Food and Agriculture Organization of the United Nations

ISSN 0254-6019

Pastoralism

Making variability work

FAO ANIMAL PRODUCTION AND HEALTH / **PAPER 185**

FAO ANIMAL PRODUCTION AND HEALTH / **PAPER 185**

Pastoralism

Making variability work

Food and Agriculture Organization of the United Nations
Rome, 2021

Required citation:
FAO. 2021. *Pastoralism – Making variability work*. FAO Animal Production and Health Paper No. 185. Rome. https://doi.org/10.4060/cb5855en

ISSN 0254-6019 [Print]
ISSN 2664-5165 [Online]

ISBN 978-92-5-134753-9

Cover photo: ©Tendance Floue/Gilles Coulon

Contents

Acknowledgements

This document has been written by Saverio Krätli and Ilse Koehler-Rollefson, with support from Véronique Ancey, Badi Besbes, Serena Ferrari and Gregorio Velasco Gil from FAO's Animal Production and Genetics Branch.

The document has also benefited from the comments and guidance of many people at every stage of its production, during drafting of the proposal for the conceptual framework, at the 2019 Pastoralist Knowledge Hub (PKH) annual meeting of partners and on early versions of the document: Alejandro Acosta, Rob Allport, Arjun Avasthy, Wolfgang Bayer, Omar Benammour, Abdelkader Bensada, Martial Bernoux, Christophe Besacier, Guilherme Bradly, Edoardo CalzaBini, Mizeck Chagunda, Jean-Maurice Durand, Mohammad Emadi, Nadia El Hage Scialabba, Alberto Giani, Djedje Gnahoua, Fidaa Haddad, Tom Hammond, Ced Hesse, Pierre Hiernaux, Irene Hoffmann, Bernard Hubert, Barbara Jordan-Vicente, Brigitte Kaufmann, Abderrahmane Khecha, Kamal Kishore, Etienne Landais, Yon Fernandez Larrinoa, Michel Meuret, Marc Moens, Anne Mottet, Maryam Niamir-Fuller, Emmanuella Olesambu, AbdalMonium Osman, Suzanne Phillips, Ugo Pica-Ciamarra, Fred Provenza, Beate Scherf, Ahmed Shukri, Piers Simpkin, Salar Tayyib, Berhe Tekola, Bukar Tijani, Mirella Salvatore, Jeremy Swift, Gijs Van't Klooster, Andres Vater Rubio, Margret Vidar, Abdrahmane Wane, Ann Waters-Bayer, Liz Wedderburn.

The final version of the document was reviewed by Fidaa F. Haddad, Michael Ochieng Odhiambo and Vivian Onyango.

Acronyms and abbreviations

CFS	Committee for Food Security
FAO	Food and Agriculture Organization of the United Nations
GHG	greenhouse gas
GLEAM	Global Livestock Environmental Assessment Model
IFAD	International Fund for Agricultural Development
IGAD	Intergovernmental Authority on Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
JES	joint evaluation synthesis
OECM	other area-based effective conservation measures
PKH	Pastoralist Knowledge Hub
SDG	Sustainable Development Goal
UNEP	United Nations Environment Programme

Introduction

A recent foresight exercise conducted by FAO warns that "'business as usual' is no longer an option for a food-secure future. If food and agricultural systems remain on their current path, the evidence points to a future characterized by persistent food insecurity and unsustainable economic growth" (FAO, 2018). The report concludes that "high-input, resource-intensive farming systems that have caused massive deforestation, water scarcity, soil depletion, the loss of biodiversity, antimicrobial resistance of pests and diseases and high levels of greenhouse gas (GHG) emissions cannot guarantee the sustainability of food and agricultural systems ... Innovative systems are needed to increase productivity without compromising the natural resource base" (FAO, 2018a: xxvi, 156).

Recently, innovative and nature-based approaches have been receiving increased attention from many stakeholders as they consider ecological concepts and principles that optimize interactions among plants, animals, humans and the environment, while taking into account the social aspects that need to be addressed for sustainable food systems.

Pastoralism is such an innovative system: a time-tested, undervalued alternative path to food production that provides valuable lessons for the much-needed evolution towards "farming with nature"[1] and has largely untapped potential for income growth and employment in marginal areas, such as drylands and mountain areas. Estimates of the number of people involved in pastoral systems depend on the categories of pastoralism included (such as nomadic), but it can be assumed that the number of people raising livestock globally in pastoral and agropastoral systems exceeds 180 million (Kieta *et al.*, 2016: 18), living in approximately 75 percent of countries. Engaging with pastoralism has strong relevance to virtually all the Sustainable Development Goals (SDGs)[2] and is closely related to FAO's mandate on food security, equity in economic and social progress, and the sustainable management of the natural basis for food security (FAO, 2013). Three important and current global frameworks are also particularly relevant: the United Nations (UN) Decade on Ecosystem Restoration,[3] the UN Decade of Family Farming[4] and the UN Decade of Action on Nutrition.[5] Pastoralism has a key role to play in all of these frameworks.

This document is based on an extensive review of literature and policies. Two main points are made. First, pastoral systems[6] are emblematic of farming systems that work with nature: they have evolved to function *with the natural environment* and therefore *with variability.* Pastoral systems make use of variability in inputs (the short-notice and

[1] Unless specified otherwise, in this document, "farming" is used with its standard meaning of the activity or business of growing crops and raising livestock. "Agriculture" is used as meaning the science or practice of farming.

[2] SDGs 1, 2, 3, 4, 5, 13, 15, 16; see also Niamir-Fuller and Huber-Sanwald, 2019.

[3] Information available at https://www.decadeonrestoration.org/

[4] Information available at http://www.fao.org/family-farming-decade/home/en/

[5] Information available at https://www.un.org/nutrition/

[6] In this document the adjective "pastoral" is used to refer to systems, animals or products. When referring to people or groups the adjective "pastoralist" is used.

short-lived concentrations of valuable resources that occur in their natural environment) by matching it with variability in their own operational processes (for example, the capacity to move herds to the right place at the right time) in such a way as to reduce the variability of outputs (animal production and health, household food security, etc.). For this reason, pastoralism has great potential in addressing the SDGs in a scenario of climate change where variability and uncertainty are increasing globally. Second, pastoral systems have been looked at through the wrong "lens": conventional modelling and economic analysis of livestock production are locked into a view of the animal in isolation from the natural environment, and of variability as a constraint. This has contributed to the misreading of pastoralism and its potential.

After almost a century of interventions, poor understanding of pastoralism remains the most frequent cause of setbacks in pastoral development, often resulting in maladaptive practices that generate further misunderstanding in a vicious cycle (FAO, 2020; Oba, 2020). Acknowledging this weakness is a necessary first step that is routinely overlooked when practitioners leap into action. However, for a true understanding of pastoralism it is essential to be able to distinguish the features and practices that reflect its specializations from the effects of ill-informed policies and interventions, and pastoralists' adaptation or maladaptation to them.

By identifying an entry point in this entangled legacy, this paper aims to engage FAO in the mainstreaming of pastoralism – promoting FAO's corporate vision by generating an understanding of pastoralism and systematically including pastoralism in FAO's normal operations – and to present an evidence-based narrative on pastoralism for a specialist audience.

Since 2015, the Pastoralist Knowledge Hub (PKH) has created an institutional space for connecting and coordinating work on pastoralism in FAO, and an inter-departmental working group on pastoralism has been formed. The conceptual framework of this paper was discussed at the annual meeting of PKH partners in 2019 and early versions of the document have benefited from the comments and guidance of FAO staff and specialists in pastoralism worldwide.

SECTION 1

A specialization in taking advantage of variability

Based on the most up-to-date understanding and consistent with the Joint Evaluation Synthesis on FAO's and IFAD's Engagement in Pastoral Development 2003–2013 (JES) (IFAD and FAO, 2016) and FAOTERM,[7] pastoralism in this document refers to a wide family of livestock-based, livelihood and food production systems that are highly diverse but that all share a specialization in improving animals' diets (and welfare) by managing their grazing itineraries at a variety of scales in time and space. [8] Better nourished animals are healthier and more productive. Adding value by managing grazing itineraries requires adaptation to levels of variability that are characteristic of natural environments, especially the ways in which temporal and spatial variability in the distribution of moisture combines with the diversity of plant species and differences in soil and terrain morphology to result in sequences of short-lived concentrations of potential inputs. The place and time of such concentrations cannot be predicted from one year to the next, but the concentrations can be used by pastoralists who are able to arrive at the right place at the right time, and by animals that are able to benefit from the opportunities created by their herders. For this reason, pastoralism is also described as a specialization in taking advantage of variability.[9]

Pastoralism is essentially multifunctional, combining food production and livelihood systems with relatively little investment from outside. For livelihood systems in potentially rewarding but risky operating conditions, long-term reliability is critical and cannot be substituted with money (Roe, Huntsinger and Labnow, 1998). An example is the market-driven shift to cashmere production in Mongolia, which pushed pastoralists to favour short-term production strategies to exploit opportunities in the cashmere market (for example, by keeping mainly high-performance cashmere breeds), instead of long-term herd management strategies based on, for example, breed diversification. That shift, combined with other economic factors, has made producers more vulnerable to extreme winter-weather events (Murphy, 2019; Janes and Chuluundorj, 2015; Lkhagvadorj *et al.* 2013).

Critical reflection on pastoralism and development has made substantial steps forward over the last 20 years (Behnke, Scoones and Kerven, 1993; IUCN, 2012; Zinsstag, Schelling and Bonfoh, 2016), but the controversy is not over, and blends of old and new theories remain common. In light of this legacy, the relevant basis of public data and the

[7] FAOTERM, the FAO terminology portal, defines pastoralism as "an economy based on herding".

[8] See Kaufmann, Lelea and Hülsebusch, 2018. This understanding of pastoralism is consistent with the JES (IFAD and FAO, 2016) and with IFAD's recently developed knowledge tool on engagement with pastoralists (IFAD, 2018).

[9] This definition was first used in policy by the Government of Kenya: "pastoralism is an animal production system which takes advantage of the characteristic instability of rangeland environments, where key resources such as nutrients and water for livestock become available in short-lived and largely unpredictable concentrations" (Government of Kenya, 2012: Glossary).

©Santiago Carralero

Herders at Golog in Amnye Machen, 5 000 m in altitude, China.

methodologies used to produce them need to be assessed and adapted when it comes to addressing pastoral systems. For example, most indicators for measuring agriculture relate to sedentary crop farming and represent unpredictable variability in the natural environment as a constraint. It is therefore not advisable simply to increase engagement with pastoralism without also engaging with the problematic nature of the conceptual and operational framework currently available for doing so. Some interesting work in this direction is already under way on *had hoc* basis, for example concerning the methodology for calculating feed balance (Assouma *et al.,* 2018; FAO, 2020)

1.1. WORKING WITH THE NATURAL ENVIRONMENT

Pastoralism can be categorized as agroecological practices. A broad range of examples of the circular relationship between pastoralism and the natural environment, as sward for species diversity, pollination and manuring, are provided in the next section. In fact, all the ten elements proposed by FAO (2018b) as defining agroecological practices are present in pastoralism. Pastoralism relies on a *diversity* of species, animal breeds and plant varieties. It takes advantage of the *synergies* between ruminants and rangelands through the mobility of the animals and their adaptability to very seasonal precipitation and forage availability, which makes it *resilient*, and it *recycles* energy and nutrients from manure into fertilizers for pastures and crop fields, and crop residues and by-products as feed. As a consequence, pastoralism is an *efficient* system that produces high-quality protein and essential services with a minimum of resources. Pastoralism is built on shared *human and social values* as it relies on communities and families working together. It has strong *cultural and food traditions* associated with centuries of existence and evolution, which have been built through continuous *co-creation and sharing of knowledge*. Pastoral systems are often found in remote areas and rely on strong *circular and solidarity economies*, engaging producers and consumers, but also suppliers in short value chains. Finally, sustainable pastoralism requires *responsible governance* of rangelands, water and animal resources that ensures access to markets, products and services for pastoralists.

Pastoralism is based on close interactions among animals, humans and their environment (FAO, 2018a). In this document, this characteristic is referred to as working *with* the natural environment,[10] not simply extracting fodder or water but actually increasing resources for livestock, and doing so in ways that make the circular interaction with the ecosystem a constitutive part of the pastoral system itself (IIED, 2015). It could be said that such a relationship with the ecosystem is to pastoralism what the relationship with the wind is to a sailing boat: an essential aspect of what defines it and makes it work. The productivity of a pastoral herd rises *because* of the animals' and the herder's active engagement with the ecosystem. As ecosystems differ from the Arctic to the savannah, the resulting practices also differ, but the underlying logic is the same.

For example, pastoralists in the Sahel try to follow the rains. By moving south to meet the rains at the beginning of the rainy season, and then following them north as the season progresses, the herders' animals can stay on green pasture for longer than would be possible in any of the locations they visit, effectively "stretching the rainy season" in the experience of the herd (Breman and De Wit, 1983; Schareika, 2003; Thébaud *et al.* 2018). At the end of the rainy season, herds move to areas with permanent access to water, trying to secure access to good-quality dry fodder or crop residues, failed crops and fallow land. This is managing grazing itineraries at the macro-scale.

At smaller scales, for their livestock, pastoralists take advantage of concentrations of nutrients that are associated with biodiversity, or with differences in soils (for example, grass grows earlier on sandy dunes than on clay soil) or terrains, or between day and night (grass is more nutritious after a day of photosynthesis), or in the life cycle of the plant (for example, in annual plants nutrients peak just before flowering – Hiernaux and Turner, 1996). Feeding on certain combinations of plants can also improve the extraction of nutrients. Shepherds in the French Alps design the daily itinerary of their flocks with a view to stimulating the animals' appetite. They increase the quality of grazing by management, and in doing so they save money on feed supplement (Meuret and Provenza, 2014). A similar strategy aimed at influencing livestock's feeding behaviour has recently been documented among cattle herders in Hungary (Molnár *et al.,* 2020).

Animals learn to engage with their environment and can be taught how to do so.[11] Pastoralists pay great attention to their animals' behaviour and skills, trying to influence and improve them and secure their continuity in the breeding population (Krätli, 2008). Production systems centred on proved knowledge and integrated landscape management offer great latitude for creating "health" for soil, plants, wild and domestic animals, people and the climate (Provenza, 2018).

---

[10] The notion of *natural* environment is not without problems. First, it is not the only dimension of "environment"; social environments too have to be matched and people's experience of the natural environment is generally mediated by a social interface. Second, *resources* qualified as "natural" almost always entail work or human presence (e.g. water in ponds and wells, even the particular composition and distribution of biodiversity of the rangelands). In addition, the word "resource" refers to a relationship rather than an object: even natural resources are resources only in as much as they are of use to someone (Kallis, 2019; Bathelt and Glückler, 2005). In this text, "natural" is used within these limits.

[11] Behavioural Education for Human, Animal, Vegetation and Ecosystem Management (BEHAVE), a research and outreach programme at Utah State University in the United States of America, specializes in training livestock in diet and habitat selection (http://www.behave.net). For an overview on the principles behind this work, see Provenza, 2018.

BOX 1

Variability in inputs and variability in processes

Dryland food production systems, including pastoralism, have co-evolved with highly variable conditions. They have learned to harness the opportunities offered by environmental variability by integrating variability into their processes of production. In fact, pastoralists use highly variable inputs (such as pastures and water) and manage to obtain relatively stable outputs (such as milk and meat production) throughout the year. In this logic, access to a variable range of locations, even if relatively uncertain, is better than secure access to just one location; keeping a variety of species in a herd, or of crops in fields, is better than keeping just one species or crop; integrating crops and livestock at a variety of spatial and temporal scales is better than integration at just one scale (for example, seasonal or intermittent crop–livestock integration among specialist groups is better than permanent integration at the farm level). Where variability is the norm, adapting activities to work with variability rather than against it leads to higher productivity and more resilience.

