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A House Full of Trap Doors

Identifying barriers to resilient drylands in the toolbox of pastoral development

Saverio Krätli, Brigitte Kaufmann, Hassan Roba, Pierre Hiernaux, Wenjun Li, Marcos Easdale, Christian Hülsebusch

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About the authors

Saverio Krätli, freelance researcher, Editor of Nomadic Peoples journal (http://nomadicpeoples.info/NP_journal/).
Email: saverio.kratli@gmail.com

Brigitte Kaufmann, head of research, DITSLGmbH Witzenhausen at the University of Kassel, Witzenhausen, Germany. Email: b.kaufmann@ditsl.org

Hassan Roba, post-doctoral researcher at DITSL within the DAAD funded project GrassNet, and currently Program Officer African Rift Valley for the Christensen Fund.
Email: guyoroba@yahoo.com

Pierre Hiernaux, agroecologist retired from CNRS, France, Géosciences Environnement Toulouse.
Email: pierre.hiernaux@wanadoo.fr

Wenjun Li, Professor, Department of Environmental Management, College of Environmental Sciences and Engineering, Peking University. Email: wjlee@pku.edu.cn

Marcos H. Easdale, Instituto Nacional de Tecnología Agropecuaria (INTA), Bariloche, Grupo de Sistemas de Producción y Territorios, Desarrollo Rural, Argentina.
Email: easdale.marcos@inta.gob.ar

Christian Hülsebusch, CEO, DITSL GmbH Witzenhausen at the University of Kassel, Witzenhausen, Germany.
Email: c.huelsebusch@ditsl.org

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International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
email: info@iied.org
www.iied.org

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The theoretical framework for the scientific understanding of the drylands is almost the opposite today of what was mainstream in the 1970s, but the methodological infrastructure of analytical tools and practices is still catching up. As researchers and practitioners involved in dryland development depend on such infrastructure, they are often in danger of silently reproducing the old theoretical horizon even when manifestly operating in the new one. This is the issue this paper sets out to discuss.

Contents

Summary

This paper is about a gap between theory and methodology in drylands development. It argues that pockets of equilibrium thinking linger on embedded in everyday practices of research and analysis, obstructing the way to resilient drylands development. Equilibrium assumptions remain operational in off-the-shelf definitions, analytical tools and procedures (the 'methodological infrastructure' of drylands development), even when researchers and practitioners have updated their theoretical framework. Generating sound drylands data for public use must start from identifying and managing these barriers. Until then, just increasing the rigour and the intensity of data collection will not improve the representation of drylands food production systems in statistics and policy-making. The paper sketches out the issues and illustrates them with examples from a selection of concepts key to drylands development.

Discontinuity in theory. Classical ecology represented nature in terms of relatively closed systems self-regulated to a point of stability. Starting from the 1970s the universal relevance of this model has been disproved, based on the paths of reflection that led to resilience theory. This theoretical shift eventually precipitated a U-turn in the understanding of drylands food production systems, and pastoralism in particular. In the new understanding, variability is no longer seen as a disturbance but as a defining trait in the drylands, and pastoralism is not seen as economically irrational and ecologically disruptive, but as a sustainable and adaptive system *specialised to take advantage of variability.*

The slower pace of practice. During periods of intense revision of foundational principles in science, the formal theoretical framework may go out of sync with the theory embedded in the methodological infrastructure. When this happens, there is a risk of *thinking* new theory while still *practicing* the old one. Underlying assumptions qualify what is to be measured or observed, but a substantial change in the context of observation may make them obsolete and misleading. Differences that can be ignored in one context of observation might be of critical importance in others.

Discontinuity across scales. Important aspects of what makes pastoral systems more productive and more resilient are only visible at relatively large scales (geographical, temporal, social and economic). We can expect these features to be missed out by default, as a consequence of the methodology, in all cases when the wider picture is obtained by extrapolating or even aggregating a large mass of data collected at a lower scale (eg through household-level surveys, sets of localities, or temporal snapshots).

From thinking 'parts' to thinking 'relationships'. Whereas input-intensive agriculture invests in sealing off the cycle of production from the natural environment, specialist drylands food production systems invest in the interaction with the environment. To reflect this difference in the analysis, it is necessary to move away from the tradition of representing the world in terms of closed systems of 'parts' defined by inherent features, and instead focus observation on relationships, that is placing at the centre of understanding not 'parts' but 'context'.

The language for talking about pastoralism. Technical definitions are designed to serve theory but they rarely change at the same pace. An exploration of the barriers embedded in the methodological infrastructure of drylands development therefore starts from its technical language and legacy of classifications. Three general issues are identified. First, conventional definitions of pastoralism assume perfect overlap between cultural identity and economic activity – or livestock management and ownership – but this is no longer the case. Second, they qualify pastoralism 'by subtraction' (eg lack of crop-farming), without engaging with what makes these systems adaptive. Third, they represent drylands production in terms of rigid systems defined by clearcut boundaries, therefore disregarding the adaptive capacity of interfacing variability with variability, for example by combining and recombining relationships at different scales – which is key to resilience.

Measuring productivity. When designing livestock sector development strategies for drylands regions, it is crucial that the definitions of key animal production parameters effectively capture what matters in drylands systems. At present key definitions such as production, productivity and performance assume the stabilised production environment characteristic of input-intensive systems. Where resources and outputs are highly variable in space and time, an adequate representation of the production process requires higher resolution than the level conventionally associated with these concepts.

Defining resources. A 'resource', by definition, is understood by a relationship *by someone doing something*. 'Natural' resources are commonly understood as 'things' (whether or not tangible), an approach that assumes *a priori* a particular set of relationships. Unfortunately this usually excludes the relationships that define resources for small-scale drylands systems to function successfully and reliably.

Managing risk. Risk management is usually equated with risk reduction, but small-scale food producers in the drylands specialise in risky enterprises. Their rewards are highest when risk is taken and managed with the lowest possible incidence of disasters, not when it is avoided. Avoiding risk and managing risk may therefore be strategies going in opposite directions.

Ecological fragility. At least since the 1990s, 'fragility' in ecology has no longer referred to a biophysical characteristic but to a relationship; a circumstance triggered by a particular kind of management being used in relation to a particular kind of environment. That the drylands are still often described as 'fragile ecosystems', meaning a structural limitation, is therefore confusing.

Ecological efficiency. The efficiency of animal production systems is usually measured by focusing on the rate of conversion of feed input into output, assuming non-feed inputs such as fossil-fuel energy to be substantially the same for all systems. With this approach, pastoral systems by default score lower than intensive livestock production systems. If non-feed inputs are included in the analysis however the ranking often reverses.

Crop-livestock integration. Crop-livestock integration is commonly understood as mixed farming, which is at the scale of the farm. This single-path approach conceals the multitude of ways in which integration has developed in the drylands; especially as livestock mobility allows for discontinuous patterns of integration over time and space, at a variety of scales and with little trade off in specialisation.

Household and beyond. A key underlying assumption, if relying exclusively on a household-based approach, is that the knowledge captured at that scale remains relevant at higher scales. In pastoral systems, this is rarely the case. Besides, definitions of household standardised for both monogamous and polygamous contexts tend to distort parameters that are key to the analysis of pastoral systems, such as livestock holdings and mobility.

Demographic growth. Narratives linking demographic growth in pastoral populations to rangeland degradation embed assumptions based on crop-farming systems, such as an expansion of means of production and a reduction of fallow periods. In reality, the herd growth rate of a fast growing pastoral family is more likely to slow down under increasing intakes to satisfy needs.

Statistical data. The need for updating the methodological infrastructure of drylands development should also be understood in relation to the ongoing global revision of agricultural data and the way of generating them. Off-the-shelf processes of appraisal, even when executed by the book and extended to effectively cover dryland regions, would still lead to misrepresentation.

To establish a way forward, an online participatory platform has been set up with two objectives: (*i) to* collect a critical mass of examples of 'barriers' embedded in the methodological infrastructure of drylands development; and (*ii) to* mobilise interest and debate around the challenge of revising and updating the infrastructure, sharing knowledge of existing options for quantitative analysis in contexts dominated by variability as well as ideas for innovative approaches to capture relevant data in the drylands.

Introduction

The understanding of variability and the limits of equilibrium thinking in ecology has paid a great deal of attention to the drylands, further consolidating its presence in development circles along with the growing popularity of resilience theory in public knowledge and amongst policy makers.

The old theoretical horizon of drylands development – a conceptual framework that emphasises the desirability of stability, equilibrium and predictability – lingers on however, embedded in off-the-shelf methodology at all scales of operation. The practical dependence on this legacy results in a basis of misconceptions about the functioning, performance, and service capability of drylands food production systems, with important fallout in terms of policies and interventions.

Unpacking the methodological barriers that hinder drylands development from operationalizing the new perspective on variability has become a pressing challenge. Unless these barriers are identified and managed, even increasing the rigour and the intensity of data collection will not be sufficient to improve the representation of these systems in statistics and policy making.

This paper is written by researchers concerned directly or indirectly with the challenge of generating drylands data for public use. It is addressed to other researchers, but also to policy makers and donors who need such data to be representative of reality; and to people engaged in advocacy and lobbying, who need to articulate the problem of misrepresentation of drylands food production. As pastoral systems are often the production and livelihood systems with the highest comparative advantage in the drylands (eg Rass 2006; Toutain *et al.* 2012; McGahey *et al.* 2014), they are centre-stage in our analysis, but understood in relation to their economic context and particularly to crop farming.

By tracking the relationship between theoretical framework and methodological tools in drylands development, this paper engages with a heterogeneous set of issues from a range of disciplines. Each issue deserves a study in its own right, but here they are only addressed briefly, mostly from a trans-disciplinary perspective, in order to illustrate the main argument of the paper.

Section 1, introduces the building blocks of our analytical framework: our use of the notions of underlying assumption, commensurability, scale, discontinuity, and relational understanding. Section 2, presents three biases in the legacy of data on pastoralism and discusses the tradition of classification. Section 3, deals with a selection of concepts that often appear in policy documents and research projects and that are critically important in the design and implementation of processes of appraisal concerned with the livestock sector and pastoral systems in particular. Section 4 relates the need to update the methodological infrastructure of pastoral development to the ongoing global revision of agricultural data. The last section wraps up the discussion and proposes a way forward.

Building blocks

1

> 'The limits of my language are the limits of my world' (Ludwig Wittgenstein, *Tractatus Logico-Philosophicus*, 1922: 5.6).

This paper focuses on a range of discrepancies within the theoretical framework of drylands development – particularly when engaging with pastoral systems – and its methodological infrastructure. By 'methodological infrastructure' we refer to the basic operational elements of method: from technical definitions, systems of classification, indicators, and the procedures for data collection, to wider processes of standardization and analysis.

Our point of departure is that the ways of classifying and measuring reality contribute to the processes that shape it. The transformations brought about by development follow not only from its direct interventions but also from the ways the context of intervention is framed by the definition of the problems and the possible solutions.[1]

This opening section provides an overview of the shift in pastoral development theory and presents some key conceptual elements used in the paper: the notion of underlying qualitative assumptions in the methodological infrastructure, issues concerning commensurability and scales, and the notion of relational qualification.

