A global characterization of pastoral mobility types

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Abstract

Pastoral mobility is an integral part of pastoralist livelihoods and is a key element for its sustainability. It is nevertheless subjected to different disruptive threats, which highlight the need to understand it at the global level. A global typology of different pastoral mobility types can help understanding the local benefits it provides and advance protection strategies that take into account the local circumstances, but it is currently missing. Here we present a classification of a total of 12 types, based on the combination of biophysical and land tenure factors. We discuss the applicability of the typology to different pastoralist systems and show the further use it has for understanding pastoralist systems, developing comparable sustainability indicators, and promote positive policies to sustain pastoral mobility worldwide.

Introduction: why pastoralism is still important

The study of pastoralist livelihoods has relevance for a wide span of disciplines, ranging from archaeology to economics and environmental sciences (Manzano et al forthcoming). If considered as a production strategy, pastoralism can be defined as an extensive livestock raising system that utilizes rangelands based on traditional knowledge. It shows highly diverse strategies but all being specialized in maximizing fodder resources by managing mobility at a variety of scales in time and space (Kaufmann, Hülsebusch, and Krätli 2018). Mobility is therefore a centerpiece element since the start of pastoralist societies (Frachetti 2012:7). This is coherent with its adoption by highly mobile hunter-gatherers after colonization, considering similarities in terms of mobility needs, physical endurance, and knowledge of the landscape (Spooner, Firman, and Yalmambirra 2010; Lieberman et al 2020).

The relevance of pastoralist livelihoods is attested by their wide distribution. Despite insufficient data for a precise assessment (Johnsen et al 2019), pastoralism is undoubtedly the most widespread land use, with an extension of between one quarter and a half of all emerged lands (Manzano 2015). Large uncertainties exist for pastoralist populations, but it is estimated that the current number of world pastoralists is in the range of hundreds of millions (Johnsen et al 2019). More importantly, pastoralism is the main livelihood in areas with conditions unsuitable for crop agriculture – the latter only occupying 12% of the global land area (FAO 2011). The key to achieve such extraordinary performance is to maximize outputs in variable non-equilibrium systems (Sullivan and Rhode 2002). The mobility of livestock allows for a flexibility and dynamism in resource use that takes superior advantage of scattered, unpredictable resources. Social dynamics point to the critical role of commons as a way to establish shared resource use (Herrera, Davies and Manzano Baena 2014), while fine-tuned adaptations to the local conditions require adapted local breeds capable of withstanding mobility, which have been subjected to lengthy breeding processes (Hoffmann, From and Boerma 2014).

Pastoralist livestock is a fundamental piece of the global food system. It produces very nutritious foods such as meat or dairy that are key for the development of small children (Alonso, Domínguez-Salas and Grace 2019) as well as valuable fibers, and the high added value derived from such high-quality products is very important to populations in remote areas. Unsurprisingly, pastoralism contributes significantly to the agricultural domestic product, as e.g. 40% in Niger (Rhissa 2010), 50% in Kenya (Nyariki and Amwata 2019) or 88% in Mongolia (Shagdar 2002). Its contribution is generally higher in arid and semi-arid countries where grazing ecosystems are prevalent and herd mobility is a necessity (Manzano-Baena and Salguero-Herrera 2018; Nugteren and Le Côme 2016). Resilience of pastoral systems is clearly enhanced by the capacity of flocks to move. It maximizes variable environmental conditions by modifying their movement schedule and can also maximize the fodder species chosen or the investment previously done in chosen relationships. Pastoral mobility can also contribute to better adapt to the increased uncertainty brought up by global change. The fine adaptation of pastoralism to the local ecosystems, mirroring the behavior of wild herbivores, has also highlighted the role of livestock mobility to prevent ecosystem fragmentation or disappearance of pollinators, which is much increased in respect to sedentary livestock grazing systems (García-Fernández et al. 2019), or to allow for tree regeneration (Carmona et al 2013). Unsurprisingly, pastoral mobility can have a critical role at the maintenance of protected areas (Yılmaz et al 2019) and is considered positively and supported by the Common Agricultural Policy of the European Union through several measures such as direct support to "areas with natural and other specific constraints" (Nori 2019), i.e. marginal lands. In agro-pastoralist contexts mobility can also promote the efficient use of resources (Peterson, Deiss, and Gaudin 2020), e.g. agricultural fallows or crop residues, and increase the overall productivity of the system by providing fertility and closing nutrient cycles (Powell et al 1995). Further to its role in increasing agricultural productivity, such mechanisms also contribute to the development of a circular economy. Given the advantages of livestock mobility both in economic and environmental terms, the paramount role of mobile pastoralism becomes clear (Davies et al 2018) for achieving livestock-related Sustainable Development Goals (FAO 2018).

Mobile pastoralist systems are highly profitable (Fernández-Giménez & Ritten 2020), up to several times more than sedentary/static grazing systems – as seen e.g. for Botswana (3 times), Uganda (2 times) or even Zimbabwe (up to 10 times) (Scoones 1995). In northern Norway, an elaborate rangeland management system is put in place by Sámi pastoralists for harnessing the high diversity of plants, geological features, and seasons (Krätli 2015). Their reindeer move around the landscape not only taking such factors into account, but also the flock's social structure or how productive the previous year was.

Livestock mobility also a useful tool for landscape management and restoration. Many studies present evidence for Europe (Manzano-Baena & Salguero-Herrera 2018), Africa (Weber and Horst 2011), Central Asian mountains (Kerven et al 2012), India (Chaudhry et al 2011) or Mongolia (Fernández-Giménez et al 2015). But there are also examples from regions less often showcased in pastoralism studies, such as Chile in South America (Root-Bernstein et al 2017), the United States in North America (Huntsinger, Sayre, and Wulfhorst 2012), Azerbaijan in the Caucasus (Neudert et al 2015), Kazakhstan in Central Asia (Kerven et al 2008), Namibia in Southern Africa (Menestrey Schwieger and Mbidzo 2020), or Australia (Lentini et al 2011; McAllister 2012). Invariably, the degree of mobility in livestock practice shows to be a tool to increase resilience and sustain biodiversity.