Source: MISEREOR. 2019. Pastoral Development Orientation Framework Aachen, Germany, Development Agency of the German Catholic Bishops' Conference (MISEREOR). www.misereor.org

1.2. MAKING VARIABILITY WORK

Pastoralism takes advantage of the variability in potential inputs – which are maximized and turned into actual inputs – by matching it with the variability (or "flexibility" or "optionality")[12] in its own operational processes. Mobility and flexible land tenure systems are the most obvious examples of variability embedded in the operational processes of pastoralism. Other examples are the matching of livestock reproductive cycles with expected resources, or the circular economy of crop–livestock integration – achieved through seasonal or intermittent contact between specialized groups of pastoralists and farmers[13] – and increasingly of new forms of rural–urban linkages through youth migration and the investment of pastoral surpluses in periurban or town-based businesses (Ancey *et al.,* 2020; Catley, Lind and Scoones, 2012; Gertel and Le Heron, 2011).

Studies of livestock breeding systems in pastoral contexts found that animals are deliberately bred for variability, albeit not random. There is selection for "best types", but attention to avoiding uniformity. A "good herd" should have several types of animals: a variety

[12] "Flexibility" is used in the literature on crop farming (Mortimore and Adams, 1999). "Optionality" comes from the language of finance (Taleb, 2012). Both terms refer to the creation of an operational space in the face of uncertainty, where the available knowledge is too little for prediction.

[13] In environments driven by variability, pastoral mobility allows for intermittent crop–livestock integration at a variety of scales over time and space and without compromising specialization (Schiere *et al.*, 2006: 10; Scoones and Wolmer, 2002; Landais and Lhoste, 1990). This particular form of crop–livestock integration is also described in Seré and Steinfeld (1996: 19): "pastoralists have developed arrangements with crop farmers, whereby the pastoralists have access to the crop residues and crop producers benefit from the recycling of nutrients to the soil via animal manure. Both the crop and the animal system are managed by distinct decision makers, but decisions are closely interrelated".

BOX 2

Regenerative agriculture and pastoralism

Plants turn dirt into soil, and diverse arrays of plants turn soil into homes that nurture herbivores, omnivores and carnivores below and above ground. Regenerative agriculture uses scientific understanding of these processes to enhance the viability of soil, with little need for fossil fuels and their associated greenhouse gas (GHG) emissions to produce fertilizers, herbicides and pesticides for growing and protecting crops. In nature, plants produce diverse arrays of compounds (phytochemicals) that serve as fertilizers, herbicides and pesticides. Phytochemicals also engender the health of animals and humans, removing the need for the nutrition supplements and pharmaceuticals used in contemporary agriculture and food processing. When applied to raising crops and managing grazing, knowledge of these processes can enhance the water-holding capacity and fertility of soils and mitigate climate change by fixing carbon in soil and reducing emissions of methane from livestock. By managing grazing to create diverse arrays of phytochemically rich plants (including as rangeland, pasture and crops), livestock producers practising regenerative agriculture increase profitability by enhancing the health of soil, plants, animals and humans. Using principles that mimic the processes of nature, they are departing from the current industrial perspective to one of working with nature to enable ecological processes and environmental health. In light of this trend in transforming the ways of agriculture, pastoral systems around the world are at the forefront of "modern" farming and grazing practices.

Source: Fred Provenza, Professor Emeritus, Department of Wildland Resources, Utah State University, United States of America.

of species, but also within-breed diversity, with a variety of capacities to make the most of variable opportunities (Kaufmann, 2007; Krätli, 2008).

This distinction between variability in inputs and variability in processes is critical to understanding the logic of pastoralism. Embedding variability in the operational processes of the pastoral system so as to match the variability in inputs in the system's environment can produce an experience of stability relative to the "here and now" of the herd, and correspondingly lower the variability in outputs. In the example of "stretching the rainy season", the herds experience a relative stability in the availability of inputs by being moved strategically through a sequence of short-notice and short-lived (i.e., highly variable) concentrations of potential inputs.

Innovative approaches inspired by agroecological principles, such as holistic management and regenerative grazing, effectively move "modern" animal husbandry closer to pastoralism, building on the same logic of biomimicry and working with the ecosystem.

1.3. A "VANTAGE POINT" AND BASIS FOR DISCUSSION ON ADDRESSING CLIMATE CHANGE

The predominant approach to pastoral development has been to represent environmental variability as an obstacle, as is still common today. Pastoralists' ways of matching their processes to input variability in order to increase the productivity of their herds – for example, through mobility or diversification – have been understood in negative terms as ways of coping with a hostile environment.[14] However, the representation of variability, especially the shift from seeing it as an anomaly to acknowledging its normality, has been at the centre of the major theoretical transformation in ecological sciences since the 1970s. Examples are provided in the next section.

This alternative understanding of pastoral systems as specialized in engaging with highly variable natural environments has been interwoven into a much larger theme of reflection on variability/uncertainty and the role of the environment, encompassing a great range of disciplines within the scientific community.[15] In the latest development, pastoral systems are described as "managing non-measurable uncertainties well beyond the capabilities of formal risk methodologies … a key service … foundational to the world economy in times of great uncertainty and complexity" (Roe, 2020).

Pastoralism's specialist approach makes it not only a sustainable livestock system, but also a vantage point from which to obtain a particularly clear and open view of the much-needed reconsideration of agriculture and food systems in relation to resilience and climate change. Around the world, pastoral systems have effectively managed to produce food *with* the natural environment rather than in antagonism with it. This alone deserves attention and the mobilization of efforts to better understand, secure and promote the specialization of pastoralism.

[14] See the discussion of "pastoral risk" in Krätli, 2016: 489–490.

[15] With examples in ecology – resilience thinking (Berkes, Colding and Folke, 2003); biology – epigenetics (Jablonka and Lamb, 2005); economics – the circular economy and "doughnut economics" (Raworth, 2017); policy analysis – work on high-reliability organizations (Roe, Huntsinger and Labnow, 1998; Roe, 2020); and agricultural science – "ecoagriculture" (Scherr and McNeely, 2007), "systemic perspectives" (Bawden, 2007), "agri-culture" (Pretty, 2002) and "sustain*agility*" (Jackson *et al.*, 2010). See also Ancey, Avelange and Dedieu (2013) on uncertainty in agriculture and recent reviews by Scoones (2019) and Nori (2019).

SECTION 2

Need for a new understanding

As people's view depends on the "lens" through which they look, a critical assessment of the various lenses available would seem to be a prerequisite for any project of knowledge generation, especially when looking in unfamiliar directions. Pastoral systems have long been viewed through the wrong lens. As shown in the previous section, such approaches have generally led to a view of variability as inherently problematic and, even more significantly, they have focused the view of animal husbandry on the animal in isolation from the natural environment.

Being conditioned to view variability as a problem has led pastoral development actors to try to replace it with stability and uniformity. Efforts in this direction made no distinction between variability in inputs (the environment) and variability in processes (the pastoral system) and concentrated on changing the pastoral system by reducing or eliminating mobility. Other common examples from the history of pastoral development include practising indiscriminate cross-breeding with exotic breeds optimized in relation to a few genetic traits, to the detriment of the complex epigenetic specialization of pastoral livestock populations; promoting rigid and exclusive ownership that undermines the traditional flexible governance frameworks of pastoral lands; and promoting uniform crop–livestock integration at the farm scale, undermining the multi-scale forms of crop–livestock integration among specialist groups of producers, as found in pastoral regions.

Focusing consideration of animal production on the animal has had equally far-reaching consequences, especially as the natural environment then becomes by default an economic outer space for externalities. These "lenses" go a long way back, to the origins of animal production as a scientific discipline during the industrial revolution in mid-nineteenth century Europe. The new discipline of animal science combined rural economy, "hygiene" and zoology into a programme committed to the values of industrial agriculture (Porcher, 2017; Jussiau, Montméas and Parot, 1999; Landais and Bonnemaire, 1996; Russell, 1986). A crucial novelty was the project of "emancipating" animal husbandry from the natural environment.

©Shepherds School Inland/Federico Marquez

Shepherds of Picos de Europa, Asturias, Spain.

2.1. BEYOND THE "UNIVERSAL" THEORY OF AGRICULTURAL EVOLUTION

Since its origins and into the 1950s, animal science represented the animal as a machine,[16] and even since then system boundaries have been drawn around the animal, modelling it as a metabolizing device of which the inputs and outputs can be measured and optimized (Spedding, 1988).

This conceptual framework, designed to keep the natural environment out of sight, has been the default blueprint for the analysis and representation of pastoral systems in development. With this perspective, pastoralism is comprehended as a precursory stage in a universal theory of agricultural evolution. In the words of scientist Hans Jahnke of the International Livestock Centre for Africa (ILCA):[17] "From the point of view of agricultural evolution pastoralism belongs to the same pre-machine category of land use as shifting cultivation … long-range migration as a form of adaptation to ecology in a pre-technical world in one case [pastoralism], and the application of modern technology in an artificially controlled environment in another [animal science]" (Jahnke, 1982).

Animal scientists working with livestock keepers in highly variable environments have become aware of the limitations of their "environment-blind" model, and have made efforts to address it by introducing new parameters such as "productive adaptability" or "on-farm performance" (Bonsma, 1949; Horst, 1983; Peters, 1989; Lemke *et al.,* 2005). These improvements have helped to operationalize the general model in tropical settings, but they have not resulted in a positive understanding of a relationship with the natural environment or variability, nor have they improved the representation of pastoralism in the context of development. The understanding of animal production as hingeing on an emancipation from nature, which is still at the core of animal science, continues to translate, even today, into an understanding of pastoral development as emancipation from pastoralism (development *out* of pastoralism).[18]

---

[16] Robert Bakewell (1725–1795), considered to be the "father" of modern animal husbandry in the United Kingdom of Great Britain and Northern Ireland, famously described sheep as "a machine for turning grass into mutton" (Porter, 1982; see also Russell, 1986). The metaphor was used in animal science in the United States of America at the beginning of the twentieth century. Thomas Shaw, expert in animal husbandry at the University of Minnesota, argued in his *Animal Breeding* (1901) that livestock should be viewed as "machines for manufacturing agricultural products into forms more concentrated and possessed of a higher value", while Carl Warren Gay, professor of animal industry at the University of Pennsylvania, talked of "the animal machine" in his 1914 *The Principles and Practice of Judging Live-Stock* (in Knapp, 2019). In France, early definitions of animal science by its founders consistently refer to animals as machines: Eugène Baudement (1816–1863): "Animals are living machines, not as a figure of speech but in the most rigorous sense of mechanics and industry"; André Sansom (1826–1902): "The 'zootechnie' is the science of production and exploitation of living machines"; Raoul Baron (1852–1908), "animal scientists are the engineers of the living machine, the production and operation of which they oversee"; Martial Laplaud (1883–1971): "The aim of animal science is to teach theory and practice of the means of earning money from domestic animals"; André-Max Leroy (1892–1978): "The purpose of animal science is the study of the laws through which [to] secure returns from capital by the mediation of animals" (quoted in Jussiau, Montméas and Parot, 1999; Porcher, 2017). The metaphor became truly unpopular following the publication of Ruth Harrisons' *Animal Machines* in 1964 denouncing animals' living conditions in intensive agriculture.

[17] Now known as the International Livestock Research Institute (ILRI).

[18] "Development *out* of pastoralism" is explained in MISEREOR (2019). In discussing the theory of change for new projects, the International Fund for Agricultural Development's (IFAD's) recent guidelines for a holistic approach to pastoral development warn that: "Encouraging people to move out of pastoralism may lead to greater poverty" (IFAD, 2018: 25).

2.2. A DISTINCT APPROACH TO PRODUCING FOOD WITH LIVESTOCK

During the long history of pastoral development policies and interventions, the phenomenon of pastoralism has conventionally been represented through a model that does not actually model it at all. The consequences of this practice are far reaching, even conceding that many of the professionals working with pastoralists have tried their best to adapt the model to reality. Many more have expected reality to fit the model.

Pastoral systems are better conceptualized as a distinct trajectory of evolution in the economic use of livestock and an altogether alternative approach, rather than a subset within a dominant typology of animal production based on a project of emancipation from the natural environment.

Eventually, the conceptual framework for animal science will need to be expanded and transformed in order to effectively represent this alternative trajectory. Although technological innovation was first mobilized to serve the project of emancipating animal production from nature, it can just as well be put to work in support of farming *with* nature. Pastoralism is perfectly compatible with modernization.[19] In fact, pastoralism is setting the course for the future, as all livestock production will eventually have to work with the natural environment.[20] This might seem unlikely, but persisting with an outdated understanding of modernization as fossil fuel-based emancipation from nature seems even less possible in light of the small margin of manoeuvre left even just to keep global warming within an increase of 1.5 °C (IPCC, 2018).

Many of the questions that over the years have proved so difficult to answer, generating an impression of pastoral systems as being too messy to work with, originated from looking at it with the wrong lens. Asking the right questions would stimulate the right answers from pastoralism.

2.3. CURRENT SIGNIFICANCE OF PASTORALISM

Pastoralism is the predominant – often the only possible – food production strategy in the world's permanent grasslands, which cover approximately two thirds of agricultural land globally (FAO, not date), and interacts seasonally with other landscapes and ecosystems such as crop farming, forests or wetlands. No reliable global figures, and extremely few longitudinal data sets, are available on the magnitude of pastoral systems according to official definitions. Numbers for the livestock sector are often based on old estimates that are mechanically updated (Salmon *et al.,* 2019; Behnke, 2010; Jerven, 2013). Estimates of the global number of people in pastoral systems depend on the categories that are included (such as nomadic, transhumant or agropastoralist) and how those categories are defined (for example, their degree of mobility, associated land tenure systems and degree of diversification). All figures being admittedly speculative, a recent review produced within the framework of the Global Strategy to Improve Agricultural and Rural Statistics reckons

[19] The opportunities effectively available to pastoralists are still scant, but examples are well documented from the Islamic Republic of Iran to Kenya and the Sudan to Mongolia, and ranging from the use of motorized vehicles, portable water pumps and water bladders served by cystern-trucks, to mobile banking and Geographic Information Systems (GIS) mapping. Recent examples include CENESTA and Global Forest Coalition (2017), Vogelsang (2019) and Seid *et al.* (2016).

[20] As part of what Hubert and Ison (2011) refer to as "a paradigm shift from resource sufficiency to functional integrity".

BOX 3
Pastoralism

"Pastoralism is a livestock-keeping system that specialises in taking advantage of environmental variability, managing grazing itineraries at a variety of scales so that livestock feed better than without a herder". As in any other definition, a relatively neat boundary is functionally created from a reality where the boundaries are inevitably porous and blurred.

Source: MISEREOR. 2019. Pastoral Development Orientation Framework, Aachen, Germany, Development Agency of the German Catholic Bishops' Conference (MISEREOR). www.misereor.org

that "the global total is likely to be considerably greater … than 180 million" (Kieta *et al*., 2016: 18).[21]

Many administrations traditionally fragment pastoral systems into subcategories of producers according to artificial parameters[22] such as degree of mobility or degree of involvement in crop farming, and this contributes to confusion about their magnitude. In its 2019 report, the Intergovernmental Panel on Climate Change (IPCC) reckons that: "Due to the widespread diffusion of pastoralism, improved grassland management may potentially affect more than 1 billion people, many of them under subsistence agricultural systems" (IPCC, 2019: 303).

Based on the definition formulated in the previous section, "pastoral systems" include all herder-operated livestock production or livelihood systems specialized in working *with* the natural environment, whatever their level of specialization or degree of diversification (such as the inclusion of crop farming, trading, etc.). Mobility is key to making the most of variable environments, and these alternative "lenses" are likely to have relevance not only for pastoralism but also for "livestock" questions in general, which have also proved difficult to answer in contexts where isolating the animal from the environment has not been a viable option (Pica-Ciamarra *et al.,* 2014).

[21] See also Johnsen *et al.* (2019) on the general poverty of data on pastoralism, and Jerven (2013) on public data in Africa.