1.1 Discontinuity in theory

When looking at the drylands today, including the 'traditional' production systems such as pastoralism, the landscape one is faced with unavoidably reflects the legacy of a long history of rural development. Intended and unintended processes of transformation in some countries go back more than a century.[2] For most of this history, pastoral development has been intertwined with ecological arguments.[3]

Classical ecology represented nature in terms of relatively closed systems self-regulated to a point of stability. In the 1970s, the boundaries of validity of this 'equilibrium' model were fundamentally reconsidered. In the new understanding, the equilibrium model is no longer the cornerstone of ecological explanation, but just a province in a much bigger world dominated by variability, its relevance limited to particular temporal and spatial scales (Pickett *et al.* 2007).[4]

This paradigm shift did not simply concern the different behaviour of particular ecosystems but alternative ways of conceptualising the natural world: one emphasising stability and linearity, and the other emphasising complex dynamics (variability) and circularity of causes and effects. The alternative is a matter of analytical convenience more than one of right and wrong: although living (or complex) systems are never, strictly speaking, at equilibrium, it can be convenient to treat them as such for analytical purposes.[5]

The paradigm shift in ecology stems for the realisation that the convenience of assuming structural equilibrium and stability is not universal, but is limited to particular analytical purposes under particular circumstances. A fundamental argument in resilience thinking is that the set of these circumstances is shrinking and that there is a pressing need for a science capable of engaging with unpredictability as the norm.[6]

As ecology was going through this fundamental reorganisation, the African famines of the 1970s and 1980s triggered unprecedented waves of research on pastoral systems.[7] By the end of the 1980s, the theoretical framework that pastoral development had inherited from the colonial observers was being challenged by a critical mass of new empirical evidence emerging from a range of disciplines.[8]

[1] For example, forestry focused on commercial timber eventually turns forests from places of ecological complexity and multiple uses, to places of simplified ecology and utility (Rajan 2006). Similarly, research on gender and development has shown that appraisal methods predominantly sensitive to men's activities and worldview, contribute to a world where men's activities and worldview become predominant (e.g. Hodgson 2000). The general issue, close to Foucault's notion of governmentality (cf. Morton 2010), has been extensively analysed in anthropology (Douglas and Hull 1992; Bowker and Star 2000), including with specific attention to rural development (Scott 1998).
[2] The idea is not new (cf Hogg 1982), but references to pastoral systems as 'traditional' remain common in development literature.
[3] Amongst many other possible sources: Sandford 1983; Davis 2004; Rao and Casimir 2003; Williams 2002; Kerven 2003; Du 2012.
[4] On the drylands, cf. the seminal work on the determinant nitrogen and phosphorus control on rangeland productivity in Mali (Penning de Vries and Djiteye 1982); and the work of IRD ecologists and hydrologists in Senegal (Bille 1977), and Burkina Faso (Grouzis 1988). The linear arrangement of vegetation dynamics that goes with the Clementsian climax equilibrium was questioned in the 1970s in the work on savanna-forest ecotone and agro-ecosystems, that paved the way to 'stage and transition' models (Hiernaux 1975; Peltre 1977; de Miranda 1980).
[5] On these themes, see the groundbreaking paper by Sullivan and Homewood (2003).
[6] Holling *et al.* (1998) stress the need of 'moving beyond the Newtonian tradition of mechanistic explanation based on reductionist, controlled experimental analysis, towards a science that is integrative [...] and that focuses on variability and uncertainty as absolutely fundamental, instead of as "noise" to be excluded from the analysis' (cited in Scoones 1999: 494). Malhotra in Folke *et al.* (2002: 3) on adaptive management: 'We are facing "permanent white-waters", which demands strategies for adaptation to uncertainty in contrast to the conventional emphasis on optimisation based on prediction […] "We have put a tremendous emphasis on quick response instead of planning. We will continue to be surprised, but we won't be surprised that we are surprised. We will anticipate the surprise"'.
[7] Cf. Monod (1975); Wilson and Clarke (1976); Gallais (1977); Breman *et al.* (1978); Boutrais (1978); Salzman (1980); Galaty *et al.* (1981); IDRC-ILCA (1983); Sandford 1983; Benoit (1984); Adamu and Kirk-Greene (1986); Galaty and Johnson (1990); Fratkin *et al.* (1994).
[8] The seminal works associated with the 'New Range Ecology' paradigm shift are well known: Ellis and Swift (1988); Westoby *et al.* (1989); Behnke *et al.* (1993); Scoones (1994). A parallel reflection on the economic importance of pastoral mobility was also taking form in the francophone context, for example in the works of Bernus (1990), and Digard *et al.* (1992). As early as 1974, OSTROM geographer Henri Barral talked of 'l'indispensable re-mobilisation des éleveurs Saéliens' [the necessity of reverting Sahelian pastoralists to mobility] (Barral 1974: 135).

BOX 1. PASTORAL SYSTEMS AS FUNCTIONAL ADAPTATION

Mobile pastoral systems have been found to be significantly more productive than ranches (per hectare), and more sustainable and resilient than mixed farming in the same environment (Wilson and Clarke 1976; Colin de Verdière 1995; Hiernaux and Turner 2002). Work amongst pastoralists in Kazakhstan found that 'Mobility virtually ceased in the post-Soviet 1990s, but is re-emerging […] Non-mobile livestock have lowered productivity compared to mobile livestock' (Kerven *et al.* 2006: 99).

The herds of specialised pastoral groups have been found capable of securing a diet that is higher in nutritional content than the average value of the range they graze on (Breman and De Wit 1983; Schareika *et al.* 2000). The added value of pastoral management is closely related to selectivity, both in human activities (e.g. mobile herding selecting time and space of grazing) and animal behaviour (e.g. selective feeding).

If mobility is critical to optimise animal nutrition, flexible land tenure arrangements and communal management (not to be confused with the 'open access' of the *Tragedy of the Commons*, cf. Eggertsson 2009) are critical to guarantee such strategic mobility (Lane 1997; UNDP 2003; van den Brink *et al.* 2005; Fernández-Giménez 2001).

Following the reconsideration of the equilibrium model in ecology, the shift in pastoral development theory hinged on the way of representing variability in the drylands (eg patchy precipitations and drought): from a disturbance in a system that naturally tends towards a steady-state, to being seen as a defining trait.

Through the lenses of equilibrium thinking, drylands variability had been seen as a problem that development was to solve by introducing uniform and stable conditions. This included settling pastoralists and introducing ways of centrally controlling grazing and stock numbers.[9]

In the new understanding of pastoralism and the drylands, variability is the baseline to produce with[10] and pastoralism is an adaptive system *specialised to take advantage of variability*[11] – its strategies are rational and, when not distorted by overwhelming political or economic constraints, economically effective and ecologically sustainable. In this perspective, the task of pastoral development is to understand, support and possibly improve adaptive strategies, starting from securing mobility and the reproduction of pastoral specialist knowledge.

Blends of old and new understanding have represented mobility as a necessary coping strategy in the face of a hostile natural environment characterised by scarcity of resources. This focus on 'push factors' ignores that, as a routine practice, pastoral mobility peaks with the rainy season; that is, it is 'pulled' by abundance rather than 'pushed' by scarcity.[12]

As with the more general paradigm shift in ecology, the representation of variability as structural in the understanding of pastoral systems and the drylands has important affinities with resilience theory.[13] Following concerns for global climate change, efforts to develop explanatory models more effective in representing realities where stability is not the rule are taking place on a wide front of scientific domains.[14]

[9] Cf. Sandford: 'A… consequence of the Mainstream view [of pastoralism] is the tendency for pastoral development to assign a key role to firm intervention by government and to management of resources by government officials. There is much talk of need for *control* and *discipline*. This follows from distrust of existing pastoral institutions and from the belief that modern science has discovered the technical solutions to the problems of the pastoral areas' (1983: 17–18).

[10] Characterising pastoralism by a strategic orientation to take advantage of variability is a choice based on the observation of these systems. The ultimate objective of such a strategic orientation is breeding livestock. Its main institutional tool is commonly managed resources (Ensminger and Rutten 1991; Lane 1997; Agrawal 2001; Thébaud 2002; Moritz *et al.* 2013).

[11] Behnke and Scoones (1993: 14–15): 'The producer's strategy within non-equilibrium systems is to move livestock sequentially across a series of environments … exploiting optimal periods in each area they use … Herd management must aim at responding to alternate periods of high and low productivity, with an emphasis on exploiting environmental heterogeneity rather than attempting to manipulate the environment to maximise stability and uniformity'. Tracking and exploiting variability has also been observed in dryland cropping systems, for example through niche-creation for particular crops, crop association, crop rotation or soil fertility management; cf. for example the analysis of polycropping techniques in West Africa by Paul Richards (1985).

[12] The characterization of pastoral mobility exclusively as a coping strategy is still occasionally found today, even in specialized forums, eg Nkedianye *et al.* (2011).

[13] Cf. For example in the notion of a 'constructive role of instability' (Holling *et al.* 1995) and the emphasis that 'resilience is not only about being persistent or robust to disturbance. It is also about the opportunities that disturbance opens…' (Folke 2006: 259); but already picked up in relation to the drylands by Walker *et al.* (1981: 473): 'Comparison of the dynamics of various savanna and other natural systems leads to a conclusion that the resilience of the systems decreases as their stability (usually induced) increases'. On pastoralism and resilience, Niamir-Fuller (1998). For a simple discussion of discontinuity in relation of resilience, cf Krätli, Swift and Powell 2014.

[14] From the work on complex dynamics (Leach *et al.* 2010); adaptive systems (Westley 2002); high-reliability systems (Roe and Schulman 2008; Roe *et al.* 1998); developmental systems (Oyama *et al.* 2001); asymmetric distribution and risk (Taleb 2007, 2012); and resilience (Folke *et al.* 2002).

1.2 Underlying assumptions

This paper addresses underlying assumptions in the methodological infrastructure – the toolbox – of pastoral development. Underlying assumptions are necessary to even the most basic processes of observation, no matter how empirical in their approach. Always *qualitative* in nature, such assumptions embed and enact theory (deliberately or not). With fundamental transformations like the U-turn described in the previous section, the theory embedded in the methodological infrastructure may go out of sync with the new formal theoretical framework. When this happens, there is a risk of thinking new theory while still enacting the old one without realising it.

Our use of the term 'qualitative' is not in opposition to 'quantitative'. There is a great need for observation-based quantitative data on pastoral systems and drylands food production systems in general. Our point here is that quantitative data collection rests by necessity on an ability to *qualify* what differences 'count' and therefore need to be counted.[15] This ubiquitous qualitative foundation does not, in any way, undermine the value of quantitative analysis: it is what makes it possible. We therefore see the qualitative and quantitative dimensions of analysis not as opposed to one another but tied in a complementary and sequential relationship.

A quality is a *distinctive* attribute or characteristic. With 'qualitative assumption' we refer to the fundamental stage in quantitative appraisal: identifying what is to be measured by representing it through a set of distinctive attributes or characteristics (qualities) considered relevant to the process of observation.[16]

The system for allocating funds to primary education in Kenya offers a good example of 'qualitative assumptions' at work in quantitative analysis. For each district, the primary education budget is calculated every year on the basis of the number of children enrolled in school, a certain amount per child. This system of funding embeds a qualitative assumption about school enrolment (i.e. 'children-in-school' = 'children-in-school-age'). Transferred from countries where this can be taken for granted, this assumption does not apply in Kenya where there is great geographical discontinuity in enrolment rates. The mismatch has important practical consequences. With allocation of funds based on this method, the districts with underdeveloped educational services – typically associated with low enrolment rates – are being locked into a poor school-service trap and will not be able to improve their situation, while the majority of funding goes to the districts already most endowed in terms of educational services – those with the highest enrolment rates (Elmi and Birch 2013).

It is the work of qualitative assumptions to outline from the context *only* the attributes that are considered relevant to the process of observation. In general this simplification is a strength rather than a weakness (as in a well-known metaphor, there is no use for a map that is as large and complex as the territory it represents[17]). If the context changes in some fundamental way, however, the qualitative assumptions about what is relevant may become an obstacle to observation.

1.3 Commensurability

Relevance and effectiveness are not the only rational driving choices in the construction of qualitative assumptions. The power and credibility of quantitative analysis also depend on comparability or, more technically, commensurability. Values are commensurable when they are measurable by a common standard. In turn, commensurability depends on the capacity to control the processes of qualification. Guidelines for the standardisation of indicators and measuring procedures are examples of such mechanisms of control in the attempt to secure commensurability.

For achieving commensurability in an ever-changing world, unstable qualitative differences are stabilised in the analysis through methodological means. Technical definitions qualifying *what* is being measured are critical in doing so. Definitions are *abstract objects* used to interface reality and stabilise it for the sake of observation, so that not measurement *per se* but *commensurable* measurements become possible.

[15] Cf. Porter: 'In practice, as Nancy Cartwright argues, it is impossible even to set up a statistical analysis without assuming some explanatory structure' (1995: 19, referring to Cartwright, 1989).
[16] Spencer Brown (1979) qualified observation itself as the capacity to differentiate. Gregory Bateson, a key figure in the development of systems theory, pointed out that 'perception operates only upon difference. All receipt of information is necessarily a receipt of news of difference' and qualified information as 'the difference that makes a difference' (Bateson 1979: 29).
[17] In the short story *On the Exactitude in Science*, the Argentinian writer Jorge Luis Borges imagines an empire where cartography becomes so rigorous that the map of the empire coincides point by point with the empire itself, only to fall in disuse soon after (Borges 1946, referred to in Daston and Galison 2007: 48). In modeling, this argument is known as the Bonini's paradox: 'As a model of a complex system becomes more complete, it becomes less understandable. Alternatively, as a model grows more realistic, it also becomes just as difficult to understand as the real world processes it represents' (Dutton and Starbuck 1971: 103).

A good example is the definition of '(whole) milk unit' used to measure production in dairy systems. Differences in fat content present in real cow milk are normalised to a conventional 'full fat milk' (often 3.5 per cent fat content but not always, eg it is 3.25 per cent in the US). By this device, 100 litres of real milk at 2 per cent fat translate into 57 litres of standard 'milk', while 100 litres at 5 per cent fat translate into 142 litres.

Definitions are generated under the influence of pre-existing conditions (the methodological infrastructure[18]), as well as contextual requirements, before becoming themselves part of the infrastructure. In order to serve the requirements of commensurability, definitions must exist in coherent families, populating all the spheres of application of a theory. Thus, there is a strong link between a theory and the definitions that populate it: definitions are carriers of theory.