Threats to pastoral mobility

While the abovementioned evidence should drive to a general promotion and encouragement of pastoral mobility, the contrary is rather happening at the global scale due to varied causes. The current process of global change is setting a challenging scene for mobile pastoralism. Sustained world population growth and increased demand for animal products from affluent populations in mid-income countries, along with the already high level consumption of animal products in developed countries, are promoting intensification of livestock production at the expense of sustainability (Gerber et al 2013). Current calculations anthropogenic climate change place a disproportionate blame on pastoralist systems even if the policy recommendations derived from such calculations are deemed to be ineffective (Manzano & White 2019). The incertitude introduced by climate change also highlights the need to adopt resilience-based production systems, where the adaptability of mobile pastoralism is proven to be key to overcome increasing volatility. Yet a general perception of mobility to be “primitive” hinders positive policy development, especially in lower-income countries that are pursuing aggressive modernization policies (de Jode 2009).

While the political control of citizenship has sometimes argued to be behind sedentarization policies (Ptackova 2012), their reason is more often economic: the provision of services such as healthcare or education is also deemed to be cheaper for sedentarized populations in the short term, at least if the costs of collapsing pastoralist systems to the economy are ignored (Behnke and Kerven 2013), so governments and agencies mostly opt for service delivery models that leave mobile populations out. Veterinary health issues and perceived higher risk of disease spread also raise governmental concerns (McGahey 2011). Restrictions around national borders, or conflicts, are also pervasive factors that disincentivize pastoral mobility. Particularly severe is the loss of resources needed for the practice of pastoralism, which can cause a complete abandonment of the livelihood. This can happen due to natural circumstances, such as drying of natural wells or flooding of grazing areas, or soil loss due to natural erosion or increased land degradation. But more often, access to resources – and hence mobility – is lost because of resource appropriation, not just because of corruption but also when the value of pastoralist systems is not adequately considered. The use of land previously accessed by pastoralists, either exclusively or in coexistence with other livelihoods, may hence be switched to excluding uses such as industries, mining, restrictive protected areas or intensive crop agriculture. Ignoring pastoralist livelihoods during the design of investments for market access may also put mobile pastoralism at a disadvantage that ends with economic displacement from other productive activities. A common disruption of pastoral mobility in high-income countries is also the development of infrastructure (notably roads, railroads or airports, but also urban sprawl) ignoring the existence of pastoralist corridors, which may or may not be demarcated.

Disruptions in the governance of pastoral lands is also an important aspect (Herrera, Davies and Manzano Baena 2014; FAO 2016). Often, the disruption of mobility does not have its roots in the disturbances during the transit periods of pastoralists, but rather in problems of access to resources. Pastoralists should enjoy their traditional and statutory rights – some of which are addressed also by SDGs, such as SDG 16 on good governance. States should promote and secure pastoralism, and hence pastoral mobility, based on their contribution to common welfare (including ecosystem services) at local, national and global scale. Land access should be secured, colliding land uses should be regulated, and conflict should be prevented.

The loss or restriction of mobile pastoralist systems poses great challenges, not only for pastoralists themselves but for society at large. The first consequences will appear in terms of conflict and impoverishment, as restricted mobility leads to overcrowding or grabbing and unavailability of key resources. In the longer term, decline in biodiversity and increase of land degradation will appear – ironically, often tagged as "overgrazing". The combination of poverty and deterioration of the natural resource base will cause youth unemployment and increased inequalities, which will in turn have a negative impact on gender relations and, generally, on prevailing social conflict (Manzano & Slootweg 2017). Collapse of mobility also annihilates the whole agro-pastoralist system, disrupting the relationships of mutual dependence and benefit between crop farmers and livestock keepers, increasing competition for resources among them, and fueling conflict.

Advancing understanding to preserve pastoral mobility

In the last decades, the positive role of pastoral mobility is being increasingly recognized, in a process tightly linked with the recognition of its social, environmental and economic values (Niamir-Fuller 1999; Khalighi 2007; Manzano-Baena and Salguero-Herrera 2018). Concepts as closely associated with pastoralists as 'degradation', 'overgrazing' or 'desertification' are being nuanced or even challenged as a whole (Butt 2016; Benke and Mortimore 2016). This has driven a series of recognitions about the value of pastoral mobility, including:

- the full implementation of existing policy frameworks such as the certificates of transhumance for the ECOWAS 1998 Transhumance Protocol (Davies et al 2018:57), or the development of the 2012 White Book on Transhumance in Spain (Red Rural Nacional 2013), after the enactment of the 3/1995 Law on Drove Roads.
- new development of legislation such as the 2006 Pastoral Charter in Mali, the 2016 Transhumance Act in Neuquén, Argentina (Fernández 2019), or the 2020 IGAD Protocol on Transhumance
- the recognition of Mediterranean and Alpine transhumance as Intangible Cultural Heritage of Humanity (UNESCO 2019)
- donor- or civil society-driven initiatives for community mapping that facilitate community-driven mobility schemes (Flintan 2012).

For an adequate policy development that guarantees the preservation of pastoral mobility, its understanding must be advanced. While comparisons of pastoralist societies across time, space and scales offer a great opportunity to bridge the existing knowledge gaps (Manzano et al forthcoming), to our knowledge there has been no attempt to characterize the different types of mobility at the global scale beyond distinguishing between vertical and horizontal transhumance. Conversely, researchers have expressed the challenge of coming up with a strict definition of pastoral mobility/transhumance (Costello and Svensson 2018:8). A characterization that is able to rationalize the intrinsic diversity of pastoralist mobility can be useful not only for cross-comparison in anthropological studies, but also for better understanding the drivers of sustainability and for better, tailor-made legislation to the different mobile pastoralism systems.

