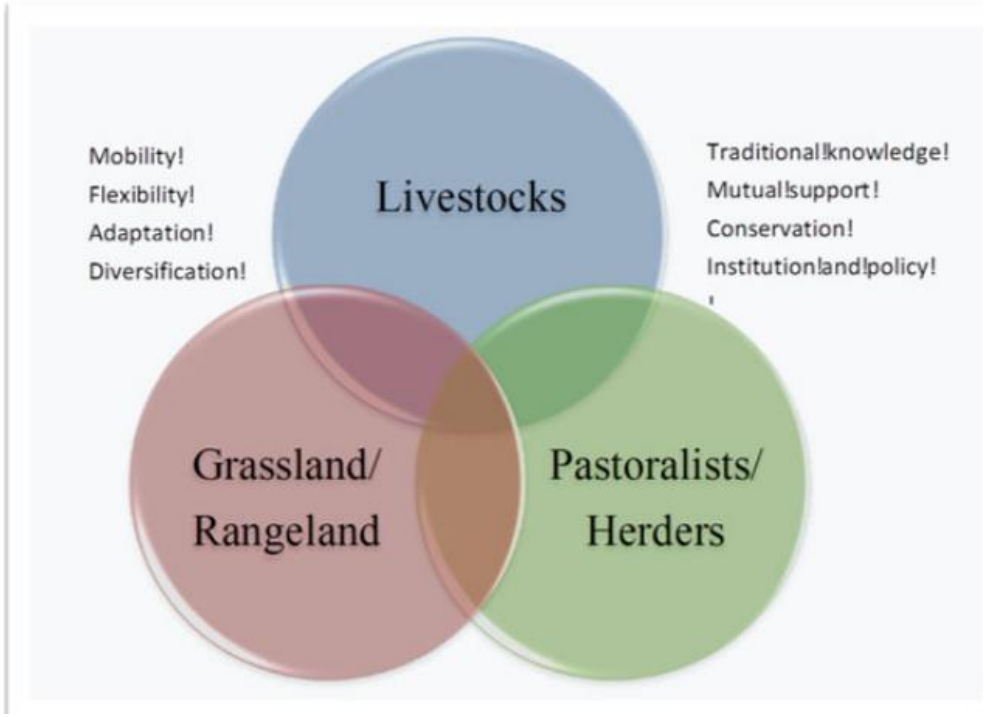

Fig. 1 Characteristics of pastoral systems

Source: Dong et al. (2016)

landscape to better accommodate their needs, and second, due to the multifunctional nature of pastoralism (e.g., food, fibre, drought power, social status, and identity, etc.) that make this a very appealing activity to conduct in many regions of the world. Pastoral systems can be defined as *"adaptive network of biophysical and social flows generated and maintained by the movement of shepherds and livestock"* (Oteros-Rozas et al., 2012). Thus, they are socio-ecological systems with strong human-nature interactions. Today some researchers estimate that there are between 500 million and 1 billion pastoralists in the world (Niamir-Fuller and Huber-Sannwald, 2020). Due to the near-global ubiquity of pastoral systems, there are many different terms for the people who practice extensive livestock management. As this dissertation has a wide geographic scope, all people who practice extensive livestock

management will be referred to as pastoralists and we will use the term pastoral systems in reference to extensive livestock systems. These terms have been chosen due to their recognition in scientific literature (Ben Hounet et al., 2016; María E. Fernández-Giménez and Estaque, 2012; Niamir-Fuller, 2016; Scoones, 2020).

The role of pastoral systems in addressing global challenges

Despite their global range, pastoral systems all share certain attributes (Fig. 1). They are characterised by adaptivity to different political, ecological, climatic, and economic environments that face uneven temporal and spatial distribution of resources, as well as their capacity to generate multiple goods and services out of them. They use a variety of feed sources depending on the resources available to them. This can include pastures, tundra, forests, crops and rangelands and even hedgerows and urban margins. The multifunctional nature of pastoral systems points to the great capacity of this activity to provide multiple goods and services, which on some occasions transcends pastoral communities and can be

Box 1
United Nations Sustainable Development Goals
Sustainable pastoralism can particularly contribute to goals 1, 2, 3, 8, 10, 15 and 16

Goal 1	End poverty in all its forms everywhere
Goal 2	End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Goal 3	Ensure healthy lives and promote well-being for all at all ages
Goal 4	Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all
Goal 5	Achieve gender equality and empower all women and girls
Goal 6	Ensure availability and sustainable management of water and sanitation for all
Goal 7	Ensure access to affordable, reliable, sustainable and modern energy for all
Goal 8	Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all
Goal 9	Build resilient infrastructure, promote inclusive and sustainable industrialisation and foster innovation
Goal 10	Reduce inequality within and among countries
Goal 11	Make cities and human settlements inclusive, safe, resilient and sustainable
Goal 12	Ensure sustainable consumption and production patterns
Goal 13	Take urgent action to combat climate change and its impacts
Goal 14	Conserve and sustainably use the oceans, seas and marine resources for sustainable development
Goal 15	Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss
Goal 16	Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels
Goal 17	Strengthen the means of implementation and revitalise the global partnership for sustainable development

Source: www.un.org/sustainabledevelopment/sustainable-development-goals

Box 1 *Source:* Zinsstag et al., 2016a. Displaying the SDGs and highlighting where pastoralism can help to contribute to specific SDGs.

understood as Ecosystem Services (ES) or Nature Contributions to People (NCP) (Dean et al., 2021; Dong et al., 2016; Starrs, 2018). In doing so they are essential in helping to address many global challenges as conceptualised by the sustainable development goals (SDGs, see box 1). Due to the near global ubiquity of pastoral systems, and their ability to use two-thirds of the agricultural land not suitable for intensive production, such as rangelands and mountains (Ho, 2016; Liechti and Biber, 2016; Pardini, 2004; Zinsstag et al., 2016b), the can influence biodiversity and landscapes around the world. Some researchers even claim that pastoral systems are among the most efficient forms of natural resource management in arid, semi-arid and high-lowland contexts, such as the Mediterranean basin, as they manage the use of spatially and temporally separated resources such as fodder for grazing (Blench, 2001a; Bonfoh et al., 2016; Niamir-Fuller and Huber-Sannwald, 2020). Pastoral systems, as complex socio-ecological systems also modify landscapes creating a wide range of ecological niches through moderate pressure both from livestock grazing and direct manipulation of landscapes, making pastoral systems vital for biodiversity promotion and conservation (SDG 15). Pastoral systems create diverse landscapes through the grazing and movement patterns of livestock (Davies; P. Herrera; et al., 2016; Köhler-Rollefson, 2016; Niamir-Fuller and Huber-Sannwald, 2020; Sandstrom and Strapasson, 2017).

In addition, through the provision of food, pastoral systems are particularly relevant to SDG 2 - Ending hunger and promoting sustainable agriculture. Pastoral systems, as a form of traditional or peasant agricultural systems, are rarely export-driven systems and instead serve to supply nutritious food to local populations using extensive agricultural practices (Rivera-Ferre, 2008) In fact, a recent study (Lowder et al., 2021) stated that small and family farms are vital for global food security. These practices are generally characterised by having high labour requirements and low inputs, highlighting the potential of pastoral systems to enhance global agricultural sustainability. In line with this, pastoral systems significantly contribute to the GDP of many countries through the creation of food and its distribution through informal markets (IUCN, 2008; Krätli et al., 2013; Manzano et al., 2021; Zinsstag et al., 2016b), Several authors stress that this point makes pastoral systems economically vital for many industrialising countries (SDG1; SDG8) (El Bilali et al., 2020; Krätli et al., 2013; Rueff and Rahim, 2016). They do this through the creation of high-quality, traditional food products, such as cheese, meat and animal fibres, such as wool or leather, Although the potential of

pastoral systems to reduce poverty is greater when they can have access to local and international markets (Davies, 2008; Sendyka and Makovicky, 2018; Wu et al., 2014). Accordingly, agri-food systems such as pastoral systems should be analysed through frames that consider the complexity of the system (Rivera-Ferre et al., 2013) and not only through the analysis of individual variables (Manzano et al, 2021).

Challenges facing pastoral systems

Unfortunately, pastoral systems have been historically ill-considered by the many governmental and societal institutions (Scoones, 2020), often being framed as "archaic" (Davies and Hatfield, 2007). This is due in large part to both the colonial policies of considering traditional systems/people as inferior and the desire for modernisation, industrialisation and globalisation of agricultural practices, combined with governments tendencies to prefer sedentary agriculture compared to mobile pastoral systems (López-i-Gelats et al., 2016; Scoones, 2020) and ultimately, the inconvenience of having societal groups which belong nowhere and are thus, more difficult to control by the state. Despite this, it has been shown that pastoral systems have a role in addressing many global problems (Box 1), today some researchers continue to frame them as economically unproductive and responsible for land degradation (Gobindram et al., 2018; Zerboni and Nicoll, 2019). This helps to understand why governments are rarely accepting pastoral systems and consistently implement unfocused or negligent policies that require pastoral systems to simplify due to the privatisation of resources and the limiting of pastoral mobility (Bonfoh et al., 2016; Davies; P. Herrera; et al., 2016; Davies and Hatfield, 2007; Morton, 2010).

This has led some researchers to claim that pastoral systems are among the most politically marginalised systems on the planet (Bonfoh et al., 2016). López-i-Gelats et al. (2016) highlighted the many ways that pastoral systems continue to face marginalisation, particularly through the encroachment of pastoral lands by other activities and the benign neglect of many policymakers. Niamir-Fuller and Huber-Sannwald (2020) suggest that many pastoral systems in the world are not actively marginalised or neglected but instead suffer from *benign neglect*, where pastoral systems are not actively neglected but merely never considered. Although a growing body of research suggests that pastoral systems face continuing marginalisation due to a lack of recognition of their importance at different governmental and societal levels (Davies; P. Herrera; et al., 2016; Johnsen et al., 2019;

Manzano et al., 2021; Schareika et al., 2016) pastoral systems survive today in the face of increasing agricultural intensification and land abandonment due to their capacity for adaptation. Pastoral systems have responded to their vulnerability to social, environmental and economic challenges through the use, among other resources, of Traditional Ecological Knowledge (TEK). TEK increases pastoral resillence by giving context-specific regional adaptations based on specalised knowldge of how to best use spaitally and temporraly scare resources (Fernández-Giménez, 2015; Hobbs et al., 2014; Oteros-Rozas et al., 2013a). TEK as defined by Gómez-Baggethun et al., 2013 refers to "*the body of knowledge, beliefs, traditions, practices, institutions, and worldviews developed and sustained by indigenous, peasant, and local communities in interaction with their biophysical environment*" (Gómez-Baggethun and Reyes-García, 2013). TEK holds the potential to allow pastoral systems to adapt to changes and maintain resilience (Fernandez-gimenez and Fernandez-gimenez, 2014; Hobbs et al., 2014). It is vital to remember that TEK is not a static concept and should not be seen as replacing modern techniques but as something that works parallel to them, allowing pastoralists the potential to integrate new techniques into the context of their TEK

This thesis sides with those researchers who consider pastoral systems to be creators and maintainers of multiple goods and services (Fernández-Giménez, 2015; Hobbs et al., 2014; Oteros-rozas, 2015). Those multiple goods and services often transcend the very pastoral community and have often been conceptualized as Ecosystem Services (ES) and more recently as Nature's Contributions to People (NCP). Both frameworks claim to measure the tangible and intangible services/contributions of socio-ecological systems, although the NCP claims to come from a different ontological base. The ES conceptual framework has been the established framework for the study of human-nature systems since 2005 with the release of the Millenium Ecosystem Assessment (Millennium Ecosystem Assessment, 2005a), which promoted the use of multiscale and multisectoral analysis to capture complexity. Although the framework has faced criticisms for not being inclusive enough of social sciences. In response to this, the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES), created the NCP framework (Díaz et al., 2018) to be more context-specific and more inclusive of social science (Refer to theoretical framework section in chapter 2 for a more in-depth analysis) Both conceptual frameworks claim to allow for a holistic view of the ecological, political and social dynamics of socio-ecological systems such

as pastoral systems. This can be demonstrated through the multiple goods and services that pastoral systems contribute to society, such as the creation of landscapes that are enjoyed by society, their contribution to global food security (López-Santiago et al., 2014; Rivera-Ferre et al., 2016) or the creation of culture and identity. And it is in this context that conceptual frameworks of ES and NCPs will be used here to construct a narrative to help increase the understanding of the true effects of the drivers of change affecting pastoral systems.

Research gaps addressed

Considering all the above, there is still limited research on how to analyse those systems where human-nature interactions are strong and that through this interaction they provide public goods and services. The main gaps I will be addressing in this thesis deal with the framing of the human-nature relationship within pastoral systems as an example of a human-nature system, highlighting the tangible and intangible contributions both created and maintained by pastoral systems and their drivers of change. I combine this with how the inadequate framing and analysis of such systems result in an inadequate understanding of their contributions to human survival and thus, to inadequate policies. This will contribute to the discussion regarding the human-nature relationship and the ontological perspectives taken by researchers.

All human-nature systems use and produce public goods and services which can be conceptualised as ES or NCP, although according to some research the explicit interaction of humans in the creation of public goods and services are rarely investigated (Fischer and Eastwood, 2016). Particularly for the case of pastoral systems, there is to date no work being done that analyses holistically the contributions of pastoral systems as users and producers of ES/NCP at the global or Mediterranean level. As a result, the role of policies impacting pastoral systems as instruments to enhance or constrain the associated NCP/ES is not yet known. To contribute to filling this research gap we propose to understand pastoral systems as complex socio-ecological systems with strong human-nature interactions and producers of multiple NCP. From this perspective, we also analyse how policies, as external drivers of change, impact the ability of pastoral systems to produce their linked NCP, thus affecting the ability of pastoral systems to address global challenges.

Objectives and hypothesis

This thesis aims at contributing to the socioecological systems and pastoral literature by picturing pastoral systems as complex socio-ecological systems to both recognise the numerous goods and services provided by them and highlight the role they can play in addressing global challenges. In this context, the general objectives of this work are, first, to provide more evidence of the inherent complexity of pastoral systems and, second, to determine if this complexity is currently acknowledged by researchers and policymakers. The main question I will try to answer here is if the lack of awareness of the complexity of pastoral systems, particularly in academia and in the policy-making domain, undermines the capacity of pastoral systems of providing their multiple goods and services, which here will be framed as Ecosystems Services and Nature's Contribution to People. To address these two general objectives, the following specific objectives (SO) will be addressed:

- SO1. To examine if the Nature's Contribution to People framework, proposed as a framework to analyse complex systems, is suitable for the analysis of pastoral systems (Chapters 3 and 5).
- SO2. To identify drivers of change in pastoral systems which affect the ability of pastoral systems to provide goods and services (Chapters 3 and 5).
- SO3 To analyse if the pastoral research community employs complex lenses in making sense of pastoral systems, particularly the multiscale and multisectoral approaches recommended by the Millennium Ecosystem Assessment. (Chapter 4).
- SO4. To determine if policymakers consider pastoralism through complexity, by examining the main policies impacting pastoral systems in the Mediterranean basin (Chapters 5).

The hypotheses that will be tested throughout this thesis are:

Hypothesis 1 – The Nature's Contribution to People is appropriate for the analysis of socio-ecological systems.

Hypothesis 2 – Researchers of pastoral systems fail in embracing the complexity of pastoral systems.

Hypothesis 3 – Pastoral systems are producers and maintainers of ES/NCP at the global and regional scales.

Hypothesis 4 - Policies as a driver of change impact the public goods and services produced by pastoral systems.

Objectives	**Structure of the report and hypothesis addressed**
To provide more evidence that pastoral systems are complex socio-ecological systems and determine if their complexity is currently acknowledged by researchers and policymakers	Developed in the introduction and discussion.
To examine if the Nature's Contribution to People framework, proposed as a framework to analyse complex systems, is suitable for the analysis of pastoral systems	Developed in Chapter 3 and Chapter 5. **Hypothesis:** The Nature's Contribution to People is appropriate for the analysis of socio-ecological systems.
To identify drivers of change in pastoral systems which affect the ability of pastoral systems to provide goods and services	Developed in Chapters 3 and Chapter 5. **Hypothesis:** Policies as a driver of change in pastoral systems can impact the public goods and services produced by pastoral systems.
To analyse if the pastoral research community employs complex lenses in making sense of pastoral systems,	Developed in Chapter 4. **Hypothesis:** Researchers and policymakers of pastoral systems do not embrace the complexity of the systems.
To determine if policymakers consider pastoralism through complexity, by examining the main policies impacting pastoral systems in the Mediterranean basin	To determine if policymakers consider pastoralism through complexity, by examining the main policies impacting pastoral systems in the Mediterranean basin

Table 2. Objectives and hypothesis addressed in this thesis and the chapters where they are discussed.

Methodology

To address the objectives of the thesis I have used different methodologies to allow me to capture the complexity of pastoral systems as an example of a human-nature system, namely: Qualitative comparative analysis (Chapters 3 and 5), to allow for the systematic analysis of large amounts of data, leading to the identification of trends in the literature. Network analysis (Chapter 3), to identify relationships between different elements of pastoral systems identified in the literature, such as the relationship between pastoral mobility and different drivers of change. Semi-structured interviews (Chapter 5), to identify policies that impact pastoral systems across the Mediterranean basin.

A Qualitative comparative analysis (QCA) was performed in chapters 3 and 5 to conduct a qualitative meta-analysis of the existing academic literature on the relationship between pastoral systems and the ES/NCP provided by them. QCA is an adequate methodology to reveal patterns across the Literature through a process of iterative rereading and recoding. In recent years the QCA has become popular in the analysis of socio-ecological systems (Dean et al., 2021; López-i-Gelats et al., 2016). In the case of this thesis, the published papers were used as our data, not the data used by each of the studies, this allowed for a collection of non-standardised and qualitative information. The implementation of a QCA requires several steps:

i)The identification of the research question. In the case of chapter 3, this question was: What NCP are created and maintained by pastoral systems. What are the characteristics of pastoral systems and what are the drivers of change of pastoral systems?

ii) Then, inclusion criteria for selecting the literature to examine needed to be clearly defined. In chapter 4 of this thesis, some of the inclusion criteria included being published before a certain date, and the pastoral system under examination must be located within the Mediterranean basin. If an article did not meet any of these criteria it was excluded from further analysis. Pastoral systems need to use a mobility system.

iii) Literature should then be collected, in the case of this thesis, the literature was collected using custom search strings in Scopus (Chapter 3) and Web of Science (Chapter 4).

iv) Papers should then be selected for analysis based on the fulfilment of all the inclusion criteria. This was done through the analysis of the article's title, then its abstract and lastly a full reading of the article.

v) Once the papers have been included, the papers can be analysed for the identification of variables of interest (such as mobility system or NCP/ES created) through a process of reading and rereading, coding and recoding and registering them in the database through the creation of a binary database (1 Yes, 0 No).

QCA is a method that allows for a combination of qualitative case focused methods with elements of quantitative variable focused methodologies (Ragin, 2014). QCA was designed for grouping variables that display similar configurations by using Boolean algebra, these scientific papers deal with pastoral systems and NCPs. The benefits of a QCA are that it allows for large amounts of data to be systematically analysed, allowing researchers to identify trends in the literature. In the case of this thesis, a QCA allowed for examining if the complexity of pastoral systems is fully acknowledged by researchers. This was done by using the number of NCP/ES identified in the literature and the number of times different NCP/ES were identified as an indicator of the complexity of pastoral systems. The use of a QCA also provided the opportunity to examine if the NCP framework was appropriate for the analysis of socioecological systems such as pastoral systems through the identification of NCP in the literature (Chapter 3).

Chapter 3 of this thesis uses a Network analysis to identify the relationship between mobile pastoral systems, their drivers of change that were identified in the literature, grazing systems and NCP they produce. A network analysis allows for the systematic investigation of network processes (Diani, 2002). This makes networks a powerful way of representing patterns of interactions between different parts of a system and is an increasingly used tool to study socio-ecological systems (Dean et al., 2021; Hanaček and Rodríguez-Labajos, 2018; Leister et al., 2019). Network analysis is a method traditionally associated with mathematics and computer sciences, but in recent years has seen increasing interest in many other fields (Butts, 2009). The study of networks is a growing and interdisciplinary field that combines social and biological sciences along with many others. Network analysis works on the assumption that relationships are important and it attempts to map the interactions between

variables. A network as described by (Newman, 2010) is “a collection of points joined together in pairs by lines”. To create a network, each element under investigation is referred to as a node (In this thesis a node could be any NCP identified in the literature), relationships between nodes are represented via lines between them that are referred to as edges. The network is then represented by a graph displaying the pairwise relationship between nodes (Butts, 2009). The network analysis was performed using NodeXL (Smith, M. et al., 2010) with only connectivity levels between 34-344% being sown to present only the strongest connections and to avoid the graphs being overly clumped. The use of a network analysis helped to identify which drivers of change affected the ability of pastoral systems to produce different NCP. Specifically the use of a Network analysis allowed for the identification of policies as an important driver of change in mobile pastoral systems.

This thesis has worked with data that has been collected from semi-structured interviews in chapter 5. Semi-structured interviews allow for a middle ground between highly focused and structured questionnaires. Which are designed for large sample sizes and primarily closed-ended questions and highly fluid unstructured discussions consisting of open-ended questions, with smaller sample sizes but greater depth of information. Semi-structured interviews allow for a blend of open and closed-ended questions with the ability to perform follow up questions, which allows for new topics to be discovered and explored (Adams, 2015). Semi-structured interviews are regularly used for the study of socio-ecological systems and particularly pastoral systems (Fernández-Giménez, 2015; López-i-Gelats et al., 2011). As they are well suited for use with questions that may benefit from additional follow-up inquiries. The interviews were conducted as part of the European project PACTORES[1] to identify policies that impact pastoral systems, to identify specific challenges to pastoral communities resulting from policy implementation in each case study region in the

Mediterranean basin. The use of semi-structured interviews allowed for an examination of how policies as a driver of change influence the ability of pastoral systems to produce NCP/ES. As part of PACTORES, 164 semi-structured interviews were performed by project partners in each of the case study regions with expert informants between January 2018 – May 2019. The expert informants were selected to capture a diverse range of perspectives regarding pastoral systems. These interviews were then supplemented with an additional round of questions to pastoral academic experts in each of the study areas. This resulted in 235 policies

[1] PACTORES webpage: https://www.pactores.eu/

being identified as important to pastoral systems. 83 of the policies were later excluded due to repetition or lack of connections with NCP. Leaving 146 policies for analysis. I was responsible for the inductive process of analysing the policies to allow for the identification of trends across the case study regions.

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Chapter 2: Theoretical framework

Introduction

To address the objectives of this thesis I will use three conceptual frameworks to allow me to capture the complexity of pastoral systems: Socio-ecological systems (SES), Ecosystem Services (ES) and Nature Contributions to People (NCP). Fundamentally all three of the frameworks in this thesis fall under the umbrella of sustainability sciences, which means that each of the frameworks seeks to "*understand the fundamental character of interactions between nature and society and to encourage those interactions along more sustainable trajectories"* (Kates et al., 2001). Each of the frameworks that have been selected for use in this thesis have an interdisciplinary perspective and development. This means each of the frameworks used, can be used by researchers from diverse scientific backgrounds (ecology, social science, economics) and encourages interdisciplinary scientific thought regarding environmental sustainability.

I have used the Socio-ecological framework (SES) (Ostrom, 2009, 2007), which has evolved from empirical research on commons, collective action and institutions in systems that have common pool resources. The SES was developed from an institutional economics standpoint and is focused on understanding the complexity of systems, making it an interdisciplinary framework. The goal of socio-ecological scholars is to examine how socio-ecological systems can be sustainable for different groups. According to Partelow 2018, sustainability in the context of the SES *is "the development and maintenance of contextually appropriate institutions that can enable actors to cooperate and use resources in a way that allows for the long-term and equitable availability of those common resources"* (Partelow, 2018).

The Ecosystem Services (ES) framework (Millennium Ecosystem Assessment, 2005a). The ES concept was created as a method to communicate the importance and impact of the natural world on society. The ES concept has been around for a long time, scattered between the disciplines of economics and ecology (Costanza et al., 1997; Norgaard, 2010) with Gómez-Baggethun et al., 2010 tracing its epistemology back as far as the 17th century (Gómez-Baggethun et al., 2010). The ES framework was originally designed to better identify options to achieve sustainability goals and to help create a better understanding between trade-offs and synergies across stakeholders in decisions regarding the environment (Millennium Ecosystem Assessment, 2005b).

The Nature's contribution to people framework (Díaz et al., 2018) can be considered the latest evolution of the ES framework and has been designed to be more inclusive of intangible values than the ES framework and as such more emphasis has been placed on the importance of social science perspectives. Each of the conceptual frameworks used are briefly outlined below.

Socio-ecological system framework

The SES framework was designed to create a common vocabulary among sustainability researchers across academic disciplines (Ostrom, 2009, 2007). As a response to scholars that used to develop simple models to analyse complex systems, the SES framework is the product of extensive collaboration between different researchers from different disciplines. SES as defined by (Ostrom, 2009) are *"composed of multiple subsystems and internal variables within these subsystems at multiple levels…[where resource systems and governance systems] relatively separable but interact to produce outcomes at the SES level, which in turn feed back to affect these subsystems and their components, as well other larger or smaller SESs".*

At its heart, the socio-ecological system (SES) framework acknowledges that all resources used by humanity are embedded in a complex socio-ecological (human-nature) system. SES combine complex interactions of i) Users (individuals using a given area in diverse ways including for recreation or commercial reasons), ii) Governance systems (any government or organisation that manages the defied territory, the rules related to use of the territory and how they are created), iii) Resource systems (an area encompassing a specified territory such as high mountain communal pastures) and iv) Resource unit (water, trees, wildlife, pasture) systems (Fig.1) (Mcginnis and Ostrom, 2014; Ostrom, 2009). (Table 1) displays a list of second-tier variables of socioecological systems which have been adapted from Ostrom (2009) (Mcginnis and Ostrom, 2014). The SES framework was developed from the work already done by the Institutional analysis and development (IDA) framework and as such the two frameworks can be said to be closely related (Mcginnis and Ostrom, 2014). The core of the IDA framework is the "action situation" where actors engage with each other, and all parties affect the results that are valued differently by each of the actors.

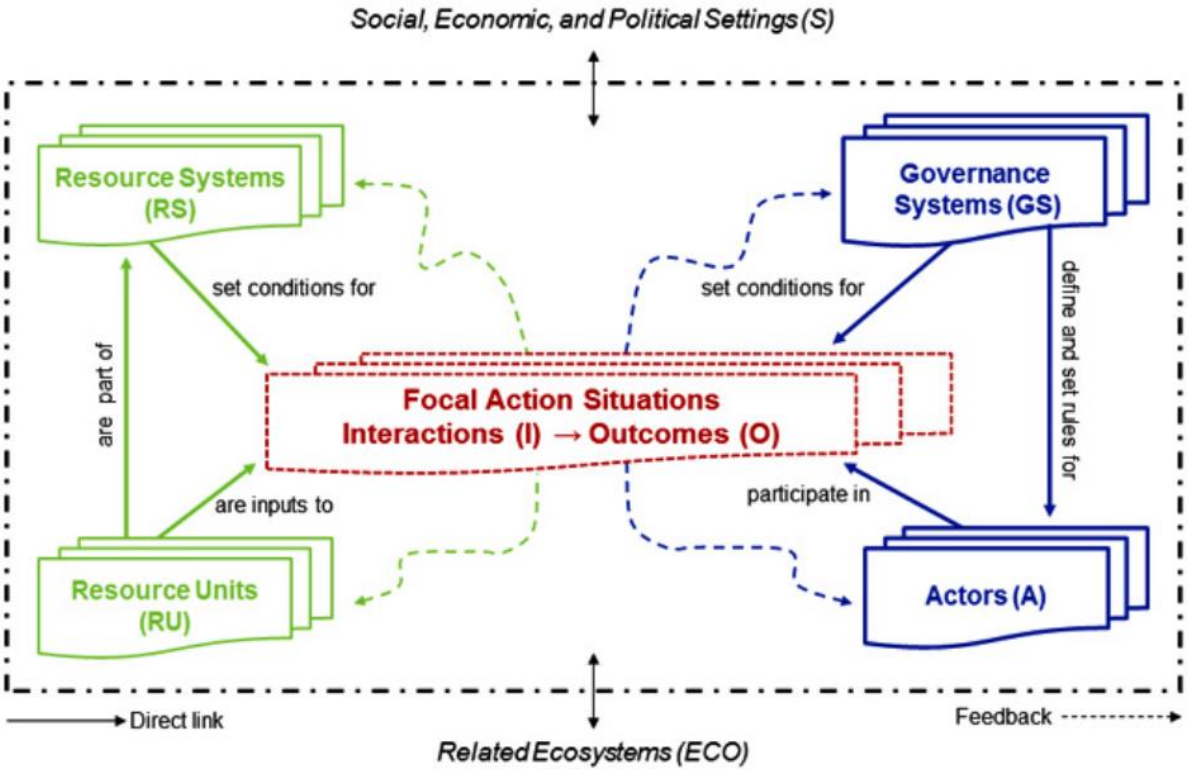

Fig. 1 Main components of the Socioecological system framework.

Note: *Solid boxes denote first-tier categories. Resource Systems, Resource Units, Governance Systems, and Actors are the highest-tier variables that contain multiple variables at the second tier as well as lower tiers. Action Situations are where all the action takes place as inputs are transformed by the actions of multiple actors into outcomes. Dashed arrows denote feedback from action situations to each of the top-tier categories. The dotted-and-dashed line that surrounds the interior elements of the figure indicates that the focal SES can be considered as a logical whole, but that exogenous influences from related ecological systems or social-economic-political settings can affect any component of the SES. These exogenous influences might emerge from the dynamic operation of processes at larger or smaller scales than that of the focal SES* (source: *Mcginnis & Ostrom (2014)*).

First-tier variable	Second-tier variables
Social, economic, and political settings (S)	S1 – Economic development
	S2 – Demographic trends
	S3 – Political stability
	S4 – Other governance systems
	S5 – Markets
	S6 – Media organizations
	S7 – Technology
Resource systems (RS)	RS1 – Sector (e.g., water, forests, pasture, fish)
	RS2 – Clarity of system boundaries
	RS3 – Size of resource system
	RS4 – Human-constructed facilities
	RS5 – Productivity of system
	RS6 – Equilibrium properties
	RS7 – Predictability of system dynamics
	RS8 – Storage characteristics
	RS9 – Location
Governance systems (GS)	GS1 – Government organizations
	GS2 – Nongovernment organizations
	GS3 – Network structure
	GS4 – Property-rights systems
	GS5 – Operational-choice rules
	GS6 – Collective-choice rules
	GS7 – Constitutional-choice rules
	GS8 – Monitoring and sanctioning rules
Resource units (RU)	RU1 – Resource unit mobility
	RU2 – Growth or replacement rate
	RU3 – Interaction among resource units
	RU4 – Economic value
	RU5 – Number of units
	RU6 – Distinctive characteristics
	RU7 – Spatial and temporal distribution
Actors (A)	A1 – Number of relevant actors
	A2 – Socioeconomic attributes
	A3 – History or past experiences
	A4 – Location
	A5 – Leadership/entrepreneurship
	A6 – Norms (trust-reciprocity)/social capital
	A7 – Knowledge of SES/mental models
	A8 – Importance of resource (dependence)
	A9 – Technologies available
Action situations: Interactions (I) → Outcomes (O)	I1 – Harvesting
	I2 – Information sharing
	I3 – Deliberation processes
	I4 – Conflicts
	I5 – Investment activities
	I6 – Lobbying activities
	I7 – Self-organizing activities
	I8 – Networking activities
	I9 – Monitoring activities
	I10 – Evaluative activities
	O1 – Social performance measures (e.g., efficiency, equity, accountability, sustainability)
	O2 – Ecological performance measures (e.g., overharvested, resilience, biodiversity, sustainability)
	O3 – Externalities to other SESs
Related ecosystems (ECO)	ECO1 – Climate patterns
	ECO2 – Pollution patterns
	ECO3 – Flows into and out of focal SES

Table. 1 Displays Second-teir variables of a social-ecological system. (source: *Mcginnis (2014)* and adapted from *Ostrom (2009)*)

The framework was originally designed for the application of common-pool recourses management situations (Mcginnis and Ostrom, 2014) but has now evolved to include areas such as rangeland management, conservation and food systems (Risvoll et al., 2014; Vallejo-Rojas et al., 2016). Now the SES framework is used more as a tool to diagnose sustainability in socio-ecological systems, such as pastoral systems (Dean et al., 2021; Easdale et al., 2016; Fernández-Giménez, 2015), highlighting the appropriateness of using the SES framework to analyse the complexity of pastoral systems, as demonstrated by several authors (Fernández-Giménez, 2015; Manzano et al., 2021; Risvoll et al., 2014). The SES framework is commonly associated with other conceptual frameworks that acknowledge the inherent complexity of nature-society interactions such as the Ecosystem Services and Resilience frameworks, and most recently the Nature's contribution to people framework (Dean et al., 2021; Manzano et al., 2021; Partelow, 2018). The SES framework does not have general guidelines or methods for its application, although several publications have tried to provide guidance and examples (Hinkel et al., 2015; Partelow, 2016). According to Partelow (2018), a lot of the research (including this thesis) uses the SES framework as a tool to provide a new conceptual lens to reanalyse existing data – such as meta-analysis. This is due in part to the difficulties in collecting enough primary data on all variables in a case study (Partelow, 2018). These difficulties have been extensively explored by Hinkel et al., 2015, 2014 but include misinterpretation of a tiered framework, knowing and understanding how to use diagnostic methodologies and the problem of analysing socio-ecological systems holistically.

The SES framework, while inclusive and flexible by design (Ostrom, 2007, 2009), suffers from a few problems, which have raised some criticism. The problem which is most consistent with all the frameworks used in this thesis is the theme of an anthropogenic narrative of the framework. Ostrom's use of the term "Users" (Ostrom, 2009, 2007), and later the use of the term "Actors" (Fig. 1) (Mcginnis and Ostrom, 2014), allows the SES framework to be discussed in utilitarian and ultimately anthropocentric terms. Also, the inclusivity and adaptability of the framework has allowed for a wide range of interpretations about how the different variables of the framework are applied and how different variables are defined, as discussed by Partelow in his review of the SES framework (Partelow, 2018). For example, the term social capital has different contextual definitions, it may be considered the degree of trust (Gutiérrez et al., 2011) or it may refer to exchanges in social networks (Borgatti et al., 2009).

Unfortunately, the contextuality of SES variable's definitions can cause an issue of comparison between one SES and another.

Despite all this, I believe that the SES framework is one of the most complete frameworks for acknowledging the complexity of socio-ecological systems, such as pastoral systems. Especially through its use as a conceptual lens, as it can be easily combined with other frameworks. In the case of this thesis, the combination of the SES conceptual lens with the Ecosystem Services and Natures Contribution to People framework has allowed for a richer and more complex analysis of pastoral systems.

Ecosystem services

Ecosystem Services (ES) is a concept of major environmental and political importance. The Millennium Ecosystem Assessment (MEA) synthesis report defines ES as "*the benefits ecosystems provide to human wellbeing'* (Millennium Ecosystem Assessment, 2005a).