The need to maintain coherence within a set of definitions (and sometimes between sets), to secure commensurability, means that there are usually significant trade offs (therefore resistance) associated with change within these sets, even when definitions are acknowledged to fall short of meeting their contextual requirements.

The commensurability of milk production is locked onto the attribute 'fat content' because, in intensive milk production systems, milk is rated according to fat content. While as a commensurability device the definition of 'milk unit' based on fat content can be used with any production systems, the assumption that what *matters* is fat content implies that intensive milk production systems, and the respective value chain, are the context against which relevance is determined.

In a different context of observation, commensurability of milk production could be based on other parameters such as density, colour, or perhaps the content of antibiotics, hormones[19] or detergent; or the proportion of product that a system wastes prior to marketing.

In production environments where discontinuity is predominant, such as those where pastoral systems operate, 'period of production' (for example) would be a more significant parameter than 'fat-content' in measuring milk production. From the point of view of pastoralists, 1 litre of milk produced during the dry season or during a drought has a higher value than 1 litre produced during the wet season.[20]

Differences that can be ignored in one context of observation might be of critical importance in others. When commensurability devices outgrow their native domains – for example when they are made to serve a global approach to food production and natural resource management – there is high potential for confusion and distortion.

1.4 Scales

Calls to pay more attention to issues of scale have been around for some time in resilience literature. For example, Carpenter *et al.* (2001) have highlighted the possibility of resilience trade offs across scales,[21] while Cumming *et al.* (2006) have looked at scale mismatches in social-ecological processes.[22]

A recently proposed synthesis, the Dryland Development Paradigm (DDP), calls for heightened awareness of slowly evolving conditions ('slow variables' only visible at large temporal-scales) and cross-scale interactions, while warning against the confusion that can therefore be expected from the traditional analytical focus on the relatively fast variables.[23]

Quantitative analysis aimed at collecting data representative of drylands animal production needs to match the scales of relevance *within* the system under analysis. Important aspects of what makes pastoral systems more productive and more resilient are only visible at relatively large scales (eg geographical, temporal, social, economic). We can expect these features to be missed out by default –

[18] The basis of pre-existing conditions is described as 'infrastructure' by Bowker and Star (2000: 35): 'Infrastructure is transparent to use […] it does not have to be reinvented each time or assembled for each task, but invisibly supports those tasks […] Infrastructure does not grow *de novo*; it wrestles with the inertia of the installed base and inherits strengths and limitations from that base. Optical fibers run along old railroad lines, new systems are designed for backward compatibility; and failing to account for these constraints may be fatal or distorting to new development processes […] The normally invisible quality of working infrastructure becomes visible when it breaks'.

[19] http://www.news.harvard.edu/gazette/2006/12.07/11-dairy.html

[20] Amongst Rendille pastoralists in Kenya, the type of camel that yields in absolute terms the highest milk production per milking session is called 'weak' (*Dabakh*). This is because high performance depends on high availability of green fodder. During the dry season, the body condition of this camel type decreases fast, affecting milk production sometimes to the point of starving the calf. At the other extreme, the Rendille distinguish a camel type that has a lower milk production during the wet season, but is able to maintain a good body condition and adequately feed its calf during the dry season. They call this type 'strong' (*Godan*) (Kaufmann 2007). The higher value of milk in the dry season is also reflected in the purchase price. Milk purchased from pastoral producers during the rainy season has a cost of about 0.30 Euro per litre, whereas milk during the dry season sells for about twice as much.

[21] Cf. Carpenter *et al.* (2001: 779): 'However, resilience in one time period or at a particular scale can be achieved at the expense of resilience in a later period or at another scale […] confusion can be avoided by answering the question, "Resilience *of* what *to* what?" – That is, over what time period and at what scale?

[22] Cf. Cumming *et al.* (2006: 14): 'We hypothesize that many of the problems encountered by societies in managing natural resources arise because of a mismatch between the scale of management and the scale(s) of the ecological processes being managed'.

[23] Cf. Reynolds *et al.* (2007); and complemented with a few more socio-economic global drivers, Easdale and Domptail (2014).

as a consequence of the methodology – in all cases when a wider picture is obtained by extrapolating or even aggregating a large mass of data collected at a low scale (eg through household-level surveys, sets of localities, or temporal snapshots). In these cases, the analytical tools fail the theory.

For example, strategic mobility is usually in the form of migration groups, from a few households to hundreds, and requires large social networks and intelligence work beyond the reach of a single household.[24] Therefore household-based scale of observation alone will fail to capture all the key dimensions.[25]

Similarly, cost-benefit analysis of land-use options normally follows a 'hectare per hectare' comparison based on the size of the area to be converted. Projects to convert pastoral land to crop farming unfailingly target dry season grazing reserves because of their higher fertility. In pastoral systems, dry season grazing reserves are relatively small areas that enable the economic exploitation of much larger territories. Therefore losing them means not only losing their value in pasture (possibly quite a small value in absolute terms) but also the economic and social benefits of using the larger territory for production and livelihood (a much bigger value). Cost-benefit analysis based on a 'hectare per hectare' comparison may fail to capture economically crucial interdependency involving higher scales (Rodriguez 2008; IUCN 2011).[26]

1.5 Continuity and discontinuity

1.5.1 Lenses for 'parts' and lenses for 'relationships

Whereas input-intensive agriculture invests in sealing off the cycle of production from the natural environment, specialist drylands food production systems invest in the opposite direction: in the interaction with the environment. In their case, the 'differences that make a difference' are to be found in the *relationships* between parts rather than in the parts themselves. To reflect this, the processes of qualification also need to become *relational* (see Box 2), moving away from the tradition of representing the world in terms of closed systems relatively self-regulated to a point of stability (ie in terms of models conceptualising and organising parts as 'things', forgetting the context that defines them).

BOX 2. 'RELATIONAL' APPROACH

'What do we mean by "relational"? In botanics, those who study the arrangement of leaves and branches in the growth of a flowering plant would 'think of "leaf" not as something flat and green but as something related in a particular way to the stem from which it grows and to the secondary stem (or bud) which is formed in the angle between leaf and primary stem. Similarly, the modern linguist thinks of a "noun" not as the "name of a person, place or thing", but as a member of a class of words defined by their relationship in sentence structure to "verbs" and other parts […] A relational approach defines "things" first by their relationships rather than by inherent features. In this way, a relational approach highlights "context" and places it at the centre of understanding (knowledge making)' (Bateson 1972: 154, 153).

An effort to capture relational processes of circular causality is reflected, for example, in the concept of 'social-ecological system' in resilience thinking, introduced by Berkes and Folke (1998) 'to stress the integration of "humans-in-nature" and the arbitrariness of representing social and ecological systems as distinct' (Folke, 2006: 261).

An experiment also in this direction is the definition of pastoralism given in the policy for the development of Arid and Semi Arid Lands (ASALs) adopted by the Government of Kenya in January 2012. This definition is particularly interesting to us because it characterises pastoralism as a 'discontinuity-based' strategy (taking advantage of variability and heterogeneity, see section 1.3 above) and because it is a development of principles that had already informed the African Union's Policy Framework on Pastoralism (African Union 2010):

[24] Cf. Agrawal (1999); Férnandez-Giménez (2000), Schareika (2003); McCabe (2004); Kaufmann (2007); Marty *et al.* (2009); Greenhough (2012); Behnke *et al.* (2011); Xie and Li (2008).
[25] This does not mean it cannot support the analysis when in combination with other qualitative methods, eg Manoli *et al.* (2014).
[26] A recent contribution to the analysis of the methodologies behind the debate on land grabbing starts with a quote from Witold Kula's *Measures and Men* (1986) reminding us that: 'One hectare may not be equal to another […] Adding up hectares, whose value and profitability vary, does not mean adding like to like, and there is nothing… that makes valid the assumption that the owner of ten hectares of land is twice as rich as the owner of five hectares' (Edelman 2013: 485).
[27] This view of pastoralism as a discontinuity-based strategy is rooted in the 'new range ecology' paradigm shift, cf the quote from Behnke and Scoones (1993) in note 11 above. This perspective is gradually being appropriated by pastoral grassroots organizations. For example, it has been discussed and is in the process for defining the new five-year strategy by the member associations of Billital Maroobe, the largest and still expanding network of pastoral organisations in West Africa, including Benin, Senegal, Burkina Faso, Niger, Mali, Nigeria, Mauritania, and soon Chad (Dodo 2011).

'Pastoralism: The term refers to both an economic activity and a cultural identity, but the latter does not necessarily imply the former. As an economic activity, 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. Crucial aspects of pastoralist specialisation are: 1. The interaction of people, animals and the environment, particularly strategic mobility of livestock and selective feeding; and 2. The development of flexible resource management systems, particularly communal land management institutions and non-exclusive entitlements to water resources' (Republic of Kenya 2012: iii).[27]

Rather than being defined by inherent characteristics, here 'pastoralism' is defined by *relationships* between producers (eg in the way access to key resources is regulated), as well as between them and the environment (eg the use of mobility and feeding selectivity for maximising animal nutrition).

In practical terms, traditional typologies generate questions about collections of 'objects' (e.g 'how many pastoralists?' or 'how many head of livestock?'). Relational definitions, like the one adopted in the ASAL policy in Kenya, generate questions about relationships, questions such as 'what impact can be expected from transforming the strategy of production defined by this system of relationships?'

Quantitative analysis based on relational definitions is not without challenges, but there is little point in perfecting appraisal mechanisms if the underlying assumptions in these methodologies ignore, or externalise as noise, precisely what matters most at the level of the system (eg relationships). As summed up by lateral-thinking theorist Edward De Bono (1971: 22): 'It is not possible to dig a hole in a different place by digging the same hole deeper'.

The next section looks at some key problems in the legacy of data and qualifications in pastoral development.

The language for talking about pastoralism

2

Even when a fundamental change of perspective is accomplished in science, there is a 'memory effect' in the datasets as new generations of data necessarily build on older generations. In part, this explains why the representation of pastoralism in public knowledge remains so frequently entrenched in narratives of deficit (including the understanding of mobility as primarily a coping strategy). This section discusses such a 'memory effect' in the legacy of data and their traditional organisation.

2.1 Three historical biases

By looking at environmental variability as a problem, development efforts in pastoral areas have traditionally started from the question 'what would *we* do in this environment?' This unfailingly leads to attempts to transfer approaches successfully used to improve agricultural and livestock production in more temperate regions (as both development as a global project and the sciences that inform it are rooted in Western tradition). Most of the knowledge yielded in the context of development work has been generated and organised with a view to answer this question. We propose to call the way this perspective has affected data on pastoralism 'the technocratic bias'.[28]

A great deal of the data on pastoralism has been generated in conjunction with, or immediately following, periods of crises (the 1969–1974 and 1983–84 Sahel famines being the most obvious examples). Crises are the periods when large funds become available and significant numbers of pastoralists are attracted to settlements by relief programmes. The critical mass of this body of research puts off balance the literature on pastoralism. We propose to call this *'the humanitarian bias.'*

Outside periods of crisis, mobile pastoralists have been hard to reach by development programmes, being scattered, difficult to locate, to follow or kept in touch with by outsiders.[29] As a result, data piled up much faster where specialisation happened to be lower or less visible, eg on households that due to loss of livestock and increased dependency on external support could be located in the vicinity of settlements (Little *et al.* 2009). We propose to call this aberration in the data '*the specialisation bia*s.'

2.2 Typologies

Definitions are related to the theoretical framework they are designed to serve. Changing the theoretical framework unsettles this system of relationships until adjustments are made to integrate the changes at all the relevant levels.

Definitions of pastoralism are generally nested in typologies or classifications of livestock systems and agricultural systems. In principle, classifications are intended to be functional to particular domains, not absolute. Therefore no typology is expected by scientists to be satisfactory outside its domain of dependence; however, particularly in the transition from science to policymaking, or the design of development interventions, the domain of dependence and the domain of use stop overlapping. For example, governments and international institutions usually prefer to standardise a classification in relation to themselves rather than in relation to specific domains of use.

