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# Examining pastoral systems using the Natures Contribution to Peoples framework – A Meta-analysis

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## Introduction

Ecosystem services (ES) is a concept of major environmental and political importance. The Millennium Ecosystem Assessment (MEA) synthesis report defined ES as “the benefits ecosystems provide to human wellbeing’ (Millennium Ecosystem Assessment, 2005). The latest evolution of the ES concept is Nature’s Contributions to People (NCP) created by the Intergovernmental Science-policy Platform on Biodiversity and Ecosystem Services (IPBES) (Díaz et al., 2018). The NCP concept is building on the 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) claim that a significant number of researchers who specialise in ecosystem services 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. These three groups are then broken into 18 different categories. Each of the 18 different categories can be in more than one of the three main groups simultaneously (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 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 pastoralism (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 the 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 the ecosystems. As an example, Leister et al., (2020), through a systematic review, applied the NCP framework to mountains ecosystems. However,

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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, pastoralism. Thus, we believe that the NCP can contribute to better understand 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 a socio-ecological system (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, pastoralism is primarily a food production system, but it is also a cultural and environmental activity that creates 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 pastoralism 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

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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 Nature's Contributions to People (NCP) or Ecosystem Services (ES) (Chan et al., 2012; Díaz et al., 2018; Oteros-Rozas et al., 2012; Sendyka and Makovicky, 2018). As a complex socio-ecological system 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, particularly pastoral systems, 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 which are the main drivers of change in pastoral systems and how these drivers of change are connected to different NCP.

## Methodology:

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:

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- 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.

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 pastoralism in the region must be described.
- The socioeconomic and ecological context of the pastoralism in the study should be described.
- The livestock management system in the article is characterised by mobility.

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.

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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 pastoralism 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).

**Table 1.** Example of how the information in the articles examined was translated into the NCP framework using a cross section of articles examined during the analysis.

Title	Year	Country	Livestock 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.

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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 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

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. 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.

Relevant information from included papers was organised in a database with 10 different categories i) authors; ii) title of the article; iii) publication journal; iv) year of publication; v) DOI; vi) study continent; vii) study country; viii) livestock system; ix) movement system; x) NCP; xi) drivers of change. The variables livestock system and movement system are defined in Table 2.

A spreadsheet database was made in a spreadsheet and variables were coded in the database. 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 Pearsons 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

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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](http://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 30%-35% (i.e., number of edges considered in the analysis over total number of existing edges) is shown in order to avoid the graphs being overly clumped.

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

**Table 2.** Description of all livestock 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



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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 article in Oceania. Mountains were used in 84% of the pastoral studies 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.