Methods

To arrive to this characterization, we did a revision of studies describing mobility types and, when available, mobility regulations across all continents. The list of studies reviewed (Table 1) is not exhaustive, but it intends to be representative of pastoral mobility systems worldwide. Characteristics from multiple typologies may also overlap in a single pastoral mobility system, adding complexity that must be accounted for.

While social and cultural factors do shape pastoral mobility, it is the availability and access to natural resources that conditions it most. Pastoral mobility corridors and mobility areas have been shown to correspond to ancient wildlife migratory corridors (Manzano & Casas 2010). Hence, the ecological factors shared by both include a response to seasonal variability in grass production, and optimization of year-long grazing across different climates, vegetation types and topography (Breman and de Wit 1983). Mobility is also a powerful strategy to respond to climate fluctuations , animal diseases or conflict (Morton 2007), as well as to enlarge genetic pool for breeding (Kaufmann, Lelea, and Hülsebusch 2016), political relations (Irons 1974, Elam 1979, Scott 2009), or access to livestock markets (Starrs 2018, Jahel et al 2020). The capacity of pastoralists to implement adaptation strategies for climate change relies on the adequacy of animal breeds to tolerate different stressors, such as drought, parasites, or change in feed composition, and their capacity to move – traits that pastoralist breeds have been selected for to match local conditions (Pilling and Hoffmann 2011).

Mobility is also conditioned by the surrounding human environment. Lack of passable roads e.g. due to landmines and forcing sharing of facilities with motorized traffic is known to have driven collapse in some pastoral mobility systems, as in Bosnia and Herzegovina (Manzano et al 2009). Development of infrastructures such as roads and communication structures, mining areas, or exclusion areas in or around natural reserve zones, can also heavily impact pastoral mobility. On the other hand, trade routes have coexisted with pastoral migration routes and contributed to the interest in maintaining them (Jensen 2003; Frachetti 2012). Trade and communication purposes may also sometimes be pre-existing, as is the case for indigenous pathways pre-dating Travelling Stock Routes in Australia (Spooner, Firman, and Yalmambirra 2010).

Factors defining pastoral mobility, both from a historical and from a current perspective, include:

- **Biophysical conditions:** The availability of grazing resources depends on plant growth, which in turn depends on rainfall distribution, topography, or local ecology. The local plant resources will condition the type of animal used, e.g. camels in hyper-arid landscapes, reindeer in the arctic, llamas/alpacas and yaks in South American and Asian highlands, respectively. Pastoral livestock breeds thrive by adapting to local biophysical conditions, not only in their physical make-up but also in their emotional and psychological preferences. For example, in Britain develop a spatial bond to the topographical and vegetation conditions in their unfenced commons through a process called "hefting" (Gray 1996; Pieraccini 2012), based on their territorial instincts (Gray 2014). The composition of the herd may also be adjusted, as in changing proportions between goats and sheep depending on the abundance of shrubs. Other biophysical factors can also play a role, such as targeting grazing areas because of the presence of saltlicks or medicinal plants that prevent disease or even adjustments of mobility routes in response to disease outbreaks.

- **Tenure type:** Although the ecological factors may motivate certain patterns of mobility, it is the tenure arrangements that determine if this is possible. Here, not only land rights and passage rights may be more important than actual land ownership – e.g. both a National Park and a federal rangeland in the U.S. are owned by the U.S. Government, but while pastoralists are not allowed in the former, the latter is their main land resource (Huntsinger, Forero, and Sulak 2010). Conversely, land under private property can also be designated for public passage of herds (Biber 2010; Communauté de Communes Causses Aigoual Cévennes 2015).
- **Availability of services:** This includes trading posts, temporary markets or any other area with better marketing opportunities, or areas where infrastructure such as veterinary services is available. With increasing importance for the delivery of education and human health services, they are also becoming conditioning factors of pastoral mobility.
- **Political, social and cultural objectives:** Pastoralist livelihoods greatly depend on their social relations. Maintaining such relations and meeting certain cultural goals can greatly condition pastoral mobility, which may imply attending festivals and celebrations, or going to a pilgrimage. Avoiding enemies or obstacles of political

nature, including conflict zones but also disrupting infrastructures, are also a factor behind the itineraries chosen.

Our compilation of case studies below shows that some variables are more relevant than others in shaping pastoral mobility typologies locally. We divide them along a two-dimensional defining gradient (Figure 1), namely:

i) a biophysical variable (plant productivity associated with climate and topography), identified below with capital vowels for main types (A, E) and small cap consonants for sub-types (b, c, d; and f, g),

ii) a social variable (land tenure), identified below with numbers (1, 2, 3).

We interpret that both variables have been the major forces historically structuring the logic of pastoral mobility. Mobility can be more determinately conditioned by other factors such as markets or existing infrastructure such as wells (Jahel et al 2020), or factors belonging rather to the policy environment such as forest/conservation policies that restrict mobility, large-scale mining, or deployment of irrigation infrastructure in drylands aimed at increasing crop production. However, the matrix through which livestock moves, e.g. between trade posts, will be mostly conditioned by the two types of variables mentioned. They will also be most relevant for anthropological considerations, because of the greater influence they may have had in the distant and recent past.

Mobility conditioned by climate & topography

Type A. Horizontal movements

Horizontal pastoral mobility implies the transit of livestock across landscapes where their altitude will not determine their plant productivity or availability, or water availability. In these cases, their variability is explained by large-scale seasonal patterns.

Particularly if not funneled (see type 1 below), horizontal transhumances are interpreted as a nomadic “random movement”, which is seem by authorities as unplanned and makes it difficult to understand the need of protecting it. However, pastoralists do perform purposed movements with the aim of optimizing livestock productivity (Table 2). Additionally, the same ecosystem function benefits observed in well-demarcated corridors (García-Fernández et al 2019) will apply to more diffuse forms of pastoral movement – only they are more difficult to test scientifically.