While developed for various uses, all traditional classifications of livestock systems represent differences as a matter of *degree*. For example: degree of mobility, or of *proximity to a sedentary condition* (nomadic, transhumant, sedentary); degree of involvement in agriculture (pure pastoralism, agro-pastoralism, mixed-farming); or involvement with modernisation (traditional, ranching, peri-urban); degree of interaction with the market economy (subsistence, market-driven); degree of average rainfall or proximity to a temperate climate (systems belonging to desert, arid, semi-arid, and sub-humid zones); or degree of livelihood dependence on livestock (with 'pastoralists' being households who rely on livestock for at least *n* per cent of their economy).[30]

There are three general 'barriers' embedded in this legacy. First, the definitions of pastoralism in these classifications assume pastoral cultural identity and pastoral economic activity – or livestock management and ownership – to overlap. While this might have been largely true in the 1960s, it is not the case anymore. Today, people who identify culturally with pastoralism may be town-based professionals; people who depend on herding may be stockless, while investors from a non-pastoral background, or impoverished settled

[28] Following the paradigm shift in the understanding of pastoralism and the drylands, the traditional pastoral-development question 'what would ***we*** do in this environment?' has been replaced with 'what do ***pastoralists*** do in this environment? (ie how do they manage to produce what they produce?)' (eg Kaufmann 2011). It is this kind of question – not the 'technocratic' perspective that survives in modernisation policies – that opens up a view of modernisation where scientific and technological development can be put at work to support innovation ***within*** the logic of specialised pastoral production strategies – a genuine modernisation of pastoral production rather than modernisation ***instead*** of pastoralism (cf Krätli ***et al.*** 2013c).

[29] This situation is changing. As mobile phones networks are extended to cover the pastoral regions, innovative methodological solutions are being explored to take advantage of the new opportunities. For example, Tufts is carrying out a longitudinal study on pastoral mobility in Sudan, making use – amongst other methods – of weekly semi-structured interviews with herders over the phone, thus being able to secure regular contact even in regions where insecurity would make more standard research impossible (Young ***et al.*** 2013).

[30] Cf. Otte and Chilonda (2002: 11): 'livestock production systems may be classified according to […] integration with crop production, the animal-land relationship, AEZ [agro-ecological zone], intensity of production, and type of product […] size and value of livestock holdings, distance and duration of animal movement, types and breeds of animals kept, market integration of the livestock enterprise, economic specialization and household dependence on livestock […] In principle, there can be as many classifications as there are possible combinations of criteria'.

pastoralists, may have livestock holdings in the pastoral system, looked after by waged labour or relatives. Therefore failing to make the distinction between identity and economic activity or between management and ownership can be a cause of considerable confusion.[31]

Second, the typologies qualify pastoralism by reference to what appears to be missing from a given model (settlement, modernisation, crop farming, the market economy, etc.). We refer to this practice as 'definition by subtraction'. Definitions by subtraction result in a perception of pastoral systems and their resource basis as 'residual', where the attribute 'pastoral' denotes what is left after the subtraction. For example, in this perspective applying the attribute 'pastoral' to land denotes land that has no other agricultural uses, or is even wasteland.[32]

Third, they conceptualise production systems as rigid entities, unrelated to one another and defined by clearly cut boundaries, but in the drylands this is rarely the case.[33]

Categorisation by proximity to a sedentary condition (degree of mobility: nomadic, transhumant, sedentary)

The categories 'sedentary' and 'nomadic' are generic terms that do not define an animal production strategy in any significant way. Transhumance is a technical term from the European tradition, where it does not refer to a stage between 'sedentary' and 'nomadic'. The use of these categories as sequential stages is therefore unjustified.

The qualitative assumption in this classification is that 'sedentary' represents the standard against which the other categories are defined.[34] At times, 'mobility' is not even mentioned as a discrete category, implying that there is only one category – sedentary – and *degrees* of proximity to it. For example, mobile pastoralists may be classified as '*en voie de sédentarisation*' (about to settle), as in the 2001 Niger policy for the development of the livestock sector (MRA 2001: 18); or 'partially settled', as in the dataset of the Index Based Livestock Insurance project (IBLI) in Marsabit, Kenya (ILRI 2014: 48).

These suggestive representations are not without impact. In the case of Niger, a policy for the development of the livestock sector removes animal production based on mobility from its representation of the sector: there is only one possible system of production, namely sedentary, with producers in it or still evolving towards it.[35] In the case of Kenya, the IBLI report describes the survey sample as composed of 24% 'fully settled' households, 73.5% 'partially settled' and 2.5% 'nomadic'. Of course, 'partially settled' households are also 'partially nomadic' and therefore more than three quarters of the surveyed households (76%) do make use of mobility.[36] The impression from this typology however, is that mobile animal production in Marsabit is negligible and disappearing.

Categorisation by proximity to crop farming (degree of farming: pure pastoralism, agro-pastoralism, mixed farming)

The qualitative assumption in this case is that the presence of any degree of cultivation represents a fundamental difference. Also in this case, the terms of the categorisation are often treated as sequential stages on an evolutionary trajectory – an idea with deep roots in the Western tradition (see Box 3) and further strengthened by the Boserupian theory of agrarian change.

The simplest classification in this family uses two categories: 'sole-livestock systems' and 'crop-livestock systems', with two sub-categories in the former (of which 'pastoral' is one) and 13 in the latter; one per kind of 'dominant combination of crops' associated with a generic 'livestock' (Seré and Steinfeld 1996; Fernández-Rivera et al. 2004; Ly et al. 2010). Variations along these

[31] Cf Krätli and Swift (2014) for a discussion of this point.
[32] Cf. the image of the dartboard used to categorise livestock systems in a recent global policy document: 'If we visualize the agricultural landscape as a dartboard, with the bull's-eye representing the most productive, intensively farmed, systems – those with the largest concentrations of mixed crop-livestock farms today – and the outermost rings representing pastoral areas that are the least productive and populated, and most marginal and sizable, of agricultural lands, we would view the rings in between these two extremes as the extensive mixed farming systems' (ILRI 2010: 7). The string of subtractions in the definition of pastoralism is evident: (un)productive systems using (un)productive, (un)populated, (in)accessible and (un)wanted lands.
[33] Cf. Toulmin 1983; Bonfiglioli 1990; Mace *et al.* 1993; Scoones and Wolmer 2002; also section 3.8 in this paper.
[34] A recent historical study on Mali points out that the categories of 'sedentary' and 'nomadic', introduced by the colonial administration and used interchangeably with those of 'agriculturalists' and 'pastoralists', had no equivalent in the local languages: 'Censuses, tax records, and other administrative paperwork systematically opposed the "sedentary" inhabitants of "villages" and "districts" with the "nomads" living in "fractions" and "tribes". These categories also justified the ascription of an exclusive space of reference to both sides: the river valley to the villagers, and the desert to the nomads' (Grémont 2012: 136).
[35] The 2007 Niger General Census of Agriculture and Livestock distinguished between 'sedentary', 'transhumant', and 'nomadic' livestock (cf Pica-Ciamarra *et al.* 2014).
[36] An underlying assumption in the settlement of pastoralists was that they would, anyway, eventually become farmers, therefore the sooner the better. However, in today's urbanizing and interactive world, the very notion of settlement has been transformed. People (whether pastoralists or not) not only become mobile in new ways, but new technologies such as telephone banking have opened up new ways of deriving livelihoods from spatially distant places. Some of these transformations are being explored by the 'connectivity' perspective in Saharan studies, for example including the phenomenon of ephemeral desert settlements, merely as infrastructure to illegal trade and as precarious in their location as the nature of the activities they serve (cf. McDougal and Scheele 2012; Scheele 2012).

BOX 3. THE 'TRIPARTITE-THEORY' AND THE OPPOSITION OF PASTORALISM AND CROP-FARMING

This approach has a long legacy. The Greek philosopher Aristote (384 BC-322 BC), for whom the benchmark of civilisation was his own agricultural world in the Mediterranean plains, and whose work was held as foundational in Western science well into the modern era, classified 'nomadism' as the earliest stage of humanity, the opposite extreme to 'crop-farming' along a spectrum that went through the intermediate stages of 'banditry', 'fishing' and 'hunting' (Trousset 1982). Echoes of this tradition have long dwelled in Western scientific imagination and can be recognized in the 'tripartite theory' – representing pastoralism as a transitional stage between hunter-gathering and farming.

This model found fertile ground not only in the socio-evolutionist renaissance of the colonial era (cf Khazanov, 1984), but also in the theory of 'ecological succession' being developed in the US during the same period by Frederic Clements (1874–1945), where different stages lead to a state of equilibrium through competition. In *Saving the Prairies*, Ronald Tobey analyses the influence of socio-evolutionary theories – and of neoclassical economics – on the development of the theory of ecological succession (Tobey 1981).

The representation of livestock keeping and crop farming on an evolutionary trajectory found a home in the Boserupian theory of agrarian change (Boserup 1965), contributing to a tunnel vision on the landscape of possibilities for crop-livestock integration (Scoones and Wolmer 2002).

Adapted from: Krätli S., Monimart M., Jalloh B., Swift J. and Hesse C. 2013. Evaluation of AFD Group interventions in pastoral water development in Chad over the last 20 years. Final Report, French Development Agency, Paris.

lines use 'grazing-only' or 'grassland-based' livestock-only production systems, but are still in opposition to mixed crop-livestock farming (Steinfeld et al. 1997). The definition of agro-pastoralism usually includes a degree of mobility, but is also used to exclude it. Similarly, the definition of transhumance may or may not include the mobility of the whole family.[37]

In development literature, the 'agro' of 'agro-pastoralism' is often used to qualify the nature of pastoralism (a certain kind of pastoralism), rather than simply an additional strategy (pastoralism plus some crop farming). This use can be misleading. In practice, within agro-pastoral households, specialised crop-farmers operate alongside specialised pastoralists and – *as far as animal production is concerned* – there is little difference with the systems categorised as 'pure pastoralism'.[38] Therefore the addition of the suffix 'agro' does not highlight a difference that makes a difference to pastoral production, but rather to a perspective centred on crop farming. On the other hand, a shift from pastoralism to farming in the drylands is often the result of push factors and impoverishment rather than pull factors and development (Little *et al.* 2008; Headey *et al.* 2012). Some analysts have proposed seeing 'agro-pastoralism' as an unstable continuum, with keeping livestock and practicing crop farming being part and parcel of the same logic (Bonfiglioli 1990).

Categorisation by proximity to 'modernisation' (traditional, ranching/peri-urban)

In this case pastoralism is categorised not as the result of an analysis, but by default. The term 'traditional' could refer to skills and knowledge on livestock management being 'passed' from one generation to the next; however, used in opposition to 'modern' it usually carries the meaning of 'outdated' and somehow belonging to the past. Categorisation as 'modern' is currently based on indicators that have to do with superficial similarities with Western agricultural history, more than with actual innovation in the context of

[37] Hinging on the degree of mobility, Gerber ***et al.*** distinguish between 'transhumant' (mobility involves the whole family) and 'semi-transhumant systems' (mobility involves only some family members), and define 'agro pastoralism' as 'a production system where all the family and livestock are sedentary' (2010: 179).

[38] For example, in North Kordofan households self-defined as 'sedentary farmers', but with substantial livestock holdings, were found to make use of mobile management strategies normally associated with pastoral systems (Krätli ***et al.*** 2013a). In China, two-way movement (swinging) between mobile pastoralism and sedentary strategies has been recorded in the Altay Steppes (Tsui 2012).

the local system of production. These are typically: building of physical infrastructures (no matter whether innovative or not); the use of services (no matter if unresponsive and ineffective); or the intense use of external inputs (no matter whether as a result of innovation or loss of alternative resources). In many countries, the theory of change in pastoral development continues to frame modernisation as the final stage of a process that necessarily passes through intensification and sedentarisation.[39] Yet, there is no reason why modernisation of pastoral systems should not build on pastoral production strategies, using scientific research and technological innovation to strengthen and improve them (IIED and SOS Sahel 2010; Krätli *et al.* 2013c).

Categorisation by proximity to the market economy (degree of commercialisation: subsistence, market-driven)

This categorisation can help an economic analysis, but in practice is often used instead of the analysis, with pastoralism categorised as a 'subsistence economy' *by default*. Dependence on the market for staple food and most household needs is common in pastoralism however, and in fact increases with specialisation.[40] The Wodaabe cattle herders in Niger, who are amongst the most specialised pastoralists in Africa, depend on the market for almost all their needs apart from milk and butter. On the other hand, mixed-farmers use livestock as an investment of cash crop revenues, and new absentee owners (urban-based, often not from a pastoral background), can afford to keep large herds just for beauty and status.

Categorisation by proximity to temperate-climate conditions (degree of average rainfall: true desert, arid, semi-arid, sub-humid)

In this case particular systems of production (pastoralism, agro-pastoralism, mixed farming) are associated with particular agro-ecological zones along an increasing gradient of humidity.[41] The ordering assumption is evident, with the implication that pastoralism *belongs* to a certain agro-ecological zone, and therefore mobile pastoralists moving across zones are just visiting and somehow 'out of place'. This denies significant pastoral history in sub-humid and humid areas (eg in Cameroun, Guinea, or the Central Africa Republic) and ignores that many pastoral groups spend most of the year (the dry season) in sub-humid areas.