The concept first appeared in the United States more than 30 years ago as a response to ecosystems degradation (Chaudhary et al., 2015). Seminal books such as *The limits to growth* (Meadows et al., 1972)*, The tragedy of the Commons* (Hardin, 1968) and *Silent Spring* (Carson, 1962) helping to draw attention to the natural environment and human interactions with it. A key moment happened in the 1970s when the *Study of Critical Environmental Problems (SCEP)* struggled to list the services provided by natural systems, this became *public services* followed by *nature services* and finally *ecosystem services* in 1981 (Chaudhary et al., 2015).

The real breakthrough for the academic acceptance of ES came in 1997 with two seminal works, the nature article *The value of the world's ecosystem services and natural capital* by (Costanza et al., 1997) and the book *Nature's services: societal dependence on natural ecosystems* by (Daily, 1997) both firmly established ES as a modern tool and concept (Gómez-Baggethun et al., 2010). The second important development for ES was the movement from academic theory into actionable policy. In 1997 Costa Rica launched the first "payments for ecosystem services" scheme (PES). PES normalised the idea of putting an economic price on nature and the concept that monitoring nature could help in its effective management (Chaudhary et al., 2015).

Five years later there were more than 300 PES projects reported globally (Landell-Mills and Porras, 2002). In 2001, the Millennium Ecosystem Assessment (MEA) was launched resulting

in many non-governmental organisations (World Wildlife Fund) as well as multilateral organisations (World Bank) adopting the ES and PES framework (Chaudhary et al., 2015). The framework's profile continued to be developed by the creation of policies such as The United Nations Programme on Reducing Emissions from Deforestation and Forest Degradation (REDD).

Since 2005 and the release of the MEA synthesis report, the ecosystem services concept has continued to evolve and become a more comprehensive framework that tries to incorporate the view of a wide array of disciplines from economics, ecology, and social sciences. This evolution has been extensively tracked by (Díaz et al., 2018). The MEA framework promotes the use of multiscale and multidisciplinary outlook and categorises all ecosystem services into four different categories (Alcamo, 2003; Millennium Ecosystem Assessment, 2005a): i) Supporting services, such as primary production and soil formation; ii) Provisioning services like food, fuel and raw materials such as wood and fibres; iii) Regulating services such as climate and extreme event regulation; and finally, iv) Cultural services which account for all recreational, spiritual, educational or aesthetic services provided by ecosystems.

The ES framework has been extensively used for the study of pastoral systems (Fernández-Giménez, 2015; Huntsinger and Oviedo, 2014; Oteros-rozas, 2015; Rueff and Rahim, 2016) as it has provided researchers with a utilitarian way of communicating the complexity of pastoral systems and has increased awareness of the social goods created and maintained by pastoral systems. Today some authors even claim that the ES discourse has become the dominant discourse when discussing human-nature relationships in policy and environmental science (Muradian and Gómez-Baggethun, 2021).

Despite its popularity, the ES framework has been criticised for several reasons. Some authors claim that it is too utilitarian and focuses too much on the commodification of nature as a way to capture nature societal value, focusing too much on economic and biophysical methodologies to establish value. Other authors claim that it is a highly politicised tool that is responsible for the exclusion/marginalisation of other world views. (Díaz et al., 2018; Jackson and Palmer, 2015; Kull et al., 2015; Lele et al., 2013; McCauley, 2006; Muradian and Gómez-Baggethun, 2021; Pascual et al., 2014; Redford and Adams, 2009). Studies on cultural ES have also been under represented compared other ES as highlighted by (Díaz et al., 2018; Hanaček and Rodríguez-Labajos, 2018). This is because cultural ecosystem services and context-

specific views, world views and value systems are not as placed within the natural capital economic/stock framing that is so common with ES practitioners (Ellis et al., 2019). Because of this, their valuation has in general trailed behind other forms of ES as they are systematically disregarded by most of the implementations of the ES framework as externalities. Even though cultural ES have an important role in shaping environmental narratives and attitudes (Chiesura and De Groot, 2003), emphasising their value to both science and policy.

Nature's Contributions to People

In light of these criticism faced by the ES framework, the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES) set out to create a new framework that would be more inclusive of specific contexts, world views and increase the importance of culture in defining the links between people and nature. This new framework is called Nature's Contributions to People (NCP) (Díaz et al., 2018). Diaz et al. 2018 shows the evolution from ES to the updated NCP. NCP's are defined as "*all the contributions both positive and negative of living nature (diversity of organisms, ecosystems and their associated ecological and evolutionary processes) to people's quality of life*" (IPBES Plenary 5 Decision IPBES-5/1, n.d.).

NCP's are classified into 3 major groups: Material, Non-Material and Regulating NCP's. These 3 groups are then broken into 18 different categories. With each of the 18 different categories able to be in more than one of the three main groups simultaneously (Fig.2). Highlighting one of the key points of the NCP framework, that of overlapping categories and context-specific world views. A material NCP can also be a non-material NCP depending on the context. The case of pastoral systems, the wool from a sheep can be a material good, or it can be imbued with cultural properties as found in Turkey (Ocak, 2016). Food can have cultural significance beyond its physical value as described by (Kai M.A. Chan et al., 2012).

The creation of the NCP framework has created a lively debate among academics, many of whom are questioning the claims of the NCP framework (de Groot et al., 2018; Andrew N. Kadykalo et al., 2019; Kenter, 2018; Muradian and Gómez-Baggethun, 2021). Kenter (2018) expresses his concern that the IPBES has changed the known and excepted term of ES for the unknown and unexcepted term of NCP while simultaneously keeping the problem associated

with the term Ecosystem services. Muradian and Gómez-Baggethun. (2021) have been more critical of the NCP framework claiming that it continues to feed into the same utilitarian mentality as the ES

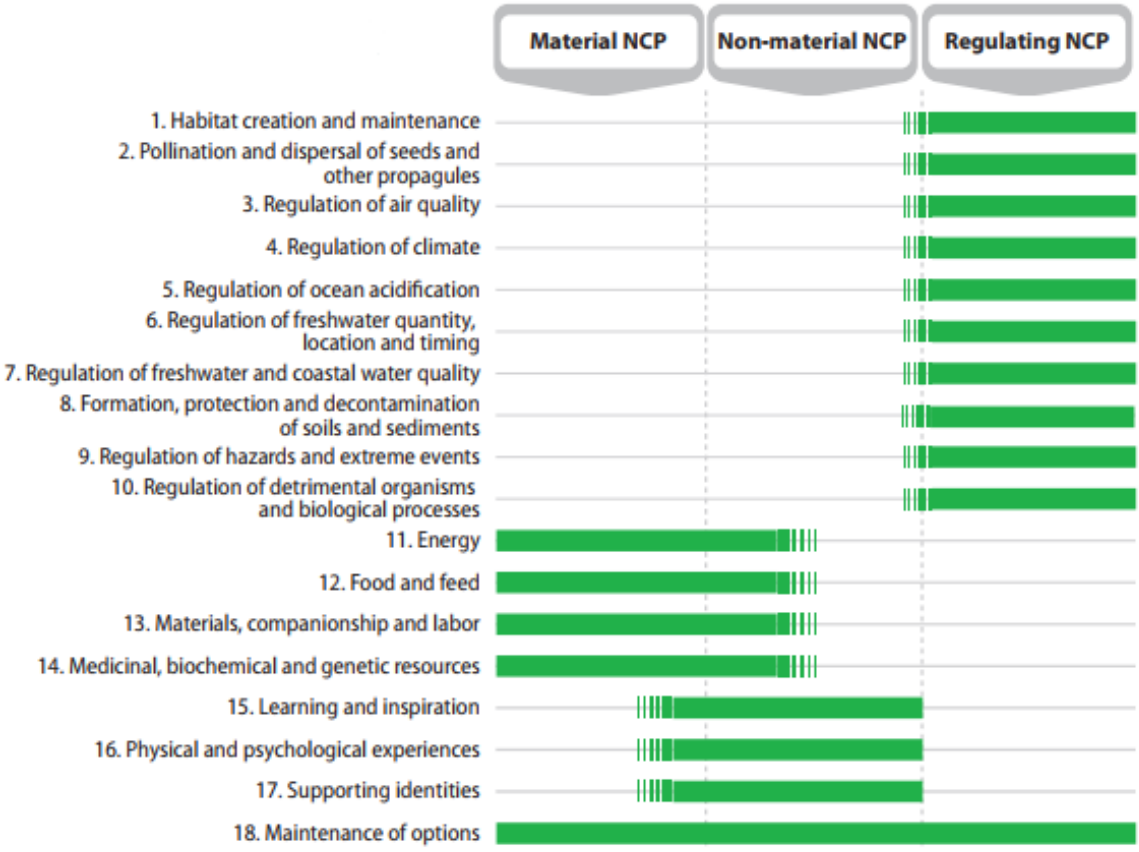

Fig.2 Nature's contribution to people categories and overlaps (source *Diaz et al., (2018)*)

framework and that it fails in setting a new discourse. Due to its continuing base in the western scientific philosophy which they claim is the root of the current global environmental crisis. Kadykalo et al. (2019), on the other hand, has produced arguably the most balanced analyses of the NCP conceptual framework to date. The authors have questioned the claims made by the IPBES that the NCP framework is a genuine paradigm shift, they then criticise that the NCP framework overstates the differences between it and the ES framework. Although in the end, they determined that the NCP framework does widen the scope of current discourse by allowing for a stronger emphasis on context-specific worldviews. Even if there is as yet, no way to rigorously operationalize the framework.

It is the belief of the author of this thesis that although the criticism of the NCP mentioned here are indeed valid and worthy of further discussion. The NCP framework does allow for a new dimension to be brought to the study of the socio-ecological system as it allows for a

deeper understanding of the context-specific cultures to permeate across different NCP groups. This is something that is acknowledged as extremely rare in the ES literature (Andrew N. Kadykalo et al., 2019). The NCP framework is already responsible for the production of new knowledge, as demonstrated by Aguilera-Alcalá et al., 2020 when highlighting the non-material role of scavengers in Spain.

The NCP framework was not designed to replace the ES framework, instead, it has the potential to act as complementary to the ES framework by allowing cultural services (in the language of the NCP framework "non-material" goods) to be highlighted. Perhaps most telling regarding the use and usefulness of the NCP framework was a study by Pires et al., (2020) when they highlighted that the decision by researchers to use either the ES or the NCP framework had little to do with the criticisms discussed here and instead were determined by the researcher's personal philosophy regarding the human-nature relationship. Researchers who prefered the ES framework were found to focus more on quantitive research methods and human demands. This contradicts a recent article by some of the most prominent ES researchers when they state that the ES framework is not anthropogenic but considers humans as a species that is integral to the biosphere (Costanza et al., 2017). Displaying a potential gap between the theory of the ES framework and the mentality of the practitioners. While researchers who used the NCP framework were more likely to prefer qualitative approaches with a co-production perspective of nature. Despite the criticism being levelled at the NCP framework, it has become an established framework for the study of terrestrial and coastal systems. This includes socio-ecological systems such as pastoral and mountain systems (Aguilera-Alcalá et al., 2020; Dean et al., 2021; Ellis et al., 2019; Leister et al., 2019; Takahashi et al., 2021).

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Chapter 3: Nature's Contribution to People as a framework for examining socio-ecological systems: The case of pastoral systems[2]

Abstract

The Nature's Contribution to People (NCP) framework builds on the Ecosystem Services (ES) concept and aims to incorporate social sciences more inclusively into economic and ecological aspects of ES. Given the emphasis of NCP around social issues, it is our hypothesis that NCP is well-positioned to analyse complex socio-ecological systems (SES) where human-nature interactions are heavily linked, such as pastoral systems. In this article, a qualitative comparative analysis was conducted to explore trends throughout the literature on pastoral systems and the viability of the NCP framework to analyse pastoral systems as an SES with strong human-nature interactions. We found that the NCP framework allows for an intuitive translation from ES. Our results show that the NCP Habitat creation and maintenance, Food and feed, and Supporting identities are the most connected to pastoral systems in the scientific literature. Given the emphasis of the NCP framework on non-material aspects of human-nature systems and the ease with which it can be applied to the literature, we suggest that the NCP framework can be complementary to the ES framework to allow for a more complete analysis of SES with strong human-nature connections.

Keywords: Human-nature systems, Qualitative comparative analysis, Ecosystem services, Sustainable agriculture, Mountain landscapes

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Introduction

The Nature's Contributions to People (NCP) concept is building on the Ecosystem Services (ES) concept and aims to incorporate social sciences more inclusively into the already established economic and ecological aspects of ES, broadening its epistemological boundaries (Díaz et al., 2018; Kadykalo et al., 2019). The NCP framework has not been designed to replace the ES framework and can be used to complete it. Pires et al. (2020) claims that a significant number of researchers who specialise in ES research are also now incorporating the NCP framework into their work (Pires et al., 2020). The NCP framework has been applied in the IPBES Regional Assessments on Biodiversity and Ecosystem Services, and in the IPBES Thematic Assessments on pollinators, pollination and food production (IPBES, 2018a, 2018b). Some authors are also now suggesting that the NCP framework provides a robust framework for the investigation of land systems (Ellis et al., 2019; Leister et al., 2019). NCP are defined as "all the contributions both positive and negative of living nature (diversity of organisms, ecosystems and their associated ecological and evolutionary processes) to people's quality of life (IPBES Plenary 5 Decision IPBES-5/1, n.d.). They are classified into three major groups: Material, Non-Material and Regulating NCP (Díaz et al., 2018). The key difference between the NCP framework and its predecessors is its scope. The final objective of the NCP framework is to push the theoretical boundaries of ES, particularly when considering context-specific views and relational values. This means engaging with issues that may not be quantifiable, i.e. cultural, institutional, and social issues. Given the strong emphasis of NCP around social issues, it is our hypothesis that NCP are well positioned to analyse those complex socio-ecological systems (SES) where the human-nature interactions are artificially separated for analytical purposes but where in fact, it is impossible to discern if the service is provided by the ecosystem or by the human action in those ecosystems. This may be the case of pastoral systems (Fernández-Giménez, 2015; Ocak, 2016) or forest management by indigenous communities (Paneque-Gálvez et al., 2018; Pérez and Smith, 2019). All of them have in common the central role of traditional ecological knowledge in the management of ecosystems. And in all of them, the co-evolution of humans with the surrounding natural environment makes it extremely difficult to understand the direction of interactions between humans and their ecosystems. As an example, Leister et al., (2020), through a systematic review, applied the NCP framework to mountains ecosystems. However, some of the NCP highlighted by the authors (animal

products from grazing, biodiversity, sense of identity) refer to the existence of a pastoral system (and culture) within the mountains (Leister et al., 2019). In other words, those ES or NCP would not exist without human actions, in this case, pastoral systems. Thus, we believe that the NCP framework can contribute to better understanding the contributions provided by those human-nature systems which cannot be fully analysed and developed through the lens of the ES framework. In this article, the NCP framework will be used to explain the interactions between pastoral systems and their environment as NCP offers the opportunity to use a novel framework to explore the complexity and symbiotic relationship of pastoral systems, conceptualised as a human-nature system, with their environment (Kadykalo et al., 2019).

As an SES pastoral systems are defined as an "adaptive network of biophysical and social flows generated and maintained by the movement of shepherds and livestock" (Oteros-Rozas et al., 2012). Pastoral systems are characterised by mobility, adaptability, and flexibility as they allow pastoralists to take advantage of the uneven distribution of natural and economic resources (Kratli et al., 2013; Krätli and Schareika, 2010; Rueff and Rahim, 2016; Zinsstag et al., 2016a). Their adaptability has allowed pastoral systems to persist since ancient times due to their ability to adapt to large scale uncertainty in terms of climate variability and resource availability (Fernández-Giménez, 2015; Ocak, 2016; Starrs, 2018). Pastoral systems are considered to be one of the most efficient forms of natural resource and land management in semi-arid and high-lowland contexts (Blench, 2001; Bonfoh et al., 2016; Davies and Hatfield, 2007) and there is strong evidence to display that pastoral systems are a sustainable and a viable form of life in many parts of the world with the ability to produce public goods and services and helping to ensure food security (Ben Hounet et al., 2016; Niamir-Fuller, 2016; Oteros-Rozas et al., 2014; Zinsstag et al., 2016b).

Thus, pastoral systems are primarily food production systems, but they are also cultural and environmental activities that create more than physical products. It is estimated that today there are between 200 and 500 million pastoralists in the world who act as stewards for 25% of the world's land (Niamir-Fuller, 2016). Regardless of its potential to promote ecological sustainability and fulfil many of the sustainable development goals (Niamir-Fuller and Huber-Sannwald, 2020), pastoral systems are in decline in many parts of the world. The decline of pastoral systems is due to a combination of different factors including i) Shifting social

perceptions that see pastoralism as an unattractive profession; ii) Unfocused governance which doesn't consider the needs of pastoral systems, leading to pastoral decline; iii) Economic systems that create markets where pastoral systems cannot compete effectively against intensive systems and iv) Changing demographics caused by the movement of people from rural to urban areas and an ageing rural population (Aryal et al., 2014; Fernández-Giménez and Estaque, 2012; López-i-Gelats et al., 2016; Niamir-Fuller and Huber-Sannwald, 2020; Sendyka and Makovicky, 2018; Stave et al., 2007).

Pastoral systems can be described as users and producers of NCP or ES (Chan et al., 2012; Díaz et al., 2018; Oteros-Rozas et al., 2012; Sendyka and Makovicky, 2018). As a complex SES and an activity in which human-nature relationships are closely interlinked, we only separate both for analytical purposes. But the human-nature relationship of pastoral systems causes complex feedback loops that make it impossible in many cases to distinguish which ES or NCP are created and maintained by the pastoral systems and thus, are linked to a traditional human activity in close linkage with nature, or which services are used by pastoral systems from the ecosystems on which they rely. Pastoral systems have been extensively studied through the ES framework (Addison and Greiner, 2016; Oteros-rozas, 2015; Seid et al., 2016; Sendyka and Makovicky, 2018) but not through the lens of the NCP framework.

Our primary goal is to determine whether NCP provides an adequate framework to understand the complexity of human-nature systems, using pastoral systems as an example, and distinguish what NCP the literature relates to pastoral systems. This will be done through the translation of the ES identified in pastoral literature into the NCP framework. We also identify through the literature the main drivers of change in pastoral systems and how these drivers of change are connected to different NCP.

Materials and Methods

1.1 Conceptual approach

For this analysis, the distribution of NCP and pastoral case studies have been examined at the continental level. Africa, Europe, Asia, Latin America, Oceania. These zones have been selected as a practical way to examine the NCP of pastoral systems.

Following the works of Rudel (2008) and Young et al. (2006), a combination of systematic review and meta-analysis was conducted with the methodology of Qualitative Comparative Analysis (QCA) (Rudel, 2008; Young et al., 2006). QCA is increasingly being used in the environmental global change field (López-i-Gelats et al., 2016; Lugnot and Martin, 2013; van Vliet et al., 2012). The QCA allows for the identification of trends within the literature through a process of reading and re-reading and coding and re-coding. This process is used in this study to conduct a meta-analysis to identify and characterise the existing knowledge in the specialized literature on the relationship between pastoral systems and social and environmental services.

The use of the QCA systematic review and meta-analysis required the following steps:

a) Characterisation of the research question: *what NCP are related to pastoral systems*.

b) Description of the case study inclusion criteria.

c) Selection of relevant literature.

d) Extraction of the literature which fulfils the inclusion criteria.

e) Selection of the relevant variables.

f) Going back to review previously read articles every time a new variable was identified.

g) Identification of trends and associations within the variables.

1.2 Data collection

A systematic literature review was performed with the goal of identifying, evaluating, and analysing the available research relevant to our research question. An operator string was created and used in the Scopus database on 06-06-19 *" TITLE-ABS-KEY (pastur* OR graz* OR herd* OR pastoral* OR semi-natural OR grassland* OR silvo* OR shepherd* AND livestock AND ecosystem-service* OR environmental-service* OR socio-eco* OR ltk OR tek AND NOT intensive)*

AND (LIMIT-TO (LANGUAGE provides, "English")) AND (LIMIT-TO (SRCTYPE , "j")) AND (EXCLUDE (PUBYEAR , 2019)) AND (LIMIT-TO (DOCTYPE , "ar"))" .

This resulted in a total of 608 peer-review articles being obtained for examination. The 608 articles were then examined against the inclusion criteria. Articles were required to display the following information as part of the selection criteria:

- Peer-review journal articles that contained primary data.
- Written in English and published before 2019.
- The relationship between pastoral systems and ecosystem services (or Nature's Contribution to People) should be discussed and examined.
- Characteristics of the pastoral system in the region must be described.
- The socioeconomic and ecological context of the pastoral system in the study should be described.
- The livestock management system in the article is characterised by mobility.

1.3 Data analysis

The primary studies chosen for the analysis were refined through a four-step process: (1) The publishing journal, (2) The title and keywords, (3) Analysing the abstract, (4) Analysing the full article. Eventually, 86 case studies were selected for analysis.

The 86 articles were each read 4 times over two months to ensure that all variables were captured for analysis and coding. As the body of literature using the NCP framework is small due to the age of the framework, ES were the primary target of the search string. The ES that were identified were then translated into the NCP framework for all case studies. Table 1. displays how information in the articles examined in this analysis was translated into the NCP framework. Here, "Habitat maintenance and creation" is considered in the literature as a result of the continuation of the traditional practice of extensive grazing and in many areas, has a direct impact on the biodiversity of the area (Bedunah and Schmidt, 2004; O'Rourke et al., 2016; Sendyka and Makovicky, 2018). "Supporting identity" is discussed as a sense of place and belonging due to generations of pastoral activity (Fernández-Giménez, 2015; Ocak, 2016). "Learning and inspiration" is interpreted through the literature as the specialised local

traditional knowledge obtained by pastoralists through generations of living and working in a region (Bedunah and Schmidt, 2004; Stave et al., 2007). “Genetic resources” required little interpretation as it is a material NCP. “Genetic diversity” is determined to be in the study when local, rare or distinct breeds are discussed (Fernández-Giménez, 2015; O’Rourke et al., 2016).

Title	Year	Country	Pastoral system	Movement system	Habitat creation & Maintenance (Regulating NCP)	Supporting Identity (Non-material NCP)	Learning & inspiration (non-material NCP)	Genetic resources (Material NCP)
A shepherd has to invent: Poetic analysis of social-ecological change in the cultural landscape of the central Spanish Pyrenees	2015	Spain	Silvopastoral	Regional & Local Transhumance	The decline in pastoral activities has allowed for afforestation to occur.	Pastoralists of the region claim their identity is directly related to their practice.	A connection is made in the paper between the need for shepherds to have a deep understanding of their animals and the mountains.	A local variety of sheep is used.
Livelihood diversification as an adaptation approach to change in the pastoral Hindu-Kush Himalayan region	2014	Hindu-kush Himalayan region	Agropastoral	Regional Transhumance/ Nomadic	Pastoralists have inhabited the region for generations, with their livestock helping to create and maintain the floristic composition of the area.	The generations of pastoralists in this region define themselves through the act of pastoralism	xx	xx
Transhumance in Central Anatolia: A Resilient Interdependence Between Biological and Cultural Diversity	2016	Turkey	Pastoral	Regional Transhumance	The long transhumance routes are generations old and the constant presence of grazers maintains the local botanical composition.	Pastoralists in this part of the world are identified by their tents which are made from their black goat hairs. They are known as “the black tent people”.	Traditional knowledge about how and where to find water and fodder, as well as the traditional knowledge of how to make their tents, is passed down from generation to generation	xx

Table 1. Examples of how ecosystem services identified in the literature were translated into the NCP framework.

After the 86 articles were fully coded, a subsequent five case studies were added to the database on the recommendation of experts in the field of pastoral systems (Annex I). Each of the case studies added was then exposed to the same reading process, where each of the new case studies added was read 4 times over two weeks

The articles were then organised into a database with 10 different categories of information being coded: i) Authors; ii) Title of the article; iii) Publication journal; iv) Year of publication; v) DOI; vi) Study continent; vii) Study country; viii) Pastoral system; ix) Movement system; x) NCP; xi) Drivers of change. Pastoral system and movement system are defined in Table 2. The database was designed to host dummy variables, where all variables were coded based on their presence (1) or absence (0). Only NCP which could be considered positive were classified (Leister et al., 2019). When insufficient data was found in articles (regarding movement systems or agricultural systems etc.), the relevant authors were contacted. Once the 91 accepted papers were fully coded, contingency tables and Pearson's correlation coefficient was performed using XLSTAT 2020.4.1 (Addinsoft, 2021). Then, the scalar product was used to assess the weight between each pair of variables and to examine the relationship between NCP and agricultural systems, movement systems, and drivers of change. This information was mapped into and shown as, a networked system, where variables were the nodes of the network, and they were linked by weighted edges (Newman, 2010). A map displaying the number of case studies and their location was created using the website site www.mapchart.net. All descriptive graphs were made in Excel and networks were created with NodeXL (Smith, M. et al., 2010). In this case, only connectivity level up to 34%-344% (i.e., number of edges considered in the analysis over the total number of existing edges) is shown to present only the strongest connections and avoid the graphs being overly clumped.

Type of Pastoral Systems/Movements	Description
Pasture-based	Rely primarily on range/grassland and the products created by their livestock.
Agropastoral	Use a mixture of range/grasslands as well as agricultural resources such as crops.
Silvopastoral	Silvopastoral systems – use forest and woodlands as an integral part of the system.
Agrosilvopastoral	Agrosilvopastoral systems – systems that use range/grasslands, combined with agricultural and forest resources as part of the system.
Nomadic	"a reliance on pastoral economic activities, with patterns of high mobility and the changing of dwellings throughout the year" (Miller et al., 2019).
Regional Transhumance	Regional transhumance is the movement of domesticated animals over substantial distances, traditionally over multiple days and between regions, depending on the local context.
Local Transhumance	Local transhumance is the movement of domesticated animals over relatively shorter distances. This movement can be either horizontal or vertical and stay within the same region, as defined by the local context.

Table 2. Description of all type of pastoral and movement systems found in the literature

Results

The earliest article found in the search results is from 2004, with the largest number of publications found in 2018. From 2016 to 2017 the number of publications fell, but publication rates increased significantly for 2018 (Supplementary material, Fig 1). The literature is globally orientated, with the global South receiving the majority of the attention (Fig 1.). Europe (n = 38), Africa (n = 25), Asia (n = 23) and Central/Latin America (n = 5) are all represented in the analysis (Fig 1.). Within these, over-representation of certain countries occurred. Spain (n = 13) has the highest number of cases, being more represented than Latin America. Africa is well represented when considering the number of countries that have case studies. However, Kenya (n = 9), Tanzania (n = 5) and Ethiopia (n = 8) account for more than half of the cases found on the continent. We did not find any articles in Oceania. Mountains were used in 84% of the pastoral systems examined in this analysis with 100% of all case studies in Asia and Latin America using mountains. 91% of European case studies use mountains and 66% of African case studies use mountains.

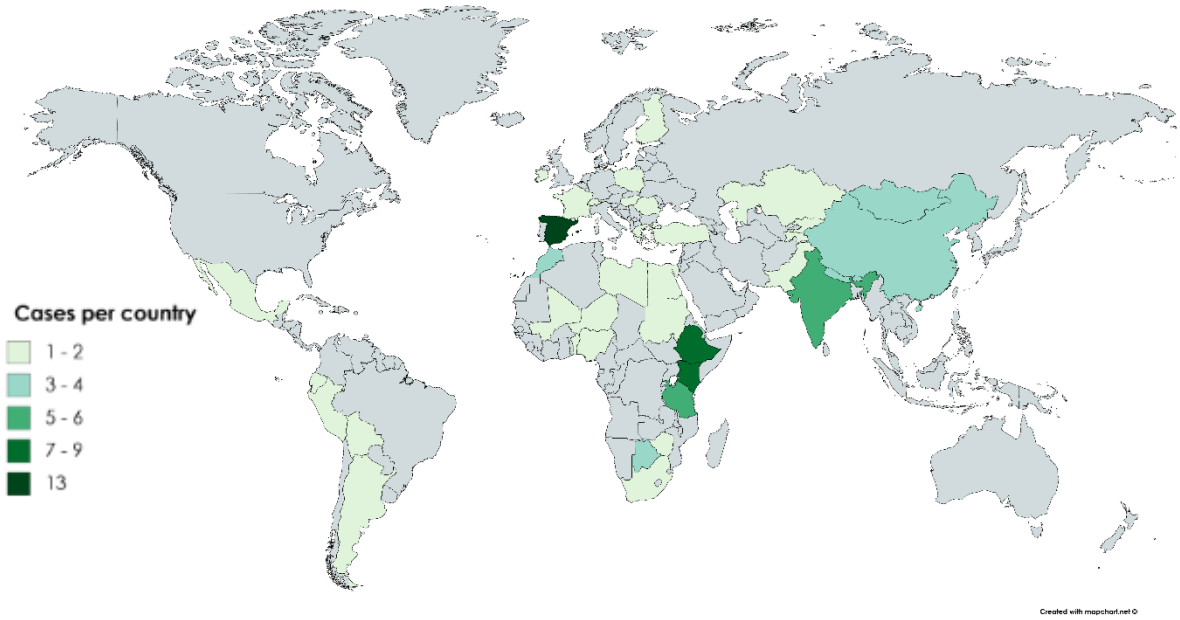

Fig 1. Distribution of case studies

Nature's Contributions to People (NCP)

The examination found that the NCP framework allowed for the easy translation of ES related to pastoral systems into NCP. A total of 18 NCP were found to be related to pastoral systems in the literature (Fig 2.). Material, non-material, and regulating NCP are all represented. Material NCP represented 35% of all NCP found in the study, Non-material NCP represented 34% and regulating NCP accounted for 30% of the NCP found. Within each of the three groups discussed here, some individual NCP are over-represented (Fig 2.)**:** *Food and Feed* as a material NCP, *Habitat creation and maintenance* as a regulating NCP and *Supporting identity* as non-material NCP, with each one appearing more than 60 times throughout the studied cases.

The distribution of these NCP via continent is displayed in (Fig 3)**.** Material NCP are the most common NCP across all continents. Non-material and regulating services have large differences in distribution. Europe has the smallest proportion of non-material NCP (30%) but has the most regulating NCP (35%) which are also largely associated with Asia (31%), while Africa has the lowest proportion of studies with regulating NCP (27%)**.** A Pearsons correlation shows that Europe is positively correlated both to regulating NCP as a group ($p = 0.05$) but also to the regulation of hazards and extreme events ($p < 0.001$) and habitat creation and maintenance (0.05). Africa, on the other hand, is negatively correlated to regulating NCP as a group ($p = 0.05$) and to habitat creation and maintenance ($p = 0.05$).

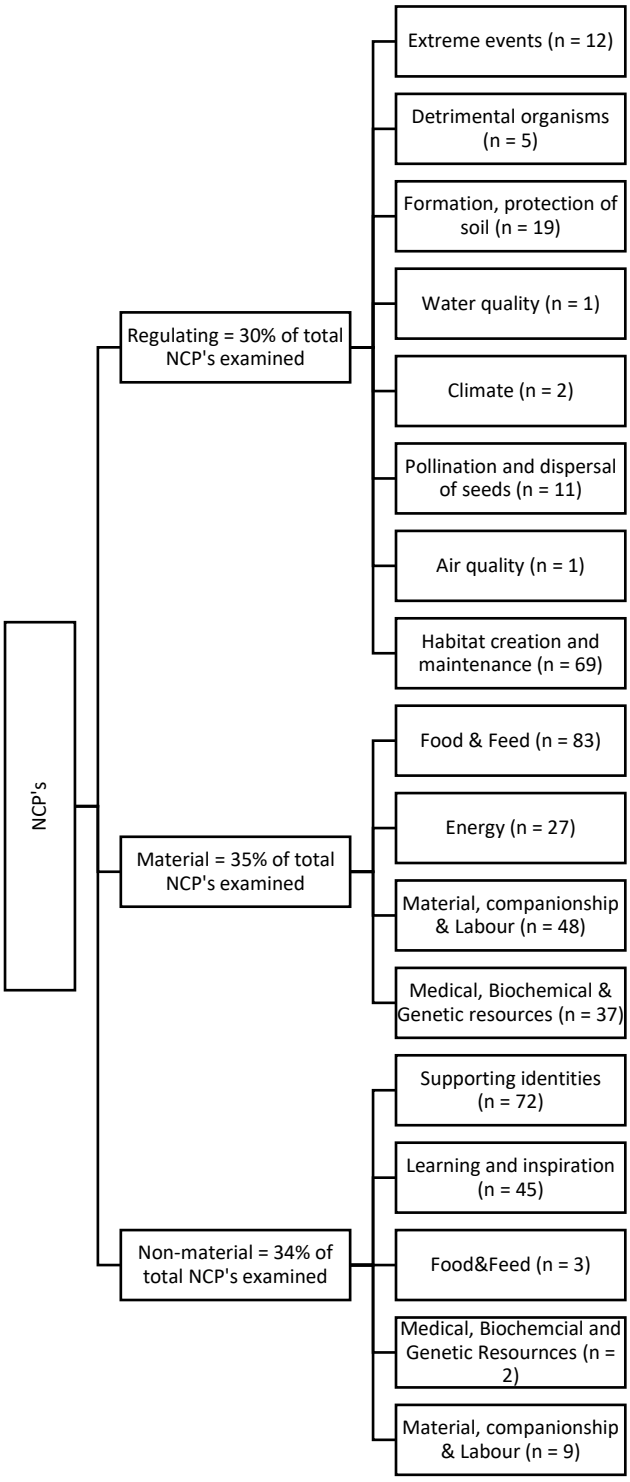

Fig 2. The distribution of NCP's throughout the pastoralist case studies; Regulating services were examined in 30% of cases. Material and Non-material services were examined in 35% and 34% of cases.

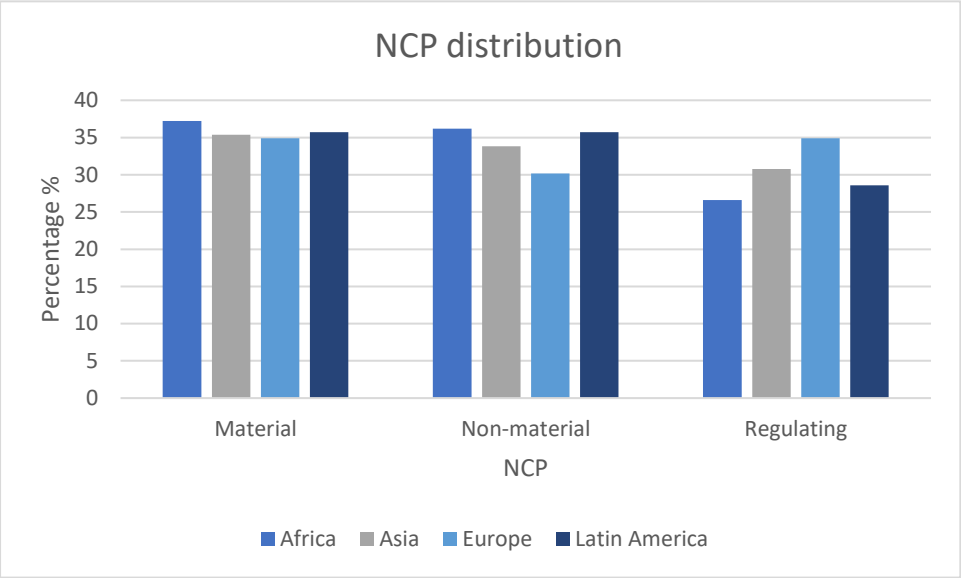

Fig 3. Distribution of NCP categories within continents displayed as percentages

Type of Pastoral and Movement system

The most common form of pastoral system analysed in the literature was pasture-based (n = 35) followed by Agropastoral (n = 25), Silvopastoral (n = 19) and Agrosilvopastoral (n = 12). Pasture-based systems are most common in Latin America (60%) and Europe (57%) and least common in Asia (44%) and Africa (21%)**.** A Pearson's correlation showed Africa (p = 0.005) and Europe (p = 0.05), respectively, being negatively and positively correlated to Pasture-based systems. Africa had the largest proportion of agropastoral systems (45%) with a corresponding positive correlation (p = 0.005) and Europe had the smallest proportion of Agropastoral systems (4%) with a corresponding negative correlation (p = 0.005). Silvopastoral and agrosilvopastoral systems were the least commonly found systems in the study with Europe having the highest proportion of Silvopastoral studies (26%) and Latin American containing no Silvopastoral studies. Latin America contained the highest proportion of agrosilvopastoral systems (20%) and Asia contained the lowest proportion of agrosilvopastoral (8%). The network analysis found strong links between agricultural systems and some NCP (Fig 4). All the pastoral systems were connected with the material NCP *Food and feed,* the regulating NCP *Habitat creation and maintenance* and the non-material NCP *Supporting identities.* Agropastoral and pasture-based systems were also connected with the material NCP *Material companionship and labour* and *Medicinal, biochemical and genetic resources*,

the non-material NCP *Learning and inspiration.* Agrosilvopastoral systems showed the least connections of all agricultural systems in the literature reviewed and is only connected to the 3 most common NCP. Silvopastoral systems are the only system to show a link to the material NCP *Energy.*

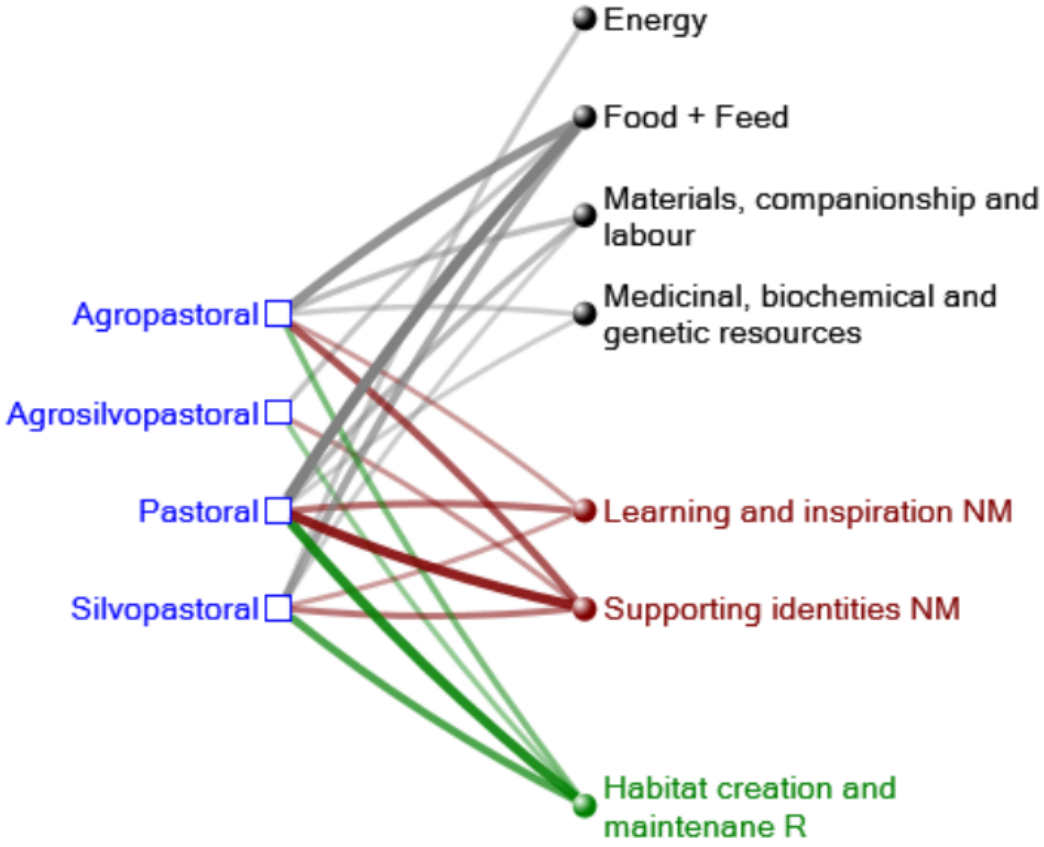

Fig 4. Network analysis of NCP and Agricultural systems. Connections displayed at the 36% connectively level. Agricultural systems are represented with square symbols. NCP are represented by spheres, NCP ending in NM are non-material NCP, NCP ending in R are regulating NCP, and NCP that do not end in a code are material NCP. The weight of the connection between variables is represented by the width and opacity of the edges.

The most common form of movement system in the literature was Regional transhumance (n = 47) followed by Local transhumance (n =34) and Nomadic movement systems (n = 19). When movement systems were examined by proportions found in each continent regional transhumance accounted for 70% of all movement systems found in Asia, with a corresponding positive correlation (p = 0.005). Regional transhumance was least commonly found in Africa (36%) with a corresponding negative correlation (p = 0.05). Local transhumance was commonly seen in Latin America (60%) and Europe (58%) and least commonly seen in Asia (15%) and Africa (29%). Europe was also seen to have a positive correlation (p = 0.005) with local transhumance and Asia was discovered to have a negative

correlation (0.05) with local transhumance. Nomadic movement systems were present in only Africa (36%) showed a strong positive correlation ($p < 0.001$), and Asia where it accounted for 15% of movement systems examined on the continent. Europe and Latin America had no cases containing nomadic movement systems with Europe having a negative correlation with nomadic systems (0.005). The network analysis (Fig 5) found strong links between movement systems and NCP, All movement systems studied were linked to the material NCP *Food and Feed,* and *Materials companionship and labour, the* non-material NCP *Supporting identity* and the regulating NCP *Habitat creation and maintenance.* Regional and Local transhumance also both shared connections with the other Material NCP *Energy and Medicinal, biomedical and genetic resources* and the non-material NCP *Learning and inspiration.* Regional transhumance also has a connection with the regulating NCP *Formation, protection and decontamination of soils* and *Pollination and dispersal of seeds.*

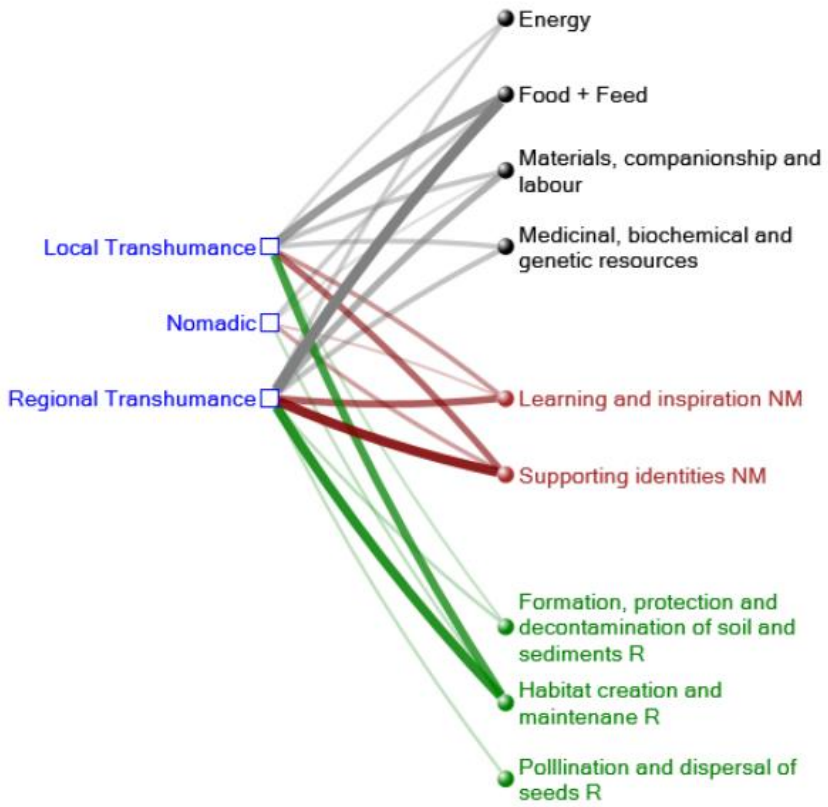

Fig 5. Network analysis of NCP and Movement systems. Connections displayed at the 44% connectivity level. Movement systems are represented with square symbols. NCP are represented by spheres, NCP ending in NM are non-material NCP, NCP ending in R are regulating NCP, and NCP that do not end in a code are material NCP. The weight of the connection between variables is represented by the width and opacity of the edges.

Drivers of change and NCP

A total of 12 drivers of change in pastoral systems were identified in the literature (Table 3). Africa is the continent most affected by the drivers of change found in this analysis. In African pastoral systems, the most common drivers of change were *Socioeconomic* (15%), *Abiotic* (14%), *Access to services* (14%), *Policies* (13%) and *Land access* (12%). In Asia, the most common drivers found were *Policies* (17%), *Socioeconomic* (15%), *Access to services* (15%), *Sociodemographic* (13%) and *Land access* (13%). Europe was found to have three primary drivers of change *Socioeconomic* (25%), *Policies* (24%) and *Sociodemographic* (13%). In Latin American, the most important drivers of change identified were *Socioeconomic* (22%), *Policies* (22%) and *Abiotic (13 %).* The network analysis (Fig 7) showed that there are three distinct groups of drivers. Group one is composed of *Socioeconomic* and *Policy* drivers as a whole that show the highest number of connections with many NCP. Group two is composed of *Access to services*, *Land access*, *Sociodemographic* and *Abiotic* drivers that show intermediate connections with many different NCP. Group three is composed of the drivers *Biotic*, *Perception, Loss of TEK* and *Land use*, showing both relatively few and relatively weak connections to only a few NCP. In particular, we found that *Food and feed* material, *Supporting identities* and *Habitat creation and maintenance* are the NCP most affected by all drivers, followed by *Material companionship* and *labour and Learning and inspiration*. In making particular connections between drivers of change and NCP, we can see for instance how *Policies* are heavily connected to all NCP or how the driver *Access to land* is also connected to all material NCP except for *Physical and physiological experiences* and the non-material NCP *Learning and inspiration*. *Loss of TEK* is shown to have two connections, to *Food and Feed* and to *Supporting identities.*

Drivers	Description
Biotic (n = 20)	Presence of disease or predators
Abiotic (n = 38)	Drought, Fire, Climate change
Sociodemographic (n = 37)	Ageing populations, Depopulation, Unemployment, Gender inequality, lack of skilled labour, Migration, Population growth, Ethnicity, Sedentarisation.
Socioeconomics (n = 63)	Tourism, Access to markets, Economic transitions (entering the free market), Industrialisation, Globalisation, Urbanisation, Political instability, Personal finances.
Perception (n = 14)	Social perception of the role of pastoralism as unattractive or inferior.
Policies (n = 61)	Policies that affect pastoral systems (International, national and local).
Land use (n = 19)	Land-use change, Land degradation, Extractivism.
Access to services (n = 42)	Access to infrastructure, education and social services
Loss of TEK (n = 12)	Loss of traditional ecological knowledge on how to most efficiently use limited resources.
Land access (n = 40)	Land governance and the right of pastoralists to access and use land.
Illegal activities (n = 4)	Illegal activities.
Pastoralism through lack of options (n = 1)	Entering pastoralism due to a lack of alternative livelihoods options.

Table 3. Drivers of change identified in the analysis

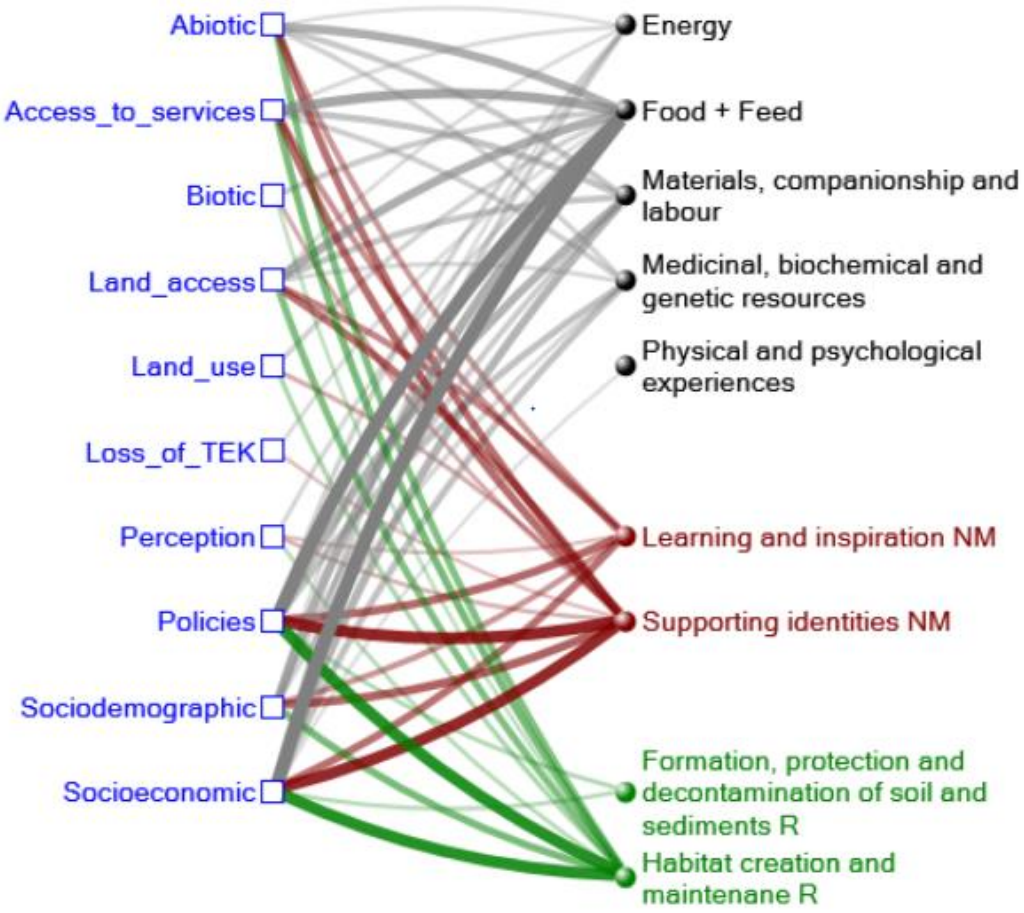

Fig 6. Network analysis of NCP and Drivers of pastoral change. Connections displayed at the 34% connectivity level. Drivers of change are represented with square symbols. NCP are represented by spheres and are displayed on the right side of the image. NCP ending in NM are non-material NCP, NCP ending in R are regulating NCP, and NCP that do not end in a code are material NCP. The weight of the connection between variables is represented by the width and opacity of the edges.

Discussion

NCP

The NCP framework has proven itself to be an appropriate framework for the examination of complex SES with strong human-nature connections such as pastoral systems. By using the ES literature on pastoral systems, we could identify, translate and classify different NCP into their various categories with intuitive ease. The NCP framework at the level of a meta-analysis has the potential to act as complementary to the ES framework and does not detract from it. With Piers et al. (2020), claiming that the combined use of both frameworks would allow for a combined perspective between more qualitative and more quantitative-based mindsets (Pires et al., 2020). Notwithstanding, we consider that the NCP framework is a tool that can provide insights for future research in pastoral systems, as it considers local traditional knowledge as a key source of information (Díaz et al., 2018; Ellis et al., 2019; Leister et al., 2019). This gives the NCP framework the potential to reveal information missing from previous searches and encourage socio-cultural approaches that are less developed in ES research as shown by (Aguilera-Alcalá et al., 2020) when highlighting the non-material roles of scavengers in Spain. Particularly identity is a core concept in the NCP framework that is relevant for pastoral systems and is not expressly stated in the ES framework (Millennium Ecosystem Assessment, 2005).

The joint use of both frameworks presents an opportunity for future research to establish a more complete picture of complex human-nature systems such as pastoral systems. Current research suggests that the choice between the use of the NCP or ES framework is currently being decided by the ideological standpoint of the researcher. Based on their perspective of the human-nature relationship with (Pires et al., 2020) highlighting the potential usefulness of incorporating both frameworks into future research to help capture multiple views. This is particularly relevant in those ecosystems in which the human action has co-evolved and contributed to the configuration of the systems and it is thus impossible to separate what is human action and what is NCP. For instance, due to the ubiquity of mountains in pastoral systems in the analysis, it is impossible within the limits of this analysis to identify to what extent the NCP related to mountains are independent to NCP related to pastoral systems. The distribution of case studies in this study reflects the distribution of NCP provided by mountains in a recent study by Leister et al., 2019 (Leister et al., 2019). The argument can be made that

many of the NCP discussed by Leister et al (2019) are indivisible from the NCP created and maintained by pastoral systems in mountains, such as cultural identity, biodiversity creation and animal by-products. Highlighting the complexity of human-nature relationships and the difficulty involved in distinguishing the NCP used by pastoral systems and the NCP created and maintained by pastoral systems. Thus, the NCP framework contributes to understanding how some human-nature systems are both producers and users of NCP.

The application of the NCP framework (Díaz et al., 2018) to a meta-analysis has allowed for the introduction of an interdisciplinary perspective in the examination of articles (Leister et al., 2019). As a result, a holistic approach can be introduced into pastoral investigations and their use, creation and maintenance of NCP related to pastoral systems. It does this by clearly showing that pastoral services are versatile and multifunctional through the design of the NCP framework which acknowledges that NCP can belong to multiple groups, particularly in the form of identity (Díaz et al., 2018). A recognised rarity in the ES literature is the acknowledgement of culture as permeating through and across ES categories as highlighted by (Kadykalo et al., 2019). Traditional breeds of sheep in the Pyrenees can be considered as both a genetic resource and as a symbol of culture and identity (Fernández-Giménez, 2015). Fibre from animals can be purely a material good, or it can be imbued with cultural importance that helps to define a people, as is the case found in central Anatolia (Ocak, 2016). Drove roads in Spain are a complex source of NCP, that combine a mixture of material (food & feed), non-material (supporting identities) and regulating (seed dispersal) services simultaneously (Hevia et al., 2016; Oteros-rozas, 2015; Oteros-Rozas et al., 2014). Movement systems are designed to maximise resource efficiency, but they can also be endowed with a cultural significance (Ben Hounet et al., 2016; Ocak, 2016; Scoones, 2020). The NCP framework also allows researchers to claim that identity is an NCP. While the ES framework allows for the identification of cultural heritage or sense of place (Millennium Ecosystem Assessment, 2005), it does not explicitly allow the identification of identity. The fact that pastoralism is a form of cultural identity is in no doubt. This investigation helps to reinforce this point and shows the recognised importance of identity within the literature (Hartel et al., 2017; Köhler-Rollefson, 2016; Liechti and Biber, 2016; Ocak, 2016; Rass, 2006; Sendyka and Makovicky, 2018). Reinforcing our argument is the results of the network analysis that shows that supporting identity is among the three most connected NCP (Fig 4, Fig 5) to different types of pastoral

systems and movements, together with food and feed and habitat creation and maintenance. It is also one of the NCP with more connections to the drivers of change linked to pastoral systems (Fig 7).

The distribution of NCP in the articles examined reflects the most important services in the eyes of researchers. Pastoral systems are primarily production systems, which have profound ecological impacts. This production system then develops into a form of identity and culture. With that in mind, it was expected that the NCP discovered would be dominated by material and regulating NCP with acknowledgement of the importance of culture. The assumption that material NCP are central to pastoral systems was validated through the results that show its importance as a production system, with *Food & Feed* being the most common NCP in the analysis, and the one with more connections to the different movements, agricultural systems and drivers of change. The assumption that regulating NCP would be a dominant group of NCP related to pastoral systems was surprisingly incorrect. While the NCP *Habitat creation and maintenance* was the third most common NCP in the analysis, as a group, regulating NCP were not common throughout the analysis. Europe was the only continent where regulating NCP were more common than non-material NCP (Fig 3). The importance placed on regulating NCP in Europe is nearly certainly the result of the common agricultural policy (CAP) found in the EU, which provides financial supports to agricultural production that respects the environmental rules stated in the CAP (Commission, 2020).

The most surprising result of the analysis was the importance placed on non-material NCP. Non-material NCP as a group is the second most important group of NCP found in the analysis in all continents except for Europe. The apparent lack of attention to non-material services in EU pastoral systems may be a negative effect of the CAP, as supports for preserving non-material NCP are limited, even though traditional pastoral systems are vital for creating biodiversity-rich landscapes (Simoncini et al., 2019). That the case studies in Africa, Asia and Latin America contain the most proportional non-material NCP is possibly related to large pastoral populations or perhaps non-material NCP are more heavily studied in developing countries. If so, this implies a biased in the literature to view pastoral systems in developing countries differently than pastoral systems in developed countries. As it is doubtful that non-material services are less common in European countries and it is more likely they are less studied. Equally, it is more likely that regulating NCP in developing countries are less well

studied than the alternative that pastoral systems in developing countries do not use, create and maintain regulating NCP.

Agricultural system

The type of pastoral systems found in this study are related to the availability of resources in the case study regions. All pastoral systems are defined by efficient and effective use of resources (Kratli et al., 2013; Krätli and Schareika, 2010; Rueff and Rahim, 2016; Zinsstag et al., 2016a). We can therefore assume that the pastoral systems discussed in this analysis are using all available ecological resources. They all showed connections with the NCP supporting identities, food and feed and habitat creation and maintenance. The lack of pasture-based systems in Africa was a surprising result as there was an initial assumption that due to the presence of the great plains in Kenya, Tanzania and Ethiopia, that pasture-based systems would be the dominant system. Agropastoral systems are the dominant pastoral system in Africa and this may be linked to the proportionally low use of mountains in African pastoral systems and the sedentarisation policies found in many African countries (Davies and Hatfield, 2007). This also highlights the integrated nature of pastoral systems in the continent as crops are integrated into livestock systems excluding the need to rely exclusively on pastures. The relatively small proportion of Agropastoral systems in all other continents may be partly explained by the apparent dependency of pastoral systems on mountains compared to African pastoral systems. Perhaps one of the most interesting results of this study is the relative lack of Agrosilvopastoral systems globally. Agrosilvopastoral systems are the most complex pastoral system and require access to many different resources. The absence of such systems may be an indication of the simplification of pastoral systems, where there may no longer need or be able to access all available resources throughout the year.

Movement systems

The act of mobility that characterises pastoral systems is multidimensional as livestock are moved for the economic benefit of pastoralists, but it also has cultural, political and social dimensions (Scoones, 2020). That nomadic movement systems are so rare is perhaps not surprising as nomadic systems require the tolerance and support of governments to ensure that nomadic pastoral systems can access necessary resources when required. Few governments are truly tolerant of nomadic systems, with many developing countries

continually favour sedentary farmers over nomadic pastoral systems (Niamir-Fuller and Huber-Sannwald, 2020) and with many countries having a history of sedentarisation policies (Davies and Hatfield, 2007; Stave et al., 2007). That nomadic systems are only found in Africa and Asia is perhaps not surprising as nomadic systems require flexible access to land and resources that accommodates dynamic land-use patterns. That nomadic systems are weakly connected with only one regulating NCP (Fig 6) strengthens the argument that regulating services are understudied outside of Europe and adds validity to the negative correlation found between Africa and regulating NCP as most nomadic systems were identified in Africa. It also highlights that the regulating services provided by nomadic systems may be overlooked by researchers. In Europe and Latin America, there is a long history of private land tenure which creates barriers to nomadic systems through denying access to land and resources. The prevalence of regional transhumance in Asia combined with the prevalence of mountains signals that regional transhumance is being used as means of resource management to deal with the unequal distribution of resources (Addison and Greiner, 2016; Aryal et al., 2014; Wu et al., 2014). The continued presence of transhumance systems in Europe, both local and regional, is due to the existence and influence of the common agricultural policy (CAP) in the EU which provides financial supports to pastoral systems, allowing for the continuation of traditional transhumance practices (Commission, 2020; O'Flanagan et al., 2011; Sendyka and Makovicky, 2018). In Spain, the continued prevalence of transhumance systems can be explained by the continued existence and legal protection of national infrastructure that facilitates transhumance activities – Drove roads (Oteros-Rozas et al., 2014, 2012) and the long history of transhumance in Spain (Starrs, 2018). The connections found between both local and regional transhumance with the NCP regulation of hazards and extreme events and with the formation, protection and decontamination of soils and sediments show the relevance of these movements for the maintenance of healthy ecosystems.

Drivers of change

Drivers of change in pastoral systems are important for understanding the challenges and pressures placed on pastoral systems. That the 3 most common NCP found in the analysis (*Food and feed*, *Habitat creation and maintenance* and *Supporting identities*) are also heavily linked to the most common drivers of change (*Socioeconomic*, *Policies*, and *Access to services*) shows the relevance of the human element in pastoral systems. For instance, for pastoral

systems to provide *Habitat maintenance and creation*, the ability to access land when needed is vital. If land access is restricted the ability of pastoral systems to provide regulatory NCP disappears (Seid et al., 2016). This ability to maintain and create habitat is an important aspect of pastoral systems when compared to intensive livestock systems, which have been shown to be a major driver of habitat degradation, mostly through deforestation for the production of monocultures for feed and intensive stocking rates (Ceballos et al., 2010; IPCC - International Panel of Climate Change, 2017; Matson et al., 1997). *Socioeconomic* and *Policy* drivers are arguably the most important drivers of change at all levels examined in this article for pastoral systems (Table 3). This helps to explain why they were found to be the most prominent drivers in pastoral systems across all continents and why they were so heavily linked to the most abundant NCP (Fig 7). That *Supporting identities* is strongly connected with these drivers shows how important identity is in pastoral systems. Typical *Socioeconomic* drivers of change in pastoral systems include entry into the free market and globalisation, as well as tourism. The influence of tourism occasionally helps to support agriculture but can also cause competition between the use of labour between pastoral and agricultural activities as seen in Hindu-Kush Himalayan Region and Kenya, (Jandreau and Berkes, 2016; Wu et al., 2014) which has the potential to affect the identities of those who change from agricultural to touristic activities. In parts of the world that have gone through political reform from formerly communist countries, being exposed to the free market and globalisation are the key drivers of change in pastoral systems (Blench, 2001; Fernandez-gimenez, 2014; Neudert et al., 2013). Loss of local traditional knowledge while not prominent in this analysis is an important driver of change. Loss of traditional knowledge is important in pastoral systems as traditional knowledge is informally taught and has been acquired through generations of trial and error. Traditional knowledge in pastoral systems is directly linked with pastoralist ability to take advantage of and use limited resources, including how to best utilise food and feed sources and can reinforce a sense of place and identity to its holders. This helps to explain why the *Loss of traditional knowledge* is linked to the NCP *Food and Feed* and *Supporting identities* (Fig7). It requires only a short break in the passing of traditional knowledge for it to disappear and once it is gone it is exceptionally difficult to recover and can cause increased livelihood insecurity as found in Kyrgyzstan after the pre-Soviet era (Schoch et al., 2010) and in transhumance systems in Spain (Oteros-Rozas et al., 2013).

Conclusion

This review applies the NCP framework to pastoral systems used as an example of complex SES with strong human-nature connections. The reason why the NCP framework suits well to analyse such systems is the strong and transversal focus on identity that NCP has. In the particular case of pastoral systems, the NCP framework has proven suitable for the examination of the literature and allows for the classification of NCP found within the case studies with intuitive ease. The NCP framework has shown itself to be complementary to the ES framework allowing for easy translation between the two frameworks. We agree with (Pires et al., 2020) when they state that the NCP framework has the potential to create new opportunities to "represent the people-nature relationship". Pastoral systems are highly complex human-nature systems that cannot be completely captured by one lens, instead, they should be studied as interactive systems that create, use, and maintain a wide array of NCP which in turn provide services to the wider ecosystem and society. To do this, the combined use of the NCP and ES framework would be needed or the expansion of both frameworks to better capture the complexity of pastoral systems or other complex systems with close human-nature interaction. The complexity of pastoral systems is highlighted when examined at the continental scale as each continent have their own set of challenges to secure the future of pastoral systems. The pastoral system and movement systems found in each country reflect a complex interaction between actors that result in the pastoral systems found in each case study. This analysis has allowed for the identification of several research gaps i) Why are non-material NCP more heavily studied in developing countries and regulating services in developed countries. ii) To what extent are NCP provided by mountains independent of pastoral systems? Or are they intrinsically linked through the close interaction of human-nature of pastoral systems that NCP in mountains are created? iii) How do drivers of change combine in pastoral systems to interact with NCP?

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Chapter 4: Ecosystem Services and Mediterranean pastoral systems[3]

Abstract

Pastoral systems have been important socio-ecological systems in the Mediterranean basin for millennia. While extensive research on pastoral systems in individual countries within the Mediterranean basin has been conducted. There has been no attempt to analyse the trends, gaps, and approaches of analysis of the Ecosystems Services created and maintained by pastoral systems in the Mediterranean basin as a region. In this article, a systematic review and meta-analysis were conducted through the implementation of a Qualitative Comparative Analysis to explore the trends and existing gaps in the academic literature dealing with Ecosystem Services and Mediterranean pastoralism.

The results highlight that pastoral systems in the Mediterranean basin are studied in terms of only a few dominant ecosystem services, primarily supporting services, and are still being approached using individual disciplines instead of a combination of disciplines, as suggested by the Millennium Ecosystem Assessment. Interdisciplinarity can better capture the multidimensional nature of Mediterranean pastoralism and the interactions among the different temporal and spatial scales it entails. Thus, more examinations of such kind are needed to fully make sense of the true contribution of Mediterranean pastoral systems.

Keywords: Socio-ecological systems, Grazing systems, Pastoralism, Global Change,

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Introduction

Pastoralism has a rich history of influencing landscapes, with archaeological evidence tracing pastoralism back 7,000 years in Europe and up to 9,000 years in northeast Africa (Dong et al., 2016; Starrs, 2018). Recent estimates have stated that between 200 and 500 million pastoralists are in the world today, using 25% of all the worlds land (Niamir-Fuller, 2016). Pastoral systems are defined as complex socio-ecological systems (Caballero et al., 2009; Ostrom, 2009) and an "adaptive network of biophysical and social flows generated and maintained by the movement of shepherds and livestock" (Oteros-Rozas et al., 2012). They are defined by their adaptability and flexibility that allows them to utilise natural and economic resources that are unevenly distributed (Krätli et al., 2013; Krätli and Schareika, 2010; Rueff and Rahim, 2016; Zinsstag et al., 2016a). Pastoral systems are a sustainable and viable way of living in many parts of the world, with an ability to produce public goods and services, such as landscape maintenance and the creation and maintenance of cultures while helping to ensure food security (Ben Hounet et al., 2016; Niamir-Fuller, 2016; Oteros-Rozas et al., 2014; Varela et al., 2018; Zinsstag et al., 2016a). They are also considered as the producers and protectors of specialised knowledge about how to best use their environment (Addison et al., 2016; Davies et al., 2016) and considered an efficient form of natural resources and land management in semi-arid and high-lowland contexts, highlighting their importance in the Mediterranean context (Blench, 2001b; Bonfoh et al., 2016; Davies and Hatfield, 2007). All this make pastoral systems relevant to many of the sustainable development goals (SDG's), particularly zero hunger (SDG2) and sustaining life on land (SDG15) (Nations, 2020; Niamir-Fuller and Huber-Sannwald, 2020; Zinsstag et al., 2016b)

Unfortunately, even with its potential to promote sustainability and help achieve several of the SDGs, pastoral systems are in decline in most of the world, due to changing demographics, land encroachment and unfocused policies (Aryal et al., 2014; María E. Fernández-Giménez and Estaque, 2012; López-i-Gelats et al., 2016; Morton, 2010; Sendyka and Makovicky, 2018; Stave et al., 2007). Some authors point that most of these detrimental trends originate on the prevalence of unfavourable narratives (López-i-Gelats et al., 2016; Morton, 2010; Scoones, 2020). Often, pastoral systems are perceived as ecologically destructive, economically unviable and "archaic" by many institutions. These unfavourable narratives seem to justify

the marginalization of pastoral systems by institutions (both governmental and societal) as pastoral systems are not framed as an adaptive system that responds quickly to changes that allows for the efficient use of scarce resources (Addison et al., 2016; Éloit, 2016; Ouedraogo and Davies, 2016). For this reason, pastoral systems are commonly marginalised and dispossessed without the recognition of their true role and without particular support measures (Caballero et al., 2009; Ouedraogo and Davies, 2016)

Ecosystem services (ES) is a concept that has gained both political and academic relevance in the last 30 years as a response to ecosystem degradation and destruction (Chaudhary et al., 2015). Although the concept of ES itself is much older than that and has been extensively tracked by Gómez-Baggethun et al. (2010), it gained theoretical relevance thanks to two seminal academic works by Costanza et al. (1997) and Daily (1997) which established ES as a concept and a tool. The practical relevance of the ES concept was realised in Costa Rica in 1997 with the start of the first payment for ecosystem services scheme (Pagiola, 2008). In 2005, the Millennium Ecosystem Assessment (MEA) synthesis report was released and defined ES as "the benefits ecosystems provide to human wellbeing" (Alcamo, 2003; Millennium Ecosystem Assessment, 2005b) and since then, ES developed to become a more inclusive framework that in practice attempts to integrate social and natural sciences. This continuous development is a response to the complex systems with which the ES concept is being applied, to allow for a more inter and transdisciplinary approach (Costanza et al., 2017; Diaz, 2018).

Given the complexity and diversity of pastoral systems as demonstrated throughout the literature (Davies; P. Herrera; et al., 2016; Fernández-Giménez, 2015; Oteros-Rozas et al., 2012), it is not possible to limit research to merely one dimension (e.g., enhancement of herbage production or improve the quality of food production). Conversely, there is the need to apply a systemic, multidisciplinary, and multiscale vision to be able to capture the multidimensional nature of pastoralism. The MEA framework has the potential to introduce such approaches which are key to the successful understanding of socio-ecological systems such as pastoral systems. As the goal of the MEA is to determine what can be done to enhance the contributions of the natural world to human wellbeing without degrading the productivity of ecosystems (Alcamo, 2003), a deeper understanding of the true complexity of pastoral

systems will, in turn, allow for the development of more appropriate pastoral policies and better planning the cohabitation of pastoralism with other economic activities and cultural practices. Such measures must be site-specific, shared between stakeholders and applied at a proper scale (Toderi et al., 2017).

As the use of traditional grazing systems modifies and maintains many Mediterranean landscapes while also producing agricultural products and supporting cultures (Ben Hounet et al., 2016; Fernández-Giménez, 2015; Ocak, 2016). Thus, pastoral systems in the Mediterranean basin are producers of ES (D'Ottavio et al., 2018; Oteros-Rozas et al., 2012). Yet, the Mediterranean basin is also a place of intense polarisation, where land abandonment and intensification are highly prominent (Caballero and Fernández-Santos, 2009; Fadda et al., 2008; Turkoğlu et al., 2016). Land abandonment is prominent particularly in upland zones where agricultural modernisation and movement of people from rural to urban areas has helped to fuel this abandonment (Plieninger et al., 2014). This movement can cause intensification in the lowland areas which is a threat for biodiversity and the connected ES (Caballero et al., 2009). One of the most prominent features of most of the Mediterranean pastoral systems is its presence in mountain areas. Apart from the presence of main plains and flatlands in much of Northern Africa and the Eastern Mediterranean regions, the Mediterranean basin contains several major mountain ranges, from the Pyrenees in Spain, the Alps in Italy and the Taurus mountains in Turkey (Nations, 2017). Pastoral systems have extensively used and shaped these mountains (Dean et al., 2021; Leister et al., 2019). Pastoral systems share features of extensive and traditional systems but include a gradient of intensification even within a particular farming system. For example, at the landscape scale, pastoral systems are considered extensive, but overgrazing can be present in specific farming units and abandonment was considered as the extreme form of extensification (Caballero et al., 2009). In this context, it has been seen how the abandonment of mountain pastoral systems in favour of tilled ones favours the loss of ecosystem services such as the soil carbon stock (Francioni et al., 2019). At the same time, such changes have repercussions not only in the mountains but also in hilly systems (Francioni et al., 2020). However, pastoral systems in the Mediterranean basin are dealing not only with key challenges in the face of climate and land-use changes but also key challenges linked to the continued marginalisation of pastoral activities globally (EU, 2018; Minang et al., 2011; Ouedraogo and Davies, 2016; Plieninger et

al., 2015; Zinsstag et al., 2016b). To address these challenges pastoral systems need to be examined without losing their complexity in the process, and should not continue to be studied in simplistic terms and singular scientific disciplines as highlighted by Manzano et al., (2021) and needs to start being considered through multiple perspectives which requires of an inter/trans-disciplinary collaboration (Rivera-Ferre et al., 2013).

This paper aims at identifying if the complexity of pastoral systems in the Mediterranean is acknowledged in the literature. This will be done by characterising the existing trends in the specialized literature on the relationship between pastoral systems and Ecosystems Services in the Mediterranean Basin. The literature has been analysed with respect to the application of the Millennium Ecosystem Assessment concepts (Alcamo, 2003) with a particular focus on the application of the multiscale and multisectoral approach. The MEA is a suitable framework to our objective due to its ability to focus on the interactions and complexity of scales with the production of ecosystem services. This will allow for an examination of whether pastoral systems are truly studied as complex systems, or if as claimed by Manzano et al., (2021), in the scientific literature there is also a lack of holistic thinking when considering pastoral systems. Together with the incorporation of different scientific disciplines within the case studies, these concepts can be considered as indicators of how holistically pastoral systems are viewed by researchers and of their multifunctionality (D'Ottavio et al., 2018). The results of this examination are mainly addressed to researchers, experts and policymakers that aim to cover knowledge gaps on pastoral systems in the Mediterranean.

Materials and methods

Study areas

The Mediterranean basin is the biogeographic zone surrounding the Mediterranean Sea that spans three continents, more than 20 countries and many more cultures. The Mediterranean has been one of the most important cultural and economic areas in the world for over 2,000 years, and to this day is an area of intense human activity and movement (Pardini, 2004). For this analysis, the Mediterranean basin has been broken into four distinct zones. These zones have been selected according to socio-political, geographical and cultural criteria to highlight similarities and differences of pastoral systems in different Mediterranean zones, (Fig. 1): (i) the Mediterranean European Union zone (EU) (France, Cyprus, Croatia, Greece, Italy, Malta, Slovenia, Spain, plus Portugal considered the Mediterranean); (ii) the Mediterranean European countries out of the Union zone (non-EU) (Albania, Bosnia and Herzegovina, and Montenegro); (iii) Mediterranean Middle East zone (ME) (Israel, Jordan, Lebanon, the occupied Palestinian territory, Syria and Turkey) and (iv) the African Mediterranean zone (AF) (Algeria, Egypt, Morocco, Libya, and Tunisia).

The EU is an important zone to distinguish as the EU is a political zone made up of industrialised countries, which shares a common agricultural policy (CAP) (Commission, 2020). The CAP provides financial supports to agricultural production, and also it contains some specific programs to enhance the respect for basic environmental rules, as stated in the CAP, with the potential for greater payments if more environmentally friendly methods of production are used (Commission, 2019; O'Flanagan et al., 2011). The African zone is comprised of several countries in the North of Africa which broadly shares a similar arid/semi-arid climate and can be classed as industrialising countries. The North African countries under examination in this study are also members of the African Union which has a specific policy for pastoral systems such as the *Policy framework for pastoralism in Africa* which was adopted in 2011, what was designed to integrate pastoral systems into development policies (Bonfoh et al., 2016). They are also countries where climate and social changes and the decline of traditional governance systems threaten pastoral systems (El Aich, 2018; Kreuer, 2011).

The Mediterranean European countries outside of the EU zone includes countries such as Bosnia and Herzegovina, Montenegro, former Yugoslavia and Albania, all of which have national agricultural policies but are not included in the CAP. The Eastern Mediterranean zone is made up of independent countries based in Western Asia made of a mixture of industrialised and industrialising countries and includes countries such as Turkey which has a highly rural population that depends largely on traditional agricultural activities (Yilmaz and Wilson, 2012). All countries analysed in the Eastern Mediterranean zone are not part of any super-national agricultural policies and instead create and use their own national agri-policies. The countries included in the different zones have a wide variety of landscapes and pastoral systems but broadly share a similar climate. Pastoral systems are present and traditional in each of these zones and have a long history of land management and maintenance as food production systems (Ben Hounet et al., 2016; Guadilla-Sáez et al., 2019; Hammouda et al., 2014; López-i-Gelats et al., 2011; Ocak, 2016)

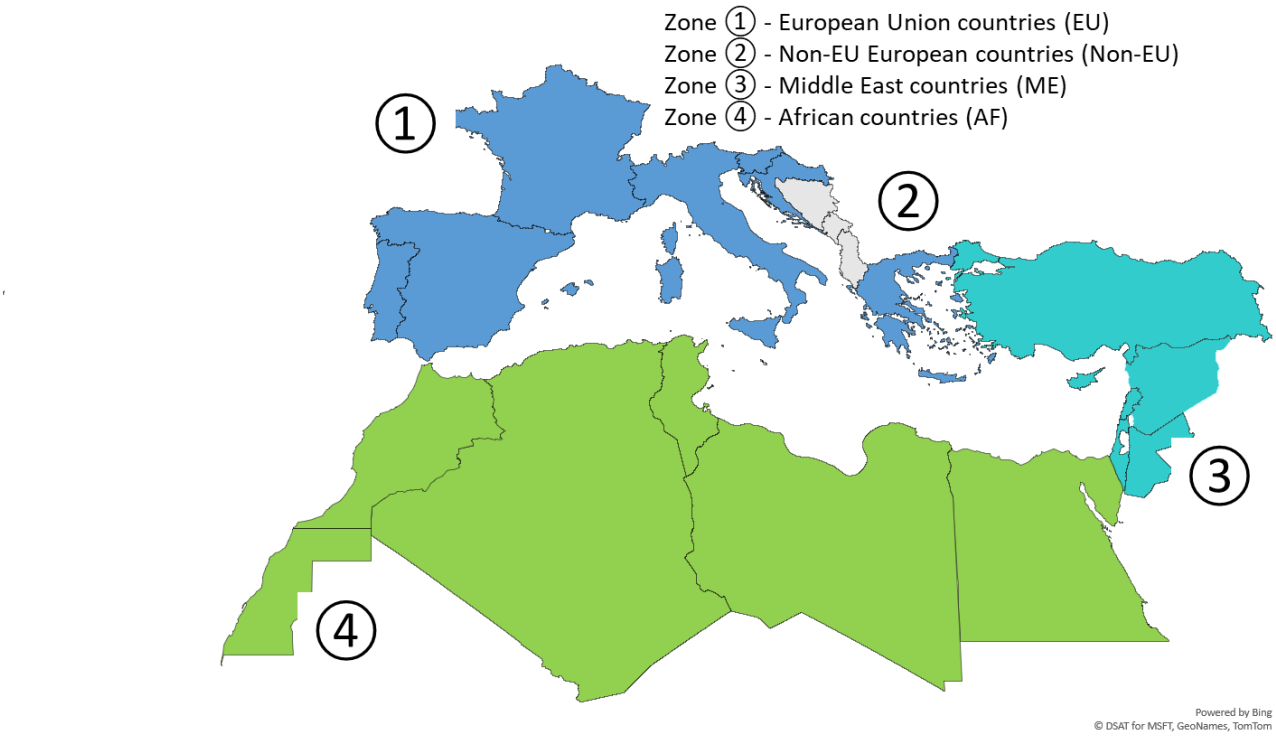

Figure 1. Map of the Mediterranean basin and corresponding countries included in the analysis and divided into four zones.

Methodology

Following the works of Rudel (2008) and Young et al. (2006), a combination of a systematic review and meta-analysis was conducted with the methodology of qualitative comparative analysis (QCA), which is increasingly being used in the environmental global change field (López-i-Gelats et al., 2016; Lugnot and Martin, 2013; van Vliet et al., 2012). The QCA allows for the identification of trends within the literature through a process of reading and re-reading and coding and re-coding. This process is used in this study to conduct a qualitative meta-analysis to identify and characterise the existing knowledge in the specialized literature on the relationship between pastoral systems and ecosystem services in the Mediterranean. The literature was analysed with respect to the application of the Millennium Ecosystem Assessment key elements, with a focus on the application of the multiscale and multisectoral approach, together with the incorporation of different types of knowledge in the study and analysis of the case studies. The studies analysed in this work did not explicitly address ES in their research objectives. It is in our work that we have analysed those pastoral papers through the lens of ES.

The use of the and qualitative meta-analysis required the following steps:

a) What and how ecosystem services are created and maintained by pastoral systems in the Mediterranean basin?
b) Description of the case study inclusion criteria;
c) Selection of relevant literature;
d) Extraction of the relevant literature;
e) Selection of relevant variables;
f) As new variables of interest are identified, all previously accepted literature should be reviewed for the new variables;
g) Identification of trends within the variables.

The Web of Science™ search engine was used to identify potential literature for a systematic review. A custom operator string was created on the 12/06/2018 to identify academic articles written in English between the years 2003 and 2019:

TS= ((grassland OR rangeland* OR shrubland* OR scrubland*) AND (grazing OR pastoral) AND (livestock OR horse* OR sheep OR cattle OR goat*) AND Mediterranean*)

From this search, 296 scientific papers were obtained with a steady increasing trend from 2002-2003. These papers were then screened against the selected inclusion criteria. Articles were required to have the following information to qualify for inclusion in the study:

- Journal articles that contained experimental data or case studies not literature reviews or meta-analysis.
- The relationship between pastoral systems in the Mediterranean and ecosystem services is discussed.
- The pastoral system is characterised.
- Papers must not be set on experimental farms or research facilities without any linkages with pastoral systems

The documents were screened using a two-part process. Part 1, Initial screening, involved the division of papers between all the authors. A total of 42 of these papers were randomly assigned to be analysed by multiple authors to ensure agreement. Through this process and according to the review criteria, 152 papers were excluded from the analysis, leaving 144 papers remaining. Part 2, Secondary screening, required the validation of agreement of the remaining 144 articles. All 144 articles were subjected to a full reading by the lead authors of the article, after which a further 36 articles were excluded.

According to the review criteria, 188 papers were excluded from this review. Some extracted paper's included literature reviews (Lovreglio et al., 2014), or the analysis was performed outside the Mediterranean basin. For example Price et al., (2010) carried out a study on the effects of grazing on grassy ecosystems in Australia. Some papers were only descriptive and did not address the relationship between pastoral systems in the Mediterranean and ES. Carmona et al., (2012) did not characterise the pastoral system while examining the functional diversity in Mediterranean grasslands. Some other papers were set on experimental farms and did not show a clear linkage with any pastoral system as found in Israel (Stavi et al., 2011). This left 108 articles to be included in the study. A subsequent 13 articles were later added via expert recommendation of various authors to better represent the Mediterranean region.

In total, 121 papers were selected for analysis (Annex II) and coding in a dummy variable database. Relevant information from included papers was organised in a database with 6 broad categories:

a) Article information (authors, year of publication, title, journal);

b) Geographic location (one of the four zones: European countries under CAP (EU), European countries non-EU (non-EU), Middle east countries (ME), African countries (AF);

c) Climate type (defined according to Kottek et al., 2006);

d) Analysed Ecosystem services (grouped into the four main groups of provisioning, supporting, regulating and cultural services) as categorized and defined as prominent by Hoffman et al. (2014)

d) Researchers' perspective in the analysis (discipline and approach).

Among the ES provided by pastoral systems, the following were analysed in detail: Maintenance of soil structure and fertility (MSF), Primary production (PP), Maintenance of life cycle and species (LFS), Habitat connectivity (HC), Food and other livestock-related products (FP), Genetic resources (GR), land degradation and soil erosion (LD), Regulation of water flows (RWF), Climate regulation (CR), Moderation of extreme events (MEE), Pollination (PO), Opportunity for Recreation (OFR), Knowledge System and Educational Values (KSE), Cultural and Historical Heritage (CHH), Inspiration for Culture Art and Design (ICA), Natural (Landscape) Heritage (NLH) (Appendix 1). When insufficient data was found in articles regarding relevant information, the authors of the given studies were contacted.

Results

Geographical and climatic distribution

The selected 121 papers and the relative 387 ecosystem services were unevenly divided between the analysed zones (Fig. 2). About 73% of the ES discovered in this study have been found in EU-zone while the Middle East and Northern Africa contributed equally for the remaining ES (about 14% for both). In general, the selected papers show a heavy biased towards Spain, with Spain having more cases than all other countries combined. Within each zone, some countries were not represented at all (i.e., zero papers) such as Slovenia for EU, Syria for Middle-East, and Egypt for Africa. Israel and Turkey were the most represented countries within Middle East and Africa zone, respectively, with Turkey as the most frequent among Middle East (Fig. 2).

In general, most of the papers were reporting studies under temperate climates with dry and hot summers (Fig. 3). This trend is confirmed for the Middle East (only studies under temperate climate with dry and hot summer for the most part) and partially in the EU and Africa zones (14 and 8 papers, respectively). Here also arid climate and only one selected paper (Gómez et al., 2003) for the EU zone are reported as carried out on continental climate.

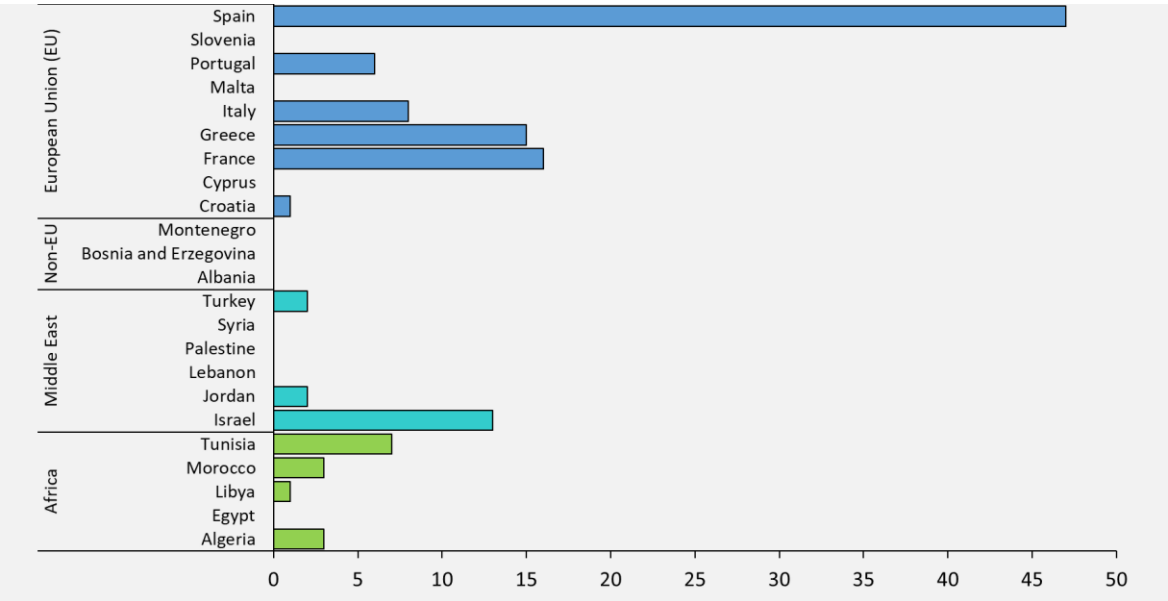

Figure 2. Distribution of case studies examined within the analysis by Mediterranean zones and by country.

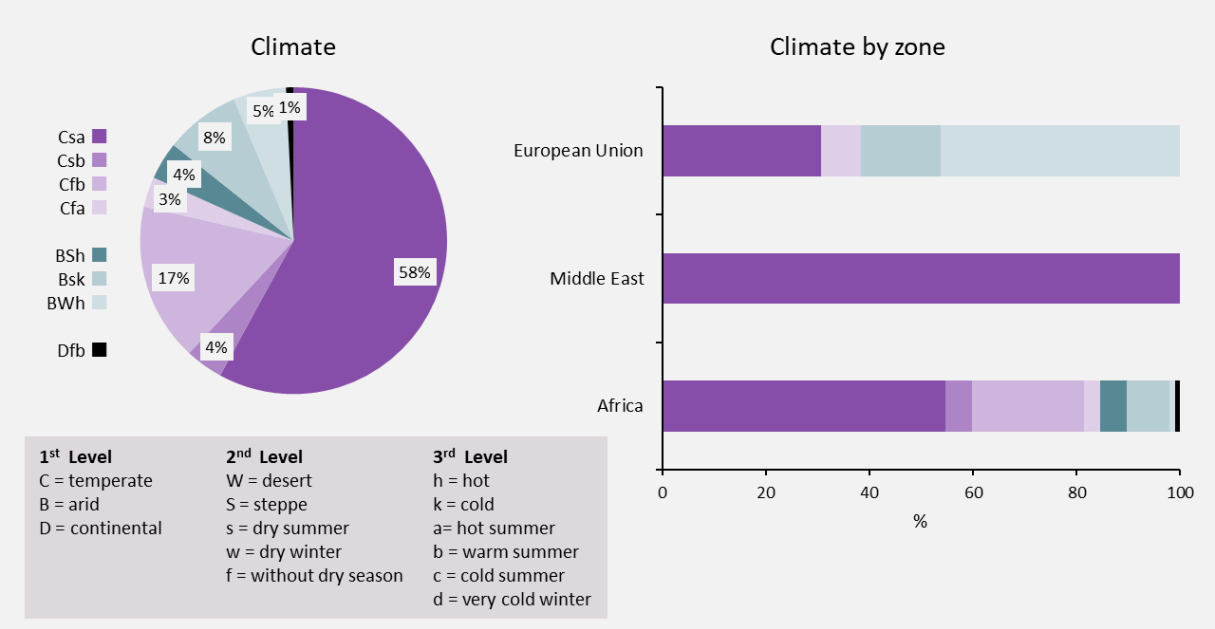

Figure 3. Percentage of the total number of case studies within each climatic zone classified according to the Köppen-Geiger climate classification

Note: Pie charts = % of the total number of analysed papers; bar charts = % of the total number of case studies within each zone.

Ecosystem services

The selected 121 papers resulted in a total of 387 ecosystem services being analysed due to the multiple occurrences of different ecosystem services within single papers (Table 1). If analysed by ES categories, most papers dealt with Supporting services (49% of the total number of the analysed papers) (Fig. 4), with 'Maintenance of life cycle and species' (in all the zones) and 'Primary production' (in EU and Africa compared to Mid-East) as more studied (Fig. 5). Concerning the Provisioning services (15% of the total number of the papers), 'Food' was more commonly found than 'Genetic resources' for Middle East countries, while the opposite trend occurred for Africa. Surprisingly, within the 121 papers included in this review, Regulating services were very marginally analysed (13% of the total number of the papers), with 'Moderation of extreme events (in EU and Middle-East) and 'Land degradation (in EU and Africa) as the most studied. Cultural Services were fairly analysed in all of the three zones (23% of the total number of the papers). 'Natural (Landscape) Heritage' and 'Cultural and Historical Heritage' were the most frequently analysed ES within the Cultural services (18% of the total number of the analysed papers) (Fig. 5). By region, in the Middle East was (mainly

'Natural (Landscape) Heritage') while and in Africa were mainly 'Cultural and Historical Heritage' and 'Knowledge System and Educational Values') (Fig. 7).

In particular, the ES 'Maintenance of life cycle and species was, in general, the most frequently analysed ES, followed by Primary production' and 'Natural (Landscape) Heritage (Table 1). The Ecosystem services that were least represented in the analysis were 'Pollination' (Regulating service) and 'Inspiration for Culture Art and Design' (Cultural service).

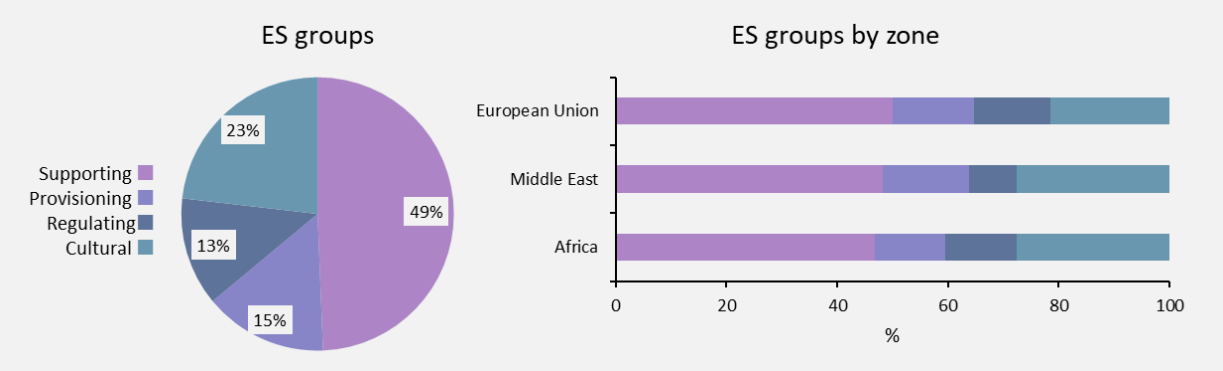

Figure 4. Percentage of ES per ES group for each zone of the Mediterranean basin. Note: Pie charts = % of the total number of analysed papers; bar charts = % of the total number of case studies within each zone.

Table 1 Ecosystem services found in the Mediterranean basin.

ES group	ES	Description	Number of ES			
			Total	EU	ME	AF
Supporting	Maintenance of soil structure and fertility	Nutrient cycling on-farm and across landscapes, soil formation	19	14	3	2
	Primary Production	Improving vegetation growth/cover	48	37	4	7
	Maintenance of Life Cycle and Species	Habitat for species, especially migratory species	108	81	12	15
	Habitat connectivity	Seed dispersal in guts and coats	15	9	4	2
Provisioning	Food	Meat, milk, eggs, honey, wool, leather, hides, skins, etc.	31	23	3	5
	Genetic Resources	Basis for breed improvement and medicinal purposes	28	20	6	2
Regulating	Land degradation	Are regarded not just as loss of soil and fertility, but also as deterioration of balanced ecosystems and the loss of ES	23	18	0	5
	Regulation of Water Flows	Natural drainage and drought prevention, influence of vegetation on rainfall, timing/magnitude of runoff/flooding	5	5	0	0
	Climate Regulation	Soil carbon sequestration, GHG mitigation	2	1	0	1
	Moderation of Extreme Events	Avalanche and fire control	20	15	5	0
	Pollination	Yield/seed quality in crops and natural vegetation; genetic diversity	1	1	0	0
Cultural	Opportunity for Recreation	Eco/agro-tourism, sports, shows and other recreational activities involving specific animal breeds	4	2	2	0
	Knowledge System and Educational Values	Traditional and formal knowledge about the breed, the grazing and socio-cultural systems of the area	13	6	2	5
	Cultural and Historical Heritage	Presence of the breed in the area helps to maintain elements of the local and/or culture that are valued as part of local heritage; cultural identity	27	17	3	7
	Inspiration for Culture Art and Design	Traditional art /handicraft; fashion; cultural, intellectual, and spiritual enrichment and inspiration; pet animals, advertising	0	0	0	0
	Natural (Landscape) Heritage	Values associated with the landscape as shaped by the animals themselves or as a part of the landscape	43	35	6	2
Total N. of Ecosystem Services			**387**	**284**	**50**	**53**

Note: Each paper can deal with more than one ecosystem service

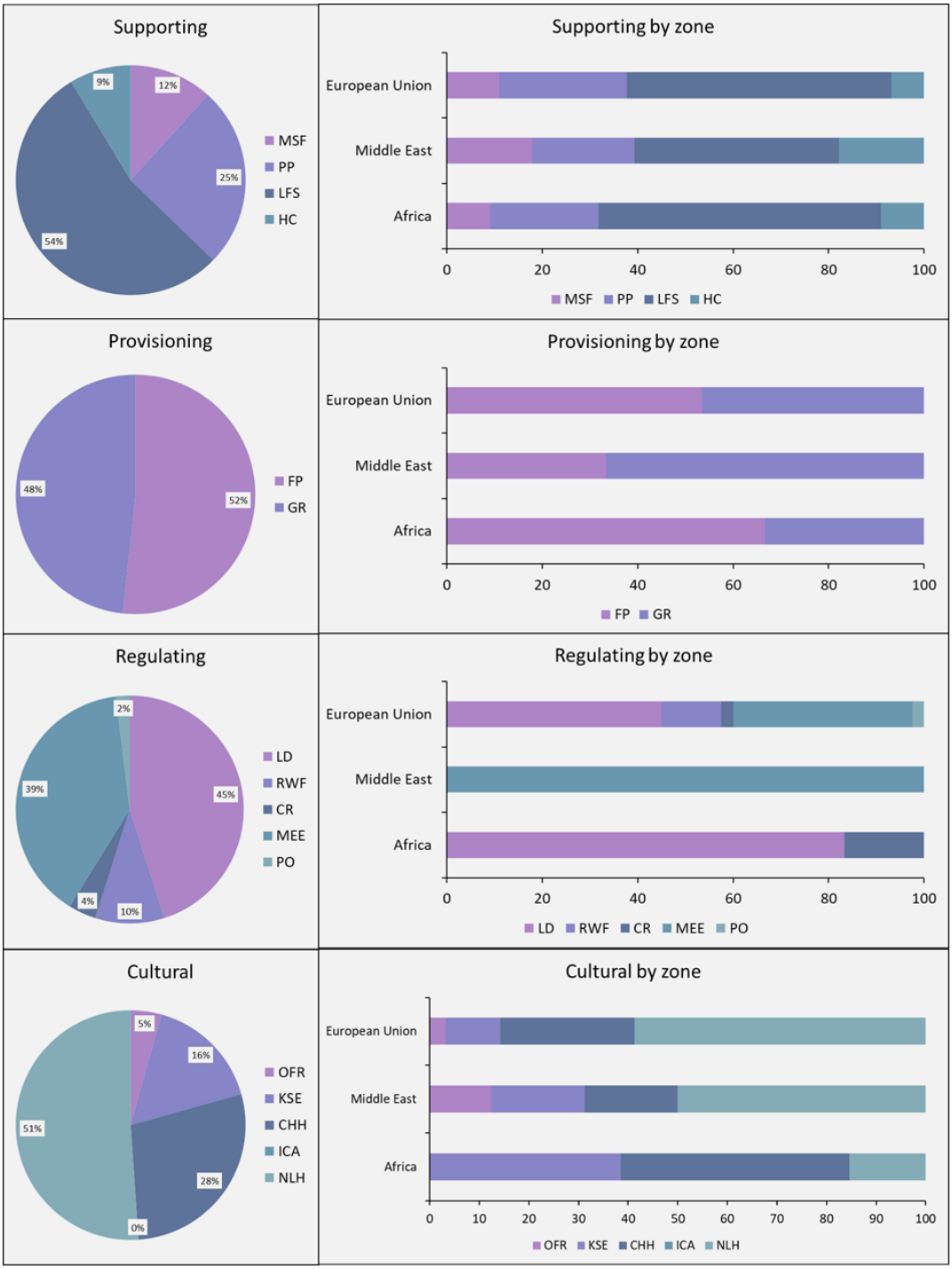

Figure.5. Percentage of findings per ES group for each zone of the Mediterranean basin.

Note: Pie charts = % of the total number of analysed papers; bar charts = % of the total number of case studies within each zone. Maintenance of soil structure and fertility (MSF), Primary production (PP), Maintenance of life cycle and species (LFS), Habitat connectivity (HC), Food and other livestock-related products (FP), Genetic resources (GR), land degradation and soil erosion (LD), Regulation of water flows (RWF), Climate regulation (CR), Moderation of extreme events (MEE), Pollination (PO), Opportunity for Recreation (OFR), Knowledge System and Educational Values (KSE), Cultural and Historical Heritage (CHH), Inspiration for Culture Art and Design (ICA), Natural (Landscape) Heritage (NLH).

The literature has been analysed with respect to the application of the Millennium Ecosystem Assessment key elements, with particular focus on the application of the multiscale and multisectoral approach, together with the incorporation of different types of knowledge in the study and analysis of the case studies.

Spatial scale

Most of the studies were conducted at the landscape (61%) and field (33%) scale in all the zones, with the Middle East having no papers adopting a farm-scale approach, which was also poorly represented in EU and Africa (Fig. 6). Landscape-scale was extensively adopted for the analysis of Supporting and Regulating services. For example, Bernués et al. (2005) carried out an analysis at the landscape scale integrating information on the actual and potential carrying capacity of contrasting livestock farming systems in the northeast of Spain. An even distribution of case studies carried out at field scale emerged within all the four ecosystem services groups with a slight tendency towards 'Maintenance of soil structure and fertility. No studies emerged for 'climate regulation' at the field scale. Farm scale was mainly adopted for the analysis of Provisioning services. As found in the case of goat milk quality related to different grazing intensities on South Spain-scrublands (Delgado-Pertíñez et al., 2013). Only two papers out of 121 adopted a multi-scale approach within the same case study, combining a field and landscape scale. In both papers data from field surveys were later used to upscale the results at the landscape scale using i) a bioeconomic model for assessing the impact of drought on Spanish Dehesa systems (Iglesias et al., 2016) and ii) on bird species of European conservation linked to grassland systems of Southern Portugal (Godinho and Rabaça, 2011).

Some papers using mainly landscape- (6 out of 121) and to a lesser extent field-scale (2 out of 121), investigated the ecosystem services also at a 'system scale'. These papers analysed mainly Supporting services and included comparative studies on dairy goat pastoral systems in Spain, France and Italy (Ruiz et al., 2009) and Morocco (El Aich, 2018). Most of the studies were conducted at local (56%) and regional (44%) scale in all the zones, with only the Middle-East having a national scale approach anyway used only in one paper analysing the environmental impacts of grazing management in Jordan (Schaldach et al., 2013).

Temporal scale

Different temporal scales were represented in all the zones, with a general prevalence of short- and long-term scales while medium-term scale assessments were less frequent (Fig. 9). Short time scale studies were equally used for all the four ecosystem services groups. For example, Supporting services over the short term included a case study on the seed dispersal by seasonal grazing of wheat stubble in the Israeli Mediterranean (Schoenbaum et al., 2009). Provisioning services over the short term included for example goat milk quality assessment (Delgado-Pertíñez et al., 2013; Mancilla-Leytón et al., 2013) or the effects of summer grazing on forage quality (Ainalis et al., 2006). Regulating services examples included, but were not limited to, land desertification modelling (Saïdi and Gintzburger, 2013) while Cultural services included analysis of the interactions between social, economic, and environmental factors in the degradation of mountain pastures (Kizos et al., 2014). Studies carried out on a medium time scales involved mainly Supporting services and in particular 'Maintenance of Life Cycle and Species' such as the generation of GIS-based scenarios to contrast shrub encroachment in the Pyrenees (Lasanta et al., 2016). Studies carried out on a long-term scale were again evenly distributed among the four ecosystem services groups and included studies on non-grazing animals (i.e., insects) biodiversity (Fadda et al., 2008; García-Tejero et al., 2013; Numa et al., 2012), studies on the effect of different grazing intensities on plant species (de Bello et al., 2007; Tárrega et al., 2009)) and reduction of wildfires (Osem et al., 2011; Ruiz-Mirazo et al., 2012). Some case studies combined different timescales and this emerged only for the analysis of Supporting services over the short and medium (Schoenbaum et al., 2009) or short and long time scale (Fadda et al., 2008; Tárrega et al., 2009).

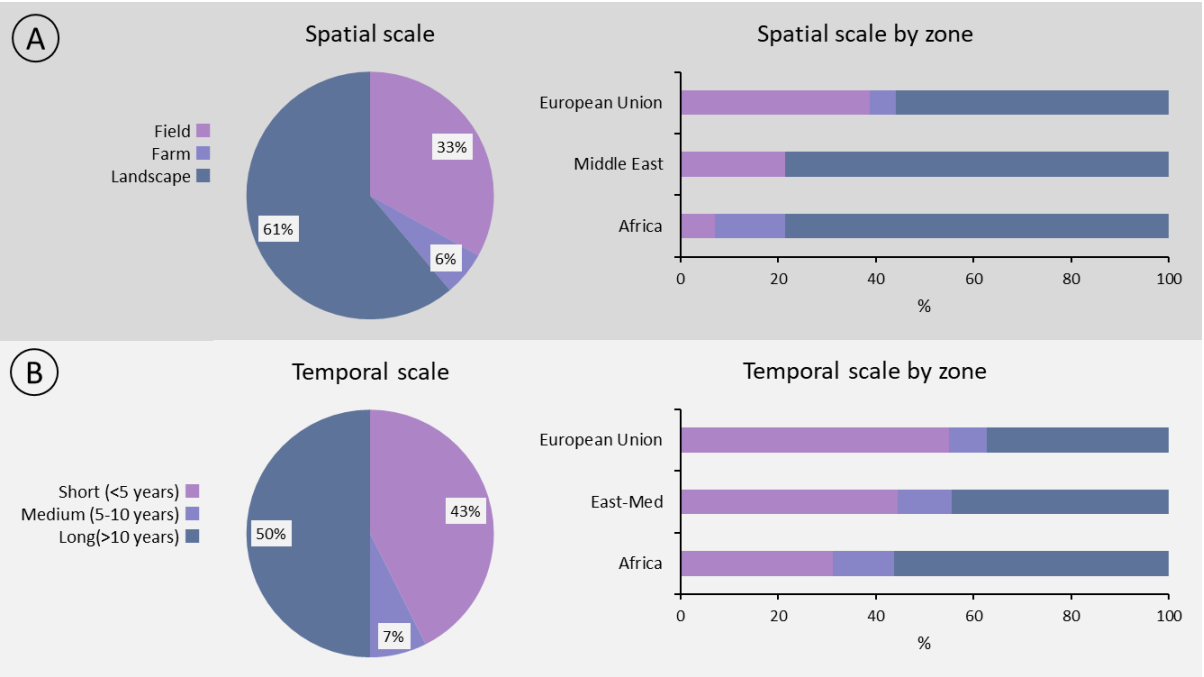

Figure 6. Spatial-temporal scale adopted within the eligible papers for each zone of the Mediterranean basin.

Note: Pie charts = % of the total number of analysed papers; bar charts = % of the total number of case studies within each zone.

Application of multi-sectoral approach in the eligible papers

Most of the analysed papers (about 70%) dealt with only one, two or three ES simultaneously (Fig. 7). Few or very few papers analysed a 'basket of ES' provided by pastoral systems. Indeed, some ES were analysed mostly alone (e.g., Life cycle of species in De Bello et al., 2007, Fadda et al., 2008 and Tarrega et al., 2009), some other ES were analysed with only another or very few ES (e.g., Maintenance of soil structure and fertility in Lasanta et al., 2006). While very few ES were analysed with a diverse array of ES (e.g., Opportunity for Recreation in Nadal-Romero et al., 2018) (Fig. 8), with specificities for each ES group and zone. If the analysis were to be conducted at the ES group level, the Supporting services were generally analysed with other ES from the same group. For example, Schoenbaum et al. (2009) investigated the effect of summer sheep grazing on wheat stubble covered all four ES within the group. Provisioning and Regulating services were mainly analysed together with Supporting services (Bernués et al., 2005). Cultural services were mainly analysed with Supporting ES except for 'Opportunity for Recreation' which was the most analysed through a multi-sectorial approach (Glasser et al., 2012; Nadal-Romero et al., 2018). However, this happened for only 4 papers (10 ES in

Glasser et al., 2012; 7 ES in Henkin et al. 2007; 6 ES in Coiffait-Gombault et al. 2012; 12 ES in Nadal-Romero E et al. 2018) out of 121 (Fig. 11)

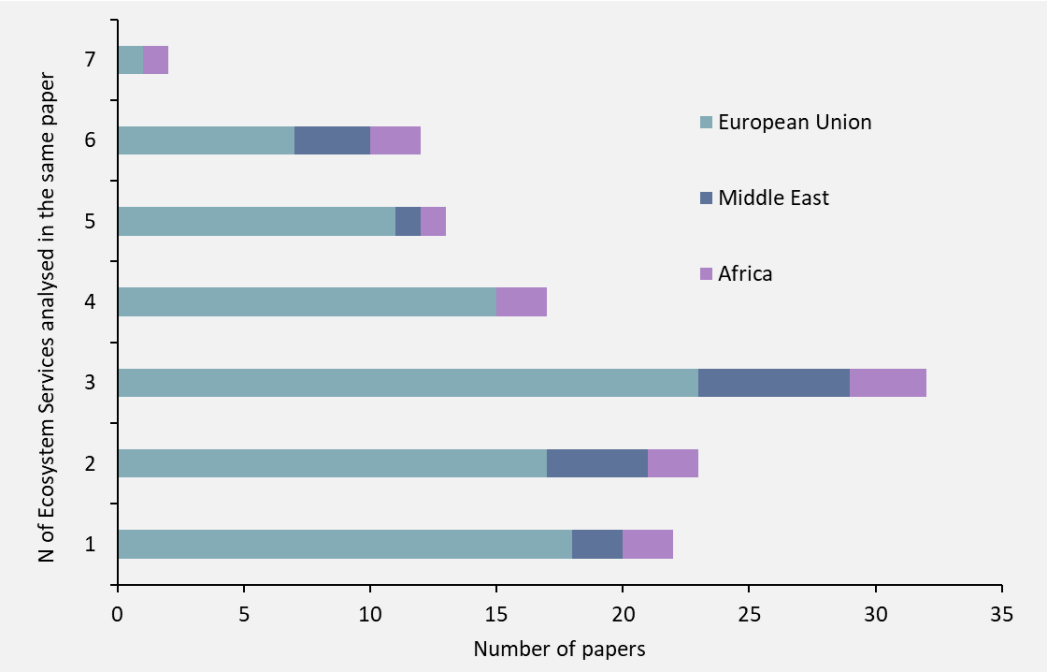

Figure 7. Number of papers eligible for the analysis (n=121) dealing with one or more Ecosystem Service

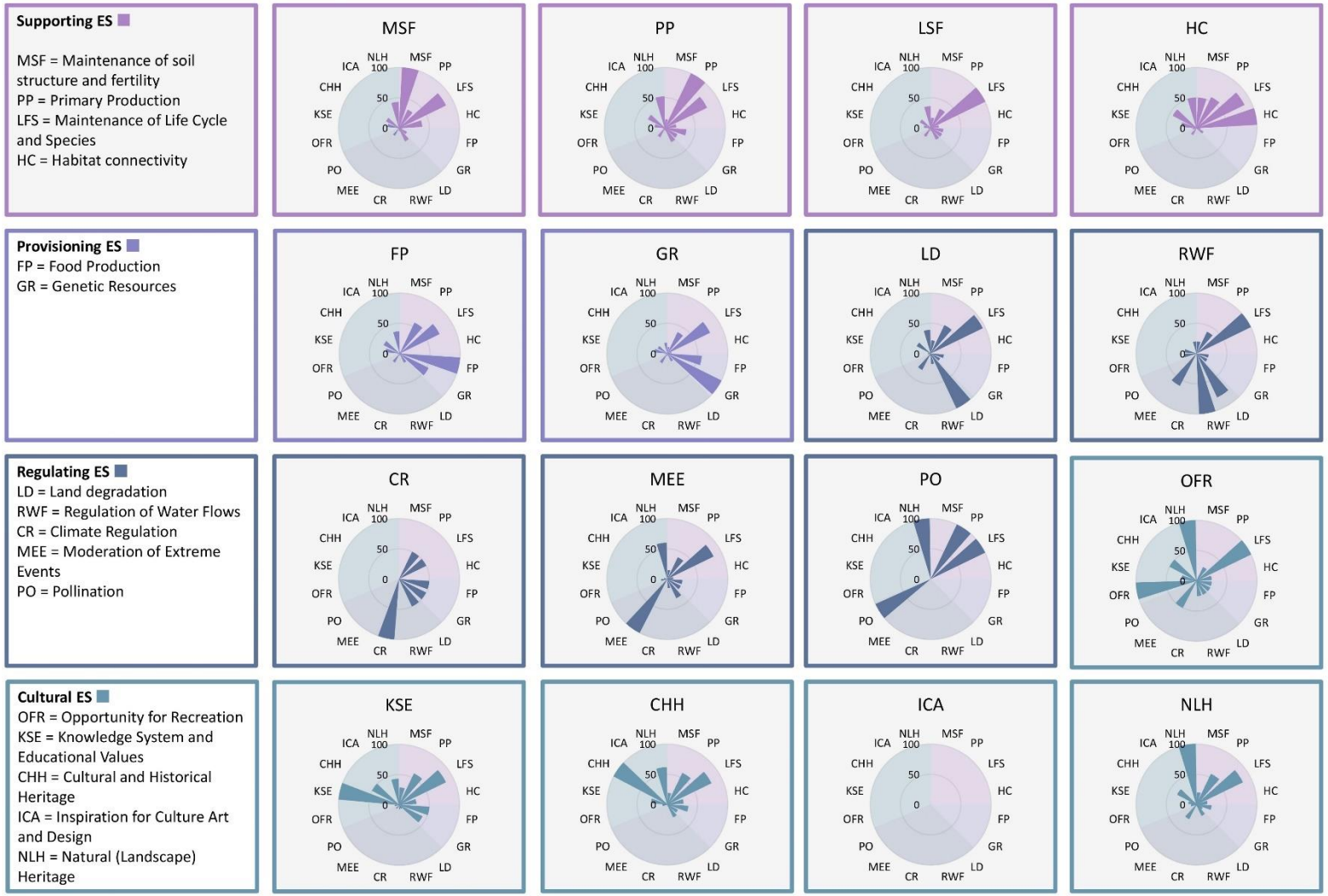

Figure 8. Comparative of how ecosystem services are aggregated within the literature.

Incorporation of different disciplines in the analysis of the pastoral systems

Across the Mediterranean basin, the approaches used in the analysis of pastoral systems fall into two categories. Pastoral systems are analysed in terms of agriculture and ecology both when considering total amounts and relative proportions (Fig. 9). In Europe, the pastoral systems analysis is dominated by an ecological approach (48%) and an agricultural approach (40%) as found in Greece (Ainalis et al., 2006) and France (Fadda et al., 2008). All other approaches (sociological, economic, anthropological, geological) represent around 12% of the disciplines used to analyse pastoral systems in the EU, with the EU having the lowest proportion of social approaches (3%) of all Mediterranean zones. The Middle East Mediterranean zone shows dominant approaches of both the ecological (48%) and the agricultural (41%) approaches used in the analysis of case studies as seen in Turkoğlu et al., (2016) and Henkin et al., (2007) in both Turkey and Israel. The Middle East Mediterranean also shows the lowest proportion of anthropological (3%) and economic (3%) approaches. African pastoral systems were predominantly analysed in terms of agriculture (37%) with the ecological approach being present in 34% of African case studies as shown by Saïdi and Gintzburger, (2013) in Algeria and Tarhouni et al., (2017) in Tunisia. The anthropological (6%), geological (6%) and social (9%) approaches were all better represented in Africa than any other part of the Mediterranean.

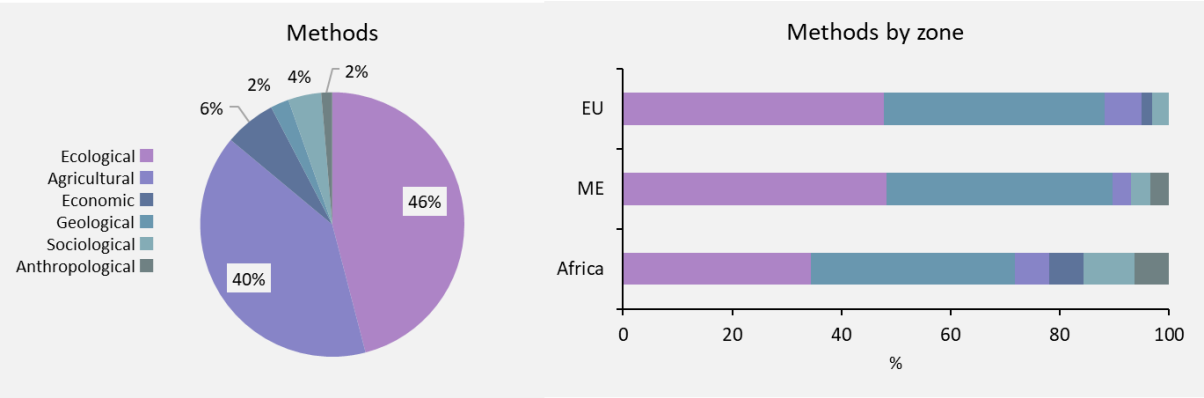

Figure 9. Disciplinary approaches used in the analysis of the case studies for each zone of the Mediterranean basin.
Note: Pie charts = % of the total number of analysed papers; bar charts = % of the total number of case studies within each zone.

Integration of interdisciplinary perspectives in the analysis of the case studies

Agricultural and ecological approaches demonstrated to be mostly integrated into the analysis of the pastoral systems in all the Mediterranean zones (Fig. 10). In other cases, economic studies demonstrated to be mostly integrated with agricultural (in EU) and social (in Africa) approach, and less with an ecological approach. Social approaches seem the most integrated with all the other approaches, with a net prevalence in the Middle East and Africa compared to EU case studies.

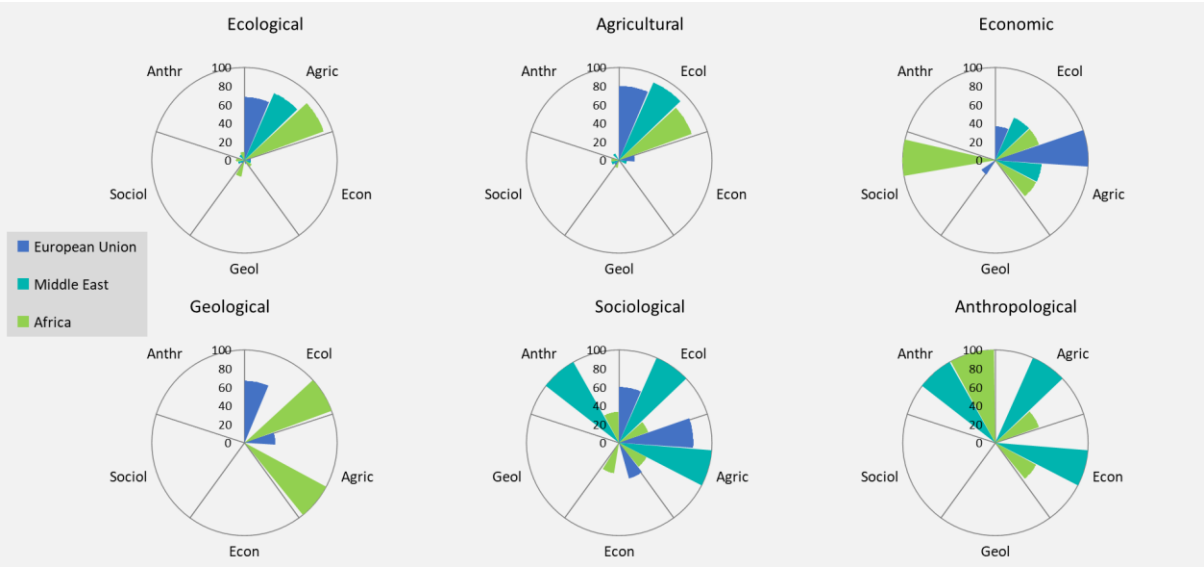

Figure 10. Disciplinary approaches used in the analysis of pastoral systems for each zone of the Mediterranean basin (% of case studies within each zone).

Discussion

This paper presents the status of ES in Mediterranean pastoral systems by applying the MEA framework as an analytical lens in order to elucidate if the scientific community address pastoral systems using holistic. The MEA has proven to be a useful framework for acknowledging the complexity of pastoral systems as it has allowed for the examination of scale and sectorial approaches, which have been used as indicators of complexity in this analysis. Our results revealed that only a small subsection of ES are disproportionally analysed in the literature, with researchers showing a clear focus on considering pastoral systems as landscape management and food production systems (Table 1). We have also demonstrated that the use of multiscale and multisectoral approaches are not widely used in the study of pastoral systems, which highlights a lack of consideration for pastoral systems as complex socio-ecological systems. This demonstrates a greater need to appreciate the importance of multiscale and interdisciplinary analysis of pastoral systems. This would allow for a greater acceptance of the complexity of pastoral systems across the Mediterranean basin. Finally, this analysis has examined the effect of geographic region on the analysis of ES by pastoral systems and suggested reasons why specific patterns of distribution regarding the creation of ES may have occurred, such as the influence of international policies in Europe or the prevalence of pastoral systems in Algeria and Tunisia.

This qualitative meta-analysis shows the importance of pastoral systems, as a human-nature activity) in the creation of ES as a socio-ecological system (Table 1) (Davies; P. Herrera; J. Ruiz-Mirazo; J. Mahomed-Katere; I. Hannam; E., 2016; IUCN, 2008). This study also highlights the complex array of ES provided by pastoral systems across the three different continents that span the Mediterranean basin. In this analysis, we found that provisioning, regulating, supporting and cultural services are all represented. Although supporting services in the form of habitat maintenance dominated the analysis (Table 1). This seems to be due to the fact that ecology was the most common scientific discipline used to analyse pastoral systems in the Mediterranean (as shown in Fig. 9), with relatively little attention paid to social or economic approaches. This gives credence to the argument that pastoral systems are rarely studied in a complex manner and are instead studied in terms of a few easily measured variables (Manzano et al., 2021).

To evaluate if researchers study pastoral systems as SES or as claimed by Manzano et al., (2021) they tend to be studied in terms of only a few variables, we used a multiscale and multisectoral approach using the MEA'S umbrella. Only two of the case studies examined analysed both field and landscape (Godinho and Rabaça, 2011; Iglesias et al., 2016) combined with the limited number of studies that combined studies at different temporal scales (Fadda et al., 2008; Schoenbaum et al., 2009; Tárrega et al., 2009). This displays a lack of consideration for the impact of pastoral systems across scales by the majority of pastoral systems researchers and supports the argument of Manzano et al (2021). Especially when considering that the few studies that considered multiple temporal scales all examined the role of supporting services and not a complex mixture of ES (Fadda et al., 2008; Schoenbaum et al., 2009; Tárrega et al., 2009). The multiscale approach is needed in the analysis of ecosystems because the interactions among the components can take place at more than one scale and across scales (Fig. 6) and because of the diverse way in which.ES can be studied together (Fig. 8) This is because ecosystems are highly differentiated in space and time, and single space or time measurements could potentially lead to spatial scale-mismatches (e.g., impose irrational agri-environmental measures for biodiversity conservation in protected areas) (Toderi et al., 2017) or time scale-mismatches (e.g., the estimation of soil organic changes in permanent grasslands over centuries is harder to estimate than the short-time soil CO_2 emissions in a high mowing frequency grassland) (Francioni et al., 2020). Scale-mismatches can be overcome by the integration of both formal scientific information and traditional or local knowledge. The formation of hybrid 'scientific-local' knowledge on the analysis of ecosystem services is crucial because it can both improve the findings and help to increase their adoption by stakeholders (Alcamo et al., 2003), although this analysis did not encounter any researchers adopting this hybrid knowledge standpoint despite is has been shown crucial to e.g. adapt to climate change (Shukla et al., 2019).

The multiscale approach should be used in conjunction with the multisectoral approach to better capture the complexity of pastoral systems. As the perspectives used by researchers in the analysis of pastoral systems influences how these systems are viewed and the framing used to describe them. The dominance of ecological and agricultural narratives (Fig. 9) combined with the tendency of researchers to depend on biological methodologies (Fig. 10) in their study of pastoral systems highlights the perceived importance of pastoral systems for

the biodiversity of the case study regions and the overall biodiversity of the Mediterranean basin. The dependency on biological methods and ecological narratives (Fig. 9 & 10) however has the potential to imply that pastoral systems are merely biological systems that do not have deep social, cultural, and economic aspects. As highlighted by a recent report which details the full complexity of pastoral systems in helping to achieve many of the SDGs (Niamir-Fuller and Huber-Sannwald, 2020) and their contribution to NCP creation, most of them cultural (Dean et al., 2021). This idea is supported by a recent publication by Manzano et al., (2021) which shows that pastoral systems suffer from a lack of holistic thinking by academics. Indeed, focusing on only a few ES/scientific perspectives as found in this analysis (Table 1 & Fig. 8), risks ignoring the potential cascading interactions between ES and thus, between scales. The fibre from livestock can have an economic worth, but it can also have an important cultural value as found in Turkey (Ocak, 2016). Traditional livestock breeds can be seen as an important genetic resource while simultaneously being a symbol of culture and identity as seen in Spain (Fernández-Giménez, 2015; Velado-Alonso et al., 2021). This is particularly relevant for scientists that intend to bound the analysis spatially and temporally regarding the ES being examined but not on their interaction as found for the majority of the case studied analysed (Fig. 6). This form of spatially or temporally bound analysis helps to create narratives regarding pastoral systems as simplistic and ignores the complexity of interactions that are the trademarks of socio-ecological systems (Mcginnis and Ostrom, 2014). This examination of pastoral systems using the MEA framework has shown the suitability of the MEA framework in acknowledging the complexity of pastoral systems through the use of (or lack of) multiscale and multisectoral approaches.

The presence of ES in the literature allows us to rank ES in order of importance, according to the researchers in this study. It was found that pastoralism is primarily examined regarding supporting and cultural services across the Mediterranean. This result is supported by Dean et al., (2021) when examining the NCP produced by pastoral systems. They found that non-material NCP (comparable to cultural ES) was the second most prominent NCP group globally. Inside the EU, the role of the CAP helps to explain the importance placed on supporting services (Commission, 2020; Liechti and Biber, 2016). What is interesting is that non-EU countries have nearly the same proportion of supporting services examined as EU countries, with Africa having proportionally more studies examining supporting services than the EU.

This implies that supporting services are considered the most important services by researchers across the Mediterranean basin. This is almost certainly linked to the importance of the Mediterranean as a global biodiversity hotspot (Hilton-taylor and Stuart, 2009; Nations, 2017) and the importance of the Mediterranean basin and pastoral systems for achieving many of the SDG's (Niamir-Fuller and Huber-Sannwald, 2020).

Cultural services within the EU received proportionally less attention in the literature than other Mediterranean regions, with Europe in line with that reported by both D'Ottavio et al. (2018) when examining ES provided by pastoral systems and Dean et al., (2021) when examining the Nature's contributions to people in pastoral systems. This perhaps highlights a bias in European research to see pastoral systems less in cultural terms than other parts of the Mediterranean. This apparent lack of attention to cultural services in the EU pastoral systems may be a drawback of the CAP, as supports for preserving Indigenous and local knowledge is still limited, this is even though traditional farming practices are key in creating biodiversity-rich landscapes (Simoncini et al., 2019). Pastoralism is an important form of cultural identity that is linked to a sense of place, tradition and heritage (Ben Hounet et al., 2016; Davies; P. Herrera; et al., 2016; Dong et al., 2016; Zinsstag et al., 2016a), which helps to explain the prevalence of cultural services in the African and Eastern Mediterranean (Table.1) as they are the two places on Earth with the longest tradition of extensive pastoralism (Starrs, 2018). A major finding of this examination is the apparent lack of attention that pastoralism in the Mediterranean basin has received as a regulating service, particularly outside the EU, a finding supported by Dean et al., (2021) which found outside of Europe, regulating Nature's contribution to people were not well represented in the literature. The Middle Eastern Mediterranean case studies demonstrated the least interest in considering the regulatory potential of pastoralism (Fig. 7). Considering the potential for climatic extremes in the Mediterranean, and notably drought and fires, the potential impact of pastoralism to prevent or control impacts of extreme climate events should be of great significance to many Mediterranean countries. This has been highlighted through the creation of fire breaks using livestock in the south of Spain and the reduction of biomass in Mediterranean systems (Niamir-Fuller and Huber-Sannwald, 2020; Oteros-Rozas et al., 2014; Varela et al., 2018). This highlights an interesting research gap within the literature, to examine the role of pastoral systems in different regions and the regulating services they create and maintain.

Caveats and Limitations

Our search found that many papers were excluded because the necessary information was not available within the articles, such as the mobility methods or agricultural systems. While all relevant authors were contacted to obtain any missing information, not all authors were contacted successfully. Publication bias could also be an issue, that certain topics which report significant differences are more often published than studies that find no significant differences. The information could be acquired from some but not all relevant authors. EU pastoral systems in our analysis are heavily influenced by Spain as it is the individual country with a disproportionate amount of cases that may have unduly affected the outlook of the EU pastoral system in the analysis. The Mediterranean basin is a large and diverse area, spanning three continents. While every effort has been made to reflect the complexity of these areas, language barriers were bound to create limitations within the study. As the study only included articles that were published in English, this can be considered a major limiting factor of the study. There are almost certainly relevant papers to be found in other languages outside of English, particularly in French as it is the most common language of publication in the African Mediterranean. Equally, there is a wide range of languages in the Eastern Mediterranean which may have limited the representation of countries in the analysis.

Conclusion

This study has confirmed the importance of pastoral systems as creators of a diverse array of ES across the Mediterranean basin. Although through the categorisation of the Mediterranean basin into four distinct zones, we have highlighted the consistency with which pastoralism is studied in terms of supporting services throughout the Mediterranean. The apparent lack of attention that pastoral systems have received as regulating and cultural systems highlights a lack of interdisciplinary thinking regarding pastoral systems and should be examined in future research. Multiscale/multisectoral approaches are essential for the study of pastoral systems as without the inclusion of diverse narratives, pastoral systems will be viewed in terms of only a few variables and their complexity will continue to be ignored. If studies of pastoral systems continue to ignore the diverse range of ES much of the complexity of pastoral systems will continue to be lost. Which in turn has the potential to increase the vulnerability of pastoral systems as inappropriate policies could be created based on simplistic narratives.

While the MEA framework has the potential to embrace the complexity of pastoral systems, the lack of multiscale/multisectoral approaches demonstrated by the literature demonstrates an apparent disconnection between the potential use of the framework and researchers of pastoral systems. Pastoral systems across the Mediterranean are highly complex human-nature systems that cannot be completely captured using any one focus. They should be examined as interactive systems that create, maintain, and use a wide array of ES. As ignoring any one focus, cultural, regulating, provisioning or supporting is to ignore the complexity of the relationship pastoral systems in the Mediterranean basins have with their environment. Our results however show that pastoral systems are still approached using single disciplines instead of a combination of disciplines that can better describe the system and understand the interactions among the different temporal and spatial scales, as suggested by the MEA. Thus, more efforts are needed to fully understand from a systemic perspective the true contributions of pastoral systems to sustainability.

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Chapter 5: Impact of policies on production of Nature's contribution to people in Mediterranean pastoral systems.

Abstract

Much of the Mediterranean basin is made up of a collection of semi-natural landscapes that have been co-created through generations of interactions between pastoral systems with their environments. In recent times, pastoral systems have been heavily marginalised and facing increasing vulnerability due to ecological (e.g., climate change) and socio-economic (e.g., demographic trends, policies) drivers of change. Since pastoral systems are users and providers of Nature's Contribution to People (NCP), impacts on those systems also imply impacts on the ability of pastoral systems to produce NCP. Policies are one of the main anthropogenic drivers of pastoral vulnerability. Indeed, inappropriate policies can increase the vulnerability of pastoral systems, whereas well-designed policies can increase pastoral resilience. Here, we analyse the policies impacting pastoral systems across the Mediterranean basin focusing on how they impact the production of NCP linked to pastoral systems. It was found that the ability of pastoral systems to produce NCP through the impact of policies on them was affected by three primary factors: i) The domain of the policies; ii) The geographic region of the pastoral systems, and ii) The governance level leading the policies. It was discovered that material and non-material NCP were normally impacted by policy design while non-material NCP were rarely, if ever, the main target of policies impacting pastoral systems and were instead indirectly impacted as an accidental consequence of policy. This analysis also shows that the complexity of pastoral systems is rarely acknowledged by policymakers and show a tendency to be considered in terms of only a few dimensions such as food production and landscape maintenance. This simplified manner of considering pastoral systems could, in turn, require pastoral systems to simplify, affecting their ability to produce multiple NCP.

Introduction

Pastoral systems refer to extensive traditional livestock systems that can be found all over the world. It is estimated that today there are between 500 million and 1 billion pastoralists in the world (Niamir-Fuller and Huber-Sannwald, 2020) with near-global ubiquity, making pastoral systems relevant to many global challenges. Pastoral systems are also specialised in adapting to the uneven spatial and temporal distribution of resources. This can include the movement of livestock over long distances as they move from abundance to abundance, taking advantage of spatially and temporally separated biomass for animal feed (Krätli and Schareika, 2010). This makes pastoral systems adaptable to changing environmental, economic and social conditions (Krätli et al., 2013; Krätli and Schareika, 2010; Oteros-Rozas et al., 2013a; Rueff and Rahim, 2016). Due to the adaptability of pastoral systems, they can be defined as an *"adaptive network of biophysical and social flows generated and maintained by the movement of shepherds and livestock"* (Oteros-Rozas et al., 2012).

Another defining attribute of pastoral systems is their capacity to provide the pastoral communities with multiple goods and services (e.g., meat, milk, social status, fibre, drought power, etc.). But the multifunctional nature of pastoral systems goes beyond the pastoral communities, since pastoral systems are providers of many other public goods and services, from non-material societal contributions such as the maintenance of cultures and identity (Dean et al., 2021; Fernández-Giménez, 2015), to the creation and maintenance landscapes (Dong et al., 2016; Starrs, 2018), or the provision of food, such as milk and meat production for the benefit of society as a whole. Thus, due to both the multifunctionality and adaptability, we propose to understand pastoral systems as complex human-nature systems. As such, pastoral systems have the ability to influence many peoples, transcending the activity of pastoralism through the creation of goods and services which provide services to the rest of society. This provision of good and services by pastoral systems have been analysed both using the ecosystem services framework (D'Ottavio et al., 2018; Oteros-rozas, 2015) and the Nature's Contribution to People (NCP) framework (Dean et al., 2021).

The NCP framework is the latest framework proposed by the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES) to make sense of the multiple contributions of socio-ecological systems, such as pastoral systems. It has been designed to

address the criticism of the Ecosystem Services (ES) framework of the under-representation of alternative world views and a lack of studies dealing with cultural values that are not easily quantified (Diaz, 2018; Díaz et al., 2018). NCP are defined as "*all the contributions both positive and negative of living nature (diversity of organisms, ecosystems and their associated ecological and evolutionary processes) to people's quality of life"* (IPBES Plenary 5 Decision IPBES-5/1, n.d.). There are 18 NCP that have been divided into 3 broad categories; Regulating, Material and Non-material NCP, although by design it is acknowledged that many NCP do not fit neatly into one specific category and can be placed in multiple categories if appropriate (Díaz et al., 2018a, 2018b). As such it is possible for a material NCP to also be a non-material NCP, for example, the fibres from livestock are a commodity (material NCP), but they can also have a cultural status (non-material NCP), as found in Turkey where a people use animal fibres to make their tents which gives them cultural recognition due to its colour (Ocak, 2016). The NCP framework has been previously used to analyse socio-ecological systems (Aguilera-Alcalá et al., 2020; Leister et al., 2019) and allows for the examination of pastoral systems in a holistic manner that embraces the complexity of the systems and avoids the need to simplify them (Dean et al., 2021). It does this by regarding NCP as multidimensional so that different NCP have the potential to permeate between different NCP groups. A material NCP such as fibre can also be a cultural NCP as seen in Turkey, where the fibre from goats is a key part of cultural identity (Ocak, 2016) or in Spain where local breeds are both important for genetic diversity but also helps link pastoralists with their animals (Fernández-Giménez, 2015) The NCP framework is well positioned to allow for a richer understanding of the complexity and interactions between pastoral systems and policy.

Despite their social and environmental relevance and high adaptive capacity of pastoral systems, today they are highly vulnerable systems facing multiple social, economic and environmental drivers of change (Dean et al., 2021; López-i-Gelats et al., 2016), both globally and in the Mediterranean basin. López-i-Gelats et al., (2016) have extensively categorised the many reasons for pastoral vulnerability at the global level. Some of the most important causes of pastoral vulnerability identified in the specialized literature are: (i) climate change which affects the ability of pastoral systems to deal with spatially and temporally scarce resources (Slimani and Aidoud, 2004); (ii) land-use changes that bring pastoral systems into conflict with other land use, such as tourism, which has the potential to increase pastoral income but also

creates resource conflicts between pastoral activities and tourism activities (López-i-Gelats et al., 2011; Schirpke et al., 2020); (iii) the continued marginalisation of pastoral activities globally as governments and society continue to consider pastoral systems as inefficient, or as marginal activities (Bonfoh et al., 2016; Morton, 2010; Ouedraogo and Davies, 2016; Scoones, 2020). Policies hold a special place as they are a powerful driver of change in every socioecological system, and it has been shown to have a key role in pastoral systems (Dean et al., 2021; Johnsen et al., 2019). They can contribute to pastoral vulnerability and marginalisation (Johnsen et al., 2019; López-i-Gelats et al., 2016; Morton, 2010; Scoones, 2020), impacting the NCP associated with pastoral systems (Dean et al., 2021) or otherwise contribute to the empowerment of pastoral systems and its continued survival (Bonfoh et al., 2016; Kerven and Behnke, 2011).

In the Mediterranean basin, pastoral systems have been influencing different areas for up to 9,000 years, through the modification of the landscape with extensive grazing practices (Dong et al., 2016; Starrs, 2018). It comprises 20 countries, spanning three continents and different cultural settings. Given that an estimated 80% of the Mediterranean basin can be considered as marginal land (Pardini, 2004), pastoral systems in the Mediterranean are experts in the use of arid, semi-arid areas (Niamir-Fuller and Huber-Sannwald, 2020), with long traditions of using mobility strategies to best use spatially and temporally scare resources (Ben Hounet et al., 2016; Liechti and Biber, 2016; Ocak, 2016; Oteros-Rozas et al., 2013b; Starrs, 2018). Today pastoral systems both in the Mediterranean and globally are in decline due to environmental, social and economic challenges (Dean et al., 2021; López-i-Gelats et al., 2016). In this context, the challenges faced by pastoral systems in the Mediterranean tend to result in a combination of rural/pastoral decline, land abandonment and agricultural intensification, as pastoralists either move away to more urban areas or become more sedentary, particularly in arid, semi-arid and mountain regions that characterise much of the Mediterranean basin (Chergui et al., 2018; Kizos et al., 2013; López-i-Gelats et al., 2015; Plieninger et al., 2014).

This paper aims at contributing to a better understanding of the role of policies in the preservation of the multifunctionality of Mediterranean pastoral systems and how they can impact the creation and maintenance of tangible and intangible contributions of pastoral systems in the Mediterranean. We intend to use the NCP conceptual framework as a way of understanding how policies impact the tangible and intangible contributions of pastoral

systems. In doing so an examination has been conducted across six Mediterranean countries and ten case studies.

Methodology

To examine the impact of policies on the capacity of Mediterranean pastoral systems to provide NCP, semi-structured interviews with expert informants were conducted across ten Mediterranean zones that we distributed in three geographical areas. These areas were selected considering socio-political, geographic, and cultural dimensions to illustrate the existing diversity of situations in the Mediterranean basin. here we show the similarities and

Fig. 1 Location of case studies analysed. Source: Google maps

differences of policies affecting pastoral systems across the Mediterranean basin, particularly in the European Union, North-Africa, and Eastern Mediterranean. European Union, North-Africa and Eastern Mediterranean. In the European Union (EU) geographical area we had the Spanish case study, located in El Pallars Sobirà, Catalonia; the Greek study, located in Peloponnese at Mount Zira & Mount Kyllini; the Italian case studies, located in Comune de Osilo, Sardinia and Mount Sibilini national park, Marche. In the North-Africa region, the Tunisian case study was in El Ouara, Tataouine; the Algerian case study was in Stif, Sétif. Easter-Mediterranean was represented by Turkey, with 4 case studies, two in the Antalya region, Köprülü Canyon National Park & Güllük Mountain - Termossos National Park. Turkish case studies were in the Burdur region, Kestel mountain and the Isparta region - Anamas Mountain & Kizildag National Park. Interviews were complemented with a focus group of academic experts on pastoral systems in each study region.

A total of 164 semi-structured interviews with local expert informants were conducted across ten Mediterranean zones distributed across the three regions (Fig. 1). The interviews were conducted between January 2018 and May 2019. The criteria for the selection of expert informants were designed to gain a wide range of perspectives, experiences, and knowledge. The selection of the people interviewed followed the criterium of maximization of experiences concerning pastoralism. They can be grouped into three main categories: Leading members of pastoral associations, technicians working for the local/regional administration and regional/local politicians. Expert informants were asked to identify policy measures that affect pastoral systems in the given pastoral region and to characterize which are the implications of the policy measures identified for pastoralism. Once no more policies on impacting pastoral systems were identified, interviewing stopped. On average, there were 16 interviews per case study, although there was a wide range of variability between the number of people interviewed for each case study depending on the range of knowledge of the expert informants available for each region. From five interviews in the Marche region of Italy to 15 interviews in Köprülü Canyon National Park region of Turkey. The interviews were focused on capturing how policies influenced pastoral systems in various domains, particularly: a) *The nature of policies*, to examine which types of policies most commonly affect pastoral systems. For example, policies that primarily impact the creation, use of and protection of forestry where all classified as *Forestry*, while policies focused on generational renewal, the creation of rural infrastructure and development of rural markets were considered as *Rural development*; b) *NCP impacted by policies*, to examine trends regarding which NCPs the identified policies impact; c) Key *governance levels,* with four levels of governance being distinguished in this analysis: International policies, originated at the super-national level such as the European Common Agricultural Policy; National policies, developed and implemented at the national level, such as national laws giving protection to endangered or vulnerable species; Regional policies, originated at the regional level, in the Spanish context these would be policies that originated at the level of the Catalan government, such as the creation of national parks; and finally; Local policies, implemented by local governments according to the local context. Policies can belong to more than one governance level, for example, *Habitats Directive 92/43/CEE* in Spain was categorised as being affected by International, National and Regional governance levels. This is because relevant decisions that shape the organisation of the policy are made not only at the point of policy creation such as the EU level but also at a

national level through the Italian governments regulation of traditional grazing rights and land access and regional governance levels as seen in the creation of natural parks in Catalonia.

A total of 232 policies were identified by expert informants as having impacts on policies pastoral systems in their regions. An additional round of questions was then performed asking academic experts from each study zone to identify policies that were missing that they felt were important to pastoral systems. This results in 3 extra policies being identified in two different case study regions. In total 235 policies (Annex III) were finally identified by the informants across 10 case study zones.

After the 235 policies were identified, the policies were analysed to determine their suitability to be examined using the NCP framework. This analysis resulted in 83 of the policies being excluded, either due to the lack of connection between the policies and NCP or due to policy repetition in the database. In total, 146 policies were selected for analysis with the NCP framework. The policies were coded and grouped according to the narrative of the policies with 13 different policy domains being identified.

The policies were then analysed using the NCP framework to examine which NCP were impacted by the policies. First, the policies were examined to allow for the identification of which major NCP categories and which individual NCP were impacted. After this was completed, policies were said to impact NCP either directly or indirectly. The direct impact of policies means that the policies specifically target an NCP through policy design. Indirect impacts mean that policies may not directly target an NCP but have obvious secondary effects on NCP through policy consequences. For example, the creation of National parks, which was selected by experts as a type of policy having impacts on pastoralism, is by design targeted at *Habitat maintenance and creation*, a regulating NCP. Indirectly, it also affects the non-material NCP *Physical and psychological experiences* through the creation of the opportunity to enjoy and experience nature, the distribution of NCP was analysed through distinct geographic zones, within the Mediterranean basin. This was done through the creation of a dummy variable database, so when a policy was found to impact an NCP it was coded as (1) and when it was seen to not affect an NCP it was coded as (0).

All in all, the analysis of data consisted of three steps following an inductive process: (1) Identification of the nature of policies affecting pastoral systems to classify the policies into

policy domains and examination of the impact of those policies on the NCP provided by pastoral systems, and if they did so directly or indirectly; (2) Determining how the geographical level of policies affect pastoral systems and the NCP provided; (3) Determining how the key governance levels of policies affect pastoral systems and the NCP provided.

Results

1. Policy domains affecting the NCP provided by pastoral systems in the Mediterranean

The nature of the policies was identified as a relevant element to understand the impact of policies on the capacity of Mediterranean pastoralism to provide NCP. To distinguish the nature of policies having impacts on NCP, all policies were organised, through an inductive process in cooperation with the local expert informants, into policy domains and subcategories within each policy domain. This allowed for the identification of 13 domains of policies which are described in Table. 1.

The policy domains were then analysed according to how they affect the creation and maintenance of NCP (Fig. 2 A & B). A total of 16 NCP were identified across the Mediterranean basin as being impacted by policies (Table 2). The 16 NCP are divided between regulating (38%), material (32%), and non-material NCP (30%). Four NCP dominated the analysis, each of these NCP belonged to one of the major NCP groups. The most common NCP in the analysis was the material NCP *Food & Feed* (n=76, 67% of the material NCP analysed), followed by the regulating NCP *Habitat maintenance and creation* (n=66, 51% of all regulating NCP), which was followed by the non-material NCP *Physical and psychological experiences* & *Supporting identities* (n=35, 32% of all non-material NCP).

Policy domains	**Subcategories**				
Rural Development **(n=31)**	Infrastructure (n=3)	Livelihood diversification (n=5)	Local development (n=15)	Agriproducts (n=2)	Other (n=6)
Food **(n=29)**	Organic (n=5)	Quality control (n=8)	Food production (n=8)	Intangible elements (n=5)	Other (n=5)
Livestock **(n=28)**	Animal-welfare (n=15)	Genetic diversity (n=8)	Other (n=5)	NA	NA
Environmental protection **(n=26)**	Protection of species (n=8)	Protection of the environment (n=14)	Climate change (n=4)	NA	NA

Rangeland **(n=16)**	Access (n=6)	Land conversion (n=2)	Restoration (n=7)	Other (n=1)	
Forests **(n=15)**	Creation/protection (n=9)	Control of grazing (n=4)	Other (n=2)	NA	NA
Natural parks/reserves **(n=12)**	Creation (n=4)	Infrastructure (n=4)	Regulations (n=3)	Other (n=1)	NA
Control/Introduction of organisms **(n=10)**	Disease (n=4)	Species numbers (n=3)	Reintroduction of wildlife (n=3)	NA	NA
Tourism **(n=9)**	NA	NA	NA	NA	NA
Farm investment **(n=8)**	NA	NA	NA	NA	NA
Extreme events **(n=7)**	NA	NA	NA	NA	NA
Creation/protection of watering points **(n=6)**	NA	NA	NA	NA	NA
Other policies **(n=5)**	NA	NA	NA	NA	NA

Table 1. Main policy domains affecting the NCP provided by pastoral systems in the Mediterranean with subcategories. *Note:* NA represents no sub-categories

NCP Categories	NCP	Total No	EU	North Africa	Turkey
Regulating	Habitat creation & maintenance	66	N=39 D=23, ID=16	N=14 D=9, ID=5	N=13 D=10, ID =3
	Regulation of climate	17	N=10 D=1, ID=9	N=3 ID=3	N=4 D=1, ID=1
	Freshwater quantity, location, and timing	8	N=4 D=4	N=3 D=2, DI=1	N=1 DI=1
	Fresh and coastal water quality	7	N=5 D=5	N=1 D=1	N=1 DI=1
	Detrimental organism and biological control	18	N=13 D=10, DI=3	N=0	N=5 D=2, DI=3
	Hazards and extreme events	9	N=4 D=4	N=1 DI=1	N=4 D=3, DI=1
	Formation, protection, and decontamination of soil	11	N=5 D=5	N=5 D=5	N=1 D=1
Material	Energy	7	N=5 D=3, DI=2	N=1 DI=1	N=1 DI=1
	Food & Feed	76	N=56 D=26, DI=30	12 D=7, DI=5	N=8 D=7, DI=1
	Materials, companionship, and labor	5	N=2	N=0	N=3

			D=1, DI=1		**D=2, DI=1**
	Medical, biochemical, and genetic resources	**26**	**N=19** **D=16, DI=3**	**N=2** **D=2**	**N=5** **D=3, DI=2**
Non-material	**Learning and inspiration**	**14**	**N=10** **D=3, DI=7**	**N=1** **DI=1**	**N=3** **D=1, DI=2**
	Physical and psychological experiences	**35**	**N=21** **D=2, DI=19**	**N=6** **DI=6**	**N=8** **D=1, DI=7**
	Supporting identities	**35**	**N=23** **D=5, DI=18**	**N=5** **D=1, DI=4**	**N=7** **DI=7**
	Food & Feed	**18**	**N=16** **D=3, DI=13**	**N=1** **D=1**	**N=1** **DI=1**
	Medicinal, biochemical, and genetic resources	**7**	**N=5** **DI=5**	**N=0**	**N=2** **DI=2**

Table 2.- Number and nature of the NCP impacted through policies in the Mediterranean basin as reported by expert informants

Note: D= Directly affected by policies, ID= Indirectly affected by policies.

Food & Feed was impacted by all policies related to the creation of food for human consumption or feed for animal consumption. Food production policies found included the creation of olive plantations in Tunisia, milk processing policies found in Greece or cheese production in Italy. *Habitat creation and maintenance* was typically impacted by three different types of policies: i) the use, modification or maintenance of forests or pasture – as seen in Tunisia through its rangeland management strategy and in Turkey with its sustainable forest management policy; ii) Policies that were designed for the protection or restoration of the environment, as seen when case studies indicated the importance of Natura 2000 discussed in both the Greek and Italian case studies; iii) The creation of national parks and reserves, as found in Spain, Turkey, Tunisia and Italy. *Physical and psychological experiences* and *Supporting identity* were impacted through policies that encourage close contact with nature, such as the creation of natural parks or sustainable forestry practices across the Mediterranean basin. Reinforcing pastoral identity was impacted through strategies valuing their identities and actions, such as policies affecting generational renewal, policies giving recognition to breeder's groups as seen in Turkey, or policies promoting regional foods through the use of geographical indications such as Protected Designation of Origin (PDO) or Protected Geographical Indication (PGI) that link food with a specific regional identity (Table 3).

The impacted NCP were then divided into NCP that were directly impacted by policies and NCP that were indirectly impacted by policies (Fig. 2). When examining NCP directly impacted by policies (Table 4, 5, 6; Fig. 2A), we found that Non-material NCP were present when considering only 4 out of 13 policy domains: i) Environmental protection (4% of environmental protection policies); ii) Rural development (22% of rural development policies; iii) Food policies (11% of all food policies)*;* and iv) Tourism policies (43% of all tourism policies).

LOCATION	POLICY	POLICY DOMAIN	SUB-DOMAIN	DIRECTLY IMPACTED NCP	INDIRECTLY IMPACTED NCP	JUSTIFICATION OF IMPACT
ALGERIA	Ramsar convention of humid zones protection (1984)	Environmental protection	Environmental protection	Habitat maintenance	Food creation	Protection of wetlands is the goal of the policy, although food crops are occasionally planted by locals.
TURKEY	Creation of the Köprülü Canyon National Park in 1973 by the Turkish Government.	National Park	Creation	Habitat maintenance/creation	Physiological experiences	National Park was created as a means of habitat protection, which can lead to the enjoyment of nature.
SPAIN	Protected Geographical Indication (PGI) Vedella dels Pirineus Catalans.	Food	Intangible elements of food	Supporting identities and production of food	NA	Through the PGI label food is produced and valued due to its cultural significance.
ITALY	Diversification of agricultural activities for services related to	Rural development	Local development	NA	Learn and inspiration	The policy promotes the implementation of projects allowing people to learn and be inspired by the work of pastoralists and nature

	vulnerable and disadvantaged groups					
TUNISIA	Tree plantations	Forestry	Forest creation	Formation and protection of soil	Food and Feed production	The policies' primary purpose is to slow desertification but due to the plantation of a mixture of trees, locals can use the new plantations as a source of food and feed.
GREECE	Measures for the protection of local breeds and genetic diversity	Livestock	Genetic diversity	Genetic diversity	Cultural identity	Through the promotions of breeds better suited to transhumance, the policies help to ensure the cultural identity of pastoralists continues

Table 3. Illustrative examples of interactions between policies and NCP provided by Mediterranean pastoral systems.

Tourism was the only policy domain where non-material NCP were the most represented NCP group. Non-material NCP were not present in the other 9 policy domains. The non-material NCP directly impacted by pastoral policies were *Learning and Inspiration*, *Supporting identities, Physical and psychological experiences, Food and Feed* (Table 4).

NCP subcategory	Policy domains	Policy examples
Learning and Inspiration	Environmental protection	Hunting policies that protect specific wild animals, through the training of hunters and hunting organisations in wildlife management in Turkey
	Food	PDO certification policies in the EU and Algeria
Supporting identities,	Rural Development	Policies regarding the investment in cultural and natural heritage in rural areas in Italy
	Food	PDO certification policies in the EU and Algeria
Physical and psychological	Tourism	Policies designed to support and encourage tourism in pastoral areas in Turkey
Food and Feed	Food	PDO certification policies in the EU and Algeria

Table 4. Examples of policies directly impacting Non-material NCP in the Mediterranean.

Regulating NCP impacted directly by policies (Table 5) were found in every policy domain: Water (100%, all water policies haves direct impact on regulating NCP), Natural Parks (80% of all Natural Parks policies), Extreme Events (78%), Forestry (67%), Control/Introduction of organisms (60%); Rangeland (57%), Environmental protection (54%). Other policies (50%). Livestock (45%); Farm investment (40%), Rural development (35%), Tourism (29%),and Food (20%) policies. The regulating NCP impacted by pastoral policies were *Habitat maintenance and creation, Regulation of extreme events, Genetic resources, Formation and protection of soils, Water quantity and location, and Regulation of detrimental organisms*.

NCP subcategory	Policy domains	Policy Examples
Habitat maintenance and creation	Forestry	Creation of plantations (Sub-domain Forestry creation) in Tunisia
	Rangelands	National grazing legislation (Sub-domain, Access to rangeland) in Greece
	Environmental protection	National legislation on the protection of the environment (Sub-domain, Environment) in Turkey
	Natural Parks	Creation of national parks and reserves (Sub-domain, Creation) in Tunisia, Turkey, Spain and Italy
Regulation of extreme events	Extreme Events	Sustainable Forest management from LEADER funds used to help prevent wildfires in Spain
	Other	Maintenance of drove roads helping to reduce biomass
Genetic resources	Livestock	Subsidies for local breeds (Sub-domain, Genetic diversity) in pillar two of the CAP favour pasture preservation
Formation and protection of soils	Food	Production of olive crops (Sub-domain, Production) in North Africa
	Farm investment	The creation of environmental infrastructure
Water quantity and location	Water	Creation of water points in Italy
	Rural Development	Investment in irrigation infrastructure (Sub-domain, Infrastructure) in Italy
	Forestry	The creation of forests to control the flow of water in North Africa.
Regulation of detrimental organisms	Control/Introduction of organisms	Control of wild boar (Sub-domain, population control) in Italy. EU livestock sanitation rules (Sub-domain, disease) in Spain
	Tourism	Hunting as a form of tourism.

Table 5. Examples of policies directly impacting Regulating NCP.

Directly impacted Material NCP was the dominant NCP in only 4 out of 13 policy domains – Food (69%), Farm investment (60%), Livestock (55%), and Other policies (50%) (Table 6). For all other policy domains, Material NCP represents between 43%, as found in the Rangeland policy domain, to 20%, as found in the Natural parks policy domain. The material NCP directly impacted by pastoral policies were Genetic *resources, Food and Feed,* and *Materials, companionship and labour* (Table 6).

NCP subcategory	Policy domains	Examples
Genetic resources	Livestock	Turkish policies on the protection of local breeds (Sub-domain, Genetic diversity).
	Rural development	Dissemination of information regarding the continued use of local breeds with subsidies (Sub-domain, Local development) in Turkey
	Environmental protection	Prohibiting the hunting of newly introduced wild animals (Sub-domain, Protection) in Tunisia.
	Extreme events	Controlling biomass through the use of traditional livestock breeds in Spain
Food and Feed	Farm investments	Policies that allow pastoralists to invest in food production equipment.
	Food	Organic production policies through the CAP in Italy (Sub-domain, Organic)
	Rangeland policy	Turkish state grazing policy (Sub-domain, Access).
	Rural development	Diversification strategies (Sub-domain, Diversification) in Greece
	Tourism	Promotion of food tourism in Italy
Materials, companionship, and labour	Forestry	Sustainable forest management (Sub-domain, Creation) in Turkey
	Natural parks	Initiative for the economic and social development of the park

Table 6. Examples of policies directly impacting Material NCP.

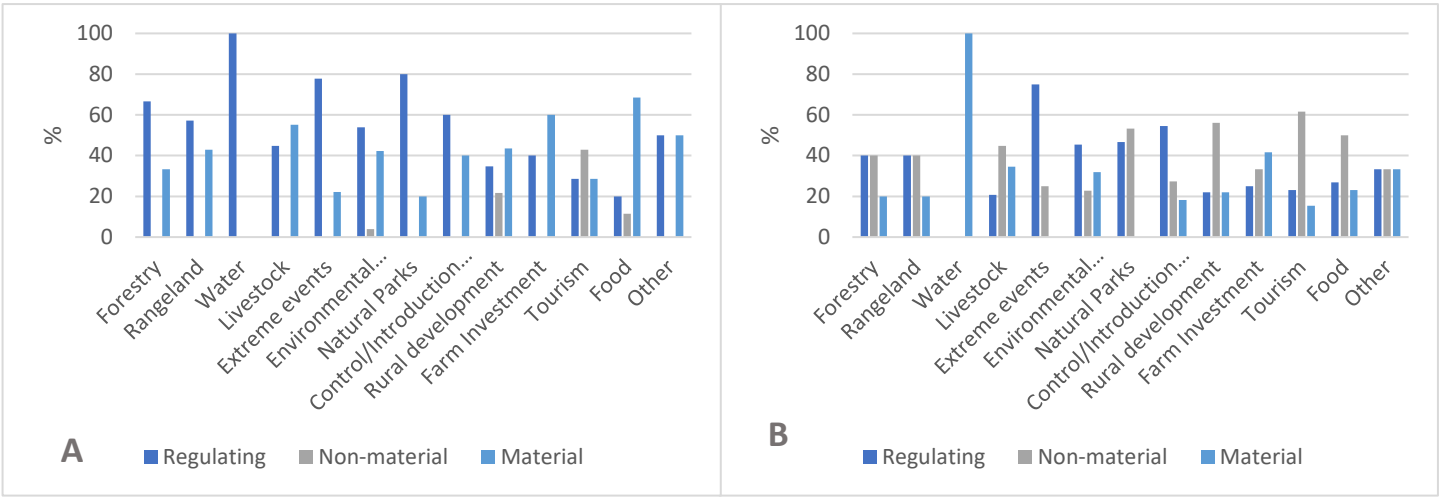

Fig. 2 Proportion of policies of different domains directly (A) and indirectly (B) impacting NCP.

Regarding the indirect impact of policy domains on NCP (Fig. 2b), we noted differences in distribution across all NCP groups (Table 7). Non-material NCP were present in 12/13 policy domains, with only Water not impacting indirectly non-material NCP: Tourism (62%), Rural development (56%), Natural parks (53%), Food (50%), Livestock (45%), Forest (40%), Rangeland (40%), Other policies (33%), Farm investment policies (33%), Control/Introduction of organisms (27%); Extreme event policies (25%) and Environmental protection (23%). The non-material indirectly impacted by policies were: *Learning and inspiration, Supporting identities, Physical and psychological experiences, and Food and Feed.*

NCP subcategory	Policy domains	Examples
Learning and Inspiration	Tourism	Through policies that encourage social and educational farms in Italy
	Natural parks	The creation of natural parks in Spain
	Environmental protection	Protecting the environment (Sub-domain, Protection) from desertification in Turkey
Supporting identities,	Rural development	Ensuring generational renewal (Sub-domain, Local development) in Italy
	Food	Ability to sell local products directly to customers (Sub-domain, Production) as seen with raw cow milk in Spain
	Livestock	Protection of local breeds associations (Sub-domain, Genetic diversity) in Turkey
	Rangelands	Through the continuation of traditional access rights to pasture in Turkey
	Farm investment policies	Helping to ensure generation renewal through access to funding
	Extreme events	CAP pillar two in Spain contributes to supporting local identities
Physical and psychological	Natural parks	The creation of natural parks in Spain
	Forestry	National forestry program (Sub-domain, Creation) in Turkey
	Other	Protection of drove roads in Spain
	Control/Introduction of organisms	Hunting as a form of recreation that encourages ties with nature in Italy
Food and Feed	Food	Organic production across the EU gives added value to the food

Table 7. Examples of policies indirectly impacting Non-material NCP.

Regulating NCP were the least represented NCP in two policy domains (Table 8): Livestock (21%), and Food policies (27%). For the remaining policy domains, Regulating NCP were impacted by 47% of Natural Parks, 22% of Rural development, 25% of Farm investment, and

23% of Tourism. The regulating NCP indirectly impacted by policies were: Regulation of climate; Regulation of freshwater quality, location and timing; Regulation of *detrimental organisms and biological processes*.

NCP subcategory	Policy domains	Examples
Regulation of climate	Natural Parks	The creation of natural parks and reserves (Sub-domain, Creation) across the Mediterranean
	Rural development	Turkey's application to the EU agriculture and development program requires that it complies with EU environmental standards (Sub-domain, Infrastructure)
	Farm investments	Investments in non-productive environmental assets in Italy.
Regulation of freshwater quantity, location and timing	Food policies	Reforestation policies (Sub-domain, production) in Algeria.
Regulation of detrimental organisms and biological processes	Livestock	Animal health (Sub-domain, Animal welfare) policies in Algeria
	Tourism	Hunting of pest species in Turkey

Table 8. Examples of policies indirectly impacting Regulating NCP.

Material NCP were not indirectly impacted by Extreme events policies while all Water policies only indirectly impacted NCP. Other policies indirectly impacting material NCP were: Farm investment (42%), Livestock (34%), Environmental protection (32%), Food (23%), Rural development (22%), Forestry (20%), Rangeland (20%), Control/Introduction of organisms (18%) and Tourism policies (15%). The material NCP indirectly impacted by policies were (Table 9): Energy; Food and Feed; Materials, companionship, and labour; Medicinal, biochemical and genetic resources.

NCP subcategory	Policy domains	Examples
Energy	Farm investments	Funding for non-agricultural activities in Italy
	Environmental protection	Stopping desertification through the planting of trees which can then be used as firewood in Turkey.
	Tourism	Diversification funding in Italy encourages the development of renewable energies
Food and Feed	Water	National steppe renewal policies in Algeria encourage the creation of water points which incidentally increases the amount of feed for livestock but also encourages the production of food crops
	Livestock	Livestock traceability and welfare policies as found across the EU
	Food	Animal welfare policies in Algeria
	Forestry	Encouraging the creation of feed and food crops in North Africa
	Rangeland	
	Control/Introduction of organisms	Food traceability policies in Italy that are designed to control disease in livestock which affects food production and food quality
Material, companionship, and labour	Environmental protection	Stopping desertification through the planting of trees which can then be used as a source of materials in Turkey.
Medicinal, biochemical, and genetic resources	Rural development	Knowledge transfer policies in Italy help maintain *Medicinal, biochemical, and genetic resources* through the establishment of better practices.

Table 9. Examples of policies indirectly impacting Material NCP

The impact of domains was then examined to determine which NCP were directly and indirectly impacted by policies (Table 10). It was found that regulating NCP such as *Habitat maintenance and creation* or the *Regulation of detrimental organisms or extreme events* and

material NCP, such as *Food and Feed* or *Medicinal, biochemical and genetic resources,* were commonly found to be directly impacted across policy domains. An interesting result arose when the regulating NCP *Regulation of climate* was seen to be commonly indirectly impacted by a number of policy domains such as Forestry, Rural development, Rangelands, and Natural parks. Equally, while the majority of non-material NCP were consistently indirectly impacted across all policy domains. In the policy domain Food, we found that *Supporting identities* was directly impacted due to the presence of PDG and PGI certification programs.

Policy domain	NCP Category	NCP subcategory directly impacted	NCP subcategory indirectly impacted
Forestry	Regulating	-Habitat maintenance and creation -Formation and protection of soil -Regulation of climate -Energy	NA
	Material	-Food and Feed -Energy -Materials, companionship, and labour	-Food and Feed
	Non-material	NA	-Supporting identities
Rangeland	Regulating	-Habitat maintenance and creation -Formation and protection of soils -Regulation of extreme events	-Regulation of climate -Habitat maintenance and creation
	Material	-Food and Feed	-Food and Feed
	Non-material	NA	-Supporting identities -Physical and psychological experiences
Water	Regulating	-Formation and protection of soils -Regulation of freshwater quantity location and timing -Regulation of freshwater and coastal water quality	NA
Livestock	Regulating	-Habitat maintenance and creation -Regulation of detrimental organisms and biological processes	NA
	Material	--Medicinal, biochemical, genetic resources	NA
	Non-material	NA	-Supporting identities -Medicinal, biochemical, and genetic resources
Extreme events	Regulating	-Habitat maintenance and creation -Regulation of extreme events	NA
	Material	NA	-Food and Feed
	Non-material	NA	-Supporting identities
Environmental protection	Regulating	-Habitat maintenance and creation -Regulation of climate	-Habitat maintenance and creation -Regulation of climate
	Material	-Food and Feed -Medicinal, biochemical, and genetic resources	-Food and Feed -Materials, Companionship, and labour -Energy
	Non-material	NA	-Supporting identities -Physical and psychological experiences -Learning and inspiration
Natural Parks	Regulating	-Habitat maintenance and creation	-Regulation of climate
	Material	NA	NA
	Non-material	NA	-Physical and psychological experiences -Learning and inspiration
Control/ Introduction of Organisms	Regulating	-Regulation of detrimental organisms and biological processes -Food and Feed	-Habitat maintenance and creation -Physical and psychological experiences

	Material	-Medicinal, biochemical and genetic resources	-Food and Feed
	Non-material	NA	NA
Rural development	Regulating	-Habitat maintenance and creation	-Habitat maintenance and creation -Regulation of detrimental organisms and biological processes -Regulation of climate
	Material	-Food and Feed -Medicinal, biochemical, and genetic resources	-Food and Feed
	Non-material	NA	-Supporting identities -Physical and psychological experiences -Medicinal, biochemical, and genetic resources
Farm Investment	Regulating	NA	NA
	Material	-Food and Feed -Materials, Companionship, and labour	-Food and Feed -Energy
	Non-material	NA	-Supporting identities -Food and Feed
Tourism	Regulating	-Regulation of detrimental organisms and biological processes directly impacted	NA
	Material	-Food and Feed	NA
	Non-material	NA	-Supporting identities -Physical and psychological experiences -Food and Feed
Food	Regulating	-Habitat maintenance and creation	NA
	Material	-Food and Feed -Materials, Companionship, and labour	NA
	Non-material	-Food and Feed -Supporting identities	-Food and Feed
Other	Regulating	-Habitat maintenance and creation -Regulation of detrimental organisms and biological processes	-Habitat maintenance and creation -Regulation of climate
	Material	NA	-Food and Feed
	Non-material	NA	-Physical and psychological experiences

Table 10. Examples of policy domains impacting the NCP provided by Mediterranean pastoral systems, directly and indirectly. Note: R: regulating; M: material; NM: non-material; NA: Not applicable.

2. Policy domains and impacted NCP analysed by geographical region in the Mediterranean

The geographic location of policies was also found to be important in influencing pastoral systems in the Mediterranean. This highlights the importance of political context when considering pastoral systems and how this, in turn, can impact the creation and maintenance of NCP created by pastoral systems. This analysis revealed that the policies domains impacting

pastoral systems were not evenly spread throughout the Mediterranean with EU countries having the largest percentage of all policy types (Fig. 3). The EU region was the only region that contained all of the different policy domains identified and accounted for at least 40% of policies, for all policy domains: Water (67%), e.g. the creation and maintenance of watering points; Livestock (79%), with an emphasis on animal welfare policies and providing subsidies to use traditional breeds; Control/Introduction of organisms (80%), like the reintroduction of large carnivores such as bears in Spain and the control of best species such as boar in Italy; Rural development (77%), with the CAP rural development program having many policies for local development and generational renewal; Farm investment (88%), to allow pastoralist to purchase infrastructure and materials; Tourism (78%), with policies designed to encourage rural tourism through diversification; Food (69%) through policies that ensure food quality standards, such as food traceability policies, organic certification and PDO standards; Natural parks/reserves (58%) through the creation and maintenance of natural parks and infrastructure; Extreme events (57%), such as the reduction of biomass to prevent fires; Rangelands (56%), through policies that ensure access rights to traditional users as found in Italy and protects pastures; Other (100%), like the protection of drove roads in Spain; and Forests (40%), through policies that determine access rights into the forest and forest improvement/protection schemes.

North Africa did not have any policies from the domains Tourism, Farm investments, Extreme events, Livestock and Others which were identified by the expert informants as affecting pastoralism. North Africa accounted for 27% of Forestry policies, like the creation of tree plantations to stop desertification and policies concerning prohibiting access to forests for grazing; 10% of Control/Introduction of organism policies, like the reintroduction of wild harbours such as gazelles; 6% of Rural development policies, like national rural development policies that encourage decentralisation, and increasing rural infrastructure; and 17% of Food policies, like crop production policies such as cereals and olives. Eastern Mediterranean (represented by Turkey) had policies in all groups except for Water and Other. Turkey contained 33% of all Forestry policies described, like the creation and development of forests and the control of grazing in forests ; 19% of Rangeland policies, such as policies designed to control traditional access rights to rangeland and determining pasture boundaries; 21% of the livestock policies, with policies focusing on animal welfare and supporting the use of local

breeds; 43% of the Extreme event policies, with policies designed to manage and control wildfire through the reduction of biomass; 23% of the Environmental protection policies, such as the Kyoto protocol and the UN convention combatting desertification; 25% of the Natural Park policies, like the creation and development of national parks; 10% of the Control/Introduction of organisms policies, like policies focusing on reducing goat numbers; 16% of the Rural development policies, such as the development of markets and the dissemination of training for rural communities; 13% of the Farm investment policies, through e.g. funding that allows pastoralists to purchase physical assets; 22% of the Tourism policies, like the development of rural tourism markets; and 14% of the Food policies, such as Organic certification standards and ensuring food safety standards.

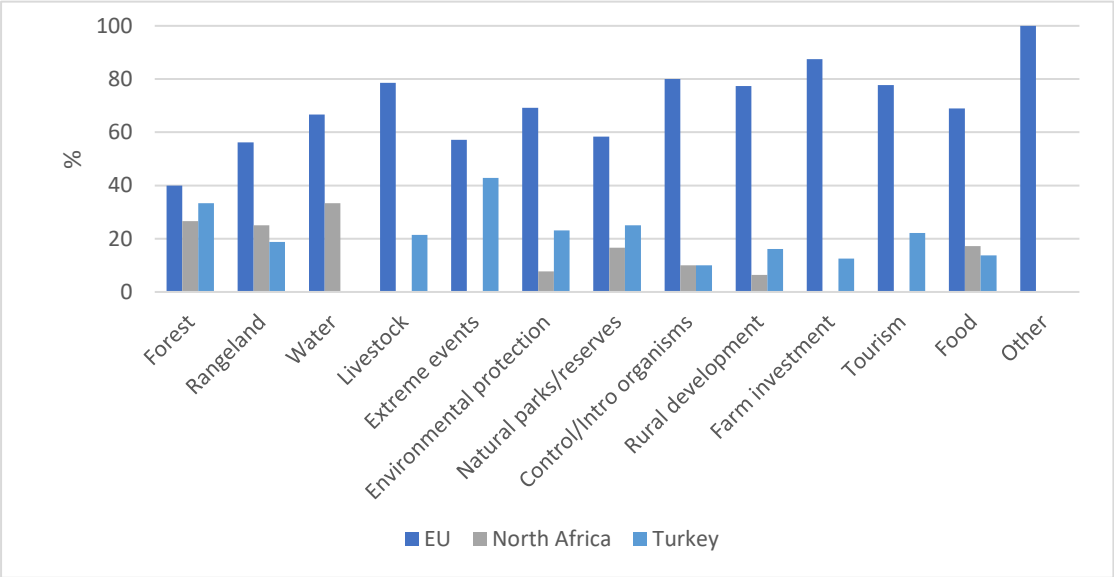

Fig. 3 Geographical distribution of the main groups of policies impacting on the NCP granted by Mediterranean pastoralism policy groups between Mediterranean regions in percentages**.**

Regarding the direct and indirect impact of policies on NCP by geographic region, a similar pattern was found throughout the Mediterranean, with regulating and material NCP being more commonly directly impacted and non-material NCP being indirectly impacted by policies (Fig. 4). In the EU, 65% of Regulating NCP were directly impacted, mainly through the creation and maintenance of protected areas, and 35% of Regulating NCP were indirectly impacted by policies. A total of 56% of Material NCP were directly impacted by policies and 44% indirectly. For Non-material NCP, only 17% were directly impacted by policies – by PDO and PGI recognition and investments to preserve local heritage, while 83% were indirectly impacted

by policies, e.g. through the creation of natural parks and reserves which allow for a closer connection to nature, or through rural development policies included in the CAP to help ensure generational renewal and support identities and the support of local cultural institutions to support local customs such as hunting.

In North Africa, 63% of Regulating NCP were directly impacted – through rangeland creation and maintenance policies compared to 37% that were indirectly impacted by policies. Material NCP showed a similar pattern with 60% directly impacted and 40% indirectly impacted by policies. Regarding Non-material NCP, 15% was impacted directly by policies compared to 85% indirectly, mainly by rural development programs that help to support cultural identities and the creation of natural areas which increase the opportunity to connect with nature. In Turkey (Eastern Mediterranean). Regulating NCP were directly impacted by 59% of policies compared to 41% indirectly impacted. 71% of Material NCP were directly affected compared to 29% indirectly affected and only 10% of Non-material in Turkey are directly impacted by policies, and 90% being indirectly impacted, mainly by forest management policies that help support rural identities and the creation and maintenance of protected areas, that increase the opportunities to connect with nature. Thus, we find a common pattern of distribution with direct impacts of policies primarily affecting Regulating and Material NCP while rarely affecting non-material NCP. Indirect impacts of policies on the

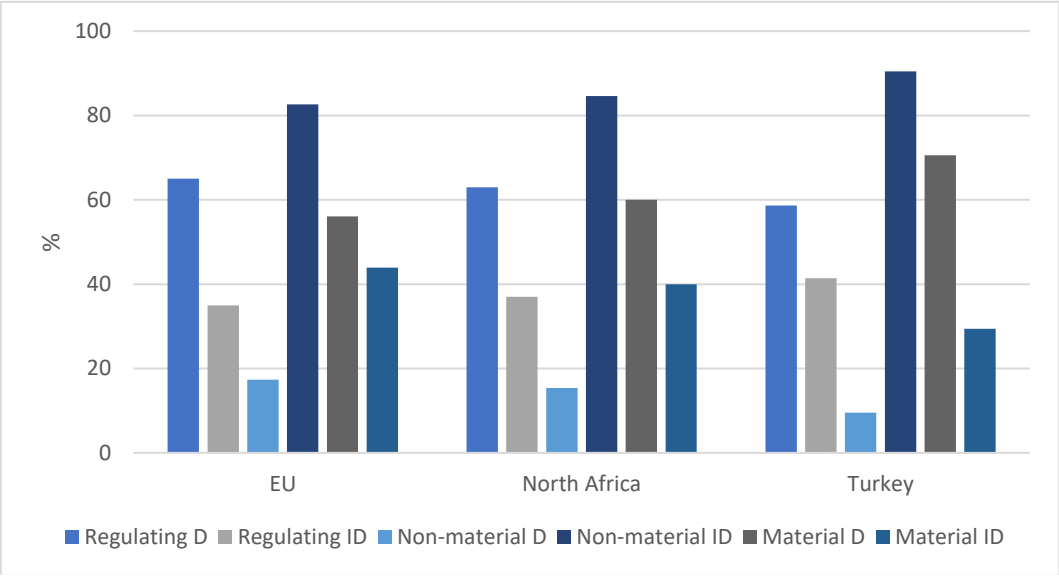

Fig. 4 Geographical distribution of Direct and Indirectly impacted NCP from policies

Note: 'D' means direct impact, and 'ID' means indirect impact.

other hand show only a minor effect on both Regulating and Material NCP, but a profound effect on non-material NCP in each of the Mediterranean regions studied.

3. Key governance level of the policies affecting pastoral systems across the Mediterranean by region

Pastoral systems in each Mediterranean country are affected by a unique and diverse combination of policies mainly led at different governance levels. We found that according to the key governance level in the development of policies the impacts of the policies on the capacity of Mediterranean pastoralism of providing NCP was diverse. At the international level, we find the European Common Agricultural Policy (CAP) (Commission, 2020) or the UN desertification policy (UNCCD), both of which outline a set of practices and desired goals for all member states that prescribe to the policies. At the national level, as in the case of the Turkish constitution that affects pastoral systems through national legislation. At the regional level, as seen in Spain through the creation of national parks by regional governments; or at the local level, such as the regulation of water use in Italy. Here the policies affecting pastoral systems were categorised via their key governance levels. The key governance levels of policies are important for establishing at what levels policies both originate and are influenced by. This allowed for the identification of unique distributions of key governance levels in each geographic region (Fig. 5). Internationally led policies were found to be the most evenly represented form of policy governance 29% of EU policies, 26% in North Africa and 14% in Turkey. For the EU, examples of these policies included environmental protection policies such as Natura 2000, or Habitats directive policies across the EU; Internationally led policies regarding the domination of origin of foods as seen in Italy and Spain as well as policies from the CAP being found through the entire EU. In North African policies regarding the protection of local Bouhezza cheese through Geographic Indication policies were identified, as were policies regarding the protection of natural parks and reserves -Law No. 11-02 of 17/02/2011 on the Protection of Protected Areas, Natural Parks and Nature Reserves, in Turkey some examples include the UN conventions on biodiversity and desertification and international policies on the prevention of extreme events such as forest fires. Nationally led policies were predominant in North Africa representing 74% of all North African policies. They included the creation of the Oued Dekouk natural reserve in Tunisia and the national strategy for sustainable rural development in Algeria. In Turkey, nationally led

policies represented 44% of all Turkish policies, which included policies like the National forestry program, the creation of Köprülü Canyon National Park and the Turkish constitution. Lastly, national led governance represented 25% of EU policies. In Spain, this was highlighted

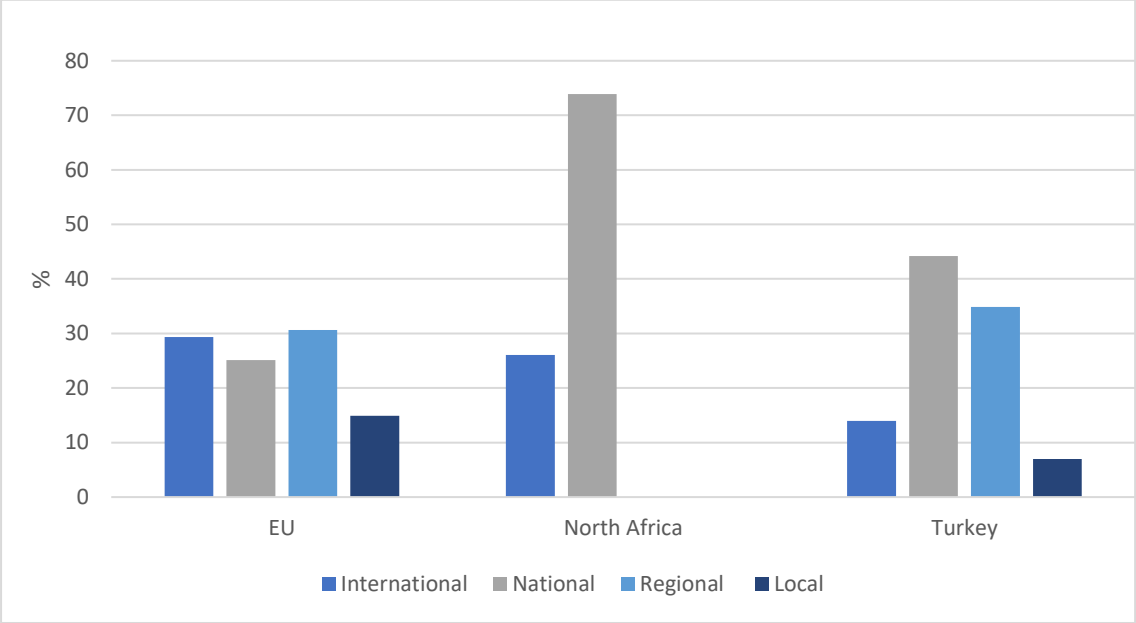

Fig. 5 Distribution of the key governance levels of the policies impacting the capacity of Mediterranean pastoralism of providing NCP.

when examining the protection of traditional cattle routes and the national forest act. While in Greece national policies were directed towards multifunctional farms and food processing. Concerning regionally led governance, Turkey had 35% and the EU 31% of their pastoral policies affected by this level of governance. In Turkey, examples include the provincial breeding programs and the creation of National parks. In the EU regionally led governance was seen to impact policies in the creation of protected areas in Spain with the Alt Pirineu natural park and the Sibillini Mountains national park in Italy, North Africa had no policies affected by regionally led governance. Policies representing locally-led governance were the rarest types of policies found 15% in the EU and 7% in Turkey. In the EU these policies included the creation and management of hunting reserves in Spain and the enforcement of traditional grazing rights in Italy. In Turkey, these policies included policies regulating hunting and the protection of pastoral properties. In North African, no policies were identified that could be considered locally-led.

The correspondence of different key governance levels was examined via policy domains to determine how key governance levels of policies and the nature of the policies affect pastoral systems. The distribution of key governance levels of each of the policy domains were also

analysed to allow for a deeper understanding of how policies impact NCP through different governance levels (Fig. 6). No single governance level was found to be disproportionately represented, although locally-led policies were not the dominant form of governance in any policy domain.

Internationally led policies were the dominant governance level in only two policy domains, specifically Livestock and Environmental protection, these include policies that promote and support the use of local livestock breeds as found in Greece and Italy through the CAP, and policies that impact animal welfare as found in Turkey with its animal welfare policies, and Environmental protection policies such as the conventions on biological diversity and desertification. Food policies, Other policies and Farm investment policies were not dominated by a single form of governance but instead displayed an equal distribution of governance across two or more levels of governance – EU policies on food traceability were identified as being influenced by international, national and regional governance, while PGI policies were influenced by international and regional governance; Farm investment policies through rural development programs were found to be influenced at all governance levels. Locally led governance was found to be the least represented governance level across all policy domains except for Water, (where it matched international and regional governance for representation) Natural Parks – Compensation for damage caused by wildlife in Italian national parks; Tourism – Turkish hunting laws; Other policy domains – reduction in energy consumption by Italian agri-companies (where it was matched by regional governance).

National-led governance was found to be the most represented form of governance in four of the policy domains – Forestry, Rangeland, Water and Other policies. This can be explained by the presence of forestry and rangeland policies reported in Tunisia and Algeria which include Olive tree plantation policies and rangeland management policies. As well as water point creation and protection policies in North Africa and the EU, particularly in Italy and the protection of drove roads in Spain.

Regionally led governance was found to be the predominant governance level in five policy domains: Extreme events - In the form of preventing fires through biomass control as found in Turkey and Spain, Natural parks - Through the creation and maintenance of natural parks and reserves throughout the Mediterranean basin, Control/Introduction of organisms - Through the introduction of large carnivores as seen in Spain, or the control of infectious

disease as seen in Spain and Italy through sanitation regulations and disease eradication programs, Rural development -through EU rural development funding such as mountain payments to keep people from abandoning mountain areas and CAP rural development funding in Italy supporting the creation of producers organisations, and Tourism policies - Hunting as a form of tourism as found in Spain and Turkey, with Italy having policies specifically aimed at promoting and developing tourism in pastoral areas.

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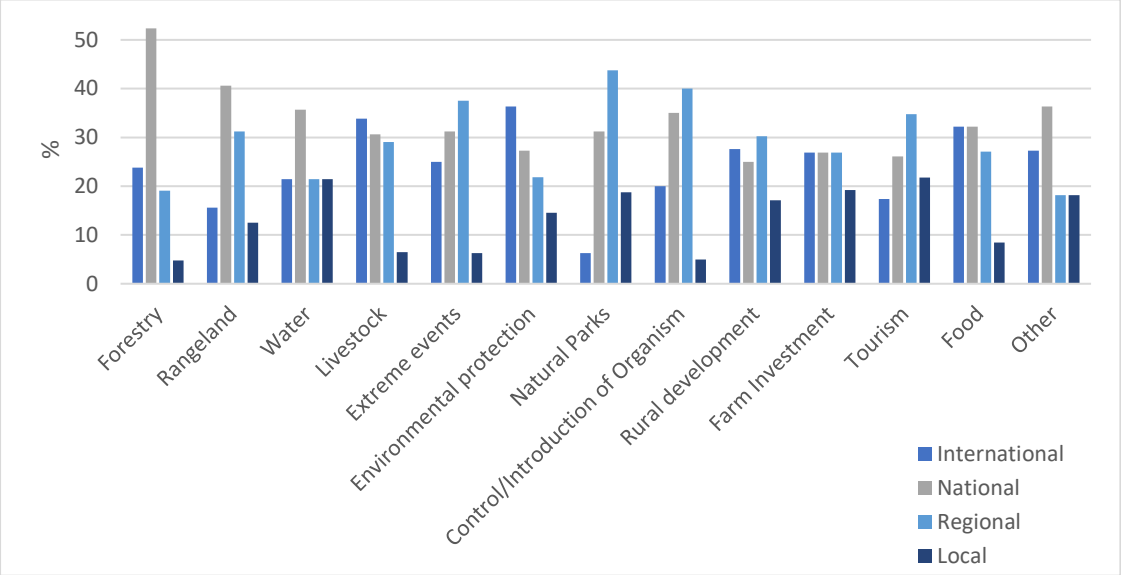

Fig. 6 Distribution of the key governance levels in the making of the policies of different domains impacting the NCP provided by Mediterranean pastoral systems

It was found that key governance levels of policies were an important factor in determining which NCP were impacted and if these NCP were directly or indirectly impacted. Here, the effects, both direct and indirect, on NCP provided by Mediterranean pastoral systems is examined according to the different key governance levels of the policies. Nationally-level led policies was found to be the most common group affecting Regulating NCP across the Mediterranean (37%)., such as the creation of nature reserves/national parks in Tunisia and Turkey or the implementation of Habitat directives in Spain. This was followed by regional-led policies (28%), where the implementation of Habitat directives was found to be influential across the EU. In Tukey, these policies included rules regarding wild forest fire prevention and the development of national parks. Internationally-led policies (22%) through the rangeland management strategies in Tunisia, wildfire management policies in Turkey and CAP regulations in the EU. Locally-led policies (12%), which was always the least represented form

of governance across all NCP groups were represented by policies such as the regulation of hunting reserves in Spain and the management of national parks in Italy. *The Regulating NCP impacted by governances were: Habitat creation and maintenance, Extreme events, Protection of soils'* and *Regulation of detrimental organisms* (Table 11).

NCP subcategory	Governance Level	Examples
Habitat creation and maintenance	Nationally led	The creation of national parks and reservices in Tunisia, Turkey and Italy
	Regionally led	Habitat's directives in the EU and the development of national parks in Turkey
Extreme events	Internationally led	Wildfire management in Tunisia
Protection of soils		CAP regulations in the EU
Regulation of detrimental organisms	Locally led	Hunting reserves and regulations in Spain

Table 11. Examples of governance levels impacting Regulating NCP.

Material NCP were primarily impacted by national-level led policies (30%) (Table 11) as demonstrated in Turkey through its policies regarding food and feed standards and its policies regarding its application of policies regarding EU agricultural and rural development programs affecting its food and feed production. This was followed by internationally-led level governance (29%), which can be demonstrated with policies such as DOI and PGI to increase the recognition of local products in Italy, Spain and Algeria. And in Turkey through the application of UN conventions on biological diversity and desertification. Regionally-led level governance (27%) was seen through the reintroduction of large carnivores in Spain, Milk processing policies in Greece, and the protection of local livestock breeds in Italy. Lastly, locally-led (13%) level governance through the protection of access rights in Spain, Turkey and Italy allowed for the use and creation of animal feed. The Material NCP impacted were: Food and Feed, and Genetic resources (Table 12).

NCP subcategory	Governance Level	Examples
Food and Feed	Nationally led	The compliance to EU food safety standards in Turkey.
	Internationally led	The use of DOI and PGI certification across the Mediterranean.
	Regionally led	Milk processing policies in Greece
	Locally led	Protection of access rights to traditional pastures in Spain, Turkey and Italy
Genetic resources	Internationally led	The UN convention on biological diversity in Turkey
	Regionally led	Reintroduction of brown bears in Spain and the protection of local breeds in Italy.

Table 12. Examples of governance levels impacting Material NCP.

Non-material NCP were most impacted by regional (31%) (Table 13) through the creation of natural parks and reserves across the Mediterranean which increase the possibility of physical and physiological experiences with nature. This makes it the only major NCP group where regionally led governance was more important than nationally or internationally led governance. Regionally led governance was then followed by nationally led governance (29%) and policies which helped support pastoral identities such as Algerian rural development program and policies which increase contact with nature such as natural park policies as found across the Mediterranean., internationally led governance (25%) and policies such as the protection of origin of local products through the PDO and PGI labels. Locally led (16%) governance, as demonstrated in Spain through the regulation of hunting, has cultural implications and provides the opportunity for physical and physiological experiences. Local governance levels were also found in Turkey where local identities were supported by ensuring access to traditional land use. Non-material NCP impacted by governance levels were: *Physical and psychological experiences and Supporting identity.*

NCP subcategory	Governance Level	Policy Examples
Physical and psychological experiences	Regionally led	The creation of natural parks and reserves in Turkey, Italy and Spain
	Locally led	Regulation of hunting in Spain
Supporting identity	Nationally led	Algerian rural development program
	Internationally led	PDO AND PGI certification
	Locally led	Ensuring traditional land use in Turkey

Table 13. Examples of governance levels impacting Non-material NCP.

When the governance of NCP was then analysed by directly and indirectly impacted NCP (Fig. 7a, b), different levels of distributions were found. National-level policies were found to be the most prominent for regulating and material NCP for both direct and indirect policies. Regional policies were, in general, second in relevance after the national one, and the most important governance level for non-material NCP such as *supporting identities* and *physical and psychological experiences.* Regulating NCP that were directly impacted by policies showed a similar distribution pattern to Regulating NCP when not considering the level of impact. They were primarily impacted by National governance (38%) followed by regional governance (28%) with international governance (23%) and local governance (12%) being the least represented. Directly impacted Material NCP were well represented and showed a similar distribution pattern to Material NCP when not considering the level of impact. With International, National (30%) and Regional (28%) governance levels well represented but not local governance (12%). Governance levels for NCP that were indirectly impacted by policies displayed a similar distribution to directly impacted NCP for both Regulating (International governance (21%), National governance (36%), Regional governance (29%) and Local governance (13%) and Material NCP (International governance (28%), National governance (31%), Regional governance (26%) and Local governance (15%). Governance affecting Non-material NCP which is indirectly impacted by policies shows a notable difference when compared to governance affecting Non-material NCP that is directly impacted. National and Regional policies account for 30% each, while international governance accounts for 23% and local policies 16%.

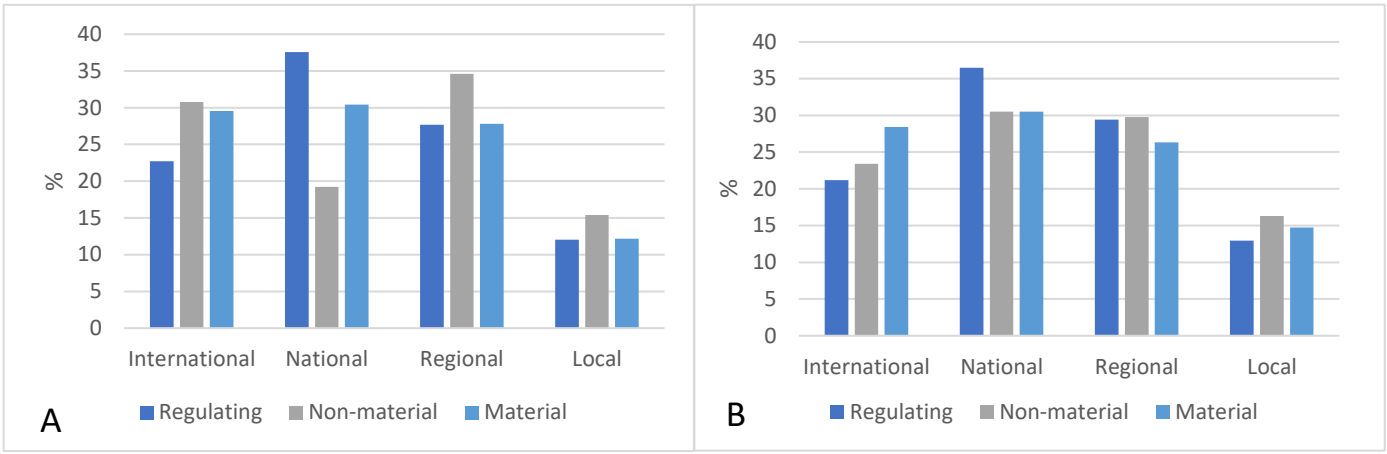

Fig. 7. Distribution of the key governance levels in the making of the policies directly impacting NCP (A), and in those indirectly impacting NCP (B).

Discussion

In this analysis, we first show that pastoral systems in the Mediterranean basin are impacted by a broad array of policies and that these policies affect the capacity of Mediterranean pastoral systems to provide NCP. At least 13 policy domains were identified. After this the impact of police both directly and indirectly on NCP were analysed to determine the importance of different policies on NCP, this resulted in identifying that the impacts on NCP were not homogenous. Material and Regulating NCP show a tendency to be directly impacted by policies whereas non-material NCP are normally indirectly impacted by policies (Fig. 4). Following this, we identified the importance of geographic location for the distribution of different policy domains. Finally, the key governance levels in the making of the policies and the geographic location were also found to be key elements affecting the capacity of pastoral systems of providing NCP both directly (policy design) and indirectly (policy consequence).

Policy domains played an important role in identifying the types of policies that are considered important in Mediterranean pastoral systems and for identifying which types of policies influenced NCP. We found that the distribution of NCP directly and indirectly impacted by policies domains was not homogeneous (Table 10). While the trend across this analysis was that material and regulating NCP are directly impacted while non-material NCP were indirectly impacted, there were some specific NCP that ignored this trend. The regulating NCP *Regulating climate* was the only regulating NCP to be commonly impacted indirectly, this is due to the ability of large-scale environmental regulations such as the creation of natural parks, environmental protection, management of rangelands or rural development policies that encourage the use of renewable energy sources can have on the climate. Highlighting the complex role of policies in regulating climate and addressing climate change, even when policies are not directly designed to do so. Equally, the non-material NCP *Supporting identity* was directly impacted nearly exclusively by the existence of food policies such as PGI certification which directly attach additional worth to food due to both regional identity and traditional knowledge, to traditional projects. That the creation of food is one of the few ways that policies are trying to make a direct location to identity shows the lack of attention that other policy domains pay to local pastoral identity. As it is possible to link pastoral identity through other pastoral practices, their traditional grazing practices could be

acknowledged as important in fire prevention, or their identity could be further acknowledged in traditional landscape management or movement systems.

That Rural development policies dominated the analysis (Table 1) was unexpected as one of the original assumptions of this research was that policies concerning livestock and land access would be the dominant policies encountered. Instead, Rural development policies, particularly local development policies seem to play an important role in the maintenance of pastoral systems by helping to ensure that people continue to live in rural areas and continue to work in pastoral systems. This is done by helping to ensure generational renewal of pastoral practices as found in Greece where the generational renewal policy helps to establish the next generation of pastoralists. Equally in Turkey, they are developing markets for local goods through the nationally led forest program which aims to develop markets for forest goods, creating income diversification and helping to develop the economy of rural areas. This implies that the most important policies for pastoralists are not policies designed to address pastoralism, they are instead designed to help slow rural abandonment or increase opportunities for the diversification of rural incomes. As such, they have an indirect effect on pastoral systems (López-i-Gelats et al., 2015, 2011; O'Rourke et al., 2016). That both Food and Livestock policies were also prominent in the analysis is unsurprising as pastoral systems are primarily food production systems using livestock (El Aich, 2018; Sendyka and Makovicky, 2018; Yilmaz and Wilson, 2012). Although the total lack of animal welfare policies in Tunisia and Algeria was unexpected as it implies that Livestock policies are more important within the EU and Turkey, especially considering the prominence of Food policies in Algeria and Tunisia, although it seems that food production is the primary concern and may be a result of the prominence of nationally led, top-down policies in this part of the Mediterranean. Compared to the EU, where there is a greater variety of key governance levels influencing policies and where food quality and organic certification are important food policies.

Pastoral systems are important food production systems that have a profound effect on landscapes, justifying the emphases placed on regulating and material NCP by policies in this analysis (El Aich, 2018; Mancilla-Leytón et al., 2013; Ocak, 2016; Oteros-Rozas et al., 2013a; Plieninger et al., 2004; Varela et al., 2018). Specifically, the regulating NCP *Habitat creation and maintenance* and the material NCP *Food & Feed* were the most common NCP impacted by policies (Table. 2). The ubiquity of both these NCP across the study highlights the potential

usefulness of pastoral systems to different global issues and the importance of policymakers recognising pastoral systems. Given that between 500 million to 1 billion people globally are considered pastoralists, pastoral systems have an important role to play in global food security, and life on land particularly in arid and semi-arid and mountain areas such as the Mediterranean basin (Niamir-Fuller and Huber-Sannwald, 2020). When this is combined with the importance of the Mediterranean basin as a global biodiversity hotspot (Cuttelod et al., 2008; Myers et al., 2000) and the risk of extreme climate events associated with climate change, especially drought and fire risks (Chergui et al., 2018; Cuttelod et al., 2008; Slimani and Aidoud, 2004; Varela et al., 2018) the focus of policies on regulating and material NCP seems logical.

Our results cement the importance of regulating and material NCP associated with pastoral systems and the importance of pastoral systems to the Mediterranean basin in the eyes of policymakers and the literature. But this analysis also highlights the lack of attention received by non-material NCP in pastoral systems across the Mediterranean basin (Table 2 &10). This lack of attention to non-material NCP in pastoral systems is also reflected in the low representation in the literature of cultural ecosystem services (non-material NCP) in agricultural landscapes, as highlighted by Hanaček and Rodríguez-Labajos, 2018. Non-material NCP are regularly and seemingly systematically impacted indirectly through policy consequence and not through policy design across all case study regions (Fig. 4) and national/regional governance (Fig. 7b). This shows not only a disregard for the intangible elements of pastoral systems but highlights the importance of contextualisation in policy analysis. The importance of the contextualisation of policies can be demonstrated when examining the impact of policy domains on non-material NCP. The Tourism, Natural parks and Rural development domains (Fig. 2b) are the most important policies for supporting non-material NCP, with these policy domains having the potential to support pastoral identity and customs through the diversification of incomes. That said, income diversification can in the long run compete with pastoralism over resources such as land use and manpower as found both in Spain (López-i-Gelats et al., 2011) and mountain regions globally (Schirpke et al., 2020).

The apparent dichotomy of policies focusing on a small subsection of regulating and material NCP (Table 2) and the lack of policies that directly impact non-material NCP (Fig. 2) was

expected. Regrettably focusing on only a small number of regulating and material NCP goes in line with the narrative of pastoral systems devoid of culture and suggests a lack of systems thinking when considering pastoral systems by policymakers. The proportional lack of non-material NCP throughout this analysis suggests that policymakers rarely consider the intangible elements of pastoral systems (Table 2). López-i-Gelats et al. (2016) suggests that policymakers are generally disconnected from pastoral realities and as such, many policies are not well adapted to address many elements of pastoral systems, including the intangible elements associated with them. Manzano et al (2021) highlight that pastoral systems at a global level are rarely considered as complex systems that need holistic management, even by researchers, and are instead generally considered in terms of only a few variables (Manzano et al., 2021), such as biodiversity and food creation as demonstrated in this analysis.

Tunisia and Algeria had the highest percentage of policies that impacted on regulating NCP particularly *Habitat maintenance and creation.* This highlights the priorities of the experts on pastoral systems in these regions. Given the relatively arid climate of the Southern Mediterranean, it was expected that experts on pastoral systems consider policies concerning *Habitat maintenance and creation* to be critical, given that landscape management is a key issue across the Southern Mediterranean (El Aich, 2018; Nefzaoui et al., 2012; Saïdi and Gintzburger, 2013; Tarhouni et al., 2017). What is surprising is that the North African region shows the least amount of complexity when considering either NCP impacted by policies (Table 2) or governance levels impacting policies (Fig 5). The African region has the largest proportion of regulating NCP and lowest purporting of non-material NCP of any Mediterranean region (Table 2). When this is considered in combination with the policies of the African region impacting only 13 of the 16 NCP identified in this analysis (Table 2) and the lack of regional or local governance, it implies a potentially simplistic view of pastoral systems by policymakers in this part of the Mediterranean.

In every region of the Mediterranean basin, the majority of regulating and material NCP were directly impacted by policies (Fig. 4, Table 10) and national led policies (Fig. 7a). Highlighting a tendency for top-down governance levels of policies when considering regulating and material services. Top-down governance is revealed to be a prominent feature of policies impacting pastoral systems in the Mediterranean, as more than 50% of all policy domains

were found to be impacted primarily by nationally or internationally led governance (Fig. 6). The distribution of different policies at different governance levels can be assumed to reflect the political complexity facing pastoral systems, as one of the key challenges facing all socio-ecological systems is the need to properly align governance mechanisms and problem scales (Young et al., 2006). This analysis has revealed that Rural development policies as the most prominently seen policy domain (Table 1) are subject to regionally led governance which allows the policies to be shaped to better to regional contexts. Food and Livestock policies, on the other hand, show a domain trend of top-down policies as they are impacted by internationally and nationally led governance, particularly in the North African Mediterranean. This can be interpreted as top-down policies with little space to shape policy implementation at lower governance levels through adaptive governance which would allow pastoral systems to contextually shape policies (Folke et al., 2005). It is worth noting that locally-led governance is the least or equally the least represented form of governance across all policy domains except for the Natural parks policy domain. Highlighting the lack of opportunity for local shaping of policy implementation across the Mediterranean (Fig. 7), which can strongly affect the ability of socioecological systems to quickly adapt to changing realities, especially if different governance levels contradict local governance systems (Folke et al., 2005)

In addition, many national policies have a history of aiming to change pastoral systems in a way that undermines pastoral livelihoods, this is made evident when pastoralists are forced to become sedentary due to government policies (Bonfoh et al., 2016; Dong et al., 2011). The European Union is unique in all of the Mediterranean basin because of the existence of a diversity of international policies which affect agricultural practices and food production, such as Natura 2000 (Commission, n.d.), and the Common Agricultural Policy (CAP) which is a broad spanning policy that affects many aspects of agricultural and pastoral systems (Commission, 2020; Kerven and Behnke, 2011; Lakner et al., 2021). The existence of these EU wide policies (which in many cases are linked to subsidies (Commission, 2019; Kerven and Behnke, 2011; Lakner et al., 2021; Ripoll-Bosch et al., 2013)) is the primary explanation as to why experts in the EU region identified more international policies as impacting pastoral systems than any other Mediterranean region (Fig. 5). Turkey stands out in this analysis due to the relative lack of both local and international policies found during the analysis compared to other

Mediterranean regions and the emphasis placed on regional and national policies. Turkey has a large rural community with some studies suggesting that up to one-third of the population depends on the agricultural sector and yet the economic, environmental, and social aspects of traditional agriculture are regularly ignored (Yilmaz and Wilson, 2012). Perhaps the dominance of national policies and its lack of international policy is due to Turkey's noted protectionism of its agricultural industry (OECD, 2011). Although the lack of regional or local policies as found in Algeria, Tunisia and Turkey in this analysis (Fig. 5) can represent the prominence of top-down governance in different regions with national and international policies having more potential to not specifically be designed for pastoral systems. This then has the potential to marginalise pastoral systems as national and international policies have a history of marginalising pastoral systems in favour of neoliberal policies (Postigo, 2021). Either intentionally, as found in East Africa, where pastoral customs are continuously ignored by national policymakers because they consider pastoral land management systems as "outdated" (Schareika et al., 2016), or unintentionally where pastoral systems can face benign neglect by policies due to pastoral systems being undervalued and unrecognised through lack of knowledge by policymakers (Johnsen et al., 2019; López-i-Gelats et al., 2016). This can happen if open communication between administrations and institutions fail to ensure the desired impact of policies, a risk which was sighted by Frija et al., (2019) in Tunisia when preparing tools and approaches for the assessment of rangeland governance in Tunisia. Or if legislators ignore the traditional ecological knowledge of pastoralists, a theme that has been discussed for decades in the North Africa area of the Mediterranean (Baduel, 1982). It also continues to feed the narrative of pastoral systems in other parts of Africa where pastoral systems face social and political exclusion due to negative political perceptions (Bonfoh et al., 2016).

CONCLUSION

Policymaking is having a profound effect on Mediterranean pastoral systems. This analysis has demonstrated that Mediterranean pastoral systems are impacted directly and indirectly by a large variety of policies from many different spheres. They are impacted directly through policy design and indirectly through policy consequences. These policies in turn affect the ability of pastoral systems to produce tangible and intangible contributions which here we propose to be understood as NCP. The capacity of the pastoral systems of providing these NCP, we show, was profoundly influenced by several factors, particularly: policy domains, geographic region and leading governance levels of the policies examined.

The approach employed in this analysis has revealed the existence of a dichotomy among the policies affecting pastoral systems, that is the lack of policies directly addressing non-material NCP, and the abundance of policies directly impacting regulating and material NCP, specifically *Food & Feed* and *Habitat creation and maintenance* and the influence of top-down governance on these policies. The prominence of *Food & Feed* and *Habitat creation and maintenance* being impacted by policies across the Mediterranean basin underscores the narrative of pastoral systems as vital for food security and landscape management areas across the Mediterranean basin, particularly in mountain and marginal areas. That the policies analysed in this study impact a small subsection of material and regulating NCP suggests that pastoral systems in the Mediterranean are mostly considered in simplified terms with little appreciation for their social, economic or environmental complexity. If the Mediterranean basin is to continue hosting pastoral systems and benefiting from their many social, economic, and environmental contributions, then the role of pastoral systems needs to be further acknowledged by policymakers and society.

That many of the policies that were considered important for pastoral systems were not policies directly designed to affect pastoral systems but were instead designed to slow rural abandonment and increase opportunities for the diversification of incomes in rural areas highlights a key challenge for policymakers. Thus, we need to accept the multidimensional consequences of policies and their effect on pastoral systems. This would allow for a greater acceptance of the complexity of pastoral systems which increases the opportunities to create appropriate policies to support the current and future generations of pastoralists.

Policies affecting pastoral systems in the Mediterranean basin have shown that policymakers do not consider pastoral systems through the socio-ecological lens and instead show a disturbing trend of ignoring the complexity of pastoral systems. If this ignorance of pastoral systems is the result of benign neglect or through antiquated conceptions of pastoral systems, is a topic for future research, but the result of ignoring complexity is the danger of simplification of complex systems to fit a political narrative. Pastoral systems are socio-ecological systems where the human-nature relationship is artificially separated for analytical purposes and should be more prominently placed in the wider debate about the human-nature relationship. In this study, the lack of holistic thinking by policymakers can be seen when discussing the lack of policies directly addressing non-material NCP, which are unquestionably important, and yet for the majority of policies analysed in this study are not directly considered. For future research, a study analysing the impact of non-material NCP on biodiversity and food security should be undertaken.

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Chapter 6: Discussion and Conclusions

Acknowledging that pastoral systems are complex socio-ecological systems with strong and multiple human-nature interactions, this thesis had the general objectives of, first, to provide more evidence that pastoral systems are in fact complex socioecological systems and, second, to determine if their complexity is currently acknowledged by policymakers and researchers of pastoral systems. In doing so, this work has addressed several specific research objectives:

- SO1. To examine if the Nature's Contribution to People framework, proposed as a framework to analyse complex systems, is suitable for the analysis of pastoral systems (Chapters 3 and 5).
- SO2. To identify drivers of change in pastoral systems which affect the ability of pastoral systems to provide goods and services (Chapters 3 and 5).
- SO3. To analyse if the pastoral research community employ a complex lens in making sense pastoral systems, particularly the multiscale and multisectoral approaches recommended by the Millennium Ecosystem Assessment. (Chapter 4).
- SO4. To determine if policymakers consider pastoralism through complexity, by examining the main policies impacting pastoral systems in the Mediterranean basin (Chapters 5).

Below, I have organised the discussion to address the two general objectives of the thesis. I will also discuss the limitations of this research, as well potential future research that was not addressed in this work.

Advancing in the recognition of pastoral systems as complex human-nature systems through the implementation of the NCP and ES frameworks (SO1, SO3)

The point of departure of this thesis is that pastoral systems are complex and need to be considered as such. One of the general objectives of this thesis is to provide more evidence in that direction. For that, I have used the NCP framework, as a relatively novel framework proposed by IPBES (Díaz et al., 2018) and the ES framework, which is a well estabilshed framework for the analysis of human-nature systems as a conceptual frameworks capable of embracing the complexity of pastoral systems in the process of understanding them. This

conceptual framework does this by balancing the emphasis between the social and ecological dimensions, as pastoral systems have been traditionally framed using natural sciences data. Here this framework has been applied to make sense of the ES and NCP provided by global and Mediterranean pastoral systems.

I have demonstrated in my work the NCP framework is suitable for the analysis of socioecological systems such as pastoral systems and that pastoral systems are users and producers of NCP (Chapters 3 and 5). This is due to the frameworks ability to embrace multifunctionality as it allows for the recognition of mutual states of being. For instance, in pastoral systems, material services such as food or wool can hold at the same time cultural significance. As such, animal fibres can be considered in terms of their market value, and also hold cultural values, helping to identify a people, as found in Turkey when discussing the black tent people who are named for and identified by their tents made from the fibres of their animals (Ocak, 2016). Equally, mobility systems such as transhumance are a way to ensure adequate pasture for livestock but can also play an important role in cultural identity while providing many other material and non-material contributions (Oteros-Rozas, 2015; Oteros-Rozas et al., 2014).

There is a wide body of work focused on pastoral research, but it was found across this thesis that most researchers analyse pastoral systems in terms of only a few variables, such as habitat maintenance and food production, showing that most researchers do not embrace the complexity of pastoral systems. Even more, some of the NCP associated with pastoral systems, such as *Habitat maintenance* and biodiversity, have been allocated to mountains (Leister et al., 2019). The literature also fails to acknowledge the multidimensional nature of the goods and services provided by pastoral systems, one of the cornerstones of the Nature's Contributions to People framework (Díaz et al., 2018). Additionally, when the literature was analysed using Millenium Ecosystem Assessment (MEA) principles of multiscale and multisectoral analysis (Alcamo, 2003), it was found that the literature was dominated by the use of natural sciences and that scale, both spatial and temporal, were poorly integrated. This demonstrates that despite the ES being the most dominant conceptual framework to make sense of human-nature relationships in policy and environmental science domains when analysing pastoral systems the principles of the MEA were not found to be put into practice

by the majority of researchers. This suggests the existence of a gap between the theory provided by the framework and the practices of users of the framework (Chapter 4).

My analysis also revealed that even if the multiple goods and services provided by pastoral systems are acknowledged, there is a consistent lack of embracing complexity regarding the study of pastoral systems. As chapter 4 revealed that pastoral systems were consistently considered from individual scales and disciplines which failed to capture the complexity of pastoral systems This fact goes against the principles of the socio-ecological framework (Mcginnis and Ostrom, 2014), which requires an acknowledgement of the embedded multidimensional aspects of socioecological systems regarding the users of those landscapes (pastoralists), governance systems (governments or traditional management agencies), resource systems (pastoral landscapes) and resource units (pasture, livestock etc..).

Thus, the literature examined throughout this thesis tended to focus on only a few aspects of pastoral systems, particularly the role of pastoral systems in landscape management and food production, mainly from a natural sciences perspective. This narrow focus disregards many of the other functions of pastoral systems such as their ability to regulate extreme events such as fires (Varela et al., 2018) or their role in establishing cultural identity (Fernández-Giménez, 2015). This focus on natural sciences highlights one of the most pressing elements of current socioecological research, the lack of effective integration of social sciences and natural sciences. While natural sciences will always be an important part of the study of any system which interacts with the natural world, it is examining only one half of the human-nature relationship. Social sciences are essential in understanding the multiple societal and institutional narratives and drivers that affect social systems, including their interactions with the natural world. As such, the integration of social sciences should allow a fuller understanding of how pastoral systems function. This finding supports arguments made by Martínez-Fernández et al. (2021) when they state that while there is an increasing acknowledgement to address complexity in SES, this acknowledgement is not put into practice by many researchers who work with SES. Manzano et al. (2021) also argue that pastoral researchers show a tendency to engage in the simplification of pastoral systems through the analysis of only a few variables.

The influence of policymaking on the capacity of pastoral systems of providing their associated goods and services (SO2, SO4)

To address the second general objective of this thesis, the impact of policies on NCP provided by pastoral systems was addressed. This thesis identified policies as both an important driver of change and that policymakers rarely considered pastoral systems through complexity (Chapters 3 and 5), something that is reenforced by the researchers of pastoral systems. Most policies analysed in this thesis impacted the ability of pastoral systems to create and maintain landscape or their ability to create food and feed demonstrates the simplistic view of pastoral systems by policies makers.

Despite the importance of pastoral systems in addressing global social and environmental challenges, such as food security and biodiversity through the production of nutritious foods for local populations while maintaining semi-natural landscapes rich in biodiversity. Although they face continuous marginalisation from both society and institutions (López-i-Gelats et al., 2016; Morton, 2010). Pastoral systems face many drivers of change as identified by Dean et al. (2021). These drivers of change as shown in chapter 3 are of a diverse nature. Here, policies play a key role as they can impact the response of pastoral systems to all other drivers of change, positively or negatively. In this respect, policies can claim to be a unique driver of change in pastoral systems as they play a dual role, having the potential to increase pastoral vulnerability but also pastoral resilience. If institutions undermine or undervalue the economic, environmental, or cultural importance of pastoral systems through the creation of policies not specifically designed to acknowledge pastoral realities, that ignore the intangible elements of pastoral systems and instead focus on pastoral production, they force pastoral systems to simplify. This simplistic view (Chapter 5), which is supported by the majority of academic research analysed as part of this thesis (Chapter 4), is perilous as it has the potential to inappropriately feed policymakers and thus it indirectly has the potential to increase pastoral vulnerability through the creation of inappropriate policies based on preconceived ideas of pastoral systems. For instance, policies that are designed for habitat maintenance or protection can also impact food production as seen in Algeria through the creation of olive groves to stop desertification. In doing so, this policy measure reduces rangeland for pastoralists, potentially slowing desertification but also increasing access to olive crops.

Key issues identified in this thesis concerning policies were the wide variety of policies that influence pastoral systems consistently across the Mediterranean basin, that belong to many different political domains. Policies were found to impact pastoral systems directly through explicit policy design or indirectly through unintended consequences (Chapter 5). This idea of policy design resulting in unintended consequences is a problem in many human-nature systems. A classic example of unintended policy consequences in forestry systems can be seen in areas where fortress style conservation policies exclude indigenous and traditional forestry users to protect them from anthropogenic degradation, the policies can have a detrimental impact on indigenous peoples as access is restricted to natural resources and culturally important landscapes (Domínguez and Luoma, 2020) but also the unintended effect on the NCP associated to the management of that forest by the indigenous people (Rai et al., 2021). In EU pastoral systems, this is evident in policies that encourage economic diversification strategies, such as the rural development program in the CAP. Where pastoralists diversify into the tourism sector, which provides additional incomes, those policies can also unintentionally lead to pastoralists devoting less time to agricultural activities, resulting in a simplification of pastoral systems and the partial abandonment of pastoral landscapes (López-i-Gelats et al., 2015).

In pastoral systems, well-formed policies that are aware of the multifunctionality of pastoral systems can increase pastoral resilience, allow for the continuation of pastoral practices and facilitate pastoral systems in creating public goods and services (Pardini and Nori, 2011). Poorly designed policies, on the other hand, can increase pastoral vulnerability (López-i-Gelats et al., 2016) and can also have unintended consequences which impact the ability of pastoral systems to continue creating public goods and services. Poorly designed policies have the potential to both create and perpetuate an institutional narrative that stigmatises pastoral systems due to outdated concepts of pastoral systems as environmental harmful or economically unviable. This is even though a wide body of research including this thesis disputes these antiquated concepts of pastoral systems (Dong et al., 2016; López-i-Gelats et al., 2011). This thesis demonstrates the diverse array of NCP and ES produced by pastoral systems which can be of benefit to pastoral communities but also society. Despite this, poorly designed policies have the potential to make pastoral systems more simplistic through the

pressure placed on them. This simplification is favoured by the lack of complexity in pastoral systems research, as demonstrated in the previous research objective.

Lessons Learnt

I have demonstrated in this thesis, first, that pastoral systems are complex human-nature systems; and second, that the majority of pastoral research and policies impacting pastoral systems do not embrace this complexity (Chapter 4 and 5). It is, thus, necessary to develop a broader understanding of pastoral systems that allows for better integration of the role of humans and cultures in pastoral systems. This would then allow researchers to more effectively communicate the role of pastoral systems to policymakers, helping to influence the creation of more appropriate policies.

The complexity of pastoral systems needs to be embraced and integrated to allow researchers to fully understand the multidimensional impacts of pastoral systems. Although, there are inherent challenges with the integration of multiple disciplines, as it requires addressing and understanding the complexity of pastoral systems, as well as acknowledging the plurality of knowledge. As such, researchers need to develop a communicative capacity to allow for the better integration of multi, inter and transdisciplinary approaches and narratives. As well as the ability to integrate participatory approaches to allow for the combination of TEK into scientific research, only then will the complexity of human-nature systems, such as pastoral systems, be fully recognised. Better integration of multiple disciplines and different knowledges in pastoral research would allow for the true complexity of pastoral systems to be embraced and avoid their oversimplification. This will then allow for a better understanding of how pastoral systems are important in responding to global challenges. There is an urgent need for researchers and policymakers to move away from simplistic views of complex socio-ecological systems where human-nature interactions are strong and numerous, such as pastoral systems, and acknowledge the many multidimensional trade-offs and synergies that combine to create pastoral systems.

It is vital that policymakers and researchers understand and appreciate the complexity of pastoral systems given the numerous and multidimensional goods and services they provide, as these goods and services go far beyond pastoral communities and often are of interest for society as a whole, helping to face some of the most pressing global changes (Niamir-Fuller

and Huber-Sannwald, 2020). This is, for instance, the case of food security, poverty reduction, contributing to economic growth, and supporting biodiversity. Pastoral systems have the potential to play a significant role in the coming decade as the UN declared 2021-2030 the decade of Ecosystem Restoration, due to pastoral systems ability to regulate landscapes while creating and maintaining biodiversity through extensive food production. Equally, it is the responsibility of researchers to help politicians and policymakers understand this complexity without oversimplifying pastoral systems into only a few isolated variables that ignores the synergies and trade-offs between pastoral systems (environmental, social, economic) and policies.

Limitations & biases of the dissertation

This dissertation has several limitations/caveats regarding its ability to give a complete picture of pastoral systems. The first limitation is one of language. Both meta-analyses performed in this dissertation were performed in English. This severely limited the possibility of representing several globally important pastoral areas in the world, such as Latin America where Spanish is the primary working language of academia, or North Africa, where it is normal not to publish in English, but French. There is no doubt that the monolingual element of the search string created a biased in the results. This can help explain why the EU is so dominant in the literature, even though there is proportionally much less pastoralism in the EU than in other parts of the world. Particularly compared to North Africa or Asia.

The second bias of this thesis, also related to language, comes in the form of geographic distribution. While this thesis has a wide geographic scope, with pastoral systems from 5 continents being examined, it would not be completed without discussing the prominence of Spain in the literature, and thus, the bias of the results towards this country. In both the global and regional meta-analysis Spain dominated the analysis when considering the number of case studies. Spain is one of the 25 biodiversity hotspots of the world and considered one of the most biodiverse countries in the European Union, with mountain ecosystems hosting some of the highest levels of endemic species in the country (Convention on Biological Diversity, 2016). Spain is also arguably one of the most important countries in the EU for pastoral systems and has both a long history of pastoral systems (Montero et al., 2009; Starrs, 2018) and continues to host nationally protected infrastructure to allow the continued

movement of livestock known as drove roads (*cañadas*) (Oteros-rozas, 2015; Oteros-Rozas et al., 2013). Spanish pastoral systems can also claim to be some of the most actively studied in the EU, with some of the most prominent researchers of pastoral systems regularly using Spanish pastoral systems as case studies (Fernández-Giménez, 2015; López-i-Gelats et al., 2011; Oteros-Rozas et al., 2014; Plieninger and Huntsinger, 2018). As well as multiple published meta-analyses studying agroecological systems (some of which are global in scope) showing Spanish agroecological systems, including pastoral systems to be disproportionally represented (Dean et al., 2021; Hanaček and Rodríguez-Labajos, 2018; Plieninger et al., 2014). This evidence suggests that Spain is important for the preservation and study of Mediterranean pastoral systems, but also that the narrative and framing of pastoral systems from the literature may be skewed by the Spanish perspective and that researchers of Spanish pastoral systems may in part be responsible for the productionist and landscape maintenance narrative of pastoral systems across the thesis due in part to the Common Agricultural Policy (CAP) promoting landscape maintenance and food production policies (Commission, 2020, 2019).

While the policies analyzed in this thesis aimed to reflect the Mediterranean region, many Mediterranean countries were not represented in the analysis, with the majority of case studies being located inside the European Union and being subject to the CAP. Including countries such as Morocco/Egypt and the Balkans/Israel would allow for a better representation of the Mediterranean as a diverse area and help to counteract the role the European Common Agricultural Policy has when considering Mediterranean pastoral systems. Equally, while all efforts have been made to capture policies that impact pastoral systems through the use of local experts, there was no requirement for each study zone to talk to local experts with the same role or interest in pastoral systems. Local experts who may have a more economic or political interest in pastoral systems may consider different policies important than local experts with an interest in livestock or culture.

Future Research

One of the most prominent land management debates is the land-sharing vs land-sparing debate (Green et al., 2005). The debate revolves around the human-nature relationship and if it is better to separate human activity from the natural world and consequently preserving

it or accept that human activity is part of the natural world. Land sparing has been defined by Loconto et al. (2020) as "*separating intensive agricultural land from biodiversity-rich wildlife spaces*. Whereas land-sharing is "*integrating biodiversity-rich practices into agriculture but with lower yield per hectare hence a priori less "pure" wildlife spaces left else-where*" (Loconto et al., 2020). This thesis contributes tangentially to this debate, and more research is needed. First, through the NCP provided by pastoral systems and second, through the lack of complexity in policy debates, of which the land-sharing/land-sharing is one example. In this work, we show that human-nature systems such as pastoral systems help define what is considered natural in many parts of the world. To the point where it is difficult to distinguish which ecosystems in pastoral systems are natural and which are the result of human-nature interactions. It should be the aim of future research to further examine if it is possible to distinguish the ES/NCP created by pastoral systems or created by the landscapes that host pastoral systems, or if it needs to be explicitly acknowledged that there is no way to separate the human-nature relationships in pastoral systems. This together with the global range of pastoral systems (Dong et al., 2016) Thus, their exclusion from this debate to date is surprising as academics ignore pastoral systems in the context of this land-use debate, even when the importance of pastoral systems in the provision of regulating, material and non-material NCP is beyond question. Marking this topic of interest for future research.

At the policy scale, this thesis cannot support the land-sparing concept as it fails to recognise the importance of human interactions with the natural world. Pastoral systems contribute to a diversity of NCP and ES, despite being often considered just a form of food production and landscape maintenance/creation, (Chapters 3 and 4). As a result, they play a central role in mountain, arid and semi-arid ecosystems in the creation and maintenance of non-material, regulating and material NCP and if they were to disappear due to the application of the land-sparing strategy, then all the ES/NCP they provide would also disappear. Equally, due to the exclusion of pastoral systems and pastoral rationalities from the land-use debate, this thesis finds that land-sharing debate does not fully capture pastoral realities and does not reflex the traditional sustainable land use of pastoral systems in much of the world.

Second, also linked to the same debate but to the management scale, is what we can learn from the rationality behind pastoral systems. Pastoral systems provide a third alternative between the absolutes of land-sparing and land-sharing. Pastoral systems use

interchangeable land sharing and land sparing strategies, which allows them to efficiently adapt to use spatially and temporally scares resources that can be separated over significant distances. As a human-nature system, pastoral systems are focused on maximising their yield but in equilibrium with their resources. This is done through multifunctional and complex extensive grazing practices which encourage biodiversity, and through intermediate grazing pressures without compromising yields. This rationality offers the opportunity to address the debate from a new perspective, and not as a dichotomic and exclusive perspective.

Future research should consider the role of pastoral systems, particularly mobile pastoral systems in this debate, especially in arid, semi-arid or mountain regions such as the Mediterranean basin. As pastoral systems have thousands of years influencing the landscapes and because much of the Mediterranean basin is considered marginal land due to its arid, semi-arid or mountainous nature. Pastoral systems are vital for the implementation of a land-sharing strategy in the Mediterranean as they facilitate the creation of landscapes and their associated biodiversity using complex and multifunctional grazing practices which produce a wide range of NCP. In Spain, the use of drove roads for transhumance's creates and maintains many NCP as pastoral systems help in the movement of seeds and the maintenance of landscapes through extensive grazing pressures, while simultaneously holding cultural importance to pastoralists (Oteros-rozas, 2015; Oteros-Rozas et al., 2012). Whereas in Egypt the cultural values of trees mean that the landscapes are maintained by pastoralists (Hobbs et al., 2014). Embracing the multidimensional and multifunctional nature of pastoral systems, combined with the NCP framework, which was designed to capture multifunctionality, would allow for a deeper understanding of the role of pastoral systems in this debate and perhaps allow for the distinction between landscapes that are defined by their human-nature relationships and other forms of land use.

Other topics of future study include: The implementation of the NCP framework in the analysis of biocultural practices as it has been highlighted throughout this thesis the importance of intangible elements of pastoral systems in the creation and maintenance of material and regulating NCP. The link between linguistic and biological diversity in biodiversity hotspots such as Spain has already been discussed (Gorenflo et al., 2012), but not the role of human-nature systems in maintaining these links. This thesis has exposed the role of pastoral systems in the maintenance of landscapes and biodiversity, as well as the lack of attention by

both policymakers and researchers to the non-material elements of pastoral systems. The role of pastoral systems in the Mediterranean basin in the protection and maintenance of languages/regional dialects would be a potential case study where the NCP framework would allow for the adequate integration of world views, non-material, material and regulating NCP provided by pastoral systems. This analysis would also have scope to analyse the multidimensional role of policies in influencing the maintenance of linguistic and cultural landscapes and any synergies and trade-offs that result from these policies on the NCP produced by pastoral systems.

In line with research gaps in the academic literature described above, further work is needed to better represent the literature on pastoral systems., So any future reviews should include multiple languages, such as Spanish to capture Latin American pastoral systems, and French to better capture North African pastoral systems, among others. Equally, custom search strings could be created for each NCP/ES group to comprehensively collect information on each NCP/ES. Future research into the complexity of pastoral systems should consider the trade-off, synergies, and multidimensionality of the role of intangible elements of pastoral research in helping to address global challenges, particularly how intangible elements impact the ability of pastoral systems to provide regulatory and material contributions.

Final remarks

This thesis had demonstrated that pastoral systems are complex human-nature systems. This was done through the use of a QCA at both the global and regional levels (Chapters 3 & 4) and the use of an inductive analysis of how policies impact the production of NCP in the Mediterranean basin (Chapter 5). An analysis of global pastoral systems with the NCP framework (Chapter 3) demonstrated the appropriateness of the NCP framework for use on human-nature systems such as pastoral systems and the NCP created by pastoral systems. This led to the identification of a few dominant NCP related to cultural identity, food production and landscape maintenance, while the many NCP were underrepresented. This can be contextualised as researchers focusing on only a small subsection of pastoral systems and ignoring their complexity. The identification of drivers of change in pastoral systems and their relationship with NCP demonstrated the complex nature of pastoral systems while

identifying policies as influential in pastoral systems. In Chapter 4 following the principles of the MEA, this thesis identified the lack of multiscale and multisectoral approaches adopted by pastoral researchers and the tendency to consider pastoral systems in overly simplified terms. It also found that researchers of pastoral systems focused on only a small subsection of ES, reinforcing the point established in chapter 3. Finally, the analysis of policies that impact pastoral systems in Mediterranean case study regions (Chapter 5) demonstrates that the most important policies impacting pastoral systems are not designed specifically for pastoral systems and are instead rural development policies that indirectly influence pastoral systems. When this was combined with the majority of policies focusing on regulating and material NCP, it suggests a simplified view of pastoral systems by policymakers that needs to be addressed. That is why it is the responsibility of researchers to appreciate the complexity of pastoral systems, to communicate this complexity to policymakers to avoid the creation of poor policies which negatively impact pastoral systems. Which will help pastoral systems continue for future generations while allowing society to enjoy the benefits created by them.

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Annex I: Articles analysed in chapter 3

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Annex III: Policies analysed in the Mediterranean basin in chapter 5

➢ Continent	Country	Policy
Africa	Tunisia	Creation of Oued Dekouk Natural Reserve
		Re-introduction of wild animals (gazelle, Oryx, Addax…) in Oued Dekouk natural reserve
		Prohibition of hunting wild animals (hares, wolfs, birds…) in rangelands
		Trees/ shrubs plantations
		Creation of watering points
		First and second plantation and rangeland management strategies
		Olive tree plantation
	Algeria	National Policy on agricultural and rural renewal – steppe chapter
		National Policy on agricultural and rural renewal – steppe chapter (2006-2018)
		National Policy on agricultural and rural renewal – steppe chapter (2006-2018)
		National Policy on agricultural and rural renewal – rural development chapter (PNRAR) (2006 – 2018)
		National Policy on agricultural and rural renewal – rural development chapter (PNRAR) (2006 – 2018) – cereal chain support
		Rural and agricultural development plan (PNDAR) (2000 – 2006)
		Rural and agricultural development plan (2000 – 2006) - (the national reforestation program)
		Ramsar convention of humid zones protection (1984)
		Law No. 11-02 of 17/02/2011 on the Protection of Protected Areas, Natural Parks and Nature Reserves
		The national strategy for sustainable rural development (SNDRD) – Agriculture, rural development and fisheries ministry (MADRP)
		Forest general regime law N°84-12 23/06/1984
		Bouhezza local Cheese geographic indication obtained in 2019. Bouhezz
Asia	Turkey	Creation of the Köprülü Canyon National Park in 1973 by the Turkish Government
		Long-Term Development Plan of Köprülü Canyon National Park (Approval date: 30 May 2014
		National Parks Law No. 2873
		Wild Forest Fires
		Environmental Law No. 2872
		Village law No. 442
		Law No. 4081 on The Protection of Farmer's Property
		Land Hunting Law No. 4915
		Law on The Protection of Animals Act No. 5199
		THE CONSTITUTION OF THE REPUBLIC OF TURKEY
		Forestry Law No. 6831
		NATIONAL FORESTRY PROGRAM OF TURKEY
		Official Regulation on Grazing Animals in State Forests in Turkey
		Sheep and Goat Breeding Association of Antalya Province
		Ministry of Development, 10th Development Plan, Animal Breeding Specialized Commission Report
		Action Plan for Reducing Goat Damage in Turkey
		Sustainable Forest Management (SFM) and FOREST EUROPE

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		The Kyoto Protocol (Climate change)
		UN Convention on Biological Diversity
		UN Convention to Combat Desertification
		APPLICATIONS OF EUROPEAN UNION AGRICULTURAL AND RURAL DEVELOPMENT IPARD 2014-2020 Programme, Republic of Turkey
		Small ruminant breeding in the prevention of forest fires
		Tourism Support law No. 2634
		Pasture Law No. 4342
		Veterinary Services, Plant Health, Food and Feed Law No: 5996
Europe	Spain	Protected Geographical Indication (PGI) Vedella dels Pirineus Catalans
		Creation of the Alt Pirineu Natural Park the 1st of August 2003 by the Catalan Government (Decret 194/2003)
		Alt Pirineu Natural Park subsidies to enhance the pastoral activity within the park
		Natura 2000 Network (Habitats Directive 92/43/CEE and Birds Directive 79/409/CEE)
		Brown bear reintroduction
		EU Sanitation rules: In EU on cattle Council Directive 64/432/EEC; in EU on ovine and caprine Council Directive 91/68/EEC
		Hunting and the National Hunting Reserves: Boumort National Hunting Reserve - Act 17/1991; and Alt Pallars National Hunting Reserve - Act 8/ 12.
		Forest Act ("Ley forestal – Ley de Montes")
		Sustainable Forest Management Subsidy form EU FEDER funds.
		Fire Safety Management
		First Pillar of the Common Agricultural Policy: direct payments
		Second Pillar of the Common Agricultural Policy: Rural Development Plan of Catalonia (Pillar
		Directive 91/676/CEE on the management of livestock defecation to protect water reservoirs. Royal Decree 261/1996 in Spain and Decree 139/2009 in Catalonia ("Decret de dejeccions ramaderes ")
		Regulation 853/2004 and 854/2004 on the specific norm's slaughterhouses should observe
		Act Ley 3/1995 on cattle routes
		EU Directive on food traceability CE 178/2002
		Legislative decree 16/3/2018, of 17th July, on direct selling of raw cow milk in Catalonia
		Catalan Parliament Decision 671/VIII, of 14th April 2010, which urges the Catalan Government to develop an Interdepartmental Plan on rural women and particularly on farming women.
		Catalan Act 16/2017, of 1sr August, on climate change and energetic transition
		Urban Planning of the county
	Greece	NATURA 2000 network
		Common Ministerial Decision for grazing lands Common Ministerial Decision 1058/71977/3-7-2017 and law 4351/2015 (fek A164) Reg. EU/1307/2013, Reg. EU/639/2014 and Reg. EU/640/2014
		Mountainous areas payments EU - National (Reg. EC/1305/2013)) (Rural Development Programs from 1985 until now)
		Measures for the protection of local breeds and genetic diversity
		Investments on farms (Improvement plans

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		Installation of young farmers (Generational renewal) EU - National (Rural Development Programs from 1985 until now)
		Animal health and public health issues EU and national policy framework
		Coupled subsidies EU - National (Reg. EC/1307/2013))
		Decoupled subsidies EU - National (Reg. EC/1307/2013))
		Milk processing on-farm (Common Ministerial Decision 3724/162303/ 22.12.2014)
		Multifunctional farms
		Product certification Organic livestock farming measure (Under the RDP 2014-2020)
		Unfair trading practices and market outcomes
	Italy	Single Farm Payment (SFP) (CAP 1st Pillar)
		Single Farm Payment - (CAP 1st Pillar) Greening
		RDP II pillar CAP Measure 6 – Farm and business development (art 19) Sub measure 6.1 Sub-measure: - business start-up aid for young farmers
		RDP II pillar CAP Measure 9 Sub measure 9.1 - setting up of producer groups and organisations in the agriculture and forestry sectors
		RDP II pillar CAP Measure 10 - Agri-environment-climate (art 28) Sub measure 10.1.5 Preservation of local breeds in danger of being lost to farming
		RDP II pillar CAP Measure 11 Organic
		RDP II pillar CAP Measure 14 Animal welfare
		RDP II Pillar M19 - Support for LEADER local development (CLLD – community-led local development) (art 35 Regulation (EU) No 1303/2013) V.I.T.A. Project GAL ANGLONA ROMANGIA
		RDP II Pillar – Strategy 5.8 of the Territorial Programming Approval n.19/22 of 17 April 2018 Agri-food calls Program Agreement for the Territorial Development Project "Anglona-Coros, Lands of Traditions”
		LR 11 May 2015, "Rules on the subject of agritourism, ittiturismo, fishing tourism, educational and social farms"
		Small cheese factories Art. 7 of Regional Law 15 / 2010
		Consortia for the protection of PDO Cheeses (Pecorino Romano, Pecorino sardo, Fiore sardo) and PGI Lamb “Agnello di Sardegna)
		L.R. n. 1/2009. L.R. n. 6/2009, art. 4, comma 19. L.R. n. 5/2015 Selected breeder males
		DO & PGI
		Custumary grazing-right regulations ('diritto di uso civico di pascolo' in Italian): landless resident farmers hold a customary use-right to the use of pastoral resources despite not being the owners of the land. This use-right is asserted either on private, public or collective lands, often in return for a grazing fee ("fida‟ or "tassa pascolo‟ in Italian). The owners must abide by the law and facilitate grazing under some spatial and temporal restrictions (grazing often permitted on unfenced lands and after the harvesting of the main crop, "primo frutto‟ in Italian).
		Rural prescriptions on grazing management and tillage of permanent pastures: include measures on (i) grazing in the woodlands, (ii) improvement of grasslands, (iii) grazing calendar on mountain pastures (located outside of the protected areas and Natura 2000 network) that is permitted at an altitude above 1,000 m a.s.l. from April 1st to December 15th; below 1,000 m grazing is always permitted; this calendar may be extended during a favourable season.

		LR n. 6 of 23-02-2005 "Regional Forest Law" (L.R. n. 6 del 23-02-2005 “Legge forestale regionale”): the law provides the definition of the new regional areas based on the type of vegetation cover. In particular, in art. 2 it defines in letter d) the shrubland as "any formation consisting of shrub species having a length of at least 10 meters, a width of more than 5 meters, and a cover, intended as an area of incidence of the foliage, not less than 20%, with measurements carried out from the external base of the stems "; and in letter e) the forest as "any land covered by forest tree vegetation, associated or not with the shrub, of natural or artificial origin and at any stage of development, with an extension of no less than 2,000 square meters, a medium width not less than 20 meters and a coverage, intended as the area of incidence of the foliage, not less than 20%, with measurements taken from the external base of the stems"
		LR n. 52 of 30 December 1974 "Measures for the protection of natural environments" - protected floristic areas (L.R. n. 52 del 30 dicembre 1974 "Provvedimenti per la tutela degli ambienti naturali" - aree floristiche protette)
		Directive 92/43/EEC "Habitats" + transpositions (Presidential Decree 8 September 1997 No. 357, amended and supplemented by Presidential Decree No. 120 of March 12, 2003) and national, regional and local implementation, including Conservation Management Guidelines of the Grassland and Shrubland habitats in Natura 2000 network (Measures for the conservation of Natura 2000 sites within the territory of the Monti Sibillini National Park, definitive adoption of DCD No. 19 of 04/07/2016, approved by DGR Marche No 823 of 25/07/2016) and Management plans of the Nature 2000 sites (where defined, approved and implemented)
		Berne Convention which inserts the wolf in Annex II and provides, therefore, a special protection for this species and prohibits in particular its capture, killing, detention and trade
		Washington Convention that inserts Italian wolf populations in Appendix II of CITES, which prohibits the purchase, purchase offer, acquisition in any form for commercial purposes, exposure in public for commercial purposes, for-profit use and disposal, as well as the possession, offer or transport for the purposes of disposal of specimens of the species, except for the exemptions provided for in Art. 8 of the same regulation, excluding the populations of Spain north of the Douro and of Greece north of the 39th parallel that are included in Annex B;
		Habitats Directive (92/43 / EEC), implemented by Italy with Presidential Decree of September 8th, 1997, n. 357, which inserts the wolf in attachments B and D, prohibiting the capture, killing, disturbance, detention, transport, exchange and marketing;
		Law of 11 February 1992, n. 157 which places the wolf among the particularly protected species, also from the point of view of sanctions;
		European initiative on large carnivores, Platform of stakeholders set up by the European Commission in response to the many interests and repercussions that the presence of large carnivores has on different sectors of human activities, to share issues, experiences, and main management approaches to the conservation of large carnivores;
		In the national park of the Sibillini mountains there is a regulation for the compensation of damages caused by wildlife in the Sibillini Mountains National Park approved by DCD 49/02 and subsequent modifications and additions (last modification with DCD No. 37 of 03/07/17) 2015) for the ascertainment the assessment, liquidation of compensation for damages caused by wildlife within the Park territory to agricultural and livestock and livestock heritage and to persons, except those deriving from road accidents

		In the Sibillini Mountains National Park the provision referred to in D. D. n. 542 of 21.12.2009 for the protection of the recently reintroduced Apennine Chamois, prohibits access to some areas in certain periods of the year (except for the needs of public safety and surveillance as well as monitoring of the Apennine Chamois)
		Wild boar: The wild boar (Sus scrofa) is a species whose problematic management is differentiated according to the typology of territorial areas: those in which hunting is allowed and those in which hunting is completely prohibited according to L. 394 / 1991 "Framework Law on Protected Areas", subsequently amended by Law 426/1998, and Law 157/1992 "Regulations for the protection of homeostatic wild fauna and for hunting venues". Within the territory of protected areas, Law 394/1991 establishes that the park authority is due to indemnify the damage caused by wildlife in the park.
		L.R. 5-1-1995 n7. Regulations for the wild animals' protection and for the environmental balance and regulations of the hunting activity
		Establishment of the Sibillini Mountains National Park, Presidential Decree 6 August 1993 (GU General Series No. 275 of 23-11-1993)
		Multiannual economic and social plan (Approved by the Park Community with Resolution No. 7 dated 17.11.2000; Approved by the Board of Directors with Resolution No. 21 of 26.04.2001).
		Provisional regulation for issuance of the permit by the park authority for the implementation of interventions, plants and works inside the park (Law 6 December 1991, No. 394 - Article 13) (Text approved at the meeting of the Board of Directors no. 29.03.1994 minutes No. 2, coordinated and supplemented with the amendments made with the provisions of the Board of Directors No. 126 of 17/10/1996, No 29 of 19.04.04.2000, No 56 of 17/09/2001, DCS 07 of 07.08.2004, and CD n.35 of 14.07.2008)
		Discipline for the protection and compatible use of water resources approved with DCS no. 25 of 27/04/2007
		Agro-Environmental Agreement for the Protection of Biodiversity of the Sibillini Mountains Rural Development Program 2007 - 2013 Marche Region (Reg. (CE) n. 1698/2005), DDS Agriculture, Forestry and Fishing Service No. 491 / AFP dated 02/12/2012
		Extensive zootechny (DM 01/03/18) _Support to breeders: in possession of surfaces with permanent grasslands, located in the mountain areas identified according to Reg. 1305/13 (for Marche Region coincide with the areas identified according to EU Directive 268/75) and in mountain and less-favoured areas affected by the 2016 earthquake;
		RDP M01 - Knowledge transfer and information actions
		RDP M02 - Services of consultancy, substitution, and assistance for the management of farms
		RDP M03 - Quality schemes for agricultural and food products - Sub-measure 3.1 - Support as an incentive for the costs of participation in quality systems
		RDP M03 - Quality schemes for agricultural and food products - Sub-measure 3.2 - Information and promotion actions for quality products
		RDP M04 - Investments in fixed assets - Sub-measure 4.1 - Tangible and intangible investments.
		RDP M04 - Investments in fixed assets - Sub-measure 4.2 - Tangible and intangible investments made by agri-food companies and for the reduction of energy consumption
		RDP M04 - Investments in fixed assets - Sub-measure 4.3 - rural roads and irrigation infrastructures

		RDP M04 - Investments in fixed assets - Sub-measure 4.3 - Non-productive investments for environmental purposes
		RDP M05 - Restoration of agricultural production potential damaged by natural disasters and catastrophic events and introduction of appropriate prevention measures
		RDP M06 - Development of farms - Sub-measure 6.1 - Start-up aid for the setting up of young farmers
		RDP M06 - Development of farms - Sub-measure 6.4 - Support for investments in agricultural holdings for the development of non-agricultural activities
		RDP M07 - Basic services and renovation of villages in rural areas - Sub-measure 7.1 - Preparation and updating of the Natura 2000 management plans
		RDP M07 - Basic services and renovation of villages in rural areas - Sub-measure 7.1 - Investment in recreational infrastructure for public use and tourist information
		RDP M07 - Basic services and renovation of villages in rural areas - Sub-measure 7.6 - investments related to the cultural and natural heritage of rural areas and support for the regional protection strategy of the biodiversity linked to the Natura 2000 network
		RDP M09 - Establishment of associations and producer organizations
		RDP M10 - Agri-climate-environmental payments
		RDP M11 - Organic farming
		RDP M12 - Natura 2000 and water frame directive allowance
		RDP M13 - Allowance in areas subject to natural or other specific constraints
		RDP M14 - Animal welfare
		RDP M16 - Cooperation - Sub-measure 16.1 - Support for the creation and functioning of groups
		RDP M16 - Cooperation - Sub-measure 16.2 Support for pilot projects and for the development of new products, practices, processes and technologies
		RDP M16 - Cooperation - Sub-measure 16.3 - Cooperation among small operators for different purposes in LEADER areas
		RDP M16 - Cooperation- Sub-measure 16.4 - Support for short supply chains and local markets
		RDP M16 - Cooperation - Sub-measure 16.5 - Support for collective actions for mitigation and adaptation to climatic change and for the improvement of the environment
		RDP M16 - Cooperation - Sub-measure 16.9 - Diversification of agricultural activities for services related to vulnerable and disadvantaged groups
		National disease eradication programmes
		The EU General Framework for Animal Welfare is defined in the EU Strategy for the Protection and Welfare of Animals.
		Improvement of animal production (quality, healthiness, environmental pollutants, and residues of drugs, ...) MILK
		Improvement of animal production (quality, healthiness, environmental pollutants, and residues of drugs, ...). Meat
		The requirements and procedures for granting marketing authorisation for veterinary medicinal products, as well as the rules for monitoring authorised products, are primarily laid down in Directive 2001/82/EC and in Regulation (EC) No 726/2004. These also include harmonised provisions for the manufacture, wholesale, or advertising of veterinary medicinal products.
		Animal reproduction

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		Feeding staff (production, sale, use in animals intended or not for food production) + Reg. 183/05, 767/09, 68/13; D.P.R. 281/63, 228/92; D.Lgs. 90/93, 230/99, 142/09, 26/17; D.M. 21/12/99, 23/12/02; D.D.S. 19/11/09
		Identification of the farming farms and animals (cattle, sheep, Equidae: single animal registration) and product labelling (traceability). https://ec.europa.eu/food/animals/identification_en
		RDP II Pillar Measures 3 and 4 (Sub measures 4.1 – 4.2 – 3.2) Piani integrati di Filiera - Value chain integrated plans (PIF)