Subtype A.b. Monsoonal rains in tropical drylands, where temperature is stable along the year and cold is not a growth limiting factor, causing massive differences in plant productivity and plant output quality according to rainfall. This is the case for Sahelian and East African pastoralism, as well as for Indian lowland pastoralism. Here, pastures with the highest nutritional quality are also the ones whose productivity is restricted in time (Breman and de Wit 1983; Behnke and Kerven 2013), while evergreen perennial pastures, sometimes associated with forested areas, have lower quality and higher parasite infestation but constitute a strategic resource for the dry season and in case of drought. Similar dynamics are observed e.g. for Gujarat’s Kutch area (Mehta and Srivastava 2019). In arid areas movements also funnel around water and forage points, as in Australia (Spooner, Firman, and Yalmambirra 2010), Senegal (Jahel 2020), or Iran (Naghizadeh, Didari, and Farvar 2012). However, they are not always subjected to a strong legal regulation because of not experiencing the competition with other land uses described under typology 1 below.

It should be noted that the highland pasture management in the Andean altiplano, an important area for South American camelid pastoralism, shows a similar horizontal dynamic of greener dry-season pastures (*bofedales*) vs. drier wet-season pastures (Zorogastúa-Cruz, Quiroz, and Garatuza-Payan 2012) because of the altiplano's and Andean highlands' tropical location and absence of temperature oscillations between winter and summer, in spite of happening at an altitude of 4000 m.a.s.l.

Subtype A.c. The Central Asian steppe (including Mongolia) is a cold steppe that also displays horizontal movements, although the absence of trees causes more subtle differences among vegetation types used in each season. Animals will survive the winter mostly on dead grass preserved under the snow cover, while water scarcity is the summer limiting factor (Fernández-Giménez 1999). A high degree of interannual variability, notably with *dzud* events, also causes shifts in the types of pastures used (Fernández-Giménez 2002). In spite of their apparent homogeneity, Central Asian steppe pastures are also sensitive to hurdles to mobility, both in terms of economic profit and environmental degradation (Kerven et al 2008).

Subtype A.d. The Arctic displays extreme summer-winter temperature fluctuations, sometimes to up to 80ºC, that require to shift livestock use to different vegetation types: from nutritious grasses in the open tundra summer, the time when reindeer calve, to a “survival diet” based on lichens, from the forested taiga, which is also more sheltered from winter winds (Paine 1988).

Type B: Vertical movements

Vertical movements imply that the altitude is the factor that is most determinant for livestock mobility. Livestock will change its vertical position in order to respond to mainly seasonal changes. This factor can actually act at two scales: large scale (mountains) and small scale (floodable areas).

Subtype B.f. Mountain pastoralism is at the origin of pastoralism practice in Iran’s Zagros mountains (Abdi 2003) and is present in most mountain systems subjected to, at least, variable temperature. In summer, mountain highlands host high-quality grasses (Frachetti et al 2017, Fernández-Giménez & Fillat-Estaqué 2012) where wild and domestic ruminants calve. Through migration, livestock also avoids competition with crop agriculture taking place on mountain valleys and surrounding plateaus, while being able to profit from fallows and stubbles in winter – and providing fertilizing manure. Skeletal soils in highland mountains are also particularly unsuited to ploughing, which can have a very negative effect in areas with pronounced slopes and therefore likely to be eroded. In winter, livestock escapes from the highland's low temperatures (with or without snow) by moving to the valleys, where preserved hay or stubbles may be an additional resource for surviving the winter. Such pastoralist systems are the ones showing more resilience to the economic changes in developed countries (Bunce et al 2004), possibly because of the restricted alternatives for economic development in pastoralist areas – even along history (Costello and Svensson 2018).

Alleged "inverse transhumance" patterns described for Languedoc, France (Biber 2010) and the Burren, Ireland (O'Rourke 2005) are to be understood not as vertical but as horizontal dryland mobility, as they involve very little altitudinal change and pastoral movement is rather oriented by water availability. In the Irish case it is rather a curiosity originating at a small isolated karstic landscape, with high water infiltration in summer (O'Rourke 2005), amidst a regional landscape of vertical transhumance (Costello 2015, 2017, 2018).

Subtype B.g. Floodable areas are possibly the type of pastoralism with a more restricted extent, yet it has a high relevance in important Latin American and African wetlands and are important resource areas elsewhere. They are found where large rivers cross flat areas with a certain degree of aridity. In Latin America the most paradigmatic examples are associated with some of the continent's largest river systems: the *bañados* in the Argentinian and Paraguayan Chaco, along the Pilcomayo river (de la Cruz 1996, 1998) and other surrounding wetlands (Morello et al 2007; Merenciano González et al 2018); the *pantanal* in Brazil's Paraguay River basin (Pinto de Abreu et al 2010); and the *llanos* in the Orinoco basin, shared by Colombia and Venezuela (López-Hernández et al 2005). In Africa they are found next to the region's largest rivers, consisting of the interior delta of the Niger River (Wagenaar et al

1988), the Chad Lake Basin (Moritz et al 2013), the River Nile's Sudd Wetlands (Mitchell 2013), or Zambia's Kafue Flats (Nkhata & Breen 2010). In these areas, river floodplains are seasonally flooded, forcing livestock to move to higher ground during the wet season, but making valuable pasture resources available during the dry season – sometimes of even higher quality (López-Hernández et al 2005). The cyclic dynamic of natural exclusion in these systems, with times of flooding where no one can graze, may be behind open-access systems where no provisions for restrictions in traditional governance are needed (Moritz et al 2013).

Particularly disrupting policies for mobility here involve privatization of lands in dynamic landscapes, which can greatly lower the productivity potential of these systems (Morello et al 2007), or agriculture investments in floodable areas that prevent their utilization by livestock (Behnke & Kerven 2013). Because of the high concentration of resources in a small area, pastoralist floodplains are the most sensitive areas for misguided pastoralist investments, which is a general problem for the livelihood (Manzano 2017).

Mobility conditioned by land tenure

Type 1. Along livestock corridors or known/demarcated routes

Pastoral mobility has some of its most paradigmatic examples when taking place along fix routes. Such routes are acknowledged either legally or customarily, either by national government, local government, or local institutions, thereby facilitating transit and impeding encroachment by other users. These include the *vias pecuarias* going between the southern lowlands and the northern and central mountains of Spain (Manzano-Baena and

Casas 2010), the *callejones de arreo* going between the Monte desert and the Andean highlands in Neuquén, Argentina (Baied 1989), the fifteen country cross-border transhumance corridors going between the Sahelian and coastal countries in West Africa (FAO 2012:30; Davies et al 2018:37), or the *Travelling Stock Routes* between the Pacific Coast and the Outback in New South Wales, Australia (Cameron and Spooner 2010).

Such corridors – actually more a network-shaped fractal with primary, secondary and tertiary levels (Manzano Baena and Casas 2010) – have historically emerged when the route between two seasonal poles of pasture utilization are connected through areas where conflict can arise with other land users, most notably agriculturalists. Grazing by livestock can destroy crop seedlings and cause economic loss among crop farmers, so there is a need to delimit where livestock will be transiting. At the same time, transiting livestock needs a given amount of pasture to sustain itself while moving, and agricultural encroachment on such longitudinal pastures reduce the amount of food available for the animals and therefore cause economic loss among livestock keepers. Community arrangements between crop farmers and mobile pastoralists to avoid conflict have therefore facilitated the arising of such known routes (Alidou 2016).

Sometimes, competing uses are others (e.g. forestry) but the corridor needs to be protected from the encroachment of private property in general (Rodríguez 2015). In many cases of mountain transhumance (subtype B.f above), it is the rugged terrain that constrains the possibilities to move livestock, so the resulting fix routes are protected against disruptions that would otherwise cut the whole transhumant system.

The high possibility of conflicts and the relatively straightforward procedures for physically marking corridors and monitoring abuses has made State interventions common along these corridors, e.g. in West Africa (Alidou 2016), in Spain (Gonzálvez-Pérez 2011) or in Neuquén, Argentina (Fernández 2019). Legislation for such cases has also been enacted in a more straightforward way, protecting the corridor itself (Law 3/1995 in Spain or Bill 392/2016 in Queensland, Australia).

The conservation of such corridors, once demarcated, is also more stable. They are shown to be useful to veterinary services, as it facilitates monitoring and treating animal diseases by funneling migrating herds in times of migration (Cameron & Spooner 2010), and their demarcation give an opportunity to other adapted services as well, i.e social services. Lately, industrial countries are witnessing calls for their maintenance in spite of reduced use by livestock due to agricultural intensification. Such corridors have important cultural values and also facilitate important ecological processes that make their conservation worthwhile from an environmental perspective, such as maintenance of seed dispersal and pollinators, provision of landscape heterogeneity, and acting as biodiversity corridors (Manzano Baena and Casas 2010; Lentini 2012; García-Fernández et al 2019; Vella, Gonzalez and Spooner 2020). Their stable demarcation also makes it easier to implement more cost-effective monitoring tools, such as Geographic Information Systems (GIS). Although fix corridors may be spatially too fix to respond to opportunistic use of resources (Turner et al 2016), both the fractal network of corridors (Manzano Baena and Casas 2010) and the mixed characters of some pastoral mobility systems, displaying use of both fix and variable resources, should be taken into account.

It should be noted that the historical solutions practiced to move through landscapes dominated by an excluding land use (such as crop agriculture) could provide learning for preserving mobility through other more modern land uses, such as conservation areas or large-scale mining projects.

Type 2. Opportunistic mobility through commons or public open land

A type of mobility that is not so easy to demarcate takes place in areas where land uses competing with pastoralism have not occupied most of the territory, or where other non-competitive uses exist (e.g. hunting-gathering). There is no need to funnel the mobility of livestock so strongly, even if the heterogeneity in the distribution of resources (water, shadowed rest areas) will nevertheless cause mobility patterns to be funneled along corridors (Spooner, Firman, and Yalmambirra 2010). Causes for loose spatial constraints of pastoral mobility are diverse, and often linked with local ecological characteristics, notably aridity and availability of a wide range of resources. Their opportunistic use is linked to a wider array of possibilities brought by this land tenure system; those are neither brought by the excluding land uses that surround fix corridors (Type 1 above), nor are they by the more homogeneous array of resources generally presented by croplands (Type 3 below). Most of the nomadic systems described in the literature actually are opportunistic pastoral mobilities explained here. These sustainable mobility practices can resemble rotational, holistic or Voisin rational grazing practices that are often perceived as more “modern” (Menestrey Schwieger & Mbidzo 2020). While often wrongly interpreted as just “moving around” (see type A above), such pastoral mobilities actually imply a rich knowledge of the terrain and detailed planning and organization based on a variety of reasons (Table 2).

In East Africa, pastoralism on lands under common usage is widespread, and privatized land uses through crop agriculture traditionally occupy much less land. In this case, pastoralists have customary usufruct right, which allows access to the land and to utilize the resources. Pastoral mobility under such a setting is also influenced by other factors such as environment and market. Milk economies provide an economic advantage for mobile pastoralism vis-à-vis crop agriculture: the bimodal rainfall pattern in a mostly arid landscape extends the lactating season throughout all the year (Marshall 1990). The widespread use of camel as a livestock species is a further consequence of this, as it endures longer lactation during dry seasons (Elmi 1991, Nori et al 2006, Gebremichael et al 2019). Transit is therefore easier than in e.g. West Africa (FAO 2012, Alidou 2016). Importantly, the recently approved IGAD 2020 Protocol on Transhumance foresees in its Article 4 to establish Transhumance Corridors. While such clause may have been included inspired by the existing ECOWAS 1998 Protocol on Transhumance, it may have not considered the specificities of East African pastoral mobility.

Iran’s lowlands have also a predominantly arid climate (Naghizadeh, Didari, and Farvar 2012). Historically it also limited competition with crop agriculture and provided pastoralism with a relative economic advantage, resulting in widespread common land under forest/rangeland use that was not be subjected to appropriation by private landholders or to exclusive usages. As a result, pastoralist movements were mostly arranged on a season-by-season basis (Salzman 2002). Similar trends were observed in the past in the western United States, where aridity is predominant and federal/public land predominates, facilitating the transit of pastoralist herds (Huntsinger, Forero, and Sulak 2010).

Traditionally, mobility and access to pasture in this context has been negotiated between pastoralist groups, between them and the State, or between them and local traditional and decentralized institutions – even if some sustainable open-access situations have been documented (Moritz et al 2018). The legislation developed in these cases does not have to be as strongly prescribing as for fix corridors. It is however important to guarantee the ability of herds to move along such landscapes, as in the U.S. (Huntsinger, Sayre, and Wulfhorst 2012). Changes such as the Nationalization Decree in 1963 (Khaligi 2007), the alienation and privatization of communal lands, or the increased competition with agriculture (Naghizadeh, Didari, and Farvar 2012; Tahmasebi 2012) in Iran, or the decay of pastoral mobility laws in 1976 (Starrs 2018) and the increased hurdles for mobility (Huntsinger et al 2012) in the U.S., call for the formulation of new legislation that allows to conserve or restore pastoral mobility not only in these countries, but also in many others experiencing similar processes.

Type 3. Mobility through privately owned lands

Historically, mobility has not at all been impossible through agricultural lands. In agro-pastoralist systems the same piece of land is both cultivated by pastoralists and grazed by pastoralists at different times of the year. Coexistence happens through livestock mobility, allowing interdependence thanks to the mutual benefits that animals and crops can provide to each other.

In West Africa, the drier rangelands bordering the Sahara Desert offer resilient, nutrient-rich pastures where livestock herds calve at the time of the rainy season (Breman and de Wit 1983). Further south, in areas of higher rainfall, farmers plant and grow their crops during the same season. During the dry season, pastoralists need to migrate south because of lack of water and reduction of pasture, while crop farmers have traditionally depended on the manure brought by the former to replenish fertility of soils (Powell et al 1996). The pastoralists often made oral arrangements with individual crop farmers or local traditional community leaders for permission to graze crop residues and to build temporary shelters in the fields (Waters-Bayer and Bayer 1994). Farming residue may then offer choicest fodder sources and may be chosen by pastoralists – with timing being a key factor after which pastoralists must adjust their mobility. A similar rationale of mutual benefit and interdependence will be found in other agro-pastoralist areas, e.g. in western India (Cincotta and Pangare 1996). Eastern India also showcases some interesting systems with pig pastoralism seasonally benefitting from agricultural wastes linked to wetlands (Sahu 2013).

Such systems can collapse through intensification of agricultural production, multiplying the use of mineral fertilizer, pesticides, or herbicides (Djohy, Edja and Waters-Bayer 2017), as well as the privatization of grazing resources and suppression of mobility. A further driver is crop farmers investing in livestock and thus requiring the crop residues from their fields for their own livestock. A collapse of Sahelian pastoral mobility will have dire consequences for social, economic and environmental sustainability (Diarisso et al 2015). The importance of manure is key generally for any smallholder crop-farming system in developing countries while, in countries where the crop and livestock sector have been industrialized, livestock excreta is now redundant has been reduced to a problematic waste that needs costly treatments (Herrero et al 2013). Other disruptions that agricultural intensification will cause to this system are agricultural infrastructures such as irrigation fields, dams or canals, or government-driven land schemes such as compensation for farmers.

Traditional relationships between crop farmers and mobile pastoralists are therefore mutualistic in nature, so there is no competition for resources – instead, it is based on mutual benefit. Regulation, either legal or customary, for such kind of mobility has not been required so far or has been weak. Increased conflicts and instability in the Sahel region (Manzano & Slootweg 2017) may be reflecting the consequences of intensifying these production systems and disrupting the previous benefits, as does the increased marginalization of agro-pastoralists in India (Sharma, Koller-Rollefson, and Morton 2003; Mehta & Srivastava 2019). Other types of benefits, such as market access and maintenance of social ties, are also lost when these mobility systems are lost (Fernández-Giménez & Le Febre 2006). These systems are therefore in urgent need of legislation developments that can protect them – and, ideally, also the sustainable land use that they provide.

Tenure shifts towards land privatization in areas traditionally subjected to communal management do need legislation changes to facilitate mobility – even if such privatization happens in arid areas where little competing crop agriculture takes place (Menestrey Schwieger & Mbidzo 2020). This also includes land use conversion into regimes that exclude pastoralist use even if land ownership remains unchanged, such as the gazetting of protected areas for nature conservation that are not shared with traditional activities (IUCN Protected Area Categories Ia and Ib).

Concluding remarks

The characterization of pastoralist mobilities shows clear geographic patterns (Figure 2). While the widely studied mountain transhumance systems are restricted to temperate latitudes, dryland nomadism and wetland pastoralism dominate in tropical and subtropical areas. Interestingly, the Mediterranean basin's hot, arid summers have a subtropical influence that extend to its southern shores. The North African alpha grass steppes, for example, historically displayed mobility dynamics (Bencherif 2018) that are similar to the Australian mobile pastoralist systems reviewed here.

While most systems mentioned in this paper fall into one category (Table 1), many historical or traditional pastoral systems show a mix of the typology described here. As examples, historical Spanish *merino* transhumance (Manzano & Casas 2010) and traditional Indian Van Gujjar transhumance (Gooch 2004) both fit into horizontal-monsoonal pastoralism during winter (subtype A.b in the biophysical category), but into vertical mountain pastoralism in summer (subtype B.f). In some cases, one type of mobility will depend on the infrastructure of another mobility type. An example is Sayago shire in Zamora, Spain (Prada Llorente 2016), where the short-scale mobility among fallows and between them and local hills (type 3) depends on the larger-scale network of drove roads whose regulation is to trace rather from long-distance vertical transhumant patterns (type 1; Manzano Baena & Casas 2010). Similarly, a single pastoralist mobility event can go through areas where routes are demarcated corridors, diffuse common lands, or private lands. There may be an overlapping or mix of different typologies even in a single community, who may switch over time or depending on the circumstances. With the typologies described here, however, it should be easier to understand such mix and therefore understand also the pastoralist system studied.

If legal frameworks are to be developed that is suitable for pastoral mobility, the fundamental principles of pastoral mobility must be articulated and understood. Present mobility is influenced by historical mobility routes and the various human interactions that took place on them, including access to markets or pastoral aspirations. The historical factors that define a given pastoral mobility system will inevitably vary through time (e.g. by opening of markets, building of infrastructure or changes in overall land planning). Provisions for adapting to such changes are therefore to be included in the legal regulatory texts, but they must always respect the adequacy of mobility corridors for the pastoral use, and their territorial integrity (as in Spanish Act 3/1995 Artt. 11-13). For such decisions it is essential to engage experts from multiple disciplines, as well as policy makers and of course pastoralists themselves, in conversations not only about the pastoral mobility route itself but about the whole pastoral system.

The recent developements or improvements of legislation in pastoral mobility, as in Neuquén, Argentina, or for the IGAD Transhumance Protocol in the Horn of Africa, are encouraging moves that counterbalance the disruptions in Iran or the United States. It is expected that the UNESCO inclusion of Mediterranean transhumance in the list of Intangible Cultural Heritage of Humanity will trigger further legislation developments or improvements. The intended re-focus of Europe’s Common Agricultural Policy to restore environmental services and the widespread pollination and fragmentation crisis (García-Fernández et al 2019) should also trigger favorable policies for restoration of pastoral mobility, including transhumance but also Type 3 traditional rotational practices. Problems related to tree regeneration, observed both in Spain and Mexico (Sánchez-Velásquez et al 2002; Carmona et al 2013), can also be solved through livestock mobility especially if it does not contribute to crop expansion into the forest. Our characterization should help envisioning tailor-made solutions to each case. Particularly concerning is the legislative focus on transhumance, and the lack of conductive legislation for opportunistic mobility or mobility through privately-owned land.

A wider attempt to characterize the world's pastoral systems according to this typology may clarify some of the patterns observed here. The relative homogeneity of mobility types in Africa, for example, may be both a consequence of large areas that are relatively homogeneous in climate and topography (the Sahel), but also because of smaller research resources compared to Europe. The high visibility of vertical wetland movements in our map may also be because of the interest they awake as uncommon systems (Moritz et al 2018) or because of their high productivity – but their restricted geographical importance would be showcased in a world mobility map.

As a follow-up, we propose to conduct a participatory process with current pastoralist collectives and organization, as well with academics, to come up with a comprehensive global map of pastoral mobilities, according to our classification. This can be an importance piece to improve the status of knowledge on pastoralism, and to facilitate the implementation of positive policies (Johnsen et al 2019; Manzano et al forthcoming).

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Table 1. Characterization of pastoral mobility types for different pastoralist systems, according to our new framework. A: Horizontal movements (b: triggered by monoonal dynamics; c: triggered by cold steppe dynamics; d: triggered by arctic climate and vegetation dynamics). B: Vertical movements (f: mountains; g: wetlands). 1: Fix, legally or customarily established transit corridors. 2: Opportunistic (nomadic) movements. 3: Movements through privately-owned land (mainly croplands).

Continent	**Location**	**Type**	**Source**
Asia	Gujarat, India	A.b-3	Cincotta and Pangare 1996 Mehta and Srivastava 2019
	Rajasthan, India	A.b-2	Chaudhry et al 2011
	Himachal Pradesh, India	A.b-3 / E.f-1	Gooch 2004; Scott 2009
	Odisha, India	E.f-3	Sahu 2013
	Eastern Tibet	E.f-2	Ning and Zhaoli 2002; Ptackova 2012
	Mongolia	A.c-2	Fernández-Giménez 1999, 2002; Fernández-Giménez et al 2015 ; Frachetti 2012
	Northeastern Iran (Yomut turkmen)	A.c-3	Irons 1974
	Zagros Mountains, Iran	E.f-2	Salzman 2002; Abdi 2003; Khalighi 2007; Naghizadeh, Abbas, and Farvar 2012; Tahmasebi 2012
	Kazakhstan	A.c-2	Kerven et al 2008; Frachetti 2012
	Kyrgyzstan and Tajikistan	E.g-2	Kerven et al 2012; Frachetti 2012;

			Frachetti et al 2017
Oceania	New South Wales, Australia	A.b-1	Cameron & Spooner 2010; Spooner, Firman, and Yalmambirra 2010; Lentini et al 2011; Lentini 2012; Vella, Gonzalez and Spooner 2020
	Queensland, Australia	A.b-1	Bill 392/2016 in Queensland, Australia
North America	Northeastern Mexico	E.f-3	Sánchez-Velásquez et al 2002; Lieberman et al 2020
	Western United States	A.b-1 / A.b-2 / E.f-1	Huntsinger, Forero, and Sulak 2010; Huntsinger, Sayre, and Wulfhorst 2012; Starrs 2018
Europe	Long-distance transhumance, Spain	A.b-1 / E.f-1	García-Fernández et al. 2019; Manzano Baena and Casas 2010; Gonzálvez-Pérez 2011; Bunce et al 2004:233-282; Costello and Svensson 2018:219-244
	Sayago, Spain	E.f-3	Prada Llorente 2016
	Pyrenean transhumance, Spain	E.f-1	Fernández-Giménez and Fillat Estaqué 2012; Fernández-Giménez and Ritten 2020; García-Ruiz et al 2020
	Southeastern France	A.b-1 / E.f-1	Bunce et al 2004:113; Biber 2010; Communauté de Communes

			Causses Aigoual Cévennes 2015; Costello and Svensson 2018:135-154
	Ireland's West Coast	E.f-3	Costello 2015, 2017, 2018
	Burren, Ireland	A.b-2	O'Rourke 2005
	Norway	E.f-3	Bunce et al 2004:7-68; Costello and Svensson 2018:15-42
	Romania	E.f-1	Bunce et al 2004:155-170; Hubband, McCracken and Mertens 2010; Costello and Svensson:245-263
	Eastern Herzegovina	E.f-1	Manzano et al 2009
	Azerbaijan	E.f-1	Neudert et al 2012
Arctic		A.d-2	Paine 1988
South America	Altiplano region, Perú/Bolivia	A.b-2	Zorogastúa-Cruz, Quiroz, and Garatuza-Payan 2012
	Chile	E.f-1	Jensen 2003; Root-Bernstein et al 2017
	Northern Neuquén, Argentina	E.f-1	Baied 1989; Rodríguez 2015; Fernández 2019
	Gran Chaco, Argentina/Paraguay/ Bolivia	E.g-2	de la Cruz 1996, 1998; Morello et al 2007; Merenciano González et al 2018
		A.b-2	Córdoba and Camardelli 2017; Fernández et al 2020

	Pantanal, Brazil	E.g-2	Pinto de Abreu et al 2010
	Llanos in Orinoquía, Venezuela and Colombia	E.g-2	López-Hernández et al 2005
Africa	Northern Tanzania	A.b-2	Flintan 2012
	Southern Ethiopia	A.b-2 / E.g-2	Behnke and Kerven 2013
	Southern Uganda	A.b-3	Elam 1979
	Botswana	A.b-2	McGahey 2011
	Namibia	A.b-2	Menestrey Schwieger and Mbidzo 2020
	Western Sahel	A.b-1	Breman and de Wit 1983; Powell et al 1996; Diarisso et al 2015 ; Alidou 2016; Turner et al 2016; Jahel et al 2020
	Alpha grass steppes, Algeria	A.b-2	Bencherif 2018
	Interior delta of the Niger, Mali	E.g-1	Wagenaar et al 1988
	Chad Lake basin	E.g-2	Moritz et al 2012, 2013
	Sudd Wetlands, South Sudan	E.g-2	Mitchell 2013
	Kafue Flats, Zambia	E.g-3	Nkhata & Breen 2010

Table 2. Indigenous typologies of reasons for pastoral mobility in Eastern Africa among different ethnic groups. Source: compiled by Ced Hesse during different editions of IIED's pastoral training programme (https://www.iied.org/pastoralism-policy-training-addressing-misconceptions-improving-knowledge).

	Borana	**Afar**	**Somali**	**Hamer**
Resource management: search for pasture and water	dheedumsa	leda-guran	hayan	beriqe (bona weda)
Moving to new pasture to preserve dry season grazing	godaansa dheeda	budda	naq raadis	darensa
Moving due to insecurity	baqa	dabo	baqo	shaookee
Moving for social ceremonies	godaansa jila	-----		misha weda
Moving to prevent disease and find clean place for livestock		gaba gurro		shaookee
Move to salt and minerals		beda		kooti weda
Move at the start of the rains for fresh pasture	dheeda badheesaa	-----		bargi weda

Figure 1. Hierarchical framework of pastoral mobility types.

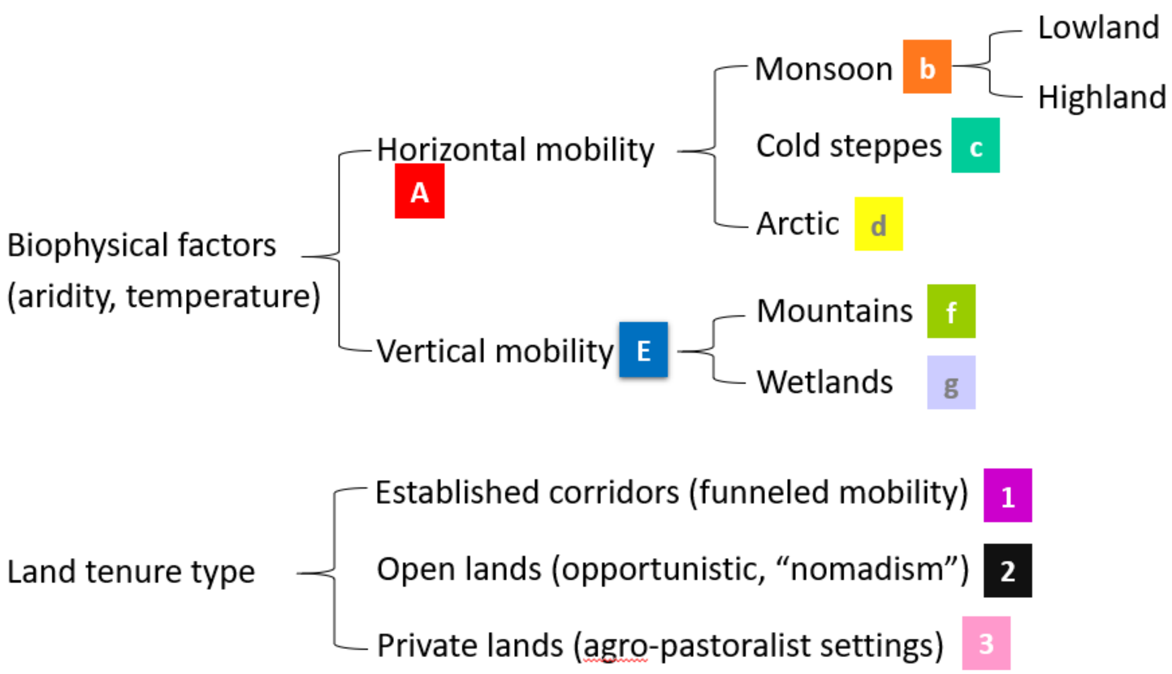

Figure 2. Global map depicting mobility types of the case studies showcased in this paper. See figure 1 for legend.