When the coupling of particular production strategies and environmental conditions is combined with the assumption of an evolutionary trajectory in agrarian change (the Boserupian theory), there is risk of 'a slippage from talking about space to talking about time' (Scoones and Wolmer 2002: 10), as when, for example, the characteristics of highland farming systems are read as indicative of the future of sub-humid or semi-arid farming systems.

This approach may also be prone to ignore historical processes through which particular groups gained exclusive entitlement to favourable areas. For example, the livestock systems in the highland agro-ecological zones are described as characterised by smallholder mixed crop-livestock systems (eg Otte and Chilonda 2002). In Kenya, this refers to a situation induced not by agro-ecological conditions but by colonialism, while ignoring the Maasai pastoral system that was there before.

Categorisation by degree of dependence on livestock

This 'economic definition' is an exception to the rule of defining pastoralism by subtraction, instead focusing on the proportion of a household's income generated through livestock (whether 'cash income' or 'total income'[42]). The positions along the gradient are not organised in a hierarchy of stages, and movement is possible in both directions (eg oscillations in the proportion of the economic portfolio represented by livestock). For this reason, this is perhaps the most neutral amongst the traditional categorisations. Even so, the focus on differences *in degree* is maintained, and the categorisation remains silent about the way the animal production system operates.

[39] For example, the ongoing works for a policy framework in Burkina Faso on agro-sylvo-pastoral systems, fisheries and wildlife: 'The State, in collaboration with […] creates the necessary conditions for a gradual transition from extensive pastoral systems to intensive systems *through the means of sedentarisation*' (SARL 2013: Art 98, emphasis added). Cf. with a paper on the aftermath of the 1970s Sahelian drought: 'As a consequence of international response to the drought, there has been an enormous mobilization of funds and personnel in the Sahel. Most "development" programs are conceived from above, and emphasize sedentarization, controlled grazing, and a shift from subsistence dairying to commercial beef production. The programs are deficient in involving herdsmen in their planning and implementation, and fail to demonstrate how the herdsmen are to be the prime beneficiaries of the changes' (Horowitz 1977: 221).

[40] Pastoralists may keep away from the markets due to unfavourable terms of trade (Kerven 1992; cf Baker 1975; Mamdani 1982).

[41] Agro-ecological zones are determined on the basis of the 'length of growing period', calculated from the ratio of precipitations over the potential evapo-transpiration (P/PET) (Koohafkan and Stewart 2008).

[42] The calculation of *cash income* only looks at the direct contribution livestock and livestock products makes to the household through cash transactions. In the calculation of 'total income' all individual components of household production, whether accumulated, marketed or consumed, are valued using shadow prices.

Focusing on the proportion of income does not allow the distinguishing of wealthy producers from households with high levels of economic diversification, or from impoverished households.[43] Similarly, households with important revenues from non-livestock sources (eg trade, employment, or combined remittances from several members) might not be captured by this definition even if their livestock holdings are substantial.

The definition also misses forms of integration and dynamic correlations above the scale of the household. For example, a household might depend on crop for income, but the crop might depend on livestock for soil fertility. Key processes characterising pastoral systems take place at a larger scale (extended family, 'clan', or even much larger and heterogeneous social settings, including specialist crop-farming groups), and concern, more than discrete units, the relationships between them (for example through the entrusting of livestock or the hiring of labour, cf Krätli and Swift 2014).

The next section looks at underlying assumptions rooted in the equilibrium perspective in some key concepts, and the problems resulting from relying on this legacy in current resilient drylands development.

[43] Thornton *et al.* (2002: 75) find that 'In general, in the arid pastoral districts [of Kenya], livestock contribute significantly more to total household income for poorer households than for those with household income levels that place them above the poverty line'. The need to differentiate by degrees of wealth and kinds of poverty within pastoral groups has been pointed out for example in East Africa by Anderson and Broch-Due (1999) and in relation to increased commercialisation (Catley and Iyasu 2010). Aklilu and Catley (2010) have drawn attention to the mistake in area-based targeting of relief interventions, of lumping together all pastoralists as 'poor', as a consequence of applying standard methodologies that are inadequate when it comes to assessing pastoral wealth (a similar point also made by Levine and Crosskey 2006).

Disciplinary trap doors

3

This section deals with a handful of concepts that often appear in policy documents and research projects, and that are critically important in the design and implementation of processes of appraisal concerned with the livestock sector and pastoral systems in particular.

3.1 Production, performance and productivity

When designing livestock-sector development strategies for dryland regions, it is crucial that the definitions of key animal production parameters effectively capture what matters in *dryland* animal production.

Development policies are usually concerned with 'increasing productivity'. In everyday English, *productivity* refers to 'the effectiveness of productive effort' (Oxford Dictionary), but in its technical uses the meaning of 'productivity' is significantly narrowed (as shown below). While a commitment to 'increasing the effectiveness of productive effort' is hardly objectionable, a commitment to increasing productivity in its technical meanings requires more careful examination.

In agricultural sciences, the term 'productivity' shares the same definition with 'efficiency'. In animal production theory, the concept of *productivity* is tightly related to those of *production* and *performance*. *Production* represents a discrete amount of a certain good (output), for example an amount of milk. Although a discrete value in principle, in practice 'production' is often expressed per year, per animal, or per unit of land. *Performance* defines production in relation to time, for example the amount of milk produced per day, or per lactation ('lactation yield' is a performance parameter). Finally, *productivity* relates production (output) to input, usually the most limiting variable input. For example, in farm economics, land, labour, and capital are assumed to be scarce, and therefore used as input parameters in measuring productivity. By the same logic, in livestock science, productivity is measured against feed (energy), which is the main variable cost-factor in input-intensive livestock systems.

In these integrated technical definitions, the assumption of a production environment characterised by stability and uniformity – ie the conditions characteristic of input-intensive systems – is always in the background (for example, monthly measurements of milk output are normally aggregated into a yearly average[44]). A problem frequently encountered in applying these concepts to dryland systems is inadequate spatial and temporal resolution. The necessity, in these contexts, of expressing seasonal differences in milk performance has long been highlighted, but it remains rare practice.[45] Where resources and outputs are highly variable in space and time, an adequate representation of the production process requires higher resolution than the level conventionally associated with these concepts.

Let's examine this in more detail with an example. In its technical meaning, 'performance' assumes that time is a uniform succession of identical units; that is, that production conditions are stable and therefore production is evenly distributed over time. In the case of milk production, an analysis of performance would measure average production over a given period (lactation yield). The *distribution* of milk production over such a period is assumed to be insignificant to the analysis.

In the drylands, however, the conditions of production are rarely steady or uniform. Different units of time can have very different significance for production. For example, temporal variability in rainfall can result in highly asymmetrical distribution of production. Thirty days during the dry season and thirty days during the wet season are identical for the clock but incommensurable vis-à-vis the system of production.

In pastoral systems, both the survival of the calf (therefore herd productivity), and the availability of surplus milk for the market depend on the way milk production is distributed in relation to environmental variability, a pattern that can be hugely different from average distribution. Certain breeds generate a surplus during the wet season, but struggle to meet the requirements of their calves during the dry season. Others produce less during the wet season but easily meet the requirements of their calves during the dry season and might even produce a surplus.

With these levels of variability, focussing on average performance over a whole year obscures the characteristics of a breed more than revealing them. Average values are adequate to represent data that are normally distributed. If the data have a bimodal distribution, neither the average nor the median gives a meaningful representation of the sample. In these cases, an evaluation at a higher temporal resolution is critical. A meaningful measurement of the breed 'performance' in these contexts would depend not on 'production'

[44] A remarkable exception, where monthly differences are retained, is Zezza *et al.* (2014).
[45] One of the earliest studies recording milk production of the Red Bororo zebu in Niger specified 'average 5–6 litres per day in wet season; average 2–3 in dry season' (Mornet and Kone 1941: 179–180). A few years later, Jean Pagot highlighted that variability in milk production could even affect breeding practices: 'milk production in tropical sahel-sudanese areas is sharply affected by climatic conditions. It seems that even the use of progeny test is impossible, particularly mother-daughter, as the comparison of average values for a relatively small number of lactations cannot give precise results against the variability of climatic conditions between years' (Pagot 1952: 188). When asked about milk production of particular animals, pastoralists distinguish between dry season and wet season (Kaufmann 2007).

BOX 4. MEASURING HETEROGENEITY AND VARIABILITY IS POSSIBLE

Several agronomic studies have analysed dryland crop farming addressing temporal and spatial variability at a range of scales, from the crop-field level (Brouwer 1993; Voortman *et al.* 2004; Rockström and de Rouw 1997), to between fields (Dutordoir *et al.* 2006; Rockström *et al.* 1999), landscape (Warren *et al.* 2001; Turner and Hiernaux 2015), and regional scales (Vintrou *et al.* 2012).

Stratified sampling models have been adapted to assess dryland resources taking spatial and temporal variability into account (eg Hiernaux *et al.* 2009b in the Gourma, Mali; or the work by the Centre de Suivi Ecologique on forage resources in Senegal, western Niger and Mauritania, eg CSE 2011).

The general principle in these models is to identify several embedded scales: from site selection at region scale (based on bioclimatic zoning, soil types, and land use history), to facies within sites (based on topography, geomorphology, hydrology, land use, and major differences in species composition), down to to strata within facies (based on vegetation bulk density). At the bottom scale, 1 square metre sampling units are selected randomly within strata with a minimum of three replicates (eg Turner and Hiernaux 2002).

Measure on samples may include herbaceous cover, height, mass, species composition, and plant density. Means and variances are calculated per strata, and then weighed by strata relative contribution to the facies, and facies to sites. So that at all levels there are 'means' of these variables but they are systematically associated to variance indicators that tell how heterogeneous are the values around the mean, and one can retrieve the extremes or probabilistic statistics.

Recent work comparing time series of satellite derived indices of vegetation production (NDVI integral over time) to series of field vegetation monitoring over the same locations have found consistent dynamics and trends (Dardel *et al.* 2014; Kergoat *et al.* 2015). This consistency is also a validation of the pertinence of the sampling design used in the field monitoring.

Ongoing monitoring started in Senegal in 1981 (Diallo *et al.* 1991; Diouf and Lambin, 2000); in the Gourma in 1984 (on-going – although limited number of sites since 2011 because of insecurity and with an interruption between 1996–98 Hiernaux 1996); in western Niger in 1994 (Hiernaux *et al. 2009c).*

Other sampling designs are used to assess the woody population and its attributes – wood mass, foliage mass, Carbon sequestration; per species, strata, life-type (Hiernaux *et al.* 2009a).

Stratified sampling of household herds and individual animals, with repeated measurements over seasons and years, could be applied to measuring heterogeneity and variability of livestock production.

over time, but on the correlation of (breed-specific) calf requirements and yield distribution in relation to the temporal variability of resources during the period under consideration.

A similar problem is encountered in analysing productivity. Pasture (feed) supply in the drylands is not steady or uniformly distributed throughout the year, but available in ephemeral concentrations. Feed is not a linear function of cost. Its optimal exploitation depends on variables such as herding competence, capacity for mobility, animals' ability to feed selectively (cf. Krätli and Schareika 2010). Pastoralists – using labour and information input – select specific areas at specific times and attempt to balance the quality and quantity of their herd's diet over time.

Assessing feed resources would require to consider both temporal and spatial variables, that is determining availability at the specific locations and times they are actually used by a given herd (therefore an analysis than can only be done *ex post*). Measuring productivity based on the sum of these values over a year gives higher results than measuring it based on average values in the area (that is ignoring both the temporal and spatial variability as well as mobility).[46]

Achieving this above average feed availability through selecting different places at different times is the principal feeding/herding strategy of pastoralists, which can *only* be detected with an appropriate resolution. If efficiency in feed utilisation is compared across production systems where the breed used in one production system cannot survive/produce on the feed

[46] In dryland rain-fed farming the farmers also make use of variability in the absence of possibilities to control production conditions. Farmers know about the different requirements of different crops, hence they strive at choosing the most appropriate area for the respective crop. While the planting areas may look fairly uniform to the external observer, the farmers differentiate the areas according to soil temperature, soil compaction, soil fertility, intensity of solar radiation, and wind exposure and will select the most appropriate planting areas for the respective crops (Heiß, 2003, Warren *et al.* 2001; Minet 2007; Turner and Hiernaux 2015). Also in this case, determining average soil conditions in the area will not explain the output of different crops that have been grown on selected areas.

used in the other, the comparative evaluation will be distorted and misleading.[47]

The differences in the feed base should be recognised. This means the actual value of 'feed' depends not only on amount/cost but also on whom feeds on them: pastoral breeds can reproduce and produce based on feed resources found in drylands, while high yielding breeds could not.

3.2 Production Potential (comparing livestock breeds)

Most specialised livestock keepers in the drylands have developed their own breeds (Kaufmann 2007, Krätli 2008). When these local breeds become the object of scientific characterisation, they are evaluated using the standard parameters of 'production', 'performance' and 'productivity' (FAO 2012). Very often the comparison of breeds is based on performance parameters only. The scientific evaluation of local breeds reflects on the perceived economic value of the corresponding production system, contributing to determining the levels of investment and the options of interventions.

The evaluation of local breeds in pastoral systems usually classifies them as 'low-performance' by comparison to a reference breed: low growth rate, low milk yield or low reproductive performance. With regard to milk yield, the reference breed can be a Holstein-Friesian kept in an input-intensive system. Evaluations based on a comparison with other local breeds kept under similar conditions (for example two pastoral breeds) are exceptional. Although it would be crucial to know whether a breed shows a higher performance 'due to a higher feed availability' or 'despite a lower feed availability', breed evaluations remain silent on differences in production conditions (eg in feed availability or quality).

Local breeds in pastoral systems are highly specialised (for example as selective feeders, or due to their capacity to maintain functionalities under extreme stress, or to pick up weight quickly as soon as conditions improve), but not 'specialised' in the technical sense of being optimised towards *one* production parameter (milk or meat).[48] Evaluating them according to their milk or meat 'production potential' captures only part of their value.

Attributing 'low performance' to local breeds in evaluations is largely a consequence of using the concept of *production potential* as the basis of comparison with the reference breed. Production potential is defined in animal science textbooks as 'the production that is realised when the requirements of the animal are fully met'. The qualitative assumption in this definition is that the amount of energy in feed is under control at all times and virtually unlimited (limited only by cost). The animal in question is an abstraction, reduced to the requirements of its metabolism as qualified in animal nutrition theories. When productivity is measured on real animals exposed to the actual feed inputs specific to the pastoral systems, the productivity of 'high-performance breeds' drops lower than the productivity of pastoral breeds using the same input, and can even be negative (the animal dies). Besides, the 'boom and bust' conditions of dryland pastoral systems (as well as others with more or less severe winter…) also reveal a capacity for compensatory growth superior to steady growth in even non-limiting conditions.

When determining production potential, real conditions relating to environment and management are considered a disturbance. While the concept abstracts from real conditions, it is not independent from a management model. The principle of relying on feed (energy) inputs in order to adjust the production conditions to the point where the animals' theoretical metabolic requirements are best possibly met, defines the input-intensive model of animal production.

When the difference between model and reality is negligible, the concept is a useful commensurability device. When applied to animal production systems that are not represented within the theoretical horizon of input-intensive animal production, its use changes without warning from description to prescription.

3.3 Resources

Consistent with the positivistic intellectual environment that produced it in Europe and the US at the beginning of the 20th century (i.e. predominantly mechanistic and reductionist), the legacy of methodological infrastructure in drylands development shows an inclination to

[47] There are important exceptions to this simplification. At least since the pioneering work of Jan Bonsma in the 1950s, scientists who operate in dryland conditions, where sealing off production from the environment proves unrealistic, have sought out ways of adapting their analytical tools, for example introducing parameters such as 'productive adaptability' or 'lifetime performance' (Cf. Horst 1983; Lemke *et al.* 2006; Haiger 1983). So far, these have remained tailor-made solutions to the 'problem' of variability, rather than new paths towards a theory of animal production finally native to environments where variability is structural; therefore developed on the principle of working *with* it rather than *against* it.

[48] Even in input-intensive systems, overstressing one parameter, for instance lactation yield, involves trade-offs with the other performance parameters. Even within input-intensive systems there is a move towards the use of more *comprehensive* parameters (eg 'lifetime performance'), following recognition that milk production and reproductive performance are interlinked and can negatively influence each other.

BOX 5. TENURE REFORMS AND LAND-USE POTENTIAL

Underlying assumptions embedded in the principle of land-use potential lead to under-estimating the economic value of pastoral production. Following the property right system in Europe, land tenure reforms in developing countries are influenced by the principle that there are 'high potential' and 'low potential' lands. This is premised on the assumption that the most economically viable use of land is either for cultivation or for residential purposes. Arid and semi arid lands (ASALs) are, by default, classified as 'low potential' lands.

On the other hand, insecure communal tenure system in the ASALs has come under pressure, especially following the unprecedented interests in land-related investments in developing countries. In ASAL environments characterised by high spatial and temporal heterogeneity and resource-use dynamics, the formalisation of tenure can result in disenfranchising multiple-right holding. In Kenya, communally managed grazing lands have been targeted for wildlife conservation, bio-fuel production, and irrigation projects among others. Increasing land-use potential in the ASALs has so far implied moving away from pastoralism.

represent 'resources' as objects. This is particularly clear in the case of so called *material* resources, of which *natural* resources are a subset. Transhumance corridors, salt licks, grazing reserves, palatable plants, or water are all examples of material pastoral resources. Rangelands are commonly grouped together with *natural* resources.

The World Trade Organisation defines natural resources as 'stocks of materials that exist in the natural environment that are both scarce and economically useful in production or consumption, either in their raw state or after a minimal amount of processing […] Natural resources can be thought of as natural capital assets, distinct from physical and human capital in that they are not created by human activity' (WTO 2010: 46). As explained in the WTO report, the qualifier 'scarce and economically useful' is there to specify that, by definition, a natural resource is a commodity that is tradable in markets. Representing pastoral rangelands as a 'natural resource' under this definition means constructing them as a commodity and therefore, in practice, claiming them as a resource for the market economy.

Representing the rangelands as a *natural* resource frames pastoral activity as a disturbance, *by definition*. The conceptual separation of 'rangeland ecosystem' and 'pastoralists' – nature and human activity – assumed by the notion of natural resource, lays out the foundations for their separation in practice (eg through land use conversion programmes[49]). It also gets in the way of an understanding of the drylands as social-ecological systems, which is critical to an approach concerned with resilience (Niamir-Fuller 1998). Pastoral rangelands are in most cases the result of centuries and sometimes millennia of human use; shaping the diversity and distribution of the vegetation in ways that, unavoidably, are related to the breeding and management systems (including equipping the territory with watering opportunities).[50]

Beside political-economic considerations, it is evident that the concept of 'resource' (like the closely related concept of 'service') implies a subject in order to make sense. A 'resource' is necessarily defined in relation to a set of users, actual or potential. It takes the set 'ruminants' to construct the material environment 'grassland' into the resource 'pasture'. In any given ecosystem, many organisms can share the same material environment using it in different ways, therefore constructing it simultaneously, and case by case as a different resource.[51]

For example, groups of Tuareg and Wodaabe cattle keepers in Niger have been observed to use the same grassland environment, including underground water, in strategically different ways. While the Tuareg move their camp closer to the water point and further away from prime pasture as the dry season advances, the Wodaabe get further away from the water point trying to remain all the time on prime pasture. The

[49] The literature on this theme is vast, from colonial conservation programmes to the current debate on 'ecological resettlement' (cf for example, Du 2012; Tadesse 2009; for an overview, Homewood 2008: 79–82. Where rangelands are artificially separated from pastoralism through 'fortress' conservation interventions, the result is not more 'natural' than it was under pastoral management, the separation itself being the result of management (the enforcement of the model through systems of policing and penalties (cf. Williams 2002).

[50] Scholars working on European pastoralism seem to be at ease with the idea that the pastoral landscape is man-made: 'The spatial distribution of LSGS [Large Scale Grazing Systems] in the Mediterranean basin is primarily conditioned by topography and climate. Within these two criteria, the structure and composition of the plant communities is related to soil conditions and the actions of humans and animals. Actual LSGS in this area are the result of a long history of influence of humans and grazers' (Caballero ***et al.*** 2009: 10, italics added).

[51] Developmental biologists and animal behaviour specialists have described this phenomenon as 'niche construction' and shown that significant differences are possible even between closely related species (Lewontin 1983; Odling-Smee ***et al.*** 2003).

BOX 6. GUM ARABIC AND FODDER

In Sudan, according to Couteaudier, 'Large gum plantations represent less than 5 per cent of the total production' (2007: 12). Although only a small proportion of the *Acacia Senegal* trees along the gum Arabic belt are planted, all *Acacia Senegal* trees are protected by the law *as farm crops*. If a camel is found to feed on an *Acacia Senegal* tree, even if grown unplanted on pastoral land, the owner of the camel is liable to law enforcement against 'damage to agriculture'. On the other hand, even large areas of pastoral land covered in fodder can be dug up for cultivation without this representing, in the eyes of the law, a damage calling for compensation. This is a sensitive and intricate issue but ulitmately based on two possible lines of argument. The first, which we could call 'naturalistic', is that an unplanted *Acacia Senegal* tree is a natural resource used for producing gum Arabic just as unplanted fodder plants are a natural resource used to produce livestock. The second line of argument, which could be called 'constructivist', is more sensitive to the historical dimension of human-environment interaction. From this perspective, even gum Arabic trees that were not planted should not be seen as 'wild': many years of human care and harvesting makes them man-made enough to be considered 'farmed'. The same argument, however, also applies to fodder. Selected and disseminated over the territory in patterns that necessarily reflect the patterns of herd management in the pastoral systems that make use of it, fodder plant populations and the entire grassland landscape are man-made enough to be considered 'farmed'. Indeed, ecologists looking at grazing management have argued that pastoral ecosystems are not 'natural' but maintained through the management of the livestock (Heitschmidt and Stuth 1991). A recent study by ILRI lists several 'environmental services' provided by pastoralism, including controlling shrub growth, dispersing seeds, stimulation of grass tilling, improvement of seed germination, break-up hard soil crusts (Silvestri *et al.* 2012). Whether one prefers the 'naturalistic' argument or the 'constructivist' one, unplanted gum Arabic trees remain in the same category as unplanted fodder plants, yet treated very differently in the law.

two groups clearly construct, simultaneously, the same material environment 'pastoral rangelands', into different resources.

More broadly, the way mobile pastoralists construct the drylands into pastoral resources is different from the way the drylands are constructed into resources by groups of producers who do not have access to mobile strategies: their respective experiences – for example whether there is drought and what it means – do not perfectly overlap (and sometimes not at all).

In the drylands, patchy precipitation means spatial and temporal discontinuity in the presence and development of vegetation.[52] The nutritional value of the range depends on the combination of its plant species and their stage of development at the moment they are being fed upon. There are significant differences in value not only between stages in the lifecycle of the same plant, but in certain cases even between day and night.[53] Some plants can result in intoxication at certain stages of their development, and with certain ruminant species but not others. Through feeding experience and habituation, ruminants can learn to thrive on plants that are known to trigger intoxications in their species.[54]

Therefore, not only the quality of plants, but also their definition as palatable (ie the definition of vegetation as pastoral 'resource' and its value) depends on the skills and competence of feeding livestock and, ultimately, on the husbandry system and the constraints it faces. Sometimes the value of certain plants depends on the nearby presence of others (eg certain straw together with certain bushes or trees during the dry season): neither of the two qualifies as a resource by itself, but both qualify when combined.

The understanding of resources as objects is characteristic of a sectoral approach, where improvement (development) is often sought out in the form of increased amounts.[55] A relational understanding of resources on the other hand, is more at home in a systemic approach (and serves it better).

[52] One of the main factors of spatial heterogeneity is spatial redistribution of rainwater, through run-off /run-on interacting with soil texture and fertility (Breman and de Ridder 1991).
[53] On the variation in nutritional content within the same plant, cf. Kim (1995), Orr *et al.* (1998) and Mayland (2000).
[54] In Niger, *Cenchrus biflorus* is sought after at sprouting stage, but avoided once mature as a cause of diarrhea in cows. On the other hand, *Zornia glochidiata* is avoided as toxic in its early phase but later sought after (Bonfiglioli 1981). On the contingent nature of pasture quality, see for example Moritz *et al.* (2013), and Meuret (2014). On learning digestive or detoxification abilities in ruminants, cf. Launchbauch *et al.* (1999), Hansen (2008).
[55] For example, sectoral water development aims at increasing the number of wells/litres of water over population, whereas a systemic approach would link improvement not to the amount of water but to the way water (or its absence) relates to production and livelihood systems; that is to its use and management (Krätli *et al.* 2013b).

For example, the analysis of pastoral systems often breaks them down into natural resources, livestock resources and human resources. Within a relational perspective, this potentially helpful simplification would express three (overlapping and recursive) sets of relationships rather than three sets of objects. What makes 'pasture' a *pastoral* resource is the possibility of accessing its nutrients where and when they peak – which depends on livestock and herd management. What makes livestock a *pastoral* resource is the animals' capacity to make good use of such a possibility, particularly (although not only) through their competence in feeding selectively – which depends on management as well as on variability in the environment. What makes herders a *pastoral* resource is the way they interact with their animals and with the environment – which is based on institutionalised forms of social interaction (eg in pasture management, information sharing or breeding networks).

From a relational perspective, improvement may be associated with *decreased* amounts as much as with *increased* amounts. For example a sequential, timely access to relatively small pasture areas may represent an improvement over un-timely access to larger areas, or a socially well-organised herd of animals with a strong bond to the herder and competent in feeding selectively, may be an improvement over a larger set of animals without those characteristics.

In certain conditions, even the *absence* of something can be a resource in the process of defining other resources. For vulnerable and marginalised people with little entitlement, the possibility of constructing part of the material environment as *their own* resource (not just *a resource*), may grow together with the level of disadvantage associated with the material environment in question, and decrease as the disadvantage decreases. For example, their access to a certain area may depend on the *absence* of a road, and they may lose access as the building of a road makes exploitation easier and more interesting to people with better entitlements. Difficult access to water points can act as a deterrent to all but the most skilled and specialised pastoralists, helping preserve the resource for circumstances of scarcity.[56]

In conclusion, representing pastoral resources as objects flattens all this critical complexity and removes from the picture most of the options for constructing resources that enable pastoral systems to function successfully and reliably. Bathelt and Glückler[57] have analysed the consequences of representing resources as objects, which they call *substantive* conception and contrast with the understanding of resources from a *relational* perspective. With regard to material resources, a substantive understanding represents them as 'production factors characterized by predefined input-output relationships' (2005: 1547). On the other hand, in a relational understanding 'material' resources are not factors with an inherent use-value and predetermined application, and therefore there are no universal best practices in constructing resources out of the material environment.

3.4 Risk

Drylands agriculture is commonly considered a risky enterprise. The common approach to 'risk' in drylands development frames it as an absolute problem and aims at reducing it. Risk management is seen as synonymous of risk aversion.

Production systems adapted to take advantage of drylands variability however (as opposed to working against it) relate to the risk it involves in a different way. As people who specialise in a risky enterprise, small producers in rainfed farming and pastoralism are risk-taking entrepreneurs. Rewards from risk-taking enterprises are highest when risk is harnessed and managed, securing the lowest possible incidence of disasters, not when it is avoided. In this light, pastoralism has been described as a high-reliability system, in analogy, for example, with air-traffic control systems (Roe *et al.* 1998).[58] In the case of air-traffic control, successful risk management means maximising the number of planes in the air – hence risk – while minimising the number of incidents. An air-traffic control strategy equating risk management with risk reduction would ground all the planes, zeroing risk but also business. Strategies aimed at avoiding risk may therefore go in opposite directions from strategies aimed at managing risk.

In contexts dominated by variability, where sufficient knowledge for prediction cannot be secured, *optionality is a substitute for knowledge* (Taleb 2012) and a way of managing risk. If I cannot predict what is my best option, my best option is to keep my options open until a decision can be made in real time. Embedding variability in the production system to interface variability in the environment increases optionality. For example: keeping a herd capable of moving fast in the right direction when empirical evidence of green pasture is finally gathered (ex post); building social capital in large geographic networks (i.e. avoiding making enemies

[56] As in the case of the borehole 'Christine' in Northern Burkina Faso (Benoit 1984). Also on pastoralists' strategies to voluntarily restrict the capacity of shallow wells in order to limit competition by other users (in eastern Niger), cf. Thébaud (1999); and Thébaud and Batterbury (2001).
[57] Bathelt and Glückler (2005) base their analysis on a broad theoretical framework combining non-essentialist perspectives on social and economic practice from institutional economics, relational economic geography, and new economic geography.
[58] High-reliability systems are largely real-time operations that depend chiefly on management. Consequently, interventions aimed at regulating all areas of the system effectively undermine its capacity to work: 'successful reliability management focuses less on safeguarding single-factor performance than on maintaining a set of key organizational processes within acceptable bandwidths' (Roe and Schulman, 2008: 159).

BOX 7. 'AVERAGE THINKING' TO STUDY ARID AND SEMI-ARID ECOSYSTEM DYNAMICS*

There is a wide consensus about the fact that arid and semi-arid environments are highly variable in space and time (McAllister *et al.* 2009). Yet, the most frequent approach to describe and analyse spatial and temporal differences in arid and semi-arid pastoral systems, is the use of averages. Common examples are the direct use of average rainfall, mean Normalized Difference Vegetation Index (NDVI), average net primary production (NPP), average forage production, average stocking rates (eg Anyamba and Tucker 2005; Golluscio *et al.* 2010; Eisfelder *et al.* 2014). The most frequent temporal windows are annual and seasonal periods, or fixed periods based on definitions of the length of vegetation growth; there is an implicit assumption that other intra-annual or inter-annual patterns or cycles are not relevant.

Variability in ecology is often analysed with simple statistics such as standard deviation or coefficient of variation (CV) (Ellis and Swift 1988, Jobbágy *et al.* 1995; von Wehrden et al. 2010; Easdale and Aguiar 2012; Irisarri et al. 2012). A threshold based on CV was even proposed as an operative definition that distinguishes between different ecosystem dynamics in arid and semi-arid rangelands (eg Ellis and Chuluun 1993; Behnke *et al.* 1993; Okayasu *et al.* 2011; von Wehrden *et al.* 2012). Another example is the concept of ecosystem functional types (ETF), used to classify and characterise functional heterogeneity of ecosystems, rather than only structural features (Paruelo *et al.* 1998; 2001; Alcaraz *et al.* 2006). Also in in these cases there is an underlying assumption that the annual cycle (with its range of fluctuation) is the only temporal pattern relevant to describe ecosystem dynamics.

There is often confusion between statistical variability (eg standard deviation, variance) and temporal variability (eg trend, short and long-term cycles) as sources of similar information. Methods are mostly based on rarely met assumptions of 'normal distribution' and linearity.

* Cf. Easdale *et al.* (2014).

if possible), in order to gain some level of negotiable entitlement to many different areas and prepare for long-distance migrations at times of a drought; and keeping a variety of animals rather than concentrating on single traits like productivity or hardiness (ie not only keeping different species, but even different 'types' within the same breed), in order to have a herd always capable of responding to a variety of situations.

3.5 Ecological fragility

Descriptions of the drylands in development literature often characterise them as *fragile* environments.[59] In these descriptions, fragility is the reverse of stability: a fragile environment is one that is prone to 'fall out of balance'. This understanding of fragility as a bio-physical characteristic of the environment is a 'memory effect', since the time when the 'equilibrium' model was still the main explanatory framework in ecology.[60]

At least since the 1990s, the term 'fragility' in ecology has referred to human-environment interaction, that is a *relationship*, rather than a characteristic of the ecosystem – in a common definition: 'fragility implies a mismatch between human use and biophysical conditions' (Turner and Benjamin 1994: 106). It is important to notice that, under this definition, fragility is no longer a structural limitation, but a circumstance that depends on a particular kind of management being used in relation to a particular kind of environment.[61]

Today, ecologists do not consider instability and resilience as opposites anymore, but talk of 'resilient drylands' while recognising variability as structural (Holling 2001; Walker 2006; Folke *et al.* 2004). Keeping the focus on fragility as a relationship, rather than slipping back into talking of 'fragile ecosystems' and 'fragile drylands', is critical.

[59] This is frequent for example in UN literature: UNCCD; UNEP; FAO; IFAD; and even the UNDP Global Drylands Imperative. A recent review of evidence on dryland pastoral systems and climate change, published by FAO, refers to the 'sustainable and adapted management of these fragile ecosystems' (Neely *et al.* 2009: 31). According to the organisers of the 11th International Conference on Dryland Development in held in 2013 in Beijing, 'Dry areas of the world have highly fragile ecosystems' (IDDC 2012).

[60] The concept of 'ecological fragility' was introduced to help define priorities in conservation management (Ratcliffe 1971) and even within that context it was not without problems. Nilsson and Grelsson (1995: 678) discuss three problems associated with the notion of ecological fragility: complexity (an ecosystem might be relatively fragile in some respects and relatively stable in others); lack of clarity (fragility is very difficult to qualify); and scale-dependence (ecosystems might manifest fragility at one scale and stability at others).

[61] Cf. Wood *et al.* (1999: 8–9): 'a sloping, moderately watered, hillside with light-to medium-textured soils could be extremely "fragile" under one use, but under another, based on better adapted technologies and management practices, could be quite productive, even over the long-term'. Also Hiernaux and Turner (2002: 135): 'risks of environmental degradation are moderate and mainly climate-driven in pastoral systems at the drier edge, while they are serious and mainly management-driven in the crop-livestock systems of the southern Sahel'.

3.6 Ecological efficiency

Pastoral systems are included, together with small-scale dryland agriculture, in global and national assessments of the ecological efficiency of current food production systems. These assessments are usually in relation to concerns for sustainability, vis-à-vis projected growth in demand and the challenge of climate change mitigation.

The methods for estimating the ecological efficiency of food production at sector level (eg livestock), are various and sophisticated, but still need to depend on huge generalisations. Thorough calculations are laborious and costly. As the data on the relative ecological efficiency of different systems are supposed to inform policy-making and investments in development and climate change mitigation, standardisation of appraisal is critical. The negotiation of guidelines for standardisation is a highly sensitive arena (one in which dryland small-scale producers of course have no say) as different ways of calculating ecological efficiency of food production involve different costs and can return substantially different results.[62]

As a proxy for the ecological efficiency of the production system, a common approach is to use the rate of conversion of feed (input) into energy available for consumption as animal products (output) by an animal's metabolism. This approach externalises non-feed inputs, assuming that there are no significant differences between production systems above the scale of the animal metabolism; or at least that the differences at that level are more significant than any other difference.

In such an evaluation, the feed efficiency of pastoral systems is by default lower than those of intensive livestock production systems. The ranking reverses however when the comparison is made at higher scales, and considers for instance 'support energy' for availing feed inputs (eg fossil fuel energy and calories burned by human labour) into the analysis.

Data at this larger scale are scanty, but it was estimated that the US pork-production system uses ten calories of support energy for each calorie output for human consumption (in the pork meat). In contrast, in pastoral milk and meat production the proportion is exactly reversed (ie efficiency is one hundred times higher), with ten calories output for human consumption requiring only one calorie of support energy (Gliessman 2007). This difference is mainly due to the fact that calories in human labour are almost the only support energy in pastoral systems.

More considerations of this kind could be made with regard to the important differences in what is considered energy available for human consumption within different systems of production. Most pastoral systems operate in market and cultural contexts where the proportion of the animal used in human consumption is generally much higher than in the global market. For example, on many African food markets, (certain) bovine skins, offals and bones (including the whole head and the hooves) qualify for human consumption. The amount of 'losses' (for human consumption) in any European abattoir would increase sharply purely on a methodological basis if measured by such eating standards.

As the assessment of ecological efficiency of food production systems focuses on increasing the metabolic efficiency of the animals, it usually stops at the farm gate. From a food-chain perspective, especially when framed in a global concern for food-security[63] as these assessments often are, this seems an odd decision. The core function of a food production system is to feed people.[64] Hence, one would expect an analysis of a system's ecological efficiency to embrace the entire chain, including post-production and consumption, especially as differences in ecological efficiency are not likely to be consistent along the chain. High-production systems are usually associated with peak losses at post-production and consumption stages (i.e. where the Carbon footprint per unit of loss is highest).[65]

Some scholars argued that the ecological efficiency of food production systems should be measured not against *weight* of product but in relation to the *transfer of nutrients* (for instance proteins) to humans (Jones 2010).[66] The assessment is further complicated however, as the *proportion* of the animal that is considered 'product for human consumption' changes substantially across countries, cultures, and levels of wealth.[67]

[62] In a well-known example, an innovative and comprehensive methodology was used to analyse the contribution of livestock sectors worldwide to anthropogenic emission of green house gasses, but the estimates calculated in this way were put in relation with existing data on other sectors of the economy, that had been generated through not-so-comprehensive procedures (Steinfeld ***et al.*** 2006; Mitloehner 2009).

[63] For an analysis of the population-environment nexus in policy narratives, cf. Keeley and Scoones (2003).

[64] We have borrowed this general argument of 'core function' from Stiglitz (2010: 5), where it is used with regard to the US banking system prior the 2008 financial crises. The argument is that the 'the lure of easy profits from transaction costs distracted many big banks from their core functions [of] providing efficient payments mechanisms [and] assessing and managing risk and making loans'.

[65] Food waste at consumer level in industrialised countries (222 million ton) is almost as high as the total net food production in sub-Saharan Africa (230 million ton). The largest proportion of such losses (over 40 percent) occurs at retail and consumer levels (Gustavsson ***et al.*** 2011). Cf also Redlingshöfer and Soyeux (2012), and the recent series of reports on the FiBL Food Wastage Footprint project for FAO (FiBL 2014).