[22] In this document, the degree of mobility and involvement in crop farming are referred to as "artificial parameters" because neither are in reality discrete and permanent traits: rigid boundaries between farming and herding are a methodological artefact (Toulmin, 1983; Marty, 1999), and mobility matters in pastoralism for its *function* not for its degree. More importantly, as explained in the previous section, it is the *variability* of processes that matters in pastoral systems, not their stability.

SECTION 3

Pastoralism provides a host of benefits

By working *with* nature, pastoralism represents an alternative perspective and a promising avenue for innovation in addressing a multitude of global challenges, with great potential to deliver on the SDGs.[23]

3.1. CLIMATE CHANGE

Pastoralism has the potential to contribute to both adaptation to and mitigation of climate change.[24] Pastoralism requires little fossil energy and is solar powered, as animals walk to their naturally grown feed instead of having it cultivated and transported to them.

Much attention and research have centred on GHG emissions from ruminant production systems, with particular focus on methane. There are technical and methodological challenges with transferring to systems that work with the variability of the natural environment, such as pastoralism, models that have been developed for assessing the GHG emissions of animal production systems that operate with the logic of isolating from such variability.[25] Although few if any life-cycle assessments of pastoral systems exist, the implicit assumption has always been that such systems cause relatively high methane emissions per unit of food produced because of the animals' fibrous diets.

Recent research sheds doubt on this set of inferences, from several angles. Primarily, findings on GHG emissions vary depending on the methodologies used. In addition, the various life times of different GHGs matter. For example, while methane is relatively short-lived, with a life time of 12 years in the atmosphere, where it is partly taken up by plants, the rate of carbon dioxide (CO_2) emissions from fossil fuel combustion currently greatly exceeds the rate of CO_2 removal, indicating that it will remain in the atmosphere considerably longer than that (Allen *et al.,* 2018). Moreover, carbon from fossil fuels is typically extracted from an inert form underground, whereas methane from ruminants comes mainly from carbon that has already been circulating in the atmosphere. Thus, for all livestock

[23] For a summary of general livestock-related contributions to the SDGs, see FAO (2018a).

[24] Neely, Bunning and Wilkes (2009). The IPCC report (IPCC, 2019: 7–108) finds that "In dryland environments, populations have historically demonstrated remarkable resilience and innovation to cope with high climatic variability, manage dynamic interactions between local communities and ecosystems, and sustain livelihoods… There is high confidence that pastoralists have created formal and informal institutions based on [Indigenous Local Knowledge] for regulating grazing, collection and cutting of herbs and wood, and use of forests across the Middle East and North Africa … Mongolia … the Horn of Africa … and the Sahel… Herders in both the Horn of Africa and the Sahel have developed complex livestock breeding and selection systems for their dryland environment".

[25] As higlighted in the work of the Livestock Environmental Assessment and Performance (LEAP) Partnership (http://www.fao.org/partnerships/leap/en/) and related efforts to develop a Global Livestock Environmental Assessment Model (GLEAM) (http://www.fao.org/gleam/en/).

systems, there is a reconsideration of the relative warming effects and dangers of methane compared with CO_2.

A shift in scale from a focus on the animal to inclusion of the whole ecosystem involved in production – the appropriate scale of observation in the case of pastoralism – triggers even more dramatically different results, as methane emissions are offset by carbon sequestration in the grasslands and overall landscapes with which pastoralists interact. A new ecosystem assessment method was recently used to measure the carbon footprint of a pastoral production system in the Sahel. With measurements at the scale of the overall pastoral system, rather than focusing exclusively on animal impact, per-hectare emissions were found to be neutral (Assouma *et al.,* 2019a; 2019b).

Some analysts also argue that when ruminants are removed from grasslands, termites can be expected to move into the empty ecological niche, leading to higher GHG emissions (Gomati *et al.,* 2011; Brümmer *et al.,* 2009; Manzano and White, 2019).

While many questions are thus still open regarding the climate-mitigating potential of pastoralism, its potential for adaptation is well documented and increasingly recognized (Hoffmann, 2010; UNEP, 2011; McGahey *et al.,* 2014; Niamir-Fuller, 2016). The 2019 IPCC report, with 110 mentions of pastoralism, clearly takes a substantial interest.

3.2. ECONOMIC CONTRIBUTION AND EMPLOYMENT

The economic value of pastoralism is poorly captured by current mechanisms of appraisal, and public data on the percentage of livestock reared in pastoral systems are often uncertain (Kieta *et al.,* 2016; Johnsen *et al.,* 2019). The general impression is that the contribution of pastoralism to the economies of many countries is significant, especially in Africa but also elsewhere (IFAD, 2018; CELEP, 2017; Robinson, Conchedda and de Haan, 2016; ILRI, 2013; World Bank, 2013; Davies and Hatfield, 2007). A recent application of the "total economic valuation approach" to Kenya's pastoral sector revealed an economic value of USD 1.13 billion per year, with the livestock and non-livestock sectors accounting for 92 percent (USD 1.04 billion) and 8 percent (USD 0.0903 billion) respectively (Nyariki and Amwata, 2019). In the Sudan, as of 2011, pastoral livestock was by value the largest subsector in the domestic economy, more important even than petroleum (Behnke, 2012). In Mongolia, the livestock industry based on pastoralism accounts for 90 percent of agricultural production (IMF, 2019). In the Islamic Republic of Iran, an estimated 40 percent of the country's 25 million goats are kept in pastoral systems (Ansari-Renani *et al.,* 2013). Some 2.5 million semi-domesticated reindeer are kept in pastoral systems in the northern regions of Eurasia. In Norway, with a national herd of about 250,000, reindeer meat production generated an income of more than USD 11 million in 2014 (Glomsrød, Duhaime and Aslaksen, 2017). For India, the world's largest producer of milk and largest exporter of beef and small-ruminant meat, it has been estimated that livestock kept in pastoral systems contributes more than 70 percent of total meat output and more than 50 percent of milk output (LIFE Network, 2016). A recent study of Ethiopia's lowlands, carried out by the World Bank and covering the period 2011–2016, found that "pastoralists seem to have experienced large decrease in the poverty head count [and] in the depth of poverty" while "depth of poverty has increased amongst agropastoralists and crop producers" (World Bank and DFID, 2019).

Pastoralists also contribute to national economies through the costs they sustain as a result of their production. A recent study in West Africa found that during annual migration a pastoralist family spends an average of about USD 2 000 (Inter-réseaux, 2017). A series of studies of the contribution of livestock to the economies of Intergovernmental Authority on Development (IGAD) member states highlighted "informal financial services" as also being important: the use of livestock as savings and investment, credit, private insurance or collective insurance ("risk pooling") (Behnke, 2010). A recent study conducted by the PKH and the International Cooperation Centre of Agricultural Research for Development (CIRAD) in Mongolia, Chad and Argentina showed that pastoralism contributes more to national economies than is usually indicated in other studies because, owing to specific characteristics such as high levels of self-consumption, pastoralists' contribution to gross domestic product (GDP) is often underestimated.[26]

In this context of data scarcity, economic research has so far overlooked the role of women in pastoral systems. Pastoralist women are responsible for the food security of their households, as they take care of the production of milk and other fundamental products. However, they are generally left out of trade – whether formal or informal – and so are not taken into account in surveys and censuses. As a result, gender-disaggregated data are even more limited.

Data on primary and secondary employment created by pastoralism are scarce, but the number of pastoralism-related jobs is likely to be significant. In Kenya's arid and semi-arid lands, pastoralism accounts for 90 percent of employment and more than 95 percent of household incomes; in addition to providing direct employment for 2.2 million people, it also sustains substantial indirect employment through trade, transport services, the leather industry and the various stages of meat consumption from slaughterhouses to restaurants (Nyariki and Amwata, 2019). In Mongolia, pastoralism and related value chains support 25 percent of employment (IMF, 2019). A small "total economic valuation" study in the United Republic of Tanzania found that, in Arusha municipality alone, meat supplied from pastoral systems supports more than 500 restaurants and related employment along the value chain (in trade, markets and slaughterhouses) (Letara, MacGregor and Hesse, 2006).

3.3. FOOD SECURITY, FOOD SAFETY AND NUTRITION

Although often decried as an "inefficient" livestock production system, with respect to protein efficiency pastoralism is high performing. Protein efficiency is reflected in the human-edible protein balance, an index value that represents the human-edible protein output per unit of human-edible protein input required to produce it. In this respect, countries with extensive pastoral systems leave other countries far behind. For example, the livestock sector in Kenya, largely made up of pastoralism, produces 20 times as much human-edible protein as it consumes, whereas in countries where the livestock systems are supposed to be highly efficient according to conventional appraisal methods, livestock is fed up to twice as much human-edible protein as it produces (FAO, 2011). Recent research indicates that livestock raised in systems that aim to create a circular economy without human-edible inputs such as cereals – as in pastoral systems – could potentially provide 20–40 percent of global protein requirements (Van Zanten *et al.,* 2018).

[26] For extensive reviews of the knowledge gaps relating to pastoralism, see for instance Hatfield and Davies (2007) and Pica-Ciamarra *et al.* (2014).

©Severo Choque

Argentina camelids.

Animal-source foods have excellent amino acid composition, with a score of 100 percent, and true protein digestibility of 95–98 percent. In addition, their protein concentrations often increase after cooking. Consequently, they are used as the reference for comparisons of protein quality, provided they are processed in ways that will not decrease amino acid bioavailability. Pastoralism is also an inexpensive way of producing high-quality animal proteins.[27] Children in poor pastoralist households show lower levels of malnutrition than children in poor households in farming communities (Marshak, Young and Radday, 2016). Migrating herds make relatively inexpensive animal proteins accessible to remote rural communities: at their arrival, fresh milk becomes available and the price of meat drops on local markets (Barraud, Saleh and Mamis, 2001; Thébaud *et al.,* 2018). Despite the well-known challenges, these systems continue to provide affordable meat to domestic markets; for example, they account for an estimated 34 percent of the red meat consumed in Ethiopia (Shapiro *et al.,* 2017). Conversely, food insecurity increases when pastoral systems are weakened (FAO, 2018d).

Countries with large pastoralist populations ensure the food security of other countries through exports. Horn of Africa countries and the Sudan supply the countries of the Arabian Peninsula. India is a major exporter to southeast Asian and Arab countries. Pastoral systems in the Sahel and the Central African Republic supply coastal countries, from Senegal to Angola (Corniaux, Thébaud and Gautier, 2012).

A multitude of studies have compared the nutritional quality of grassfed foods in production systems in the North. There is circumstantial evidence linking milk and meat from

[27] In the United Republic of Tanzania, pastoral/agropastoral systems account for 94 percent of livestock and supply 70 percent of the 1.38 billion litres of milk consumed in the country each year (United Republic of Tanzania, 2006, cited in Krätli *et al.*, 2013). In Senegal, the largest dairy company collects an average of 4 000 kg of milk per day from pastoral systems (https://www.africa-milk.org/study-sites/senegal; see also Magnani *et al.*, 2019. The IPCC 2019 Climate Change and Land report finds that "Since food insecurity in drylands is strongly affected by climate risks, there is robust evidence and high agreement that resilience to climate risks is higher [where the operating logic of pastoral systems is supported] with flexible tenure for allowing mobility for pastoralist communities, and not fragmenting their areas of movement" (IPCC, 2019: 174).

livestock fed a phytochemically rich diet in grazing systems to better human and environmental health (Clemensen *et al.,* 2020; Provenza, Kronberg and Gregorini, 2019). The same argument can be expected to apply to pastoral systems in the South. As a result, there are many regional speciality products, such as Criollo goat meat from the Neuquen region of Argentina, or Raika camel milk from camels browsing on 36 different ayurvedic plants in India (Slow Food Foundation for Biodiversity, 2019).

In growing discussions of sustainable diets and sustainable meat production concerns are raised regarding the impacts of current high levels of meat consumption on people's health and the environment, while acknowledging that: "Sustainably produced meat and fish are valuable sources of nutrition to many communities and, in certain areas, can play a key role in landscape management and maintaining ecosystem services" (FAO and WHO, 2019; WWF, no date). Pastoralism in particular is also a system that is comparatively "friendly" to animal welfare (including in the relatively long life of productive animals, e.g. up to 14-15 years in the case of cattle).

Pastoralism already plays a key role in the circular economy: biomass that is otherwise unsuitable for human consumption is utilized, and waste is minimized; everything is reused and recycled. More important, through manuring the fields, pastoral mobile herds contribute substantially to the production of crops, especially for farmers who cannot afford or do not have access to mineral fertilizers and in areas where the presence of livestock all year round is not sustainable (Behnke, 2010). In India, pastoralists' sheep have an enormous role in fertilizing fields (Köhler-Rollefson and Reddy, 2017). An important proportion of draught animals used in the cultivation of fields – 20 percent in Ethiopia (Gebremeskel, Desta and Kassa, 2019) – are bred in pastoral systems.

In the Sahel, sales of crop residues and failed crops to pastoralists have become an important source of income and a safety net for small-scale farmers. Another source of income for the poor is hay harvested from the commons and sold to peri-urban pastoralists.

Developing and optimizing the multi-functionality of pastoral systems makes countries less dependent on feed and fertilizer imports.

3.4. WATER EFFICIENCY

Pastoral systems are exceptionally water-efficient. Pastoral breeds need little water because of physiological recycling mechanisms (Doreau, Corson and Wiedemann, 2012) that enable them to tolerate longer watering intervals and make them less sensitive to water stress. In most dryland systems livestock are watered every other day, or even every second day during the dry season. During the rainy season, livestock can thrive on untreated surface water. For several months each year, pastoral herds use water in areas that are often far from human settlements. Water efficiency is poorly captured by current methods for measuring the ecological efficiency of food production systems. Ecological efficiency is expressed as production (output) over natural resources (input). However, consistent with the input parameters conventionally used in farm economics (land, labour and capital), current methods for the calculation of ecological efficiency focus on *land* as the most important input.[28] When the ecological efficiency of a livestock system is measured with "water" as the main

[28] Even the use of the total-factor productivity approach for measuring ecological sustainability in agriculture is based on land, labour and capital (Coomes *et al.*, 2019).

input rather than "land", pastoralism scores high (for example in Inner Mongolia, China) (Fan, Li and Li, 2015).

As their excreta is dispersed across vast areas of rangeland and farmland, pastoral herds do not contribute to the pollution of water (or air and soil) from high concentrations of unrecycled nutrients in livestock excreta (nitrogen, phosphorus and potassium), nor do they contribute to the substantial environmental costs involved in livestock transportation and treatment (Menzi *et al.,* 2010). Grazing also favours groundwater recharge, which is particularly valuable in drylands in enabling the percolation necessitated by various plants and plant roots (Scanlon *et al.,* 2005).

3.5. PROVISION OF ECOSYSTEM SERVICES AND MAINTENANCE OF LANDSCAPE FUNCTIONALITY

Pastoralism provides a range of ecological services in drylands and mountainous regions as well as crop-farming areas. A strong link between ecosystem services and pastoralists is rooted in the distinct cultural features and livelihood systems of pastoralism (Hoffmann, From and Boerma, 2014; Silvestri *et al.,* 2012).

High levels of livestock feeding selectivity, a complex diet and mobility make pastoral systems (when left to operate according to their own logic) particularly effective in promoting *ecosystem* biodiversity. As grazing itineraries are systematically managed, pastoral herds do more than just mimicking wild herds. Ecosystem services such as seed transportation and dispersal, control of shrub growth or stimulation of grass tilling do not occur randomly, but rather as part of a strategy of selective harvesting driven by management choices (Schareika, 2003). While promoting ecosystem biodiversity, pastoralists "steer" it towards pastoral functionality.[29] Although the focus of managing grazing itineraries is on animal nutrition, grazing management also results in *de facto* landscape management. Scientists in environmental and dryland archaeology can detect changes in the kinds of landscape functionality resulting from pastoral systems as far back as 10 000 years ago (Terrell *et al.,* 2003; Causey, 2008; Lane, 2011; Marshall *et al.,* 2018). Pastoral rangelands are therefore far from being natural in the sense of pristine wilderness because they have been shaped by millennia of management. However, they are also not *anthropogenic* in the sense that ecological functions have been broken (Sayre *et al.,* 2017; Ellis and Ramankutty, 2008).

Pastoralism has co-evolved with its natural environment, and the resultant functions need to be properly recognized, including in law, and quantified; they will continue only with the presence of pastoral herds.[30] While this important role of pastoralism as ecosystem "designer" is commonly acknowledged in Europe, even European scholars appear to find such a role more difficult to recognize (or acknowledge) in pastoral systems in other parts of the world, especially in Africa (Blanc, 2020).

Pastoral systems make a major contribution to the maintenance of local landscapes with respect to attractiveness and ecosystem functionality. Plant production and survival

[29] Anderson (2014) describes in detail the similar practice of "tending the wild" by an even less recognized group of ecosystem managers: hunter gatherers.

[30] A notable exception is the first Kenyan policy for the development of arid and semi-arid lands, in which it is promised that the "Government will: Recognise, through legislation, pastoralism as a legitimate form of productive land use and development on the same basis as farming" (Government of Kenya, 2012: 19).

are increased by moderate grazing (Oba, Stenseth and Lusigi, 2000). Grazing, including trampling, is essential for grasslands in maintaining their dense grass cover and extensive deep-reaching root systems, which then act as a filter and keep groundwater clean, thus preventing erosion (Silva *et al.,* 2019; Porensky and Veblen, 2015). Supporting or re-enabling forms of land management developed by pastoral systems is a proven and effective approach to rangeland restoration, for example in Jordan (Myint and Westerberg, 2015; UNEP, 2016). The use of controlled grazing proved more successful than the removal of ruminants in restoring vegetation cover in the Zoigê grasslands of the Tibetan plateau (Chen *et al.,* 2016).

As pastoral herds can deposit manure directly on to fields, many pastoral systems have developed in symbiotic relationships with crop farming. While the commercial value of manure produced in pastoral systems has rarely been studied, there is little doubt of its importance in countries that would otherwise depend on unaffordable mineral fertilizers that have been produced in other ways and/or imported. For example, the nitrogen–phophorus–potassium value of pastoral manure and urine in India has been calculated as equivalent to about USD 45 billion per year (Kishore and Köhler-Rollefson, 2020).

Pastoralists may use forests and, through agro-silvopastoralism, play an important ecological and economic role by connecting and supporting different land uses and ecosystems. Riparian forests are a critical and sustainable grazing resource for many pastoral systems. In dryland forests, pastoralism aids the germination of certain trees such as acacias, whose seeds need to be scarified by ruminant digestion. The controlled opening of forest areas to pastoralism can contribute to their rehabilitation. In Europe, pastoralists are paid to eliminate blackberries that prevent the regrowth of larger trees. In India, pastoralist herds help to reduce forest fires by feeding on long grass (Köhler-Rollefson, 2007).

There have also been efforts to put a monetary value on the water filtration services provided by sheep, as their hooves and feeding behaviour help to strengthen the root systems of grasses and keep the sward intact, a prerequisite for clean groundwater (personal communication from Günther Czerkus, referring to research by Peter Poschlod, University of Regensburg, Germany).

Pastoral herds and their area-specific diets add aesthetic and gastronomic characteristics to landscapes and generate income from tourism, which can be significant. For instance, New Zealand focuses on marketing grassfed livestock products, emphasizing the relationship between the animals and year-round outdoor grazing (Wedderburn, 2020; Origin Green Ireland, 2021).

3.6. SUSTAINABLE LAND TENURE MANAGEMENT AND REGIONAL INTEGRATION

A wide range of communal tenure systems implemented by pastoralists all over the world imply continually negotiated access within and across national borders, including in relation to climate change (Moritz *et al.,* 2013). At the local scale, communal tenure systems have been acknowledged as being more rational and sustainable than exclusive property rights in contexts where income streams and resources are substantially uncertain (van den Brink, *et al.,* 1991). In the thinking and vocabulary of property rights, the costs of exclusion may overcome the benefits of privatization when resources are variable and/or scattered (Baland and Platteau, 1996; Ciriacy-Wantrup and Bishop, 1975).

Togo herd crossing river.

Public policies tend to regard pastoral mobility as a problem related to a divisive approach to productive land use, even though – at a broad scale – livestock mobility allows for efficient integration of distinct crop and livestock production systems without any loss of productive specialization (section 1.2 and footnote 13). In addition, the historical linkages among different communities created through pastoral mobility offer opportunities for regional integration.

Securing pastoral mobility has become an economic and political challenge of regional or even continental importance. More secure and better regulated cross-border mobility would facilitate stronger regional harmonization of the sizeable livestock sector and might represent a best case for general integration at the regional level. This political challenge represents an opportunity for decision-makers to adopt a truly regional approach, which in West Africa, for example, would facilitate work towards greater stability in the Sahel, which also undoubtedly depends on these cross-cutting processes (Corniaux, Thébaud and Gautier, 2012). Overall, more studies specifically on regional economic and social integration are needed.

Another element for further consideration and enhancement is the potential of traditional institutions and processes of governance to enable more participatory and community-based decision-taking regarding natural resource management, as experienced in Kenya with local finance delivered at the local level (Crick *et al.*, 2019).

3.7. BIODIVERSITY CONSERVATION

Pastoral herds and flocks have been bred for resilience for thousands of years, resulting in some of the highest levels of diversity (variability) of any breeding population (Hall, 2004; Kaufmann, Lelea and Hülsebusch, 2016; Scherf *et al.,* 2008).

The droppings of grazing animals act as an incubator for a huge diversity of insects that are at the base of the food chain and that feed populations of insectivorous birds, bats and reptiles. Pastoralism does not utilize pesticides, thereby avoiding damage to pollinators such as bees, butterflies and moths. Through their fire management and pasture creation,

pastoralists facilitated environmental changes that suited honey production, making it an important aspect of their cultural identity that is still strong today (Nyariki and Amwata, 2019; Russell and Lander, 2015; Conte, 2004).

At the systemic level, the role of pastoral herds as transporters of seeds and biodiversity has been researched fairly extensively, especially with respect to sheep. Up to 25 000 seeds per sheep are carried for hundreds of kilometers, along with lizards, beetles and grasshoppers, enabling movement to new biotopes and adaptation to a changing climate. Research in Germany has calculated that the monetary value of the seed transportation services provided by sheep amounts to EUR 4 500 per year for a flock of 200 head.

While pastoralists continue to be routinely excluded from protected areas, attention to the role of indigenous peoples and local communities in conservation is increasing. Discussions of "other area-based effective conservation measures" (OECM) have highlighted the need for connectivity between protected areas and ecosystems (as biodiversity cannot survive in isolation), and for conservation in areas beyond their boundaries. OECM refers to geographically defined areas (other than protected areas) that are "governed and managed in ways that achieve positive and sustained long-term outcomes for the *in situ* conservation of biodiversity, with associated ecosystem functions and services and, where applicable, cultural, spiritual, socioeconomic, and other locally relevant values" (CBD/SBSTTA, 2018). Mobile pastoralism is uniquely placed to secure connectivity between ecosystems and conservation areas, and makes the largest contribution to the *in situ* conservation of biodiversity.

3.8. TRANSITION TO A GREEN ECONOMY

Public pressure is increasing for the transition to a green economy, defined as being low-carbon, resource-efficient and socially inclusive and directing public and private investment towards economic activities, infrastructure and assets that reduce carbon emissions, enhance energy efficiency and prevent the loss of biodiversity and ecosystem services. Both the United Nations Environment Programme (UNEP) and the International Union for Conservation of Nature (IUCN) find that pastoralism has great potential to contribute to a green economy (UNEP, 2021; McGahey *et al.*, 2014), particularly through its structural role in:

i. safeguarding natural capital across a quarter of the world's land area;
ii. embodying a multifunctional livestock management system that provides ecosystem services;
iii. maintaining soil fertility and soil carbon, water regulation, pest and disease regulation, biodiversity conservation and fire management.

In pastoral systems, a green economy is a legacy even before it is a goal.

Conclusions

There seems to be general agreement on describing pastoral systems as having suffered marginalization in the past (politically and economically), neglect (such as lack of basic infrastructure and services) or even active undermining (such as through large-scale land-use conversion and constraints on mobility) (African Union, 2010; Government of Kenya, 2012; Government of Ethiopia, 2019). In so far as this is a correct reading of history, there is no need to imagine a hypothetical future in order to understand the consequences of not supporting pastoral systems. Some of these consequences are already visible, albeit more clearly in certain areas of the world than in others, and are often described as being unstoppable natural processes resulting from demographic growth and climate change rather than largely artificially induced and reversible (Rutten and Mwagi, 2014; Gausset, Whyte and Birch-Thomsen, 2005).

CONSEQUENCES OF THE MARGINALIZATION OF PASTORAL SYSTEMS

Loss of process variability. The loss of process variability (for example, through hindered mobility) or its substitution with market-driven options accessible only to a wealthy minority has been accompanied by a shift from complementary practices to competition over resources, land fragmentation, increased frequency of crises and growing social inequality.

Spread of maladaptive strategies. Local processes of wealth accumulation, or even those aimed at securing access to critical resources, play out in regional and global processes of political-economic friction and the thriving of "us versus them" ideologies that encourage and exploit division (De Waal, 2015; Janes and Chuluundorj, 2015; Oba, 2020; Czuba, 2017; Moritz, 2006). The situation is particularly alarming in the Sahel, where the social, economic and cultural fabric of huge areas is deteriorating while the situation of insecurity and conflict calls into question the survival of pastoralism itself (Benjaminsen and Ba, 2019; UNOWAS, 2018; ICG, 2018; Thiam, 2017; de Haan *et al.,* 2014). In fact, although pastoralism and insecurity have become the new core of the debate in many regions, such as western and central Africa, triggered by political instrumentalization, there is no quantitative evidence showing that incidents associated with farming and herding grow more rapidly than overall levels of violence (Krätli and Toulmin, 2020). Conflict is not a function of mobility but rather a consequence of policy failure to effectively integrate the traditional institutions and systems of pastoralists into the planning and implementation of economic development and environment and natural resource management. Away from a simplistic framing of "herder–farmer conflict", multidimensional approaches to conflict as part of a process lead to the raising of questions regarding citizenship in rural, pastoral areas (Rangé, Magnani and Ancey, 2020).

Loss of food production potential. Losing pastoralism means losing the potential to produce protein-rich food with low inputs in areas where there is no alternative resource-efficient way of producing food and from feed resources unfit for human consumption. Grasslands

cover 40 percent of the globe. The only way of using them for food production is via pastoralism, but pastoralists' capacity to use these regions when seasonal conditions make them accessible depends on having access to feed resources elsewhere. In many areas, pastoralism has declined following the introduction of well-meant but ill-advised conservation policies and the blocking of access roads and livestock mobility routes.

Loss of livelihoods. Foregoing pastoralism means losing the most important source of income in a large part of the world. While there is a limit to the number of primary producers that can be supported through pastoralism, there is scope for employment as secondary producers if investments in infrastructure for value addition are made without undermining livelihoods in primary production.

Loss of biodiversity. The correlation between pastoralism and biodiversity is well documented and, for that reason, there are many projects in both developed and developing counties that harness pastoralism in order to conserve certain wild plant and animal species and landscapes. It is less often recognized that pastoralists also act as "keepers of genes", fulfilling an important role as developers and guardians of thousands of livestock breeds that cannot be conserved *ex-situ* – in the absence of the pastoral systems that have developed them – as their functionality is due to a complex mixture of genetic traits and learned behaviours. Pastoral breeds are first of all specialized in taking advantage of variability: the Red Bororo cattle bred by Wodaabe people is possibly the largest and tallest cattle breed in the Sahel, therefore not adapted to scarcity but rather specialized for variability in potential inputs (FAO, 2007). These breeding populations with exceptionally high levels of within-breed biodiversity (Hall, 2004) represent crucial assets for humanity in adaptating to climate change. They are also lost as a consequence of the poor understanding of pastoralism, which leads to policies aimed at replacing locally adapted breeds with exotic ones based on performance parameters measured in isolation from the environment.

Loss of social capital and traditional knowledge. Pastoral systems are repositories and developers of important dimensions of social capital and knowledge, including practical ecological knowledge that has been accumulated and refined over many generations. Many of these dimensions are tacit, their actual economic value is yet to be fully assessed, and therefore they are at risk of being understood only when it is too late (Hesse and MacGregor, 2006; Davies and Hatfield, 2007). Some have been excluded even from holistic approaches such as food systems. These dimensions include the taken-for-granted elements that make production possible: knowledge, institutions and the mechanisms of social cohesion and reproduction in a competent society. In pastoral systems, social capital and knowledge apply not only to humans but also to animals: the mechanisms of transmission of complex learned behaviours within a herd, skills such as orientation, or the organization of herds and flocks into functioning social groups. It would be extremely difficult and time-consuming to rebuild this capital if lost.

Pastoralists themselves have drawn attention to their contributions to society, including the role of women, and the challenges they experience, in at least 15 formal declarations issued between 2001 and 2018. These include the Segovia Declaration of Nomadic and Transhumant Pastoralists (2007),[31] the Declaration on Livestock Keepers' Rights (League for Pastoral Peoples and Endogenous Livestock Development, 2008), the Mera Declaration of

[31] Available at https://www.iucn.org/sites/dev/files/import/downloads/segovia_pastoralists_declaration_final.doc

the Global Gathering of Women Pastoralists (2010),[32] the Kiserian Pastoralist Statement in 2013,[33] the statement issued at a special session of the Farmers' Forum with pastoralists and livestock breeders in 2016 (Farmers' Forum, 2016), many regional declarations and five from the Association of World Reindeer Herders. In these declarations, pastoralists refer to their agro-ecological practices and express pride in their expertise and heritage. Unanimously, they identify alienation of grazing areas and constraints to mobility as major problems and request services adapted to their way of life.[34]

RECOMMENDATIONS

Access to the benefits of pastoralism depends on first boosting support by taking action in the following ways:

- improving the understanding of traditional management, practices, systems and institutions and developing ways of integrating their underlying principles into policy and planning;
- developing technical and policy programmes in pastoralism – internationally and nationally – that create a shared vision and mechanisms for capitalizing on the benefits of pastoralism;
- supporting pastoralists' mobility, including transboundary movement, by harmonizing and implementing effective regional policies and legal frameworks;
- gathering data on pastoralist households and monitoring pastoralism to inform decision-making at the national and regional levels – for instance, national census instruments can be updated with better disaggregated questions relevant to pastoralists;
- engaging pastoralists directly in policy planning and programme development to ensure effective representation, including the empowerment of women and the inclusion of young people – this participatory approach also helps to identify potential barriers that need to be changed upstream of programme implementation in order to improve outcomes;
- supporting capacity-building initiatives for the development of innovations in methods, tools and technologies relevant to pastoral systems.

[32] Available at https://landportal.org/node/8047

[33] Available at https://www.iucn.org/sites/dev/files/content/documents/the_kiserian_pastoralists_statement.pdf

[34] There is remarkably little literature on pastoralist social movements. A recent brief overview of their history and activity can be found in MISEREOR (2019).

References

African Union. 2010. *Policy Framework for Pastoralism in Africa: Securing, Protecting and Improving the Lives, Livelihoods and Rights of Pastoralist Communities*. Addis Ababa, Department of Rural Economy and Agriculture, African Union. (also available at https://au.int/sites/default/files/documents/30240-doc-policy_framework_for_pastoralism.pdf).

Allen, M.R., Shine, K.P., Fuglestvedt, J.S., Millar, R.J., Cain, M., Frame, D.J. & Macey, A.H. 2018. A solution to the misrepresentations of CO_2-equivalent emissions of short-lived climate pollutants under ambitious mitigation. *npj Climate and Atmospheric Science*, 1: 16. [online] [cited March 2021] https://doi.org/10.1038/s41612-018-0026-8

Allen, V.G., Batello, C., Berretta, E.J., Hodgson, J., Kothmann, M., Li, X., McIvor, J., Milne, J., Morris, C., Peeters, A. & Sanderson, M. 2011. An international terminology for grazing lands and grazing animals. *Grass and Forage Science,* 66(1): 2–28.

Ancey, V., Avelange, I. & Dedieu, B. 2013. *Agir en situation d'incertitude en agriculture. Dynamiques de protection et d'adaptation au Nord et au Sud.* Brussels, PIE-Peter Lang. (also available at https://www.researchgate.net/publication/314398134_Agir_en_situation_d%27incertitude_en_agriculture_Dynamiques_de_protection_et_d%27adaptation_au_Nord_et_au_Sud).

Ancey, V., Rangé, C., Magnani, S. & Patat, C. 2020. *Young pastoralists in towns and cities – Summary report. Supporting the economic and social integration of young pastoralists – Chad and Burkina Faso*. Rome, FAO. (also available at https://www.iram-fr.org/ouverturepdf.php?file=ca7216en-1582642579.pdf)

Anderson, M.K. 2005. *Tending the Wild: Native American Knowledge and the Management of California's Natural Resources*. Berkeley, California, USA, University of California Press.

Ansari-Renani, H.R., Rischkowsky, B., Mueller, J.P., Momen, S.M.S. & Moradi, S. 2013. Nomadic pastoralism in southern Iran. *Pastoralism: Research, Policy and Practice,* 3: 11. [online] [cited March 2021] https://doi.org/10.1186/2041-7136-3-11

Assouma, M.H., Hiernaux, P., Ickowicz, A., Corniaux, C., Decruyenaere, V., Diarra, A.R. & Vayssières, J. 2018. How to better account for livestock diversity and fodder seasonality in assessing the fodder intake of livestock grazing semi-arid sub-Saharan Africa rangelands. *Livestock Science,* 216: 16–23.

Assouma, M.H., Hiernaux, P., Lecomte, P., Ickowicz, A., Bernoux, M. & Vayssières, J. 2019a. Contrasted seasonal balances in a Sahelian pastoral ecosystem result in a neutral annual carbon balance. *Journal of Arid Environments,* 162: 62–73.

Assouma, M.H., Lecomte, P., Corniaux, C., Hiernaux, P., Ickowicz, A. & Vayssières, J. 2019b. *Pastoral landscapes in the Sahel: a carbon balance with unexpected potential for climate change mitigation*. *Perspective* 52: 1–4.

Baland, J.-M. & Platteau, J.-P. 1996. *Halting degradation of natural resources. Is there a role for rural communities?* Rome, FAO. (also available at http://www.fao.org/3/x5316e/x5316e00.htm).

Barraud, V., Saleh, O.M. & Mamis, D. 2001. *L'élevage transhumant au Tchad oriental*. Lyon, France, Vétérinaires Sans Frontières.

Bathelt, H. & Glückler, J. 2005. Resources in economic geography: from substantive concepts towards a relational perspective. *Environment and Planning,* 37: 1545-1563.

Bawden, R. 2007. Redesigning Animal Agriculture: a Systemic Perspective. *In* D.L. Swain, E. Charmley, J.W. Steel and S.G. Coffey, eds. 2007. *Redesigning Animal Agriculture. The Challenge of the 21st Century*, pp. 1–17. Wallingford, UK, CABI.

Behnke, R. 2010. *The Contribution of Livestock to the Economies of IGAD Member States. Study Findings, Application of the Methodology in Ethiopia and Recommendations for Further Work*. IGAD LPI Working Paper No. 02 - 10. Djibouti, Intergovernmental Authority on Development (IGAD), Livestock Policy Initiative (LPI). (also available at https://cgspace.cgiar.org/bitstream/handle/10568/24968/IGAD_LPI_WP_02-10.pdf?sequence=1&isAllowed=y).

Behnke, R. 2012. *The Economics of Pastoral Livestock Production and its Contribution to the Wider Economy of Sudan. Final Report for the Feinstein International Center*. Medford, Massachusetts, USA, Tufts University.

Behnke, R.H., Scoones, I. & Kerven, C., eds. 1993. *Range ecology at disequilibrium: new models of natural variability and pastoral adaptation in African Savannas*. London, Overseas Development Institute.

Benjaminsen, T.A. & Ba, B. 2019. Why do pastoralists in Mali join jihadist groups? A political ecological explanation. *Journal of Peasant Studies,* 46(1): 1–20.

Berkes, F., Colding, J. & Folke, C. 2003. *Navigating Social-Ecological Systems. Building Resilience for Complexity and Change*. Cambridge, UK, Cambridge University Press.

Blanc, G. 2020. *L'invention du colonialisme vert. Pour en finir avec le mythe de l'Éden Africain*. Paris, Flammarion. 343 pp.

Bonsma, J.C. 1949. Breeding cattle for increased adaptability to tropical and subtropical environments. *Journal of Agricultural Science,* 39.2: 204–221.

Breman, H. & De Wit, C.T. 1983. Rangeland productivity and exploitation in the Sahel. *Science*, 221(4618): 1341–1347.

Brümmer, C., Papen, H., Wassmann, R. & Brüggemann, N. 2009. Fluxes of CH_4 and CO_2 from soil and termite mounds in south Sudanian savanna of Burkina Faso (West Africa). *Global Biogeochemical Cycles,* 23(1). [online] [cited March 2021] https://doi.org/10.1029/2008GB003237

Bushe, G.R. & Marshak, R.J., eds. 2015. *Dialogic Organization Development: The Theory and Practice of Transformational Change*. Oakland, California, USA, Berret-Köhler.

Catley, A., Lind, J. & Scoones, I., eds. 2012. *Pastoralism and Development in Africa. Dynamic Change at the Margins*. New York and Oxford, UK, Routledge.

Causey, M. 2008. *Delineating pastoralist behaviour and long-term environmental change: a GIS landscape approach on the Laikipia Plateau, Kenya*. Oxford, UK, University of Oxford. (PhD dissertation)

CBD/SBSTTA. 2018. *Recommendation 22/5: Protected areas and other effective area-based conservation measures*. Recommendation adopted by the Subsidiary Body on Scientific, Technical and Technological Advice (SBTTA) at its twenty-second meeting, Montreal, Canada, 2–7 July 2018. Montreal, Canada, Convention on Biological Diversity (CBD).

CELEP. 2017. *Recognising the role and value of pastoralism and pastoralists*. Policy Brief, May 2017 No. 1. Brussels, Coalition of European Lobbies for Eastern African Pastoralism (CELEP). (also available at http://www.celep.info/wp-content/uploads/2017/05/Policybrief-CELEP-May-2017-Value-of-pastoralism.pdf).

CENESTA & Global Forest Coalition. 2017. *Iran in Focus: How indigenous nomadic pastoralists in Iran are using GIS maps to defend and conserve their territories*. Centre for Sustainable Development (CENESTA) and Global Forest Coalition. [online] [cited March 2021]. https://intercontinentalcry.org/indigenous-nomadic-pastoralists-iran-gis-maps-conserve/

CFS. 2012. *Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*. Committee on World Food Security (CFS). Rome, FAO. (also available at http://www.fao.org/3/i2801e/i2801e.pdf).

Chen, D., Zhang, N., Liu, L., Zhong, B., Tang, Z., Yan, W., Xu, L. & Su, G. 2016. The effect of different restoration measures on the desertified alpine grassland in Zoigê. *Chinese Journal of Applied & Environmental Biology,* 22(04): 573–578.

Ciriacy-Wantrup, S.V. & Bishop, R.C. 1975. Common property as a concept in natural resources policy. *Nat. Resources J.*, 15(4): 713.

Clemensen, A.K., Provenza, F.D., Hendrickson, J.R. & Grusak, M.A. (in press). Ecological implications of plant secondary metabolites – phytochemical correlations between soil, forages, herbivores and humans. *Frontiers in Sustainable Food Systems*, in press.

Coomes O.T., Barham B.L., MacDonald G.K.,Ramankutty N. & Jean-Paul Chavas J-P. 2019. Leveraging total factor productivity growth for sustainable and resilient farming. *Nature Sustainability* 2: 22–28.

Conte, C.A. 2004. *Highland Sanctuary. Environmental History in Tanzania's Usambara Mountains*. Athens, Ohio, USA, Ohio University Press. 233 pp.

Corniaux, C., Thébaud, B. & Gautier, D. 2012. La mobilité commerciale du bétail entre le Sahel et les pays côtiers: l'avenir du convoyage à pied. *Nomadic Peoples,* 16(2): 5–31.

Corniaux, C., Ancey, V., Touré, I., Camara, A. & Cesaro, J.-D. 2016. Pastoral mobility, from a sahelian to a sub regional issue. *In* D. Pesche, B. Losch and J. Imbernon, eds. *A new emerging rural world: an overview of rural change in Africa,* second edition. Montpellier, France, International Cooperation Centre of Agricultural Research for Development (CIRAD) and New Partnership for Africa's Development (NEPAD). 76 pp.

Crick, F., Hesse, C., Orindi, V., Bonaya, M. & Kiiru, J. 2019. *Delivering climate finance at the local level to support adaptation: experiences of County Climate Change Funds in Kenya*. Working Paper. Nairobi, Ada Consortium. (also available at https://pubs.iied.org/sites/default/files/pdfs/migrate/G04415.pdf).

Czuba, K. 2017. *Extension of State Power in Karamoja: Part 2: Karamojan Politics—Creation and Cooptation of a New Political Elite*. CCDS Working Paper Series No. 3. Toronto, Canada, University of Toronto Scarborough.

Davies, J. & Hatfield, R. 2007. The economics of mobile pastoralism: a global summary. *Nomadic Peoples,* 11(1): 91–116.

De Haan, C., Dubern, E., Garancher, B. & Quintero, C. 2014. *Pastoralism Development in the Sahel: A Road to Stability?* Washington, DC, World Bank, Global Center on Conflict, Security and Development.

De Waal, A. 2015. *The real politics of the Horn of Africa. Money, war and the business of power*. Cambridge, UK, Polity Press.

Doreau, M., Corson, M.S. & Wiedemann, S. 2012. Water use by livestock: A global perspective for a regional issue? *Animal Frontiers,* 2(2): 9–16.

Ellis, E.C. & Ramankutty, N. 2008. Putting people in the map: Anthropogenic biomes of the world. *Front. Ecol. Environ.*, 6: 439–447.

Fan, M., Li, Y. & Li, W. 2015. Solving one problem by creating a bigger one: The consequences of ecological resettlement for grassland restoration and poverty alleviation in Northwest China. *Land Use Policy,* 42: 124–130.

FAO. no date. *Grasslands, Rangelands and Forage Crops.* [online]. [cited March 2021]. http://www.fao.org/agriculture/crops/thematic-sitemap/theme/spi/grasslands-rangelands-and-forage-crops/it/

FAO. 2007. *The State of the World's Animal Genetic Resources for Food and Agriculture*, pp. 367-368. Rome. (also available at http://www.fao.org/3/a1250e/a1250e.pdf).

FAO. 2011. *World Livestock 2011. Livestock in food security*. Rome. (also available at http://www.fao.org/3/i2373e/i2373e.pdf).

FAO. 2013. *Conference. Thirty-eighth Session, Rome, 15–22 June 2013: Reviewed Strategic Framework*. Rome. (also available at http://www.fao.org/3/mg015e/mg015e.pdf).

FAO. 2016. *Improving governance of pastoral lands. Implementing the Voluntary Guidelines on the Responsible Governance of Tenure of Land, Fisheries and Forests in the Context of National Food Security*. Governance of Tenure Technical Guide No. 6. Rome. (also available at http://www.fao.org/3/I5771E/i5771e.pdf).

FAO. 2018. *The future of food and agriculture — Alternative pathways to 2050*. Rome.

FAO. 2018a. *Livestock and agroecology. How they can support the transition towards sustainable food and agriculture*. Rome.

FAO. 2018b. *The 10 Elements of Agroecology: guiding the transition to sustainable food and agricultural systems*. Rome. (also available at http://www.fao.org/3/i9037en/i9037en.pdf).

FAO. 2018c. *World Livestock: Transforming the livestock sector through the Sustainable Development Goals*. Rome. (also available at http://www.fao.org/3/CA1201EN/ca1201en.pdf).

FAO. 2018d. *Pastoralism in Africa's drylands*. Reducing risks, addressing vulnerability and enhancing resilience. Rome. 52 pp. Licence: CC BY-NC-SA 3.0 IGO. Rome. (also available at http://www.fao.org/3/CA1312EN/ca1312en.pdf).

FAO/OED. 2019. Evaluation of FAO's contribution to the Pastoralist Knowledge Hub cluster. Project Evaluation Series No. 04/2020. Rome (also available at http://www.fao.org/3/ca8460en/CA8460EN.pdf

FAO & WHO. 2019. *Sustainable healthy diets – Guiding principles*. Rome. (also available at http://www.fao.org/3/ca6640en/ca6640en.pdf).

FAO. 2020. Estimation des bilans fourragers dans la région du Sahel d'Afrique de l'Ouest et Centrale. Sous la direction de Assouma, M.H. et Mottet, A. FAO: Production et santé animales – Directives no 22. Rome. (also available at http://www.fao.org/3/ca9111fr/CA9111FR.pdf)

Farmers' Forum. 2016. Statement. http://vsf-international.org/wp-content/uploads/2016/02/STATEMENT-SPECIAL-SESSION-EN.pdf

Gausset, Q., Whyte, M.A. & Birch-Thomsen, T., eds. 2005. *Beyond Territory and Scarcity. Exploring Conflicts over Natural Resource Management*. Stockholm, Nordisk Afrikainstitutet.

Gebremeskel, E.N., Desta, S. & Kassa, G.K. 2019. *Pastoral Development in Ethiopia: Trends and the Way Forward*. Development Knowledge and Learning series. Washington, DC, World Bank. (also available at https://openknowledge.worldbank.org/bitstream/handle/10986/31818/K880276.pdf?sequence=2&isAllowed=y).

Gertel, J. & Le Heron, R., eds. 2011. *Economic Spaces of Pastoral Production and Commodity Systems*. Farnham, UK, Ashgate.

Glomsrød, S., Duhaime, G. & Aslaksen, I., eds. 2017. *The Economy of the North 2015*. Oslo and Kongsvinger, Statistics Norway.

Gomati, V., Ramasamy, K., Kumar, K., Sivaramaiah, N. & Ramanjaneya, V.R.M. 2011. Greenhouse gas emissions from termite ecosystem. *African Journal of Environmental Science and Technology,* 5(2): 56–64.

Federal Democratic Republic of Ethiopia. 2019. *Pastoral Development Policy and Strategy*. *Final Draft submitted to GOE for Approval. March 2019*. Addis Ababa, Ministry of Peace.

Government of Kenya. 2012. *Releasing Our Full Potential.* Sessional Paper No. 8 2012 on National Policy for the Sustainable Development of Northern Kenya and other Arid Lands. Nairobi, Ministry of State for Development of Northern Kenya and Other Arid Lands.

Hall, S.J.G. 2004. *Livestock Biodiversity. Genetic Resources for the Farming of the Future*. Oxford, UK, Blackwell Science.

Harrison, R. 2013. *Animal Machines.* Reissued and updated. Wallingford, UK, Centre of Agiculture and Bioscience International (CABI).

Hatfield, R. & Davies, J. 2007. *Global Review of the Economics of Pastoralism*. Nairobi, International Union for Conservation of Nature (IUCN) for the World Initiative for Sustainable Pastorlism. (also available at https://www.iucn.org/sites/dev/files/import/downloads/global_review_ofthe_economicsof_pastoralism_en_1.pdf).

Hesse, C. & MacGregor, J. 2006. *Pastoralism: drylands' invisible asset? Developing a framework for assessing the value of pastoralism in East Africa*. Issue paper No. 142. London, International Institute for Environment and Development. (also available at https://pubs.iied.org/sites/default/files/pdfs/migrate/12534IIED.pdf).

Hiernaux, P. & Turner M.D. 1996. The effect of clipping on growth and nutrient uptake of Sahelian annual rangelands. *Journal of Applied Ecology,* 33: 387–399.