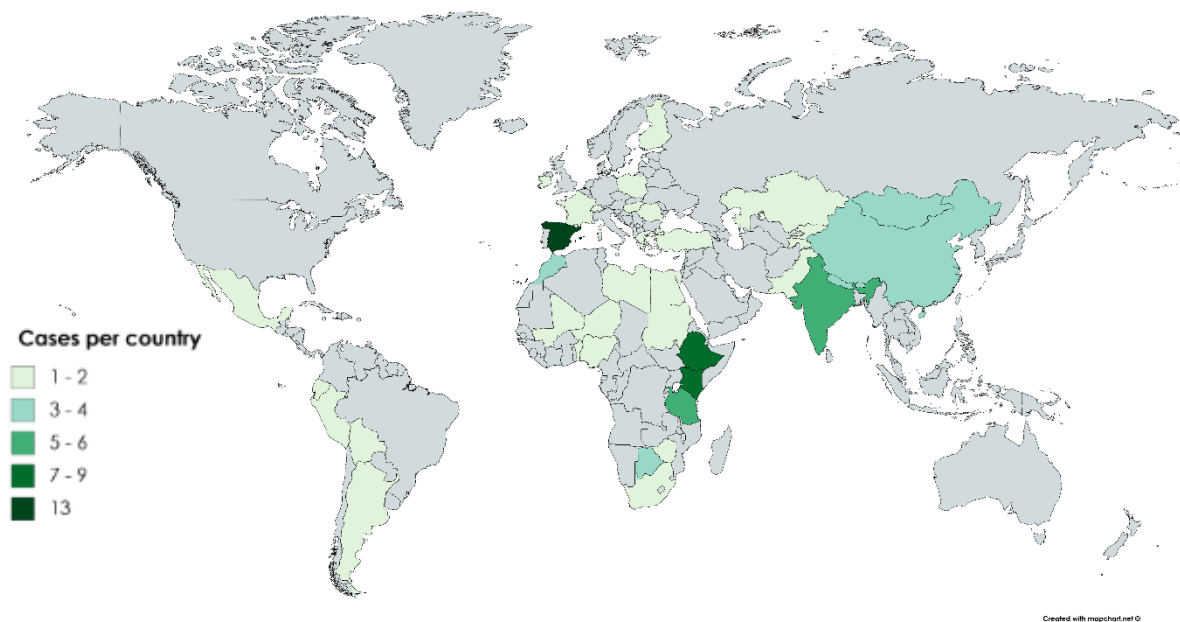


Fig 1. Distribution of case studies

## 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

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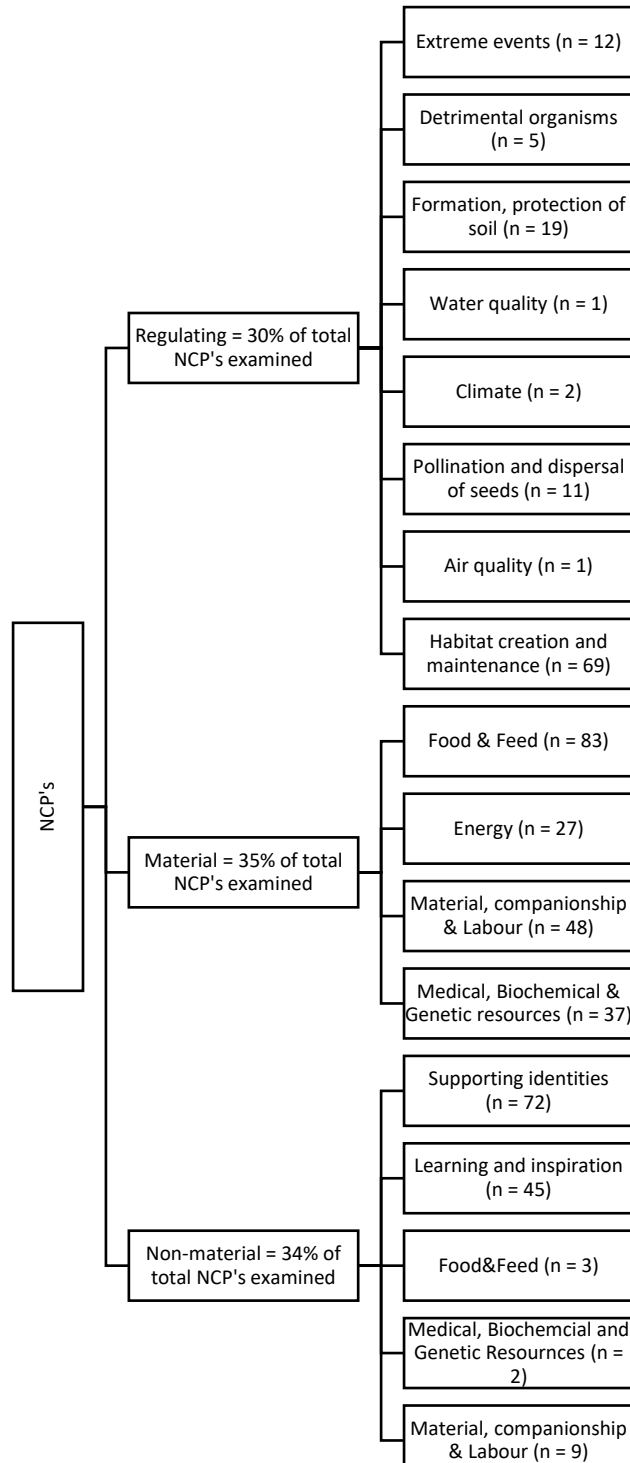
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Africa has the lowest proportion of studies with regulating NCP (27%). A Pearsons correlation shows that Europe is positively correlated both to regulating NCP as a group ( $p = 0.05$ ) but also to the regulation of hazards and extreme events ( $p = 0.0005$ ) 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 ( $p = 0.05$ ).