[66] Figures recently published by the FAO indicate that human-edible protein from livestock is produced much more efficiently in countries where the sector is dominated by pastoralism, with protein input/output ratios between 1:4 and 1:21 in India, Sudan, New Zealand, Mongolia, Ethiopia, and Kenya compared with those of intensive livestock systems where the ratios are well below or around 1:1 in Saudi Arabia, USA, Germany, China, the Netherlands, and Brazil (Steinfeld, 2012).

[67] In the definition adopted by the 2011 FAO study: "Food' waste or loss is measured only for products that are directed to human consumption, excluding feed and parts of products which are not edible. Per definition, food losses or waste are the masses of food lost or wasted in ***the part of*** food chains ***leading to*** 'edible products going to human consumption" (Gustavsson ***et al.*** 2011: 2).

BOX 8. TRADITIONS OF CALCULATION

Land-based efficiency. The ecological efficiency of a livestock system is often expressed as production (output) over the consumption of – or impact on – natural resources (input). This is consistent with the input parameters most commonly used in farm economics: land, labour and capital. In practice, analysing all inputs is costly and measurements of ecological efficiency focus on output over land-input. This traditional focus on land is maintained also in the drylands, where the most valuable resource is not land but water (eg in Inner Mongolia, Fan *et al.* 2014). When land-input is replaced with water-input, the calculation of the ecological efficiency of a pastoral production system vis-à-vis standard forms of intensive agriculture gives completely different results, with pastoral systems ranking at the top. Efficiency depends on the choice of 'most significant' input.

LCA & TLU. The measurements of enteric fermentation used in Life Cycle Assessment (LCA) are carried out by natural scientists and based on the amount of forage intake per individual animal and the fibre content of the forage. In the course of an LCA, these measurements are scaled up by economists, usually based on Tropical Livestock Units (TLU), ie 250kg live weight of ruminants. However, feed intake and digestion only coarsely relate to live weight (Menke *et al.* 1979). The energy and nutrients needed to keep livestock alive (metabolic needs) and productive (production needs and labour) vary with the size of the animal; but also in a non-linear way, in relation to species, sex and and age Schlecht *et al.* 2006; Ayantunde *et al.* 1999). Calculating forage intake based on metabolic weight per species, sex and age groups, rather than simply based on the abstract TLU live weight, would result in a better approximation. There are therefore no obvious advantages associated with the current use of TLU. The tool is a legacy from a time when handling data disaggregated by species was too complex and time consuming and therefore the simplification offered by TLU (traded against precision) was necessary. Today, with computers, such a necessity is no longer there but the use of TLU lingers on.

Differences are usually greater in the more 'peripheral' production-consumption systems. Overall, the decrease in the proportion considered 'for human consumption' seems to go hand-in-hand with the increase of the standards of per-animal productivity. The methodologies used in global analysis of food waste are still to engage with these qualitative differences.

With regard to evaluating GHG emission of production systems, ecological efficiency is defined as the ratio between emissions and production (by weight of produce). As a consequence, production systems with comparatively low production tend to have lower ecological efficiency, and hence emerge as a priority for mitigation even if their absolute net emissions are lower than in systems with higher production outcome – independently from the relationship between output and consumption.

Again, the calculated ecological efficiency depends on whether the focus is on the animals' metabolism or takes a systemic view. About 90 per cent of emissions are found to come from three sources: *i.* land-use change from forests to rangeland, or cropland, *ii.* farming (for animal feed), and *iii.* livestock's enteric fermentation (in the rumen); and, for the studies that consider it, livestock's respiration (Steinfeld *et al.* 2006). As dryland pastoralism is by definition not involved in the practices behind the first two sources of emission, its comparative ecological efficiency is substantially affected by the method and scale of analysis.[68]

3.7 Crop-livestock integration

ILRI distinguishes between extensive and intensive 'mixed systems', both categories defined at the scale of the farm: such farming is generally known as 'mixed crop-and-livestock', or just 'mixed', production systems. The farms in these systems are small in size – typically less than a few hectares – with millet, maize, rice and other staple food crops cultivated along with the raising of a mix of cattle, buffalo, sheep, goats, pigs, poultry or other kinds of domestic livestock' (ILRI 2010: 14). An important work claiming a regional perspective on livestock remains in the same tradition: 'Farming systems conducted by households or by enterprises where crop cultivation and livestock rearing are more or less integrated components of one single farming system' (Gerber *et al.* 2010: glossary)

In most dryland livestock systems with or without seasonal transhumance however, grazing circuits extend beyond farm and often village lands, and crop-livestock

[68] Livestock's respiration is not counted in IPCC guidelines on the basis that the CO2 produced in such a way can be considered offset by the CO2 the grass stops producing as the animals feed on it. Critics of this approach have pointed out that, in today's conditions of production it is not always true that animals feed on grass, but this objection does not apply to dryland pastoral systems (at least when not forced to operate outside their specialised strategies).

integration at the scale of the farm is only one in a multitude of paths (Landais and Lhoste 1990; Bonfiglioli 1990; Brink *et al.* 1995; Mortimore and Adams 1999; Scoones and Wolmer 2002).[69]

In environments driven by variability, livestock mobility allows for discontinuous patterns of integration over time and space and at a variety of scales. Farmers may rent their livestock to transhumant herders during the wet season, when farming demand for labour and land peaks and in order to take advantage of the better pasture in the drier regions. Herders find water and crop residues for their livestock on their return to the crop-farming areas after the harvest (while the animals fertilise the fields). As opposed to what is supposed to happen with mixed farming, with integration at higher scales, there is no need to compromise on specialisation: 'specialized crop farmers can form mixed systems with specialized grazers at regional levels' (Schiere *et al.* 2006: 10).

Large-scale integration can also involve livestock trade. Many long-distance livestock traders move animals on the hoof deliberately slowly through pastoral areas (using pastoral production strategies and expertise), in order to fatten them on their way to the terminal markets – minimising the costs of feedlot operations at arrival (for the Sahel, Corniaux *et al.* 2012; recorded in Sudan in Krätli *et al.* 2013a).

3.8 Household

Most statistical data, and a great deal of quantitative analyses looking at rural production and livelihood systems, focus on the household. This includes drylands early warning information systems and specialised livestock-sector surveys.

Beside practical considerations and the logic of standardisation, a key underlying assumption in relying exclusively on a household-based approach is that the knowledge captured at that scale remains relevant at higher scales. In other words, that there is continuity across scales. This is not an assumption that holds true with regards to pastoral systems however.

Because of the strategic economic importance of mobility and social capital, pastoral systems normally operate with large-scale resource networks (people, pasture information, markets) spanning over large areas and, at times, several countries. Most of the social, environmental and economic dynamics that are crucial to the functioning of these complex systems are not evident at the household scale (see section 1.4 above). Consequently, they are not recorded and remain unaccounted for, when knowledge collected at the household level is simply 'scaled up' by increasing the number of households included in the survey, no matter by how much.

Serious household-survey methodologies define 'household', rather than taking the meaning for granted. When operating in social contexts where there are both monogamous and polygamous unions, this is mandatory. Most definitions of household designed with this problem in mind try to change polygamous unions into the nuclear-household currency, either by treating them as one household or by breaking it down into as many households as the number of wives. This is how the 2009 Kenya census instructed the enumerators in this regard: 'In a polygamous marriage, if the wives are living in separate dwelling units and have separate cooking arrangements, treat the wives as separate households. The husband will be listed in the household where he will have spent the census night' (KNBS 2009: 8). Besides creating commensurability, this approach has the advantage of disaggregating information specific to the co-wife sub-unit or other segments of large homesteads, for example wealth.

When this definition is applied to a pastoral context where unions are polygamous, some key parameters are distorted; resulting in data sets that show high numbers of female-headed households, low levels of livestock holdings per household, low levels of mobility, and dependency on livestock herding (Loos and Zezza 2013 cited in Pica-Ciamarra *et al.* 2014; Krätli and Swift 2014). Once broken down into an unrelated mass of monogamous or female-headed households, partially mobile pastoral families with relatively large livestock holdings may appear in the dataset as a much smaller proportion of the sample, or even disappear altogether, broken down into a larger number of smaller units, none of which have livestock holdings important enough to allow for pastoral (mobile) production strategies. In other words, the definition of 'household' can turn what in reality may be a largely pastoral sample into a representation of it as largely non-pastoral in the dataset.

3.9 Demographic growth

Discussions of the sustainability of pastoralism in relation to demographic growth are usually accompanied by predictions of land degradation through overgrazing. The implication is that, as demographic growth amongst farmers leads to more land under cultivation (whether through the tilling of new land or the shortening of fallow periods), demographic

[69] Breman and De Wit (1983) pointed out that this interaction is particularly valuable in arid and semi-arid areas of the Sahel, where the quality of pastures usually declines from north to south; with less, higher quality biomass in the north and more, lower quality biomass in the south. According to Hiernaux and Turner (2002: 146), large-scale integration is needed to capture the whole range of benefits across this gradient: '[b]etter integration of livestock production between crop-livestock systems in the south Sahel and pastoral systems in the north Sahel also require political action to set up the appropriate institutions that can ensure livestock mobility'.

growth amongst pastoralists leads to more livestock on the range (with overgrazing presented as the equivalent of shortening the fallow period). For example, a report to the Millennium Ecosystem Assessment 2005 reads: 'The small amount of precipitation and its high variability limit the productive potential of drylands for settled farming and nomadic pastoralism, and many ways of expanding production (such as reducing fallow periods, overgrazing pasture areas, and cutting trees for fuelwood)' (MEA 2005: 63).

If the linearity of this relationship can often be the case for farming,[70] it is not so for pastoralism. There is no linear relationship between demographic growth in pastoral populations and growth in the number of livestock. No matter how fast a pastoral pastoral household is growing, it will not shorten reproduction intervals in the herd, increase the maximum possible ratio of females to males, or lower mortality rates.

If in farming there is a clear and relatively stable distinction between means of production (the land) and produce (the harvest), in pastoralism this distinction is controlled by management in dynamic ways: as males can be sold to buy females, any new born animal can be seen either as a product or as a means of production.

A herder with many children cannot simply increase production by increasing the size of the herd. The only viable option is usually to increase offtakes: whereas with a smaller family they would have sold, say, four or five bulls and used part of the gain to buy two heifers, with a larger family they need more money and therefore buy only one heifer or none, and maybe sell younger animals. Thus, a given herd is more likely to grow at a slower pace with a fast-growing household than with a slow-growing household.

Extending to pastoral conditions qualitative assumptions devised to analyse demographic growth in farming communities is misleading: demographic growth out of sync with herd growth is more likely to lead to impoverishment than to land degradation through overstocking – although impoverishment can also lead to overgrazing by reducing mobility.

[70] Even in the case of farming, there are examples where demographic growth has led to intensification and recovery rather than to land degradation (Tiffen and Mortimore 1994).

Improving agricultural statistics

4

In conclusion to our discussion, the need for updating the methodological infrastructure of pastoral development should also be understood in relation to the ongoing global revision of agricultural data and the way of generating them.

The programme is drafted in the *Global Strategy to Improve Agricultural and Rural Statistics* (World Bank 2011).[71] The *Global Strategy* paves the way for a new generation of agricultural data, integrated within national statistical systems and standardised for national and international users (for example in what concerns definitions, indicators and sampling methods). The revision affects also the way *livestock* systems are represented in statistics and, consequently, the way they are understood in policy making, both in relation to other food production systems (eg crop-farming and fisheries) and to the environment (eg water and forestry) .[72]

A recent report focussing on livestock data in Africa found that, in most cases, prevailing agricultural data collection systems do not suffice to generate the core livestock indicators needed by decision makers (Pica-Ciamarra *et al.* 2014). This situation is worse in the case of pastoral systems: 'all sources of livestock data and statistics – such as agricultural censuses, livestock censuses, periodical and *ad hoc* agricultural sample surveys, household income or expenditure surveys – rarely if ever generate comprehensive information on pastoral production systems' (*ibid*: 1).

Thus, an initiative aimed at improving statistics is welcome. On the other hand however, it is not simply a matter of ensuring that existing processes of appraisal are executed 'by the book', maybe increasing their intensity, but also adjusting to the demand the defining traits of quality: 'Understanding the demand for statistical information at the national level and what is required to supply that information is, therefore, a key element of the sustainability of an agricultural statistics system. Demand can be supported and strengthened if the statistical system is responsive to users and provides statistics that are relevant, accessible, timely, and with a level of accuracy that meets their needs' (World Bank 2011: 27).[73]

In framing data generation as 'supply' in a market-like transaction, and calling for a demand-driven approach, the *Global Strategy* implies that the improvement of agricultural data is a process open to *qualitative* alternatives.

4.1 The infrastructure of assumptions

Improvement unavoidably happens on the back of an existing infrastructure, which affects its course (cf section 1.2 above). Improvement of agricultural statistics is no exception. Historically, measuring-systems applