

Ecology, mobility and labour: dynamic pastoral herd management in an uncertain world

B. Butt

School of Natural Resources and Environment, University of Michigan, Ann Arbor, MI 48109,
United States of America
E-mail: bilalb@umich.edu

Summary

In this review, the author discusses how pastoralism, and its many constituent components, is increasingly being recognised as in tune with the changing political and ecological nature of rangelands. He describes ways in which the literature reflects this changing attitude, outlines how rangelands respond to changes in climate and explores the evolving use of livestock resources. In addition, he describes the growing recognition of factors other than livestock density that affect rangeland vegetation (i.e. density-independent relationships). The author explains how terms such as ‘carrying capacity’, ‘overgrazing’ and ‘desertification’ are often taken out of their social and political context when describing rangeland pastoralism. Next, he describes the growing recognition by the development community of the importance of the mobility model, particularly in relation to changing ecologies and politics. Finally, he outlines how labour, a central focus of pastoral herd management, is a fluid component of pastoral systems in response to changing political and ecological circumstances.

Keywords

Degradation – Environment – Labour – Non-equilibrium ecology – Pastoral mobility – Pastoralism – Politics.

Introduction

Over the last quarter-century, our understanding of how pastoral livelihoods intersect with and influence rangeland environments has grown significantly (1). Pastoralism, once considered an outdated and irrational livelihood system (2), now features prominently in discussions about the sustainability of global rangelands (3). Yet significant obstacles remain to ensuring that pastoralism, in its various forms, remains a viable livelihood strategy for the estimated 200 million pastoralists worldwide who live in rangelands (4). With pressures from changing climate and modifications in the politics of land management, pastoralists are becoming increasingly constrained in their ability to secure flexible access to resources. While we have witnessed positive changes in how the ecological nature of rangelands is characterised, and now recognise that mobility and labour are vital yet fluid components of pastoral systems, there is still much work to be done in

effectively translating research findings into policy. This paper reviews some of these challenges and delineates the current state of knowledge in the field.

Rangeland dynamics and carrying capacity

Rangelands cover more of the Earth’s surface than any other land cover (up to 40%), depending on definition (5), including up to 80% of the total land area in the Horn of Africa (6). Rangelands are characterised by low annual rainfall, which drives primary productivity, but rainfall is highly variable across time and space (7). Rangelands are also resilient socio-ecological systems with high biodiversity, which sustain hundreds of millions of livestock-keeping pastoralists (8, 9). Because of the heterogeneous nature of rangelands, pastoralists and their livestock move from

place to place in response to changes in climate and vegetation. Mobility enables pastoralists to cope with shifts in the spatial and temporal locations of forage and water resources. However, rangeland pastoralists face challenges from climate change and the politics of land management which affect their access to, use of, and control of resources (1). The effects of climate change on rangelands are highly variable, depending on geographical location, but there is broad consensus that climate change has altered, and will continue to alter, the onset, duration and intensity of extreme events, such as droughts, floods and snowstorms (6, 10, 11, 12, 13, 14).

Water management is an integral part of pastoral herd-management strategies. Rangelands characteristically have ephemeral surface water and rainfall is patchy (15). Water management depends upon the total number of animals and herd composition (e.g. numbers of cattle, sheep, goats, camels and donkeys), and is relative to the quality and quantity of water in rivers, streams and dams (16), and the availability of water at infrastructure fixed points (e.g. boreholes and wells) (17, 18), among other factors (19). In some cases, pastoralists might have to travel hundreds of kilometres to gain access to water points, while in other cases it may only be a few kilometres. Depending on the region and season, pastoralists might alternate between 'watering days' and 'grazing days' (20).

Early research on the ecological effects of climate and livestock grazing on vegetation characterised these effects as conforming to either equilibrium or non-equilibrium tendencies. The former can be described as having a tight coupling between vegetation and grazing intensity (density dependent), whereas, in the latter, factors other than livestock density influence vegetation (density independent). For some scholars, an understanding of what characterised equilibrium or non-equilibrium dynamics was based on how much rainfall accumulated within a given period, with some scientists suggesting that precipitation of less than 700 mm/year could be characterised as corresponding to non-equilibrium dynamics (21, 22). Nonetheless, there seems to have been a rapid shift from the wholesale adoption of equilibrium-based rangeland ecology to its abandonment in favour of a non-equilibrium-based understanding (23, 24). This has led some scholars to question whether the concept of non-equilibrium rangelands may be as much in danger of being misapplied as equilibrium-based models have been (23). More recently, new research indicates that the tendency to conform to either equilibrium or non-equilibrium conditions in rangelands depends upon the spatial and temporal scale of the investigation (25, 26, 27, 28).

The unqualified characterisation of environmental changes as having either equilibrium or non-equilibrium

tendencies has very different management implications for development interventions (29). The uncritical adoption of these models, without an in-depth understanding of the differently functioning environments, is partly to blame for the failure of past pastoral development projects (30). Equilibrium understanding was crucial in past assessments that pastoralists and their livestock 'degraded' their environments through 'overgrazing', leading to 'desertification' (31). The author intentionally does not define 'degradation', 'overgrazing' and 'desertification' because these words are highly contentious among ecologists and also because they are socially and politically constructed terms, used to advance certain perspectives and environmental and development goals (32, 33, 34, 35).

A central concept that has been used to assess the severity of these contentious terms is that of 'carrying capacity' (36). In rangeland ecology, carrying capacity (often synonymous and incorrectly associated with 'stocking rate') has been defined as 'the number of animals in a management unit for each year or grazing season' (37). Often embedded within the concept of carrying capacity is the idea that a given unit of land has some innate capacity to support a given number of livestock – and that, once this number is exceeded, overgrazing, degradation, or desertification could occur. These concepts and ideas were derived from regions where there is a tighter coupling between grazing actions and vegetation health, such as in Australia and the south-west of the United States. Carrying capacity models were then applied to some environments which conform to non-equilibrium tendencies, such as the rangelands of sub-Saharan Africa and Central Asia (23, 38). Carrying capacity models were overly simplistic, in both their definition and contexts. They assumed that simple addition or removal of livestock within the predefined 'management unit' could affect vegetation health (39). This was particularly useful for range managers, who could easily alter livestock numbers to achieve the goal of productive rangelands.

Given the patchy nature of rainfall, carrying capacity models were socially and politically removed from the reality of many pastoral systems (32). For example, some pastoralists, such as the Maasai, rely on socio-spatial scales which do not neatly align with the concept of a ranch with fixed boundaries (40), or Western ideas of space and time. Periodic stocking and destocking of livestock, long an adaptive strategy used by many pastoral populations to cope with changing environmental conditions (30), was seen as irrational and contributed to the idea that pastoralists 'use and abuse' rangelands. Livestock mortality can be high due to droughts, floods and snowstorms, and herd numbers are often optimised, so as to balance labour costs with changing forage availability,

while anticipating the effects of climate and extreme weather events (19, 41, 42).

Efforts to control pastoralists and their livestock led to changes in where pastoralists were able to graze (43, 44) – the pastoral commons were increasingly being eroded and corresponding changes in vegetation from this restricted livestock mobility began to appear, such as the eruption of new and less palatable species (45) and increased soil erosion (34). Many rangeland managers, often trained with inadequate understanding of pastoral movements and livelihood strategies, characterised such changes as being the product of ‘overgrazing’. There has been widespread recognition that the ‘new rangeland ecology’ – that is, non-equilibrium dynamics – is crucial to understanding how pastoralists cope with and adapt to changes in climate and vegetation.

The ecological effects of livestock are best understood through vegetative responses to grazing and nutrient cycling. Generally, stimulation of grasses peaks when moderate grazing occurs (46). Biomass produced by grasses after grazing is more nutrient-rich than biomass from ungrazed plants (47, 48). The protein content of grasses is inversely proportional to height due to lignification (49). Heavy grazing and trampling in the wet season can limit seed production, producing noticeable changes in grasses during the latter part of the dry season (50). Dryland vegetative productivity has been found to be shaped less by recent grazing history (unless very heavy) than by longer-term grazing history, coupled with seasonal and interannual rainfall variation (51, 52). Excessive grazing can cause significant defoliation in areas where migratory routes are spatially and temporally concentrated (53), increasing soil bulk density, soil runoff and erosion (54). These effects can be variable, given episodic rainfall events, which cause rapid green flushes in as little as 24 hours (55).

Nutrient cycling occurs via dung deposition of livestock through two spatial processes (56). First, dung accumulates inside animal corrals and outside homesteads where animals are released in the morning (53). These areas remain green through the transfer of nutrients from dung to soil, enhancing productivity, and become nutrient hotspots for several decades after the abandonment of homesteads (57, 58). Secondly, livestock dung is distributed across the landscape where livestock spend the greatest amount of time grazing, which is spatially and temporally patterned (53). In areas away from the homestead, cumulative plant nitrogen and phosphorus uptake in grazed areas is equal to, or slightly greater than, nutrient uptake in ungrazed control areas (51).

Pastoral livelihoods and recognition of the ‘mobility paradigm’

Despite advances in our ecological understanding of rangeland dynamics, progress in recognising how pastoralists adapt to changes in the environment (and politics) has been slow – until now. Previously, pastoral livelihoods were often characterised as outdated, irrational, stagnant, unproductive and ecologically damaging (59). The ‘cattle complex’ described pastoral populations as having large herds and limited off-take because of their cultural affinity to livestock (2). Hardin’s famous ‘tragedy of the commons’, and its specific reference to livestock owners, argued that the commons were prone to erosion and degradation, due to mismanagement and self-interest (60). As a result of these popular portrayals, many states sought to sedentarise pastoralists by confining them into native reserves and group ranches, later providing land titling and investing in infrastructure to harness livestock products, such as abattoirs and meat-canning facilities (45). These developments limited pastoral mobility and, with it, the ability to cope with environmental heterogeneity. As a result, many development policies oriented towards improving the ‘productivity’ of pastoralists often failed (45). Pastoralists were also often seen as recalcitrant populations, given that they resided at the fringes of the modern nation state. More nuanced efforts to understand pastoral mobility were based on broad descriptive analyses of migration routes and corridors (61) and on the cultural and political practices of different pastoral ethnic groups.

Over the past decade, there has been a litany of new studies which empirically demonstrate how pastoral livelihoods rely on mobility to counter environmental and political challenges (59, 62, 63) – so much so that pastoral mobility now represents the new face of sustainability efforts in rangelands (64). Recognition of the ‘mobility paradigm’ has become widespread, with several national governments (particularly in sub-Saharan Africa) formally recognising it, and providing legislative support to protect pastoral mobility (65). Despite this recognition, there are difficulties in reconciling development programmes designed to enhance mobility with landscape attributes – in other words, if one does not adequately recognise the dynamics of pastoral mobility, then there is likely to be a continuation of development failures (59).

New understandings of pastoral mobility have moved from broad and vague descriptions of animal movements as ‘haphazard’ to firmer understandings of mobility as a form of ‘planned management’. Mobility decisions involve careful and advanced planning, reflecting a balance between the

needs of different resource users, changing environments and social, cultural and political constraints. Pastoral mobility today can generally be characterised by some measure of the distance travelled and degree of dispersion. However, relying solely on metrics can lead to inadequate and decontextualised understandings of pastoral mobility (59). Pastoral and livestock movements can be based on:

- small and circular or linear movements around a homestead or enclosure (micro-mobility); this is largely the case where there is a sedentary form of pastoralism being practised
- larger-scale distances of thousands of kilometres across an environmental gradient (known as full mobility, macro-mobility, horizontal transhumance or nomadism)
- vertical movements, for example up and down mountain sides, in accordance with summer and winter pastures (also known as vertical transhumance), or
- some combination of these.

The key point here is that pastoral systems are inherently flexible, in order to take opportunistic advantage of heterogeneously distributed resources.

Methodological advances and geospatial technologies have allowed for greater accuracy in documenting the nature, magnitude and extent of mobility, and the ways in which mobility reflects changing conditions. The use of global positioning system (GPS) collars on pastoral livestock has become common practice among researchers (66, 67, 68, 69, 70). In places such as Sahelian West Africa, pastoral movements are in tune with the North-South movement of the inter-tropical convergence zone (ITCZ), which brings rainfall as the zone advances and recedes (71). Fulani transhumance pastoralists can travel between Burkina Faso in the south to northern Mali. In East Africa, rainfall tends to be patchy, also in response to the ITCZ, and there can be rapid green flushes of vegetation in as little as 24 hours after rainfall (72). Herd managers and owners respond to the availability of forage and balance the intake and expenditure of herding animals (73, 74). In Kyrgyzstan, mobility patterns correspond to movement up towards higher elevations during summer months and down to lower elevations during winter (75). In Mongolia, grazing territories shift in response to the productivity of pastures from year to year (76).

Many pastoralists also tend to keep a diversity of livestock, particularly in environments where there is niche partitioning for resources among different species. For example, cattle and sheep are predominantly grazers, while goats are browsers. Camels tend to browse at greater heights than goats. Yet it would be a mistake to assume

that pastoral livelihoods operate purely under ecological conditions – pastoral mobility is a livelihood structured around economic, ecological, socio-cultural and political dimensions. It is important to note that, in areas where pastoralists' livestock are sympatric with wildlife, such as in large parts of East, West, southern and Central Africa, pastoralists have to weigh 'planned mobility' decisions, such as where and for how long to graze in certain areas and allow grasses to recover, against 'unplanned mobility', in which wildlife (and other mobile grazers) may consume those resources that were left to recover (77).

Pastoral mobility, through flexibility, reciprocity and diversity, is supported by both formal and informal institutional arrangements. For example, in Rajasthan, India, pastoral mobility is essential to gain access to markets which serve as both economic and social centres (78). In Sahelian West Africa, pastoralists make informal arrangements with farmers after the crop harvest, in which pastoralist livestock consume agriculture residues and fertilise fields (79). Within groups, traditional conflict-resolution mechanisms exist to mediate access to grazing pastures (80, 81, 82). There is extensive use of social networks to support mobility, ranging from the use of cell phones to communicate where forage resources are located (83), to the use of motorcycle messengers to relay information on rest stops and mobility paths (84, 85).

Despite this, there are increasing constraints on pastoral mobility. The most common has been the continued loss of grazing land due to urbanisation (86), fragmentation (87), conversion to other land uses (64, 88), and the appropriation of land for conservation purposes (16), among others. Constraining mobility reduces the flexibility used to counter environmental variability. Traditional grazing lands used for coping with drought are considered 'off-limits' by conservationists, without understanding how these areas embody pastoral livelihoods and identities (89). In some cases, pastoralists have been forcefully evicted from traditional lands in efforts to preserve 'natural' habitats, in which pastoralists and their livestock were seen as destructive to the preservation of biodiversity (90).

In many parts of the world, pastoralism is being affected by increasing sedentarisation and reduced mobility (91). Where there has been a shift from collective to individual ownership of land, pastoralists have resorted to fencing off individual land parcels, reducing the size of their herds/flocks and diversifying their income sources (92). In areas where urban areas have expanded into pastoral areas, peri-urban livestock production has become common (93), with pastoralists raising dairy cattle and adopting zero-grazing production practices (94).

Labour and livestock management

Labour is the central and most demanding component of pastoral herd management. Labour is organised differently, depending on cultural (ethnicity, social organisation, class, gender), political (institutional arrangements, land tenure), economic (periodic stocking and destocking, markets, gifts, loans), and geographical (the spatial and temporal spheres of forage) attributes. Investments in labour have been closely tied to the quality of herding (16) and environmental conditions (95). Labour can be understood in a number of different ways, including human-hours, or energy expended (95). Some studies understand labour through decision-making strategies and the factors influencing herding strategies (16, 74, 96). These include the age and gender of the herder, the size and composition of the livestock herd, forage and water quality and quantity, the presence of hazards (high rivers, steep and rocky hills, predatory wildlife), prior and evolving knowledge (such as suggestions by elders or fellow herders), and whether the herder is hired or not. Generally, a higher quality of herding labour involves older and more skilled herders, with greater social networks of trust conveying knowledge of niche water and forage locations. High-quality herders are also cognisant of the individual and collective needs of livestock and alter the herding process to account for sick animals, or other problems that may occur. Lower-quality herders are often (but not exclusively) younger, less knowledgeable about the herding landscape, and have yet to build networks among fellow herders.

In many cases, pastoralists themselves own and manage livestock, both communally and individually, and pool their labour during times of stress. Herd splitting and re-joining is also a common strategy, in which younger animals are separated from healthier adults when animals have to migrate further distances in search of forage (97). Livestock raiding sometimes happens among pastoral communities, owing to a variety of reasons (98), but is often incorrectly diagnosed as being based on resource scarcity, rather than on underlying and long-neglected social and political tensions (99).

Across the world, there are a growing number of hired herders involved in the management process. This may take the form of, for example, Maasai pastoralists in southern Kenya being increasingly drafted into activities that offer more regular economic payments, such as tourism and cropping, to pay for inexpensive (and often less able) Maasai herders (100). In other cases, Fulbe and Maasina pastoralists, who have historically been livestock owners, are relegated to hired herders as capitalists from urban areas diversify into livestock keeping (101).

The quality of hired herding labour is determined, in part, by the level of remuneration offered by herd owners and additional incentives offered, such as gifts of sheep, goats and calves, in exchange for productive herding. Hired herders offer an alternative to pastoralists who seek to diversify their income sources without giving up livestock, which is still seen as a sustainable livelihood in the face of environmental and political uncertainty. Across West Africa, the nature of livestock production is changing, in that traditional Maasina pastoralists are becoming hired herders while livestock are owned by elite urban investors. Hence, there is little cultural pride in livestock husbandry and livestock are seen as little more than 'capital on the hoof' (95).

It is important to note that labour is a fluid component of pastoral systems. Labour is constantly organised and reorganised in relation to changing social, political, economic and ecological circumstances. While new institutional arrangements are altering traditional methods of herding labour, there remains a central focus on productivity and herd health, through various visible and less visible production practices. Labour production practices are highly gendered – for example, men and young boys are mostly responsible for herding livestock across the course of a grazing day and tend to focus on the veterinary care of animals, such as injecting livestock with trypanocides, washing cows with tick-removal solutions and helping with birthing (102). Less visible, but equally important, production practices undertaken by women revolve around caring for sick animals, milking, and monitoring calf and cow health (103). These practices are crucial for the maintenance of livestock production, but are often ignored by development practitioners who tend to (incorrectly) view pastoralism as being rooted in a patriarchal society (104, 105). Additionally, many states are encouraging pastoral children to attend schools, thus removing herding labour from the available pool of herders, now and in the future (106, 107). The implications of these labour shifts are not yet fully understood, though new research is beginning to tackle these questions.

Beyond disciplines, future directions and conclusions

As this review demonstrates, there has been a great deal of confusion and misunderstanding caused through disciplinary-based (mis-) understanding of people, livestock and the rangeland environment. These tensions can be partially overcome by paying more attention to cross-disciplinary approaches (108) and indigenous knowledge. Hence, there is an urgent need to better engage pastoralist communities, non-governmental organisations,

state officials and practitioners, to avoid the problems of the past and to prepare for a changing climate (109). The role and recognition of pastoral indigenous knowledge have received much attention (110, 111) and frameworks for harnessing pastoralists' indigenous knowledge for rangeland management are gaining widespread attention (112). For this to happen effectively, there needs to be greater communication, appreciation and understanding of different resource users and common goals (55). This can occur through the use of participatory mapping exercises (113, 114). Another example is the integration of joint service delivery in human and animal health, as seen in Chad (115). However, this type of approach has yet to be transferred to other parts of the world. Attention also needs to be given to the politics of dialogue, noting how certain actors and institutions benefit from development efforts while others do not, and to critical introspection of pastoral development worldwide (116, 117, 118).

This brief review has shown, firstly, how confusion surrounding the ecological dynamics of rangelands, and the role of people and livestock in influencing those dynamics, has led to poor understanding of pastoral herd management. It is now commonly accepted that non-equilibrium dynamics – that is, density-independent relationships – are most common in rangelands with a high degree of heterogeneity. Notions of 'overgrazing' and 'degradation' tend to be removed from the social and political factors influencing mobility. An understanding of environmental change in rangelands must go beyond simplistic narratives which have long surrounded pastoral peoples. ■

Secondly, an appreciation for non-equilibrium dynamics has gone hand in hand with recognition of the mobility paradigm. This review demonstrates the continued importance of pastoral mobility and points to the fact that, while metrics of mobility are an integral part of understanding mobility, they should not be the sole measure. Finally, it highlights the importance and fluidity of labour as a central concept in pasture and rangeland management. Traditional herding roles are increasingly changing, ranging from the use of hired herders to manage the herding process to shifts in livestock ownership, from pastoralists to urban capitalists.

Écologie, mobilité et travail : dynamique pastorale de la gestion des troupeaux dans un monde incertain

B. Butt

Résumé

L'auteur explique pourquoi la consonance du pastoralisme et de ses nombreuses composantes avec les transformations politiques et écologiques affectant les prairies est actuellement mieux perçue. Après avoir décrit les changements d'attitude décelables dans la littérature scientifique, il explique comment les pâturages s'adaptent au changement climatique et décrit les évolutions de l'utilisation des ressources animales. En outre, il rapporte que l'incidence sur la végétation des prairies de facteurs autres que la densité de bétail (c'est-à-dire les relations indépendantes de la densité) fait l'objet d'une attention accrue.

Il explique ensuite que les termes tels que « capacité de charge », « surpâturage » et « désertification » sont souvent utilisés en dehors de leur contexte social et politique pour décrire le pastoralisme. Il aborde ensuite la reconnaissance accrue de l'importance du modèle de mobilité par les acteurs du développement, en particulier en relation avec les évolutions écologiques et politiques. Enfin, il

explique que le travail est à la fois un aspect central de la gestion des troupeaux au sein du pastoralisme et une variable d'adaptation de ces systèmes face aux changements politiques et écologiques.

Mots-clés

Dégradation – Écologie basée sur le non-équilibre – Environnement – Mobilité des pasteurs – Pastoralisme – Politique – Travail.



Ecología, movilidad y trabajo. Gestión dinámica del rebaño ganadero en un mundo incierto

B. Butt

Resumen

El autor, tras explicar que el pastoreo y los numerosos elementos que lo constituyen gozan de un reconocimiento creciente, en sintonía con la evolución de la condición política y ecológica de los pastizales, examina cómo se ve reflejado este cambio de actitud en la bibliografía sobre el tema. También describe sucintamente cómo los pastizales responden a los cambios que registra el clima y examina la evolución del uso de los recursos ganaderos. Por otra parte, explica que cada vez se conocen y tienen en cuenta más factores, al margen de la densidad del ganado, que influyen en la vegetación de las tierras de pasto (esto es, relaciones independientes de la densidad).

El autor observa además que expresiones como «capacidad de carga», «pastoreo excesivo» o «desertificación» se utilizan a menudo desvinculadas de su contexto social y político al describir el pastoreo. Después señala que los profesionales del desarrollo son cada vez más conscientes de la importancia que reviste el modelo de movilidad, especialmente en relación con la evolución de las condiciones ecológicas y políticas. Por último explica que el trabajo, elemento central de la gestión de los rebaños ganaderos, constituye un componente fluido de los sistemas pastorales mediante el cual estos responden a los cambios que puedan experimentar las condiciones políticas y ecológicas.

Palabras clave

Degradación – Ecología del no equilibrio – Medio ambiente – Movilidad pastoral – Pastoreo – Política – Trabajo.



References

- Galvin K. (2009). – Transitions: pastoralists living with change. *Annu. Rev. Anthropol.*, **38** (1), 185–198. doi:10.1146/annurev-anthro-091908-164442.
- Herskovits M.J. (1926). – The cattle complex in East Africa. *Am. Anthropologist*, **28** (2), 361–388. doi:10.1525/aa.1926.28.2.02a00030.
- Ayantunde A.A., de Leeuw J., Turner M.D. & Said M. (2011). – Challenges of assessing the sustainability of (agro)-pastoral systems. *Livest. Sci.*, **139** (1–2), 30–43. doi:10.1016/j.livsci.2011.03.019.
- Rota A. & Sperandini S. (2009). – Livestock and pastoralists. International Fund for Agricultural Development, Rome, 1–8. Available at: www.ifad.org/irkm/factsheet/pastoralists.pdf (accessed on 16 February 2016).
- Sayre N.F., McAllister R.R.J., Bestelmeyer B.T., Moritz M. & Turner M.D. (2013). – Earth stewardship of rangelands: coping with ecological, economic, and political marginality. *Front. Ecol. Environ.*, **11** (7), 348–354. doi:10.1890/120333.
- Nassef M., Anderson S. & Hesse C. (2009). – Pastoralism and climate change: enabling adaptive capacity. Humanitarian Policy Group/Overseas Development Institute, London.

7. Bestelmeyer B.T., Okin G.S., Duniway M.C., Archer S.R., Sayre N.F., Williamson J.C. & Herrick J.E. (2015). – Desertification, land use, and the transformation of global drylands. *Front. Ecol. Environ.*, **13** (1), 28–36. doi:10.1890/140162.
8. Reid R., Fernández-Giménez M.E. & Galvin K.A. (2014). – Dynamics and resilience of rangelands and pastoral peoples around the globe. *Annu. Rev. Environ. Resour.*, **39** (1), 217–242. doi:10.1146/annurev-environ-020713-163329.
9. Reid R., Galvin K. & Kruska R. (2008). – Global significance of extensive grazing lands and pastoral societies: an introduction. In *Fragmentation in arid and semi-arid landscapes: consequences for human and natural systems* (K. Galvin, R. Reid, R.H. Behnke & N.T. Hobbs, eds). Springer, Dordrecht, the Netherlands, 1–24. doi:10.1007/978-1-4020-4906-4_1.
10. Hesse C. & Cotula L. (2006). – Climate change and pastoralists: investing in people to respond to adversity. Sustainable Development Opinion Paper. International Institute for Environment and Development, London. Available at: www.iied.org/pubs/pdf/full/11059IIEDpdf2006 (accessed on 16 February 2016).
11. Thornton P.K., Ericksen P.J., Herrero M. & Challinor A.J. (2014). – Climate variability and vulnerability to climate change: a review. *Glob. Change Biol.*, **20** (11), 3313–3328. doi:10.1111/gcb.12581.
12. Lovett J.C. (2015). – Modelling the effects of climate change in Africa. *Afr. J. Ecol.*, **53** (1), 1–2. doi:10.1111/aje.12218.
13. Sternberg T. (2010). – Unravelling Mongolia's extreme winter disaster of 2010. *Nomad. Peoples*, **14** (1), 72–86. doi:10.3167/np.2010.140105.
14. Fernández-Giménez M.E., Batkhishig B. & Batbuyan B. (2012). – Cross-boundary and cross-level dynamics increase vulnerability to severe winter disasters (dzud) in Mongolia. *Glob. Environ. Change*, **22** (4), 836–851. doi:10.1016/j.gloenvcha.2012.07.001.
15. Thébaud B. & Batterbury S. (2011). – Sahel pastoralists: opportunism, struggle, conflict and negotiation. A case study from Eastern Niger. *Glob. Environ. Change*, **11** (1), 69–78. doi:10.1016/S0959-3780(00)00046-7.
16. Butt B. (2011). – Coping with uncertainty and variability: the influence of protected areas on pastoral herding strategies in East Africa. *Hum. Ecol.*, **39** (3), 289–307.
17. Gomes N. (2006). – Access to water, pastoral resource management and pastoralists' livelihoods: lessons learned from water development in selected areas of Eastern Africa (Kenya, Ethiopia, Somalia). Livelihood Support Programme (LSP) Working Paper 26. Food and Agriculture Organization of the United Nations, Rome, 55 pp.
18. Lindsay W. (1987). – Integrating parks and pastoralists: some lessons from Amboseli. In *Conservation in Africa: people, policies, and practice* (D. Anderson & R. Grove, eds). Cambridge University Press, Cambridge, 149–167.
19. Fernández-Giménez M.E. (2000). – The role of Mongolian nomadic pastoralists' ecological knowledge in rangeland management. *Ecol. Applic.*, **10** (5), 1318–1326. doi:10.1890/1051-0761(2000)010[1318:TROMNP]2.0.CO;2.
20. BurnSilver S.B., Boone R.B. & Galvin K.A. (2003). – Linking pastoralists to a heterogeneous landscape: the case of four Maasai group ranches in Kajiado District, Kenya. In *People and the environment: approaches for linking household and community surveys to remote sensing and GIS* (J. Fox, C. Mishra, R. Rindfuss & S.J. Walsh, eds). Kluwer Academic Publishers, Boston, 173–199.
21. Ellis J.E., Coughenour M.B. & Swift D.M. (1993). – Climatic variability, ecosystems stability, and the implications for range and livestock development. In *Range ecology at disequilibrium: new models of natural variability and pastoral adaptation in African savannas* (R.H. Behnke, I. Scoones & C. Kerven, eds). Overseas Development Institute, London, 31–41.
22. Ellis J.E. & Swift D.M. (1988). – Stability of African pastoral ecosystems: alternate paradigms and implications for development. *J. Range Manag.*, **41** (6), 450–459. doi:10.2307/3899515.
23. Fernández-Giménez M.E. & Allen-Diaz B. (1999). – Testing a non-equilibrium model of rangeland vegetation dynamics in Mongolia. *J. Appl. Ecol.*, **36** (6), 871–885. doi:10.1046/j.1365-2664.1999.00447.x.
24. Sullivan S. & Rohde R. (2002). – On non-equilibrium in arid and semi-arid grazing systems. *J. Biogeogr.*, **29** (12), 1595–1618. doi:10.1046/j.1365-2699.2002.00799.x.
25. Desta S. & Coppock D.L. (2002). – Cattle population dynamics in the southern Ethiopian rangelands, 1980–1997. *J. Range Manag.*, **55** (5), 439–451. doi:10.2307/4003221.
26. Vetter S. (2005). – Rangelands at equilibrium and non-equilibrium: recent developments in the debate. *J. Arid Environ.*, **62** (2), 321–341. doi:10.1016/j.jaridenv.2004.11.015.
27. Sayre N.F. (2005). – Ecological and geographical scale: parallels and potential for integration. *Prog. Hum. Geogr.*, **29** (3), 276–290. doi:10.1191/0309132505ph5460a.
28. Von Wehrden H., Hanspach J., Kaczensky P., Fischer J. & Wesche K. (2012). – Global assessment of the non-equilibrium concept in rangelands. *Ecol. Applic.*, **22** (2), 393–399. doi:10.1890/11-0802.1.
29. Bayer W. & Waters-Bayer A. (2004). – Why is it so difficult to translate rangeland non-equilibrium theory into pastoral development practice. In *Rangelands at equilibrium and non-equilibrium: recent developments in the debate around rangeland ecology management* (S. Vetter, ed.). Papers from the International Workshop on 'Rangelands at Equilibrium and Non-equilibrium' held at the VIth International Rangelands Congress in Durban [South Africa], 26–27 July 2003. Programme for Land and Agrarian Studies (PLAAS), School of Government, University of the Western Cape/Rhodes University Botany Department/Leslie Hill Institute for Plant Conservation, Capetown, South Africa, 68–70.

30. Scoones I. (1994). – New directions in pastoral development in Africa. In *Living with uncertainty: new directions in pastoral development in Africa* (I. Scoones, ed.). Intermediate Technology Publications Ltd, London, 1–36. doi:10.1080/096145249100077821.
31. Middleton N. & Thomas D.S.G. (1997). – World atlas of desertification, 2nd Ed. Arnold, London.
32. Turner M.D. (1993). – Overstocking the range: a critical analysis of the environmental science of Sahelian pastoralism. *Econ. Geogr.*, **69** (4), 402–421. doi:10.2307/143597.
33. Scoones I. (1999). – New ecology and the social sciences: what prospects for a fruitful engagement? *Annu. Rev. Anthropol.*, **28**, 479–507. doi:10.1146/annurev.anthro.28.1.479.
34. Anderson D. (2002). – *Eroding the commons: the politics of ecology in Baringo, Kenya, 1890s–1963*. James Currey, Oxford.
35. Bollig M. & Schulte A. (1999). – Environmental change and pastoral perceptions: degradation and indigenous knowledge in two African pastoral communities. *Hum. Ecol.*, **27** (3), 493–514. doi:10.1023/A:1018783725398.
36. Roe E.M. (1997). – Viewpoint: on rangeland carrying capacity. *J. Range Manag.*, **50** (5), 467–472. doi:10.2307/4003700.
37. Heady H.F. & Child R.D. (1994). – *Rangeland ecology and management*. Westview Press, Boulder, Colorado.
38. Illius A.W. & O'Connor T.G. (1999). – On the relevance of nonequilibrium concepts to arid and semiarid grazing systems. *Ecol. Applic.*, **9** (3), 798–813. doi:10.1890/1051-0761(1999)009[0798:OTRONC]2.0.CO;2.
39. Sayre N.F. (2008). – The genesis, history, and limits of carrying capacity. *Ann. Assoc. Am. Geographers*, **98** (1), 120–134. doi:10.1080/00045600701734356.
40. Homewood K. & Rodgers W. (1991). – *Maasailand ecology: pastoralist development and wildlife conservation in Ngorongoro, Tanzania*. Cambridge University Press, Cambridge. doi:10.1017/CBO9780511525568.
41. Nkedianye D., de Leeuw J., Ogotu J.O., Said M.Y., Saidimu T.L., Kifugo S.C., Kaelo D.S. & Reid R.S. (2011). – Mobility and livestock mortality in communally used pastoral areas: the impact of the 2005–2006 drought on livestock mortality in Maasailand. *Pastoralism: Res., Pol., Pract.*, **1** (1), 1–17. doi:10.1186/2041-7136-1-17.
42. Begzsuren S., Ellis J.E., Ojima D.S., Coughenour M.B. & Chuluun T. (2004). – Livestock responses to droughts and severe winter weather in the Gobi Three Beauty National Park, Mongolia. *J. Arid Environ.*, **59** (4), 785–796. doi:10.1016/j.jaridenv.2004.02.001.
43. Fernández-Giménez M.E. (2001). – The effects of livestock privatisation on pastoral land use and land tenure in post-socialist Mongolia. *Nomad. Peoples*, **5** (2), 49–66. doi:10.3167/082279401782310862.
44. Little P.D. (1996). – Pastoralism, biodiversity, and the shaping of savanna landscapes in East Africa. *Africa: J. Int. Afr. Inst.*, **66** (1), 37–51. doi:10.2307/1161510.
45. Mwangi E. & Ostrom E. (2009). – Top-down solutions: looking up from East Africa's rangelands. *Environment*, **51** (1), 34–44. doi:10.3200/ENV.51.1.34-45.
46. McNaughton S.J. (1979). – Grazing as an optimization process: grass–ungulate relationships in the Serengeti. *Am. Naturalist*, **113** (5), 691–703. doi:10.1086/283426.
47. Noy-Meir I. (1973). – Desert ecosystems: environment and producers. *Annu. Rev. Ecol. Systemat.*, **4** (1), 25–51. doi:10.1146/annurev.es.04.1.10173.000325.
48. Skarpe C. (1991). – Impact of grazing in savanna ecosystems. *Ambio*, **20** (8), 351–356.
49. Georgiadis N.J. & McNaughton S.J. (1990). – Elemental and fibre contents of savanna grasses: variation with grazing, soil type, season and species. *J. Appl. Ecol.*, **27** (2), 623–634. doi:10.2307/2404307.
50. Hiernaux P., Biielders C.L., Valentin C., Bationo A. & Fernandez-Rivera S. (1999). – Effects of livestock grazing on physical and chemical properties of sandy soils in Sahelian rangelands. *J. Arid Environ.*, **41** (3), 231–245. doi:10.1006/jare.1998.0475.
51. Hiernaux P. & Turner M.D. (1996). – The effect of clipping on growth and nutrient uptake of Sahelian annual rangelands. *J. Appl. Ecol.*, **33** (2), 387–399. doi:10.2307/2404760.
52. Penning de Vries F.W.T. & Djiteye M.A. (1982). – *La productivité des pâturages sahéliens*. Centre for Agricultural Publishing and Documentation, Wageningen, the Netherlands.
53. Butt B. (2010). – Seasonal space-time dynamics of cattle behavior and mobility among Maasai pastoralists in semi-arid Kenya. *J. Arid Environ.*, **74** (3), 403–413. doi:10.1016/j.jaridenv.2009.09.025.
54. Powell J.M., Fernandez-Rivera S., Hiernaux P. & Turner M.D. (1996). – Nutrient cycling in integrated rangeland/cropland systems of the Sahel. *Agric. Syst.*, **52** (2–3), 143–170. doi:10.1016/0308-521X(96)00009-1.
55. Curtin C. & Western D. (2008). – Grasslands, people, and conservation: over-the-horizon learning exchanges between African and American pastoralists. *Conserv. Biol.*, **22** (4), 870–877. doi:10.1111/j.1523-1739.2008.00945.x.
56. Augustine D.J. & Frank D.A. (2001). – Effects of migratory grazers on spatial heterogeneity of soil nitrogen properties in a grassland ecosystem. *Ecology*, **82** (11), 3149–3162. doi:10.1890/0012-9658(2001)082[3149:EOMGOS]2.0.CO;2.
57. Muchiru A.N., Western D. & Reid R. (2009). – The impact of abandoned pastoral settlements on plant and nutrient succession in an African savanna ecosystem. *J. Arid Environ.*, **73** (3), 322–331. doi:10.1016/j.jaridenv.2008.09.018.

58. Riginos C., Porensky L.M., Veblen K., Odadi W.O., Sensenig R.L., Kimuyu D., Keesing F., Wilkerson M.L. & Young T.P. (2012). – Lessons on the relationship between livestock husbandry and biodiversity from the Kenya Long-term Exclosure Experiment (KLEE). *Pastoralism: Res., Pol., Pract.*, **2** (1), 10.
59. Turner M.D. (2011). – The new pastoral development paradigm: engaging the realities of property institutions and livestock mobility in dryland Africa. *Soc. Nat. Resour.*, **24** (5), 469–484. doi:10.1080/08941920903236291.
60. Hardin G. (1968). – The tragedy of the commons. *Science*, **162** (3859), 1243–1248. doi:10.1126/science.162.3859.1243.
61. Bassett T.J. (1986). – Fulani herd movements. *Geograph. Rev.*, **76** (3), 233–248. doi:10.2307/214143.
62. Niamir-Fuller M. (1998). – The resilience of pastoral herding in Sahelian Africa. In *Linking social and ecological systems: management practices and social mechanisms for building resilience* (F. Berkes, C. Folke & J. Colding, eds). Cambridge University Press, Cambridge, 250–284.
63. Niamir-Fuller M. (1999). – Managing mobility in African rangelands. In *Property rights, risk and livestock development in Africa* (J. McCarthy, B. Swallow, M. Kirk & P. Hazell, eds). International Food Policy Research Institute, Washington, DC/ International Livestock Research Institute, Nairobi, 102–131. doi:10.3362/9781780442761.
64. Yeh E.T. (2005). – Green governmentality and pastoralism in western China: converting pastures to grasslands. *Nomad. Peoples*, **9** (1–2), 9–30. doi:10.3167/082279405781826164.
65. Touré O. (2004). – The impact of pastoral legislation on equitable and sustainable natural resource management in Guinea. International Institute for Environment and Development, London.
66. Butt B. (2010). – Pastoral resource access and utilization: quantifying the spatial and temporal relationships between livestock mobility, density and biomass availability in southern Kenya. *Land Degrad. Develop.*, **21** (6), 520–539. doi:10.1002/ldr.989.
67. Moritz M., Soma E., Scholte P., Xiao N., Taylor L., Juran T. & Kari S. (2010). – An integrated approach to modeling grazing pressure in pastoral systems: the case of the Logone floodplain (Cameroon). *Hum. Ecol.*, **38** (6), 775–789. doi:10.1007/s10745-010-9361-z.
68. Adriansen H.K. (2008). – Understanding pastoral mobility: the case of Senegalese Fulani. *Geograph. J.*, **174** (3), 207–222. doi:10.1111/j.1475-4959.2008.00278.x.
69. Svoray T., Shafran-Nathan R., Ungar E.D., Arnon A. & Perevolotsky A. (2009). – Integrating GPS technologies in dynamic spatio-temporal models to monitor grazing habits in dry rangelands. In *Recent advances in remote sensing and geoinformation processing for land degradation assessment* (J. Hill & A. Roeder, eds). CRC Press, Taylor & Francis Group, London, 301–312.
70. Kawamura K., Akiyama T., Yokota H., Tsutsumi M., Yasuda T., Watanabe O. & Wang S. (2005). – Quantifying grazing intensities using geographic information systems and satellite remote sensing in the Xilingol steppe region, Inner Mongolia, China. *Agric. Ecosyst. Environ.*, **107** (1), 83–93. doi:10.1016/j.agee.2004.09.008.
71. Brottem L., Turner M., Butt B. & Singh A. (2014). – Biophysical variability and pastoral rights to resources: West African transhumance revisited. *Hum. Ecol.*, **42** (3), 351–365. doi:10.1007/s10745-014-9640-1.
72. Pettorelli N., Pelletier F., von Hardenberg A., Festa-Bianchet M. & Côté S.D. (2007). – Early onset of vegetation growth vs. rapid green-up: impacts on juvenile mountain ungulates. *Ecology*, **88** (2), 381–390. doi:10.1890/06-0875.
73. Coppock D.L., Ellis J.E. & Swift D.M. (1998). – Seasonal patterns of activity, travel and water-intake for livestock in South Turkana, Kenya. *J. Arid Environ.*, **14** (3), 319–331.
74. Coppolillo P.B. (2000). – The landscape ecology of pastoral herding: spatial analysis of land use and livestock production in East Africa. *Hum. Ecol.*, **28** (4), 527–560. doi:10.1023/A:1026435714109.
75. Fernández-Giménez M.E. & Le Febre S. (2006). – Mobility in pastoral systems: dynamic flux or downward trend? *Int. J. Sustain. Develop. World Ecol.*, **13** (5), 341–362. doi:10.1080/13504500609469685.
76. Fernández-Giménez M.E. (2002). – Spatial and social boundaries and the paradox of pastoral land tenure: a case study from postsocialist Mongolia. *Hum. Ecol.*, **30** (1), 49–78. doi:10.1023/A:1014562913014.
77. Butt B. (2014). – The political ecology of ‘incursions’: livestock, protected areas and socio-ecological dynamics in the Mara Region of Kenya. *Africa: J. Int. Afr. Inst.*, **84** (4), 614–637. doi:10.1017/s0001972014000515.
78. Agrawal A. (1999). – Greener pastures: politics, markets, and community among a migrant pastoral people. Duke University Press, Durham, North Carolina.
79. Turner M.D. (2006). – The micropolitics of common property management on the Maasina floodplains of Central Mali. *Can. J. Afr. Stud.–Rev. Canadienne Etudes Africaines*, **40** (1), 41–75.
80. Turner M.D. (1999). – No space for participation: pastoralist narratives and the etiology of park-herder conflict in southeastern Niger. *Land Degrad. Develop.*, **10** (4), 345–363. doi:10.1002/(SICI)1099-145X(199907/08)10:4<345::AID-LDR358>3.0.CO;2-8.
81. Turner M.D. (2004). – Political ecology and the moral dimensions of ‘resource conflicts’: the case of farmer–herder conflicts in the Sahel. *Polit. Geogr.*, **23** (7), 863–889. doi:10.1016/j.polgeo.2004.05.009.
82. Butt B. (2012). – Commoditizing the safari and making space for conflict: place, identity and parks in East Africa. *Polit. Geogr.*, **31** (2), 104–113. doi:10.1016/j.polgeo.2011.11.002.

83. Butt B. (2015). – Herding by mobile phone: technology, social networks and the 'transformation' of pastoral herding in East Africa. *Hum. Ecol.*, **43** (1), 1–14. doi:10.1007/s10745-014-9710-4.
84. Iselin L. (2014). – Translocal practices on the Tibetan plateau: motorised mobility of pastoralists and spatial transformations. *Nomad. Peoples*, **18** (1), 15–37. doi:10.3197/np.2014.180103.
85. Ikeya K. (2005). – Livestock economy and camel pastoralism among the Raika in India. In *Pastoralists and their neighbors in Asia and Africa* (K. Ikeya & E. Fratkin, eds). National Museum of Ethnology, Osaka, 171–185.
86. Goodall S.K. (2004). – Rural-to-urban migration and urbanization in Leh, Ladakh: a case study of three nomadic pastoral communities. *Mount. Res. Develop.*, **24** (3), 220–227. doi:10.1659/0276-4741(2004)024[0220:rmauil]2.0.co;2.
87. Galvin K., Reid R., Behnke R.H. & Hobbs N.T. (2008). – Fragmentation in semi-arid and arid landscapes: consequences for human and natural systems. Springer, Dordrecht, the Netherlands, 411. doi:10.1007/978-1-4020-4906-4.
88. Homewood K., Lambin E.F., Coast E., Kariuki A., Kikula I., Kivelia J., Said M., Serneels S. & Thompson M. (2001). – Long-term changes in Serengeti–Mara wildebeest and land cover: pastoralism, population, or policies? *Proc. Natl Acad. Sci. USA*, **98** (22), 12544–12549. doi:10.1073/pnas.221053998.
89. Shetler J.B. (2007). – *Imagining Serengeti: a history of landscape memory in Tanzania from earliest times to the present*. Ohio University Press, Athens, Georgia.
90. Brockington D. (2002). – *Fortress conservation: the preservation of the Mkomazi Game Reserve, Tanzania*. James Currey, Oxford.
91. Behnke R. (2008). – The drivers of fragmentation in arid and semi-arid landscapes. In *Fragmentation in semi-arid and arid landscapes: consequences for human and natural systems* (K.A. Galvin, R.S. Reid, R. Boone & N.T. Hobbs, eds). Springer, Dordrecht, the Netherlands, 305–340. doi:10.1007/978-1-4020-4906-4_13.
92. Galvin K.A. (2008). – Responses of pastoralists to land fragmentation: social capital, connectivity and resilience. In *Fragmentation in semi-arid and arid landscapes: consequences for human and natural systems* (K.A. Galvin, R.S. Reid, R. Boone & N.T. Hobbs, eds). Springer, Dordrecht, the Netherlands, 369–389. doi:10.1007/978-1-4020-4906-4_15.
93. Reid R., Gichohi H., Said M., Nkedianye D., Ogutu J., Kshatriya M., Kristjanson P., Kifugo S.C., Agatsiva J.L., Adanje S.A. & Bagine R. (2008). – Fragmentation of a peri-urban savanna, Athi-Kaputiei Plains, Kenya. In *Fragmentation in semi-arid and arid landscapes: consequences for human and natural systems* (K.A. Galvin, R.S. Reid, R. Boone & N.T. Hobbs, eds). Springer, Dordrecht, the Netherlands, 195–224. doi:10.1007/978-1-4020-4906-4_9.
94. Fratkin E. & Smith K. (1995). – Women's changing economic roles with pastoral sedentarization: varying strategies in alternate Rendille communities. *Hum. Ecol.*, **23** (4), 433–454. doi:10.1007/BF01190131.
95. Turner M.D. (1999). – Labor process and the environment: the effects of labor availability and compensation on the quality of herding in the Sahel. *Hum. Ecol.*, **27** (2), 267–296. doi:10.1023/A:1018725327873.
96. Sieff D.F. (1997). – Herding strategies of the Datoga pastoralists of Tanzania: is household labor a limiting factor. *Hum. Ecol.*, **25** (4), 519–544. doi:10.1023/A:1021829806765.
97. Butt B., Shortridge A. & WinklerPrins A.M.G.A. (2009). – Pastoral herd management, drought coping strategies, and cattle mobility in southern Kenya. *Ann. Assoc. Am. Geogr.*, **99** (2), 309–334. doi:10.1080/00045600802685895.
98. McCabe J.T. (2004). – *Cattle bring us to our enemies: Turkana ecology, politics, and raiding in a disequilibrium system*. University of Michigan Press, Ann Arbor, Michigan.
99. Derman W., Odgaard R. & Sjaastad E. (2007). – *Conflicts over land and water in Africa*. James Currey, Oxford.
100. Thompson M. & Homewood K. (2002). – Entrepreneurs, elites, and exclusion in Maasailand: trends in wildlife conservation and pastoralist development. *Hum. Ecol.*, **30** (1), 107–138. doi:10.1023/A:1014519113923.
101. Turner M.D. (2009). – Capital on the move: the changing relation between livestock and labor in Mali, West Africa. *Geoforum*, **40** (5), 746–755. doi:10.1016/j.geoforum.2009.04.002.
102. Bekure S., Leeuw P.N., Grandin B.E. & Neate P.J.H. (1991). – *Maasai herding: an analysis of the livestock production system of Maasai pastoralists in eastern Kajiado District, Kenya*. International Livestock Centre for Africa, Addis Ababa, Ethiopia.
103. Wangui E. (2008). – Development interventions, changing livelihoods, and the making of female Maasai pastoralists. *Agric. Hum. Values*, **25** (3), 365–378. doi:10.1007/s10460-007-9111-z.
104. Hodgson D.L. (1999). – Women's voices in a man's world: women and the pastoral tradition in northern Somali orature, c. 1899–1980. *Int. J. Afr. Histor. Stud.*, **32** (2–3), 426–427. doi:10.2307/220351.
105. Hodgson D.L. (2000). – *Rethinking pastoralism in Africa: gender, culture and the myth of the patriarchal pastoralist*. James Currey, Oxford.
106. Siele D., Swift J. & Kratli S. (2013). – Reaching pastoralists with formal education: a distance learning strategy for Kenya. In *Pastoralism and development in Africa: dynamic change at the margins* (A. Catley, J. Lind & I. Scoones, eds). Routledge, New York, 206–214.

107. Fratkin E.M., Roth E.A. & Nathan M.A. (1999). – When nomads settle: the effects of commoditization, nutritional change, and formal education on Ariaal and Rendille pastoralists. *Curr. Anthropol.*, **40** (5), 729–735. doi:10.1086/300093.
108. Hadorn G.H., Hoffmann-Riem H., Biber-Klemm S., Grossenbacher-Mansuy W., Joye D., Pohl C., Wiesmann U. & Zemp E. (eds) (2008). – Handbook of transdisciplinary research. Springer, Dordrecht, the Netherlands. doi:10.1007/978-1-4020-6699-3.
109. Reid R.S., Nkedianye D., Said M.Y., Kaelo D., Neselle M., Makui O., Onetu L., Kiruswa S., Kamuaro N.O., Kristjanson P., Ogutu J., Burn Silver S.B., Goldman M.J., Boone R.B., Galvin K.A., Dickson N.M. & Clark W.C. (2010). – Evolution of models to support community and policy action with science: balancing pastoral livelihoods and wildlife conservation in savannas of East Africa. *Proc. Natl Acad. Sci. USA*, **113** (17), 4579–4584. doi:10.1073/pnas.09003131106.
110. Jandreau C. & Berkes F. (2016). – Continuity and change within the social-ecological and political landscape of the Maasai Mara, Kenya. *Pastoralism: Res., Pol., Pract.*, **6** (1), 1–15.
111. Oba G. & Kaitira L.M. (2006). – Herder knowledge of landscape assessments in arid rangelands in northern Tanzania. *J. Arid Environ.*, **66** (1), 168–186. doi:10.1016/j.jaridenv.2005.10.020.
112. Oba G. (2012). – Harnessing pastoralists' indigenous knowledge for rangeland management: three African case studies. *Pastoralism: Res., Pol., Pract.*, **2** (1), 1–25. doi:10.1186/2041-7136-2-1.
113. Smith K., Barrett C.B. & Box P.W. (2008). – Participatory risk mapping for targeting research and assistance: with an example from East African pastoralists. *World Dev.*, **28** (11), 1945–1959. doi:10.1016/S0305-750X(00)00053-X.
114. Bett B., Jost C., Allport R. & Mariner J. (2009). – Using participatory epidemiological techniques to estimate the relative incidence and impact on livelihoods of livestock diseases amongst nomadic pastoralists in Turkana South District, Kenya. *Prev. Vet. Med.*, **90** (3), 194–203. doi:10.1016/j.prevetmed.2009.05.001.
115. Schelling E., Wyss K., Diguimbaye C., Béchir M., Taleb M.O., Bonfoh B., Tanner M. & Zinsstag J. (2008). – Toward integrated and adapted health services for nomadic pastoralists and their animals: a north–south partnership. In Handbook of transdisciplinary research (G. Hirsch Hadorn, H. Hoffmann-Reim, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann & E. Zemp, eds). Springer, Dordrecht, the Netherlands, 277–291. doi:10.1007/978-1-4020-6699-3_17.
116. Neumann R.P. (1995). – Local challenges to global agendas: conservation, economic liberalization and the pastoralists' rights movement in Tanzania. *Antipode*, **27** (4), 363–382. doi:10.1111/j.1467-8330.1995.tb00285.x.
117. Goldman M. (2003). – Partitioned nature, privileged knowledge: community-based conservation in Tanzania. *Dev. Change*, **34** (5), 833–862. doi:10.1111/j.1467-7660.2003.00331.x.
118. Goldman M. (2011). – The politics of connectivity across human-oriented landscapes: corridors near Nairobi National Park, Kenya. In Knowing nature: conversations at the intersection of political ecology and science studies (M. Goldman, P. Nadasdy & M. Turner, eds). University of Chicago Press, Chicago, 186–202. doi:10.7208/chicago/9780226301440.001.0001.