Hoffmann, I. 2010. Climate change and the characterization, breeding and conservation of animal genetic resources. *Animal Genetics,* 41(s1): 32–46. (also available at https://onlinelibrary.wiley.com/doi/abs/10.1111/j.1365-2052.2010.02043.x).

Hoffmann, I., From, T. & Boerma, D. 2014. *Ecosystem Services Provided by Livestock Species and Breeds, with Special Consideration to the Contributions of Small-Scale Livestock Keepers and Pastoralists*. Background Study Paper No. 66 Rev.1c. Rome, FAO, Commission on Genetic Resources for Food and Agriculture. (also available at http://www.fao.org/3/at598e/at598e.pdf).

Horst, P. 1983. The concept of "productive adaptability" of domestic animals in tropical and subtropical regions. *Journal of the South African Veterinary Association,* 54(3): 159–164.

Hubert, B. & Ison, R. 2011. Institutionalising understandings: From resource sufficiency to functional integrity. *In* T. Kammili, B. Hubert and J.-F. Tourrand. *A paradigm shift in livestock management: From resource sufficiency to functional integrity*, pp. 11–16. Avignon, France, Editions Cardère.

ICG. 2018. *Stopping Nigeria's Spiralling Farmer–Herder Violence*. Africa Report No. 262. Brussels, International Crisis Group (ICG).

ICPALD. 2017. *Assessment of the total economic valuation of pastoralism in Kenya*, by D.M. Nyariki. Nairobi, IGAD Centre for Pastoral Areas and Livestock Development (ICPALD), Regional Integration Support Programme (RISP III), Intergovernmental Authority on Development (IGAD). (also available at https://icpald.org/wp-content/uploads/2019/04/Assesment-of-the-Total-economic-valuation-of-Pastoralism-in-Kenya.pdf).

IFAD. 2018. *How to do. Engaging with pastoralists – a holistic development approach*. Rome, International Fund for Agricultural Development (IFAD). (also available at https://www.ifad.org/en/web/knowledge/publication/asset/40318809).

IFAD & FAO. 2016. *FAO's and IFAD's Engagement in Pastoral Development. Joint Evaluation Synthesis*. Rome, International Fund for Agricultural Development (IFAD). (also available at http://www.fao.org/3/bd909e/bd909e.pdf).

IIED 2015. *Valuing Variability. New perspectives on climate resilient drylands development*, London, International Institute for Environment and Development (IIED).

ILRI. 2013. *Making visible the "invisible benefits" of African pastoralism will spur national and pastoral economies both*. ILRI Clippings 24 June 2013. [online] [cited March 2021]. https://clippings.ilri.org/2013/06/24/making-visible-the-invisible-benefits-of-african-pastoralism-will-spur-national-and-pastoral-economies-both/

IMF. 2019. *Greening growth in Mongolia. IMF Country Focus, 10 December 2019.* International Monetary Fund (IMF). [online] [cited March 2021]. https://www.imf.org/en/News/Articles/2019/12/09/na121019-greening-growth-in-mongolia

Inter-reseaux. 2017. *Pastoral livestock farming in Sahel and West Africa. 5 preconceptions put to the test*. Paris. (also available at https://www.inter-reseaux.org/wp-content/uploads/int-17-broch-pastoralismeuk-bd.pdf).

IPCC. 2018. Summary for Policymakers. In *Global Warming of 1.5 °C. An IPCC Special Report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty*. Geneva, Intergovernmental Panel on Climate Change (IPCC). (also available at https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf).

IPCC. 2019. Summary for Policymakers. In *Climate Change and Land. An IPCC Special Report on climate change, desertification, land degradation, sustainable land management, food security, and greenhouse gas fluxes in terrestrial ecosystems.* Geneva, Intergovernmental Panel on Climate Change (IPCC). (also available at https://www.ipcc.ch/site/assets/uploads/sites/4/2020/02/SPM_Updated-Jan20.pdf).

IUCN. 2012. *Supporting Sustainable Pastoral Livelihoods – A Global Perspective on Minimum Standards and Good Practices*. Second Edition. Nairobi, International Union for Conservation of Nature (IUCN) Eastern and Southern Africa Regional Office. (also available at https://www.iucn.org/sites/dev/files/import/downloads/manual_for_min_standards_low_resoultion_may_2012.pdf).

Jablonka, E. & Lamb, M.J. 2006. *Evolution in Four Dimensions. Genetic, Epigenetic, Behavioral, and Symbolic Variation in the History of Life*. Cambridge, Massachusetts, USA, MIT Press.

Jackson, L., van Noordwijk, M., Bengtsson, J., Foster, W., Lipper, L., Pulleman, M., Said, M., Snaddon, J. & Vodouhe, R. 2010. Biodiversity and agricultural sustainagility: from assessment to adaptive management. *Current Opinion in Environmental Sustainability* 2(1–2): 80–87.

Jahnke, H.E. 1982. *Livestock production systems and livestock development in tropical Africa.* Postfach, Germany, Kieler Wissenschaftsverlag Vauk. (also available at https://pdf.usaid.gov/pdf_docs/pnaan484.pdf).

Janes, C.R. & Chuluundorj, O. 2015. *Making Disasters: Climate Change, Neoliberal Governance, and Livelihood Insecurity on the Mongolian Steppe*. Santa Fe, New Mexico, USA, School for Advanced Research Press.

Jerven, M. 2013. *Poor Numbers: How We Are Misled by African Development Statistics and What to Do about It*. New York, Cornell University Press.

Johnsen, K.I., Niamir-Fuller, M., Bensada, A. & Waters-Bayer, A. 2019. *A case of benign neglect: Knowledge gaps about sustainability in pastoralism and rangelands*. Nairobi and Arendal, Norway United Nations Environment Programme and GRID-Arendal.

Jussiau, R., Montméas, L. & Parot, J.-C. 1999. *L'élevage en France. 10 000 ans d'histoire.* Dijon, France, Educagri Éditions.

Kallis, G. 2019. *Limits: Why Malthus Was Wrong and Why Environmentalists Should Care*. Stanford, California, USA, Stanford University Press.

Kaufmann, B.A. 2007. *Cybernetic Analysis of Socio-biological Systems: The Case of Livestock Management in Resource-Poor Environments*. Weikersheim, Germany, Margraf Publishers GmbH.

Kaufmann, B.A., Hülsebusch, C.G. & Krätli, S. 2019. Pastoral livestock systems. *In* P. Ferranti, E.M. Berry and J.R. Anderson, eds. *Encyclopedia of Food Security and Sustainability*, volume 1, pp.178-186, Amsterdam, Elsevier.

Kaufmann, B.A., Lelea, M.A. & Hülsebusch, C.G. 2016. Diversity in livestock resources in pastoral systems in Africa. *OIE Scientific and Technical Review,* 35(2): 445–459. (also available at http://boutique.oie.int/extrait/09kaufmann445459.pdf).

Kieta, N., Kvinikadze, G., Pica-Ciamarra, U., Bourn, D., Honhold, N., Georgieva, N. & Bako, D. 2016. *Guidelines for the Enumeration of Nomadic and Semi-Nomadic (Transhumant) Livestock*. Rome, FAO.

Kishore, K., and Köhler-Rollefson, I. 2020. Accounting for pastoralists in India. Ober-Ramstadt, Germany, League for Pastoral Peoples and Endogenous Livestock Development (LPP) . (also available at http://www.pastoralpeoples.org/wp-content/uploads/2020/09/Accounting4pastoralists-IN.pdf).

Knapp, N.A. 2019. *Making machines of animals: the international livestock exposition, 1900–1920*. Boston, Massachusetts, USA, Boston University. (PhD Dissertation)

Köhler-Rollefson, I & LIFE Network. 2007. Keepers of genes. The interdependence between pastoralists, breeds, access to the commons, and livelihoods. Lokhit Pashu-Palak Sansthan, Sadri (India). http://www.pastoralpeoples.org/wp-content/uploads/2011/11/keepersofgenes_web1.pdf

Köhler-Rollefson, I. & Reddy, S. 2017. *The significance of pastoralism for sustainable soil health in India*. Paper presented at the Indian Allied Health Association (IAHA) Pre-Conference on Organic Animal Husbandry, Delhi, 7–8 November 2017. https://www.ifoam.bio/sites/default/files/iaha_pre-conference_proceedings_role-of-livestock_7-8.11.2017_0.pdf

Krätli, S. 2008. *Time to outbreed animal science? A cattle-breeding system exploiting structural unpredictability: the WoDaaBe herders in Niger*. STEPS Working Paper No. 7. Brighton, UK, Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre.

Krätli, S. 2016. Discontinuity in pastoral development: time to update the method. *OIE Scientific and Technical Review*, 35(2): 485–497.

Krätli, S. 2017. Pastoralist landscapes and natural resources. Seminar 695, July 2017. Seminar – Livestock Landscapes, 22–27.

Krätli, S., el Dirani, O.H. & Young, H. 2013. *Standing Wealth. Pastoralist Livestock Production and Local Livelihood in Sudan*. Khartoum, United Nations Environment Programme (UNEP) and Feinstein International Centre, Tufts University. (also available at https://fic.tufts.edu/wp-content/uploads/TUFTS_1339_Standing_Wealth_5_online.pdf).

Krätli, S. & Toulmin, C. 2020. *Farmer–herder conflict in sub-Saharan Africa?* IIED research report. London, International Institute for Environment and Development (IIED).

Krätli, S., Hülsebusch, C., Brooks, S. & Kaufmann, B. 2013. Pastoralism: A critical asset for food security under global climate change. *Animal Frontiers,* 2(5): 42–50.

Landais, E. & Bonnemaire, J. 1996. La zootechnie, art ou science? Entre nature et société, l'histoire exemplaire d'une discipline finalisée. *Le Courrier de l'environnement,* 27(4): 23–44.

Landais, E. & Lhoste, Ph. 1990. L'association agriculture-élevage en Afrique intertropicale: un mythe techniciste confronté aux réalités du terrain. *Cahiers des Sciences Humaines,* 26 (1–2): 217–235.

Lane, P.L. 2011. An Outline of the Later Holocene Archaeology and Precolonial History of the Ewaso Basin, Kenya. *Smithsonian Contributions to Zoology,* 632: 11–30.

League for Pastoral Peoples and Endogenous Livestock Development. 2008. *Declaration on Livestock Keepers' Rights.* http://www.pastoralpeoples.org/wp-content/uploads/2020/01/12_08_27_BHP_Liga_Declaration_neu.pdf

Lemke, U., Markemann, A., Binh, N.T., Thuy, L.T., Delgado Santivañez, J., Kaufmann, B. & Valle Zárate, A. 2004. The Uplands Program Set up "On-Farm Performance Testing Schemes" as a component of village breeding programs for pigs in North Vietnam. Presented at Deutscher Tropentag 2004, Berlin, 5–7 October 2004.

Letara, J., MacGregor, J. & Hesse, C. 2006. *Estimating the economic significance of pastoralism: The example of the nyama choma sector in Tanzania* London, RECONCILE and International Institute for Environment and Development (IIED).

LIFE Network. 2016. *Kullu Call For the Recognition of the Importance of Common Pool Resources (CPRs) and Pastoralism for India's Livestock Sector*. Kullu, Himachal Pradesh, India, LIFE Network. (also available at http://fes.org.in/studies/kullu-call.pdf).

Lkhagvadorj, D., Hauck, M., Dulamsuren, C. & Tsogtbaatar, J. 2013. Twenty Years After Decollectivization: Mobile Livestock Husbandry and Its Ecological Impact in the Mongolian Forest-Steppe. *Human Ecology,* 41:725–735.

Magnani, S. 2016. *Le lait local au Sénégal: intensifier pour développer? Dynamiques socio. techniques et anthropologie des pratiques*, Paris, École doctorale de l'EHESS. (PhD thesis)

Magnani, S., Ancey, V. & Hubert, B. 2019. "(Dis)ordered intensification?" Techno-political models, resource access and pastoralist/agribusiness relations in the Middle Valley of the Senegal River. *Nomadic Peoples,* 23(1): 5–27.

Manzano, P. & White, S.R. 2019. Intensifying pastoralism may not reduce greenhouse gas emissions: wildlife-dominated landscape scenarios as a baseline in life-cycle analysis. *Climate Research,* 77: 91–97.

Marshak, A., Young, H. & Radday, A. 2016. *Water, Livestock, and Malnutrition. Findings from an Impact Assessment of "Community Resilience to Acute Malnutrition" Programming in the Dar Sila Region of Eastern Chad, 2012–2015*. Somerville, Massachusetts, USA, Feinstein International Center, Tufts University.

Marshall, F., Reid, R.E.B., Goldstein, S., Storozum, M., Wreschnig, A., Hu, L., Kiura, P., Shahack-Gross, R. & Ambrose, S.H. 2018. Ancient herders enriched and restructured African grasslands. *Nature*, 561(7723): 387–390.

Marty, A. 1999. La division sédentaires-nomades. Le cas de la boucle du Niger au début de la période coloniale. *In* L. Holtedahl, S. Gerrard, M.Z. Njeuma and J. Boutrais J., eds. *Le pouvoir du savoir de l'Arctique aux Tropiques*. Paris, Karthala.

Mathez, A. 2018. The institutionalization of pastoralism at FAO. A focus on the Sahel Region. Understandings, circulation of ideas, and mobilization of capacities. Rome, FAO. (unpublished working paper)

McGahey, D., Davies, J., Hagelberg, N. & Ouedraogo, R. 2014. *Pastoralism and the Green Economy – a natural nexus?*. Nairobi, International Union for Conservation of Nature (IUCN) and UNEP.

Menzi, H. Oenema, O., Burton, C., Shipin, O., Gerber, P., Robinson, T. & Franchesini, G. 2010. Impacts of intensive livestock production and manure management on the environment. *In* H. Steinfeld, H. Mooney, F. Schneider and L. Neville, eds. *Livestock in a Changing Landscape Vol. 1 Drivers, Consequences and Responses.*- Washington, DC, Island Press.

Meuret, M. & Provenza, F., eds. 2014. *The Art and Science of Shepherding. Tapping the Wisdom of French Herders*. Austin, Texas, USA, Acres.

MISEREOR. 2019. Pastoral Development Orientation Framework Aachen, Germany, Development Agency of the German Catholic Bishops' Conference (MISEREOR).

Molnár, Z., Kelemen, A., Kun, R., Máté, J., Sáfián, L., Provenza, F., Díaz, S., Barani, H., Biró, M., Máté, A. & Vadász, C. 2020. Knowledge co-production with traditional herders on cattle grazing behaviour for better management of species-rich grasslands. *Journal of Applied Ecology*, 57(9): 1677–1687.

Moritz, M. 2006. The Politics of Permanent Conflict: Farmer-Herder Conflicts in Northern Cameroon. *Canadian Journal of African Studies,* 40(1): 101–126.

Moritz, M., Scholte, P., Hamilton, I.M. & Kari, S. 2013. Open access, open systems: pastoral management of common-pool resources in the Chad Basin. *Human Ecology*, 41(3): 351–365.

Mortimore, M. & Adams, W.M. 1999. *Working the Sahel: environment and society in northern Nigeria*. Routledge, London.

Murphy, D. 2019. "We're Living from Loan-to-Loan": Pastoral Vulnerability and the cashmere-debt Cycle in Mongolia. *In* D.C. Wood, ed., *Individual and Social Adaptations to Human Vulnerability*. *Research in Economic Anthropology,* 38:7–30.

Myint, M.M. & Westerberg, V. 2015. *An economic valuation of a large-scale rangeland restoration project through the Hima system in Jordan*. Report for the ELD Initiative of the International Union for Conservation of Nature. Bonn, Germany, Economics of Land Degradation Initiative (ELD) and *Deutsche Gesellschaft für Internationale Zusammenarbeit* (Germany Agency for International Cooperation – GIZ).

Neely, C., Bunning, S. & Wilkes, A. 2009. *Review of evidence on drylands pastoral systems and climate change. Implications and opportunities for mitigation and adaptation*. Rome, FAO, Land Tenure and Management Unit.

Niamir-Fuller, M. 2016. Towards sustainability in the extensive and intensive livestock sectors. *In* J. Zinsstag, E. Schelling and V. Bonfoh, eds. *The Future of Pastoralism*. *OIE Scientific and Technical Review,* 35(2): 371–387.

Niamir-Fuller, M. & Huber-Sanwald, E. 2019. Pastoralism and Achievement of the 2030 Agenda for Sustainable Development: A Missing Piece of the Global Puzzle. *In* S. Lucatello, E. Huber-Sannwald, I. Espejel and N. Martínez-Tagüeña, eds. *Stewardship of Future Drylands and Climate Change in the Global South: Challenges and Opportunities for the Agenda 2030*, pp. 41–56. Springer International Publishers, Cham, Switzerland.

Nori, M. 2019. *Herding Through Uncertainties – Principles and practices. Exploring the interfaces of pastoralists and uncertainty. Results from a literature review*. Florence, Italy, Robert Schuman Centre for Advanced Studies, European University Institute.

Nyariki, D.M. & Amwata, D.A. 2019. The value of pastoralism in Kenya: Application of total economic value approach. *Pastoralism* 9: 9 [online]. [cited March 2021] https://doi.org/10.1186/s13570-019-0144-x

Oba, G. 2020. *African Environmental Crisis: A history of science for development*. Oxford, UK, Routledge.

Oba, G., Stenseth, N.C. & Lusigi, W.J. 2000. New Perspectives on Sustainable Grazing Management in Arid Zones of Sub-Saharan Africa. *BioScience,* 50: 35–51.

Origin Green Ireland. 2021. [cited March 2021]. https://www.origingreen.ie

Peters, K.J. 1989. Trends in on-farm performance testing of small ruminants in sub-Saharan Africa. *In* R. Trevor Wilson and A. Melaku, *African Small Ruminant Research and Development*. Proceedings of a conference, Bamenda, Cameroon, 18–25 January 1989. Addis Ababa, International Livestock Centre for Africa (ILCA).

Pica-Ciamarra, U., Baker, D., Morgan, N., Zezza, A., Azzarri, C., Ly, C., Nsiima, L., Nouala, S., Okello, P. & Sserugga, J. 2014. *Investing in the Livestock Sector. Why Good Numbers Matter. A Sourcebook for Decision Makers on How to Improve Livestock Data*. World Bank Report No. 85732-GLB. Washington, DC, World Bank.

Porcher, J. 2017. *The Ethics of Animal Labor. A Collaborative Utopia*. Cham, Switzerland, Palgrave Macmillan and Springer.

Porensky, L.M. & Veblen, K.E. 2015. Generation of ecosystem hotspots using short-term cattle corrals in an African savanna. *Rangeland Ecology & Management,* 68: 131–141.

Porter, R. 1982. The Penguin Social History of Britain: English Society in the Eighteenth Century. London, Penguin Books.

Pretty, J. 2002. *Agri-Culture. Reconnecting People, Land and Nature*. London, Earthscan.

Provenza, F. 2018. *Nourishment: What Animals Can Teach Us about Rediscovering Our Nutritional Wisdom.* London, Chelsea Green Publishing.

Provenza, F.D., Kronberg, S.L. & Gregorini, P. 2019. Is Grassfed Meat and Dairy Better for Human and Environmental Health? *Frontiers in Nutrition,* 6(26):1-13.

Rangé, C., Magnani, S. & Ancey, V. 2020. "Pastoralism" and "insecurity" in West Africa. From reifying narratives to political dispossession. *Revue Internationale des Études du Développement,* 243(3): 115–150.

Raworth, K. 2017. *Doughnut Economics. Seven Ways to Think Like a 21st-Century Economist*. London, Random House Business Books.

Robinson, T., Conchedda, G. & de Haan, C. 2016. Macroeconomic Aspects of Livestock Production Systems in the Drylands of Sub-Saharan Africa. *In* C. de Haan, ed. *Prospects for Livestock-Based Livelihoods in Africa's Drylands*. Washington, DC, International Bank for Reconstruction and Development and World Bank.

Roe, E. 2013. *Making the Most of Mess. Reliability and Policy in Today's Management Challenges*. Durham, North Carolina, USA, Duke University Press.

Roe, E. 2020. *A New Policy Narrative for Pastoralism? Pastoralists as Reliability Professionals and Pastoralist Systems as Infrastructure*. STEPS Working Paper No. 113. Brighton, UK, Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre, Institute of Development Studies.

Roe, E., Huntsinger, L. & Labnow, K. 1998. High-Reliability Pastoralism Versus Risk-Averse Pastoralism. *Journal of Environment and Development,* 7(4): 387–421.

Russell, N. 1986. *Like Engend'ring Like. Heredity and animal breeding in early modern England.* Cambridge, UK, Cambridge University Press.

Russell, T. & Lander, F. 2015. "The bees are our sheep": the role of honey and fat in the transition to livestock keeping during the last two thousand years in southernmost Africa. *Azania: Archaeological Research in Africa,* 50(3): 318–342.

Rutten, M. & Mwangi, M. 2014. How natural is natural? Seeking conceptual clarity over natural resources and conflicts. *In* M. Bavinck, L. Pellegrini and E. Mostert, eds. *Conflicts over Natural Resources in the Global South. Conceptual Approaches*. Boca Raton, Florida, USA, London, New York and Leiden, Netherlands, CRC Press, Taylor and Francis Group.

Salmon, G.R., MacLeod, M., Claxton, J.R., Pica Ciamarra, U., Robinson, T., Duncan, A. & Peters, A.R. 2019. Exploring the landscape of livestock "Facts". *Global Food Security,* 25(1): 100329 [online]. [cited March 2021]. https://doi:10.1016/j.gfs.2019.100329.

Sayre, N.F., Davis, D.K., Bestelmeyer, B. & Williamson, J. 2017. Rangelands: Where Anthromes meet their limits. *Land,* 6(2): 31–41.

Scanlon, B.R., Levitt, D.G., Reedy, R.C., Keese, K.E. & Sully, M.J. 2005. Ecological controls on water-cycle response to climate variability in deserts. *Proceedings of the National academy of Sciences*, 102(17): 6033–6038.

Schareika, N. 2003. *Know to Move, Move to Know. Ecological Knowledge Among the WoDaaBe of South Eastern Niger*. Rome, FAO.

Scherf, B., Rischkowsky, B., Hoffmann, I., Wieczorek, M., Montironi, A. & Cardellino, R. 2008. Livestock Genetic Diversity in Dry Rangelands. *In* C. Lee and T. Schaaf, eds. *The Future of Drylands*, pp. 89–100. Dordrecht, Netherlands, Springer.

Scherr, S.J. & McNeely, J.A. 2007. *Farming with Nature. The Science and Practice of Ecoagriculture* IslandPress, Washington, Covelo, London.

Schiere, H., Baumhardt, R.L., Van Keulen, H., Whitbread, H.M., Bruinsma, A.S., Goodchild, T., Gregorini, P., Slingerland, M. & Wiedemann-Hartwell, B. 2006. Mixed Crop-Livestock Systems in Semi-Arid Regions. *In* G.A. Peterson, ed. *Dryland Agriculture*, 2nd edition. Agronomy Monograph No. 23. Madison, Wisconsin, American Society of Agronomy, Crop Science Society of America and Soil Science Society of America.

Scoones, I. 2019. *What is Uncertainty and Why Does it Matter?* STEPS Working Paper No. 105 Brighton, UK, Social, Technological and Environmental Pathways to Sustainability (STEPS) Centre, Institute of Development Studies.

Scoones, I. & Wolmer, W. 2002. Crop-livestock integration in Africa. *In* I. Scoones and W. Wolmer, eds. *Pathways of Change in Africa. Crops, Livestock & Livelihoods in Mali, Ethiopia and Zimbabwe*. London, James Currey Ltd.

Seid, M.A., Yoseph, L.W., Befekadu, U.W., Muhammed, A. & Fikre, Z. 2016. Communication for the development of pastoralism. *In* J. Zinsstag, E. Schelling and B. Bonfoh, eds. *The Future of Pastoralism*. *OIE Scientific and Technical Review,* 35(2): 693–709.

Seré, C. & Steinfeld, H. in collaboration with Groenewold, J. 1996. *World livestock production systems. Current status, issues and trends*. FAO Animal Production and Health Paper No. 127. Rome, FAO. (also available at http://www.fao.org/3/w0027e/w0027e.pdf).

Shapiro, B.I., Gebru, G., Desta, S., Negassa, A., Nigussie, K., Aboset, G. & Mechale, H. 2017. *Ethiopia livestock sector analysis.* ILRI Project Report. Nairobi, International Livestock Research Institute (ILRI).

Silva, V., Catr, F.X., Fernandes, P., Rego, F.C., Paes, P., Nunes, L., Caperta, A.D., Sérgio, C. & Bugalho, M.N. 2019. Effects of grazing on plant composition, conservation status and ecosystem services of Natura 2000 shrub-grassland habitat types. *Biodiversity Conservation,* 28: 1205–1224. (also available at https://doi.org/10.1007/s10531-019- 01718-7).

Silvestri, S., Osano, P., de Leeuw, J., Herrero, M., Ericksen, P., Kariuki, J., Njuki, J., Bedelian, C. & Notenbaert, A. 2012. *Greening livestock: Assessing the potential of payment for environmental services in livestock inclusive agricultural production systems in developing countries*. Nairobi, International Livestock Research Institute (ILRI).

Slow Food Foundation for Biodiversity. 2019. Raika Camel Milk, [online]. [cited May 2021]. https://www.fondazioneslowfood.com/en/ark-of-taste-slow-food/kumbhalgarh-camel-milk/

Spedding, C.R.W. 1988. *An introduction to agricultural systems*. London, Elsevier.

Taleb, N.N. 2012. *Antifragile: things that gain from disorder*. New York, Random House.

Terrell. J.E., Hart, J.P., Barut, S., Cellinese, N., Curet, A., Denham, T., Kusimba, C.M., Latinis, K., Oka, R., Palka, J., Pohl, M.E.D., Pope, K.O., Williams, P.R., Haines, H. & Staller, J.E. 2003. Domesticated Landscapes: The Subsistence Ecology of Plant and Animal Domestication. *Journal of Archaeological Method and Theory,* 10(4): 323–368.

Thébaud, B., Corniaux, C., François, A. & Powell, A. 2018. *10 Key Findings on Livestock Mobility in West Africa – A reality Check. A Research Study on Transhumance in the Sahel (2014–2017).* Paris, Acting For Life and UK-Aid. (also available at https://acting-for-life.org/app/uploads/AFL-10-Findings-March2018.pdf).

Thiam, A. 2017. *Centre du Mali: Enjeux et Dangers d'une Crise Négligée*. Macina, Mali, *Centre pour le Dialogue Humanitaire* and *Institut de Macina*.

Toulmin, C. 1983. *Herders and Farmers or Farmer-Herders and Herder-Farmers?* ODI Pastoral Network Paper No. 15d. London, Overseas Development Institute (ODI).

UNEP. 2011. *Towards a Green Economy: Pathways to Sustainable Development and Poverty Eradication* Nairobi, United Nations Environment Programme (UNEP).

UNEP. 2016. *Back to the Future: Rangeland Management in Jordan*. UNEP News and Stories 22 June 2016. [online]. [cited March 2021] https://www.unenvironment.org/news-and-stories/story/back-future-rangeland-management-jordan

UNEP. 2021. Green Economy. [online] [cited March 2021]. https://www.unenvironment.org/regions/asia-and-pacific/regional-initiatives/supporting-resource-efficiency/green-economy

UNOWAS. 2018. *Pastoralism and Security in West Africa and the Sahel. Towards Peaceful Coexistence*. Dakar, United Nations Office for West Africa and the Sahel (UNOWAS).

van den Brink, R., Bromley, D. W., and Chavas, J. 1991. *The economics of Cain and Abel: agro-pastoral property rights in the Sahel*, Working paper 11, Washington, Cornell Food and Nutrition Policy Program.

Van Zanten, H., Herrero, M., Van Hal, O., Röös, E., Muller, A., Garnett, T., Gerber, P.J,., Schader, C. & De Boer, I.J.M. 2018. Defining a land boundary for sustainable livestock consumption. *Glob. Chang. Biol.,* 24(9): 4185–4194.

Vogelsang, J. 2019. *A historic step towards securing communal land rights in Kenya*, Thomson Reuters Foundation [online]. [cited March 2021]. https://intercontinentalcry.org/a-historic-step-towards-securing-community-land-rights-in-kenya/

Wedderburn, L. 2020. Levy Oration 2019: Musings on our sustainable agriculture journey, *Journal of New Zealand Grasslands*, 82 [online] [cited March 2021]. https://doi.org/10.33584/jnzg.2020.82.3431 (also available at https://www.nzgajournal.org.nz/index.php/JoNZG/article/view/3431/3051).

World Bank. 2013. *High Level Forum on Pastoralism in the Sahel: Nouakchott (Mauritania), 29 October, 2013. Outline Document*. Washington, DC. (also available at https://ewsdata.rightsindevelopment.org/files/documents/74/WB-P147674_wde1QaZ.pdf). (also available in French).

World Bank & DFID. 2019. *Poverty and Vulnerability in the Ethiopian Lowlands: Building a More Resilient Future*. Washington, DC, The World Bank Group and the UK Department for International Development (DFID), Washington. (also available at https://openknowledge.worldbank.org/handle/10986/33422).

WWF. no date. *Sustainable Diets*. [online]. [cited March 2021]. World Wide Fund for Nature (WWF). https://wwf.panda.org/our_work/food/sustainable_diets/

Zinsstag, J., Schelling, E. & Bonfoh, B., eds. 2016. *The Future of Pastoralism*. *OIE Scientific and Technical Review,* 35(2).

FAO TECHNICAL PAPERS
FAO ANIMAL PRODUCTION AND HEALTH PAPERS

1 Animal breeding: selected articles from the *World Animal Review*, 1977 (En, Fr, Es, Zh)
2 Eradication of hog cholera and African swine fever, 1976 (En, Fr, Es)
3 Insecticides and application equipment for tsetse control, 1977 (En, Fr)
4 New feed resources, 1977 (En/Fr/Es)
5 Bibliography of the criollo cattle of the Americas, 1977 (En/Es)
6 Mediterranean cattle and sheep in crossbreeding, 1977 (En, Fr)
7 The environmental impact of tsetse control operations, 1977 (En, Fr)
7 Rev.1 The environmental impact of tsetse control operations, 1980 (En, Fr)
8 Declining breeds of Mediterranean sheep, 1978 (En, Fr)
9 Slaughterhouse and slaughterslab design and construction, 1978 (En, Fr, Es)
10 Treating straw for animal feeding, 1978 (En, Fr, Es, Zh)
11 Packaging, storage and distribution of processed milk, 1978 (En)
12 Ruminant nutrition: selected articles from the *World Animal Review*, 1978 (En, Fr, Es, Zh)
13 Buffalo reproduction and artificial insemination, 1979 (En*)
14 The African trypanosomiases, 1979 (En, Fr)
15 Establishment of dairy training centres, 1979 (En)
16 Open yard housing for young cattle, 1981 (Ar, En, Fr, Es)
17 Prolific tropical sheep, 1980 (En, Fr, Es)
18 Feed from animal wastes: state of knowledge, 1980 (En, Zh)
19 East Coast fever and related tick-borne diseases, 1980 (En)
20/1 Trypanotolerant livestock in West and Central Africa – Vol. 1. General study, 1980 (En, Fr)
20/2 Trypanotolerant livestock in West and Central Africa – Vol. 2. Country studies, 1980 (En, Fr)
20/3 Le bétail trypanotolérant en Afrique occidentale et centrale – Vol. 3. Bilan d'une décennie, 1988 (Fr)
21 Guideline for dairy accounting, 1980 (En)
22 Recursos genéticos animales en América Latina, 1981 (Es)
23 Disease control in semen and embryos, 1981 (En, Fr, Es, Zh)
24 Animal genetic resources – conservation and management, 1981 (En, Zh)
25 Reproductive efficiency in cattle, 1982 (En, Fr, Es, Zh)
26 Camels and camel milk, 1982 (En)
27 Deer farming, 1982 (En)
28 Feed from animal wastes: feeding manual, 1982 (En, Zh)
29 Echinococcosis/hydatidosis surveillance, prevention and control: FAO/UNEP/WHO guidelines, 1982 (En)
30 Sheep and goat breeds of India, 1982 (En)
31 Hormones in animal production, 1982 (En)
32 Crop residues and agro-industrial by-products in animal feeding, 1982 (En/Fr)
33 Haemorrhagic septicaemia, 1982 (En, Fr)
34 Breeding plans for ruminant livestock in the tropics, 1982 (En, Fr, Es)
35 Off-tastes in raw and reconstituted milk, 1983 (Ar, En, Fr, Es)
36 Ticks and tick-borne diseases: selected articles from the *World Animal Review*, 1983 (En, Fr, Es)
37 African animal trypanosomiasis: selected articles from the *World Animal Review*, 1983 (En, Fr)
38 Diagnosis and vaccination for the control of brucellosis in the Near East, 1982 (Ar, En)
39 Solar energy in small-scale milk collection and processing, 1983 (En, Fr)
40 Intensive sheep production in the Near East, 1983 (Ar, En)
41 Integrating crops and livestock in West Africa, 1983 (En, Fr)
42 Animal energy in agriculture in Africa and Asia, 1984 (En/Fr, Es)

43 Olive by-products for animal feed, 1985 (Ar, En, Fr, Es)
44/1 Animal genetic resources conservation by management, data banks and training, 1984 (En)
44/2 Animal genetic resources: cryogenic storage of germplasm and molecular engineering, 1984 (En)
45 Maintenance systems for the dairy plant, 1984 (En)
46 Livestock breeds of China, 1984 (En, Fr, Es)
47 Réfrigération du lait à la ferme et organisation des transports, 1985 (Fr)
48 La fromagerie et les variétés de fromages du bassin méditerranéen, 1985 (Fr)
49 Manual for the slaughter of small ruminants in developing countries, 1985 (En)
50/1 Better utilization of crop residues and by-products in animal feeding: research guidelines – 1. State of knowledge, 1985 (En)
50/2 Better utilization of crop residues and by-products in animal feeding: research guidelines – 2. A practical manual for research workers, 1986 (En)
51 Dried salted meats: charque and carne-de-sol, 1985 (En)
52 Small-scale sausage production, 1985 (En)
53 Slaughterhouse cleaning and sanitation, 1985 (En)
54 Small ruminants in the Near East – Vol. I. Selected papers presented for the Expert Consultation on Small Ruminant Research and Development in the Near East (Tunis, 1985), 1987 (En)
55 Small ruminants in the Near East – Vol. II. Selected articles from *World Animal Review* 1972-1986, 1987 (Ar, En)
56 Sheep and goats in Pakistan, 1985 (En)
57 The Awassi sheep with special reference to the improved dairy type, 1985 (En)
58 Small ruminant production in the developing countries, 1986 (En)
59/1 Animal genetic resources data banks – 1. Computer systems study for regional data banks, 1986 (En)
59/2 Animal genetic resources data banks – 2. Descriptor lists for cattle, buffalo, pigs, sheep and goats, 1986 (En, Fr, Es)
59/3 Animal genetic resources data banks – 3. Descriptor lists for poultry, 1986 (En, Fr, Es)
60 Sheep and goats in Turkey, 1986 (En)
61 The Przewalski horse and restoration to its natural habitat in Mongolia, 1986 (En)
62 Milk and dairy products: production and processing costs, 1988 (En, Fr, Es)
63 Proceedings of the FAO expert consultation on the substitution of imported concentrate feeds in animal production systems in developing countries, 1987 (En, Zh)
64 Poultry management and diseases in the Near East, 1987 (Ar)
65 Animal genetic resources of the USSR, 1989 (En)
66 Animal genetic resources – strategies for improved use and conservation, 1987 (En)
67/1 Trypanotolerant cattle and livestock development in West and Central Africa – Vol. I, 1987 (En)
67/2 Trypanotolerant cattle and livestock development in West and Central Africa – Vol. II, 1987 (En)
68 Crossbreeding *Bos indicus* and *Bos taurus* for milk production in the tropics, 1987 (En)
69 Village milk processing, 1988 (En, Fr, Es)
70 Sheep and goat meat production in the humid tropics of West Africa, 1989 (En/Fr)
71 The development of village-based sheep production in West Africa, 1988 (Ar, En, Fr, Es) (Published as Training manual for extension workers, M/S5840E)
72 Sugarcane as feed, 1988 (En/Es)
73 Standard design for small-scale modular slaughterhouses, 1988 (En)
74 Small ruminants in the Near East – Vol. III. North Africa, 1989 (En)
75 The eradication of ticks, 1989 (En/Es)

76 Ex situ cryoconservation of genomes and genes of endangered cattle breeds by means of modern biotechnological methods, 1989 (En)
77 Training manual for embryo transfer in cattle, 1991 (En)
78 Milking, milk production hygiene and udder health, 1989 (En)
79 Manual of simple methods of meat preservation, 1990 (En)
80 Animal genetic resources – a global programme for sustainable development, 1990 (En)
81 Veterinary diagnostic bacteriology – a manual of laboratory procedures of selected diseases of livestock, 1990 (En, Fr)
82 Reproduction in camels – a review, 1990 (En)
83 Training manual on artificial insemination in sheep and goats, 1991 (En, Fr)
84 Training manual for embryo transfer in water buffaloes, 1991 (En)
85 The technology of traditional milk products in developing countries, 1990 (En)
86 Feeding dairy cows in the tropics, 1991 (En)
87 Manual for the production of anthrax and blackleg vaccines, 1991 (En, Fr)
88 Small ruminant production and the small ruminant genetic resource in tropical Africa, 1991 (En)
89 Manual for the production of Marek's disease, Gumboro disease and inactivated Newcastle disease vaccines, 1991 (En, Fr)
90 Application of biotechnology to nutrition of animals in developing countries, 1991 (En, Fr)
91 Guidelines for slaughtering, meat cutting and further processing, 1991 (En, Fr)
92 Manual on meat cold store operation and management, 1991 (En, Es)
93 Utilization of renewable energy sources and energy-saving technologies by small-scale milk plants and collection centres, 1992 (En)
94 Proceedings of the FAO expert consultation on the genetic aspects of trypanotolerance, 1992 (En)
95 Roots, tubers, plantains and bananas in animal feeding, 1992 (En)
96 Distribution and impact of helminth diseases of livestock in developing countries, 1992 (En)
97 Construction and operation of medium-sized abattoirs in developing countries, 1992 (En)
98 Small-scale poultry processing, 1992 (Ar, En)
99 In situ conservation of livestock and poultry, 1992 (En)
100 Programme for the control of African animal trypanosomiasis and related development, 1992 (En)
101 Genetic improvement of hair sheep in the tropics, 1992 (En)
102 Legume trees and other fodder trees as protein sources for livestock, 1992 (En)
103 Improving sheep reproduction in the Near East, 1992 (Ar)
104 The management of global animal genetic resources, 1992 (En)
105 Sustainable livestock production in the mountain agro-ecosystem of Nepal, 1992 (En)
106 Sustainable animal production from small farm systems in South-East Asia, 1993 (En)
107 Strategies for sustainable animal agriculture in developing countries, 1993 (En, Fr)
108 Evaluation of breeds and crosses of domestic animals, 1993 (En)
109 Bovine spongiform encephalopathy, 1993 (Ar, En)
110 L'amélioration génétique des bovins en Afrique de l'Ouest, 1993 (Fr)
111 L'utilización sostenible de hembras F1 en la producción del ganado lechero tropical, 1993 (Es)
112 Physiologie de la reproduction des bovins trypanotolérants, 1993 (Fr)
113 The technology of making cheese from camel milk (*Camelus dromedarius*), 2001 (En, Fr)
114 Food losses due to non-infectious and production diseases in developing countries, 1993 (En)
115 Manuel de formation pratique pour la transplantation embryonnaire chez la brebis et la chèvre, 1993 (F S)
116 Quality control of veterinary vaccines in developing countries, 1993 (En)
117 L'hygiène dans l'industrie alimentaire, 1993 – Les produits et l'aplication de l'hygiène, 1993 (Fr)

118 Quality control testing of rinderpest cell culture vaccine, 1994 (En)
119 Manual on meat inspection for developing countries, 1994 (En)
120 Manual para la instalación del pequeño matadero modular de la FAO, 1994 (Es)
121 A systematic approach to tsetse and trypanosomiasis control, 1994 (En/Fr)
122 El capibara (*Hydrochoerus hydrochaeris*) – Estado actual de su producción, 1994 (Es)
123 Edible by-products of slaughter animals, 1995 (En, Es)
124 L'approvisionnement des villes africaines en lait et produits laitiers, 1995 (F)
125 Veterinary education, 1995 (En)
126 Tropical animal feeding – A manual for research workers, 1995 (En)
127 World livestock production systems – Current status, issues and trends, 1996 (En)
128 Quality control testing of contagious bovine pleuropneumonia live attenuated vaccine – Standard operating procedures, 1996 (En, Fr)
129 The world without rinderpest, 1996 (En)
130 Manual de prácticas de manejo de alpacas y llamas, 1996 (Es)
131 Les perspectives de développement de la filière lait de chèvre dans le bassin méditerranéen, 1996 (Fr)
132 Feeding pigs in the tropics, 1997 (En)
133 Prevention and control of transboundary animal diseases, 1997 (E)
134 Tratamiento y utilización de residuos de origen animal, pesquero y alimenticio en la alimentación animal, 1997 (Es)
135 Roughage utilization in warm climates, 1997 (En, Fr)
136 Proceedings of the first Internet Conference on Salivarian Trypanosomes, 1997 (En)
137 Developing national emergency prevention systems for transboundary animal diseases, 1997 (En)
138 Producción de cuyes (*Cavia porcellus*), 1997 (Es)
139 Tree foliage in ruminant nutrition, 1997 (En)
140/1 Analisis de sistemas de producción animal – Tomo 1: Las bases conceptuales, 1997 (Es)
140/2 Analisis de sistemas de producción animal – Tomo 2: Las herramientas basicas, 1997 (Es)
141 Biological control of gastro-intestinal nematodes of ruminants using predacious fungi, 1998 (En)
142 Village chicken production systems in rural Africa – Household food security and gender issues, 1998 (En)
143 Agroforestería para la producción animal en América Latina, 1999 (Es)
144 Ostrich production systems, 1999 (En)
145 New technologies in the fight against transboundary animal diseases, 1999 (En)
146 El burro como animal de trabajo – Manual de capacitación, 2000 (Es)
147 Mulberry for animal production, 2001 (En)
148 Los cerdos locales en los sistemas tradicionales de producción, 2001 (Es)
149 Animal production based on crop residues – Chinese experiences, 2001 (En, Zh)
150 Pastoralism in the new millennium, 2001 (En)
151 Livestock keeping in urban areas – A review of traditional technologies based on literature and field experiences, 2001 (En)
152 Mixed crop-livestock farming – A review of traditional technologies based on literature and field experiences, 2001 (En)
153 Improved animal health for poverty reduction and sustainable livelihoods, 2002 (En)
154 Goose production, 2002 (En, Fr)
155 Agroforestería para la producción animal en América Latina – II, 2003 (Es)
156 Guidelines for coordinated human and animal brucellosis surveillance, 2003 (En)
157 Resistencia a los antiparasitarios – Estado actual con énfasis en América Latina, 2003 (Es)
158 Employment generation through small-scale dairy marketing and processing, 2003 (En)
159 Good practices in planning and management of integrated commercial poultry production in South Asia, 2003 (En)
160 Assessing quality and safety of animal feeds, 2004 (En, Zh)
161 FAO technology review: Newcastle disease, 2004 (En)

162 Uso de antimicrobianos en animales de consumo – Incidencia del desarrollo de resistencias en la salud pública, 2004 (Es)
163 HIV infections and zoonoses, 2004 (En, Fr, Es)
164 Feed supplementation blocks – Urea-molasses multinutrient blocks: simple and effective feed supplement technology for ruminant agriculture, 2007 (En)
165 Biosecurity for Highly Pathogenic Avian Influenza – Issues and options, 2008 (En, Fr, Ar, Vi)
166 International trade in wild birds, and related bird movements, in Latin America and the Caribbean, 2009 (Es[e] En[e])
167 Livestock keepers – guardians of biodiversity, 2009 (En)
168 Adding value to livestock diversity – Marketing to promote local breeds and improve livelihoods, 2010 (En, Fr, Es)
169 Good practices for biosecurity in the pig sector – Issues and options in developing and transition countries, 2010 (En, Fr, Zh, Ru** Es**)
170 La salud pública veterinaria en situaciones de desastres naturales y provocados, 2010 (Es)
171 Approaches to controlling, preventing and eliminating H5N1 HPAI in endemic countries, 2011 (En, Ar)
172 Crop residue based densified total mixed ration – A user-friendly approach to utilise food crop by-products for ruminant production, 2012 (En)
173 Balanced feeding for improving livestock productivity – Increase in milk production and nutrient use efficiency and decrease in methane emission, 2012 (En)
174 Invisible Guardians - Women manage livestock diversity, 2012 (En)
175 Enhancing animal welfare and farmer income through strategic animal feeding – Some case studies, 2013 (En)
176 Lessons from HPAI – A technical stocktaking of coutputs, outcomes, best practices and lessons learned from the fight against highly pathogenic avian influenza in Asia 2005–2011, 2013 (En)
177 Mitigation of greenhouse gas emissions in livestock production – A review of technical options for non-CO_2 emissions, 2013 (En, Es[e])
178 Африканская Чума Свиней в Российской Федерации (2007-2012), 2014 (Ru)
179 Probiotics in animal nutrition – Production, impact and regulation, 2016 (En)
180 Control of Contagious Bovine Pleuropneumonia – A policy for coordinated actions, 2018 (En, Zh**)
181 Exposure of humans or animals to SARS-CoV-2 from wild, livestock,companion and aquatic animals. Qualitative exposure assessment, 2020 (En)
182 The economics of pastoralism in Argentina, Chad and Mongolia. Market participation and multiple livelihood strategies in a shock-prone environment, 2020 (En)
183 Introduction and Spread of lumpy skin disease in South, East and Southeast Asia. Qualitative Risk Assessment and Management, 2020 (En)
184 Animal nutrition strategies and options to reduce the use of antimicrobials in animal production, 2021 (En)
185 Pastoralism – Making variability work, 2021 (En)

Availability: July 2021

Ar – Arabic
En – English
Es – Spanish
Fr – French
Pt – Portuguese
Ru – Russian
Vi – Vietnamese
Zh – Chinese

Multil – Multilingual
* Out of print
** In preparation
[e] E-publication
(En, Fr, Es) = Separate editions in English, French and Spanish
(En/Fr/Es) = Trilingual edition

The *FAO Animal production and health papers* are available through authorized FAO Sales Agents or directly from Sales and Marketing Group, FAO, Viale delle Terme di Caracalla, 00153 Rome, Italy.

"Pastoralism is a livestock-keeping system that specialises in taking advantage of environmental variability, managing grazing itineraries at a variety of scales so that livestock feed better than without a herder". Elaborating on this definition, this document explains how pastoralism, by farming with nature, can address the global challenge of producing food sustainably in a context of increasing variability from climate change. It does so in addressing climate change, economic contribution and employment, food security, food safety and nutrition, water efficiency, ecosystem services, landscape functionality, resource management, regional economic integration, biodiversity conservation and the transition to a green economy.

This document aims to engage FAO in the mainstreaming of pastoralism – promoting FAO's corporate vision by generating an understanding of pastoralism and systematically including pastoralism in FAO's normal operations – and to present an evidence-based narrative on pastoralism for a specialist audience.

ISBN 978-92-5-134753-9 ISSN 0254-6019

9 789251 347539

CB5855EN/1/07.21