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**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.

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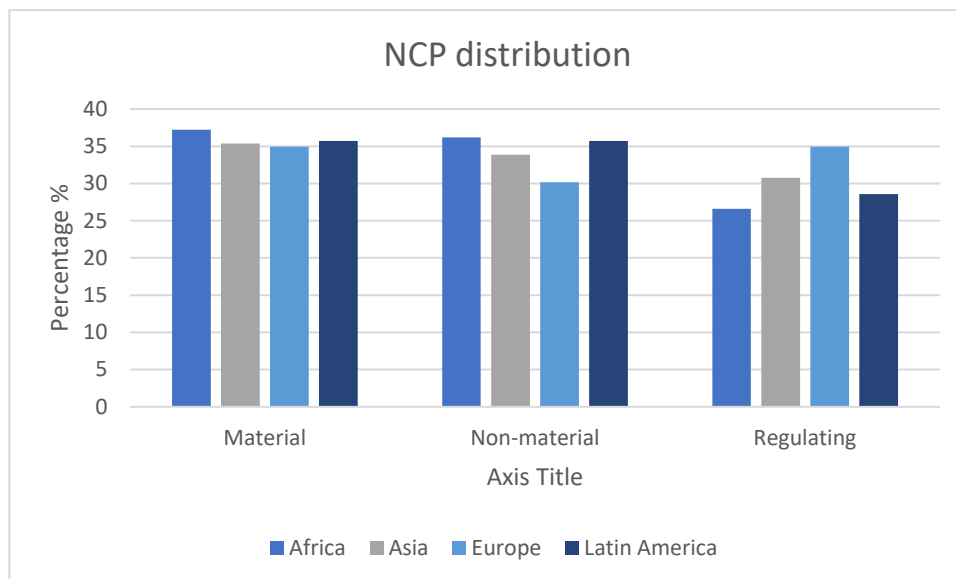


Fig 3. Distribution of NCP categories within continents displayed as percentages

## Agricultural and Movement system

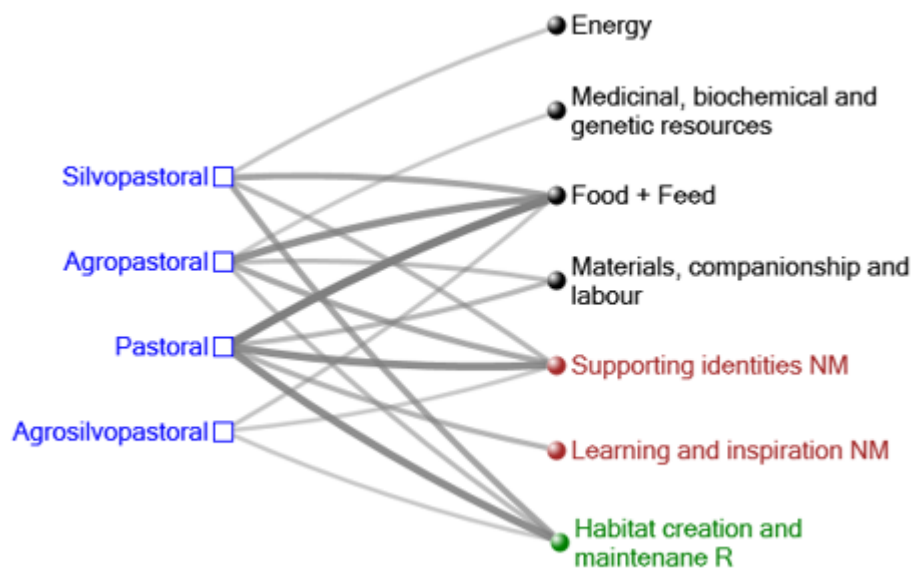
The most common form of agricultural system analysed in the literature was Pasture based (n = 35) followed by Agropastoral (n = 25), Silvopastoral (n = 19) and Agrosilvopastoral (n = 12). When examined in terms of total percentages per continent (Fig 6a), Pasture based systems are most common in Latin America (60%) and Europe (57%) and least common in Asia (44%) and Africa (21%). A Pearsons 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 systems (8%). The network analysis found strong links between agricultural systems and some NCPs (Fig 4). All the agricultural systems were connected with the material NCP *Food and feed*, the regulating NCP *Habitat creation and maintenance* and the non-material NCP *Supporting identities*. The strongest connections were found with Pasture based systems, that also showed strong links to the non-material NCP *Learning and inspiration* and the material NCP *Material companionship and labour*. Agropastoral systems also displayed strong connection with the non-material NCP *Supporting identities*, as well as the material NCP *Material, companionship*

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and labour and Medicinal biomedical and genetic resources. Agropastoral systems also showed connections with the regulating NCP *Habitat creation and maintenance*. Silvopastoral systems were also linked with material NCP *Energy*. Agrosilvopastoral systems showed the weakest connections of all agricultural systems in the literature reviewed.

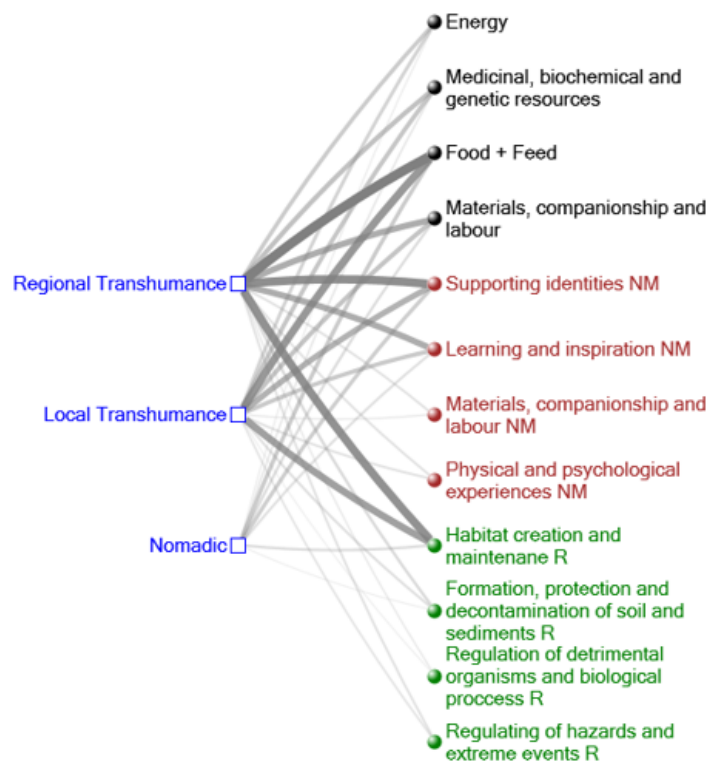


**Fig 4.** Network analysis of NCP and Agricultural systems. Agricultural systems are represented with square symbols. NCP are represented by spheres, NCP ending in NM are non-material NCP, NCP ending in R are regulating NCP, and NCP that do not end in a code are material NCP. The weight of the connection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

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**Fig 5.** Network analysis of NCP and Movement systems. 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 strength of the connection between variables is represented by the width and opacity of the edges.

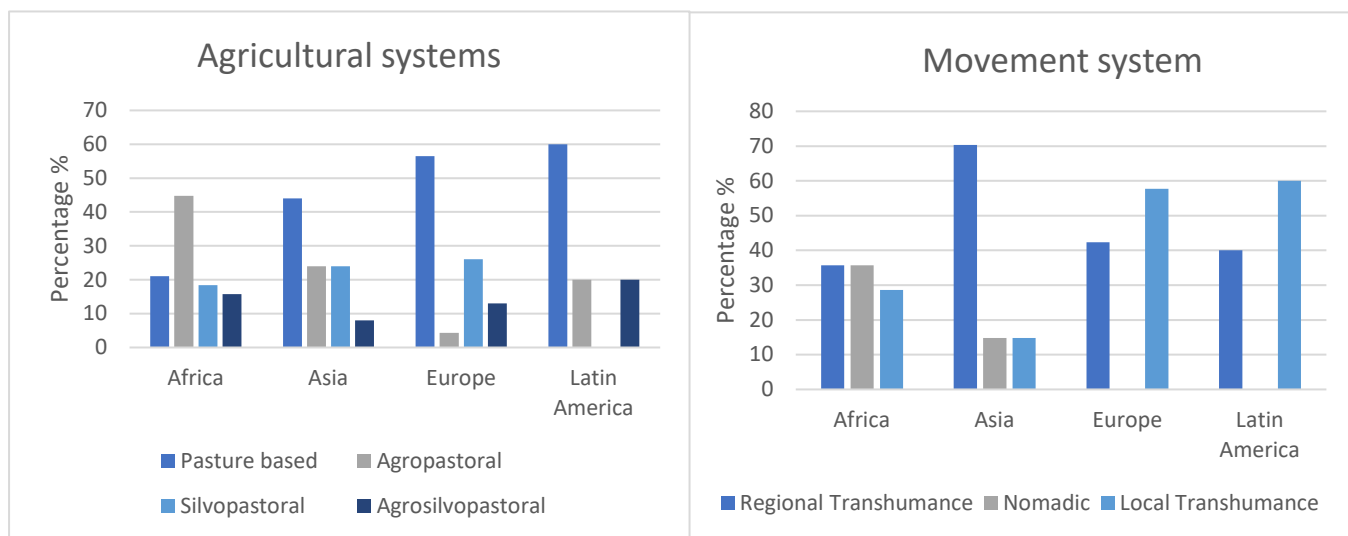
The most common form of movement system in the literature was Regional transhumance ( $n = 47$ ) followed by Local transhumance ( $n = 34$ ) and Nomadic movement systems ( $n = 19$ ). When movement systems were examined by proportions found in each continent (Fig 6b.) regional transhumance accounted for in 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 ( $p = 0.0005$ ), 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 NCPs, particularly with the material NCP *Food and Feed*, the regulating service

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*Habitat creation and maintenance* and the non-material NCP *Supporting identities*. Regional transhumance displayed 12 connections, Apart from the three mentioned above, Regional transhumance showed connections with the material NCPs *Materials, companionship and labour, Medicinal, biochemical and genetic resources* and *Energy*; with the non-material NCP *Material companionship and labour, Learning and inspiration* and *Physical and psychological experiences*; and with the regulating NCP *regulation of detrimental organisms, regulation of hazards and extreme events* and *Formation, protection and decontamination of soil and sediments*. Local transhumance displayed 10 connections. Apart from the main three mentioned above, local transhumance also displayed connections with the material NCP *Energy, Materials, Companionship and labour* and *Medicinal, biomedical and genetic resources*; and the regulating NCP *Regulating of hazards and extreme events, Formation, protection and decontamination of soil and sediments* and *regulation of detrimental organisms*; and the non-material NCP *Physical and psychological experiences* and *Learning and inspiration*. Nomadic systems had the least and weakest connections of all movement systems, displaying 8 connections, with the material NCP *Food and Feed* and *Materials, companionship and labour, Energy* and *Medicinal, biochemical and genetic resources*; with the non-material NCP *Learning and inspiration* and *Supporting identities* and with the regulating NCP *Habitat creation and maintenance*.



**Fig 6a.** Agricultural systems analysed in the study displayed as total percentages per continent.

**Fig 6b.** Movement systems analysed in the study displayed in terms of total percentages per continent.

## Drivers of change and NCPs

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 (n=X). In African pastoral

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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* 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 the 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 with the NCP *learning and inspiration*,..... or how.

Drivers	Description
Biotic (n = 20)	Presence of disease or predators
Abiotic (n = 38)	Drought, Fire, Climate change
Sociodemographic (n = 37)	Aging 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.



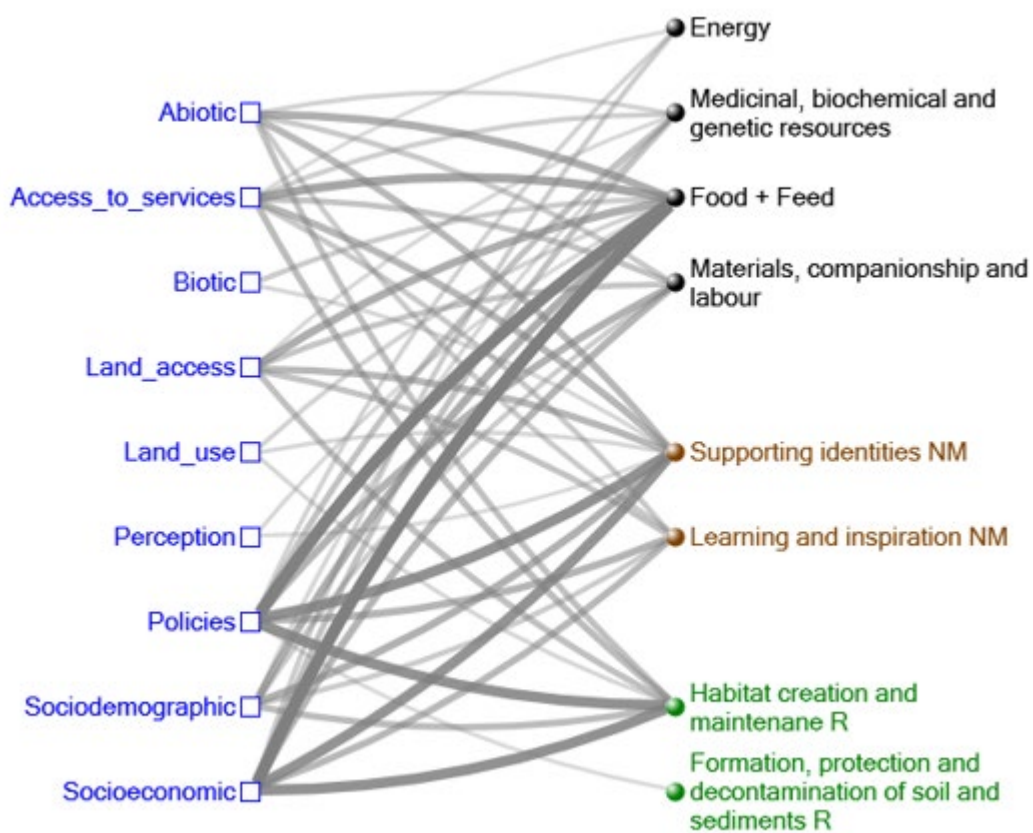
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Illegal activities (n = 4)	Illegal activities.
Pastoralism through lack of options (n = 1)	Entering pastoralism due to a lack of alternative livelihoods options.

**Table 3. Drivers of change identified in the analysis**



**Fig 7.** Network analysis of NCP and Drivers of pastoral change. 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 strength of the connection between variables is represented by the width and opacity of the edges.

## Discussion

### NCP

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The NCP framework has proven itself to be an appropriate framework for the examination of complex socio-ecological systems 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. With the distribution of case studies in this study reflecting 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.

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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 through 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 agricultural systems and movements, together with food and feed and habitat creation and maintenance. It is also one of the NCPs 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 important cultural importance of pastoralism. 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

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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 results 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 agricultural 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. 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, pasture based systems would be the dominant system. That agropastoral systems were the dominant agricultural system in Africa 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

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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 that requires access to many different resources. The absence of such systems may be an indication of the simplification of pastoral systems where pastoral systems 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. 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.

## **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

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creation and maintenance and supporting identities) are also heavily linked to the most common drivers of change (Socio-economic, 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, as intensive livestock systems are known for creating habitat degradation through the production of monocultures and intensive stocking rates (Ceballos et al., 2010). *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* driver 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. 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. 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 socio-ecological systems 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, 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

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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 agricultural 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. NCP related to pastoral systems show two distinct trends across a geographical distribution that can be taken to show the interests of the researchers. That non-material NCP are primarily studied in developing countries and that regulatory services are primarily studied in developed countries highlights a bias in the literature that needs to be addressed. 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 pastoralism that NCP in mountains are created? iii) How do drivers of change in pastoral system interact with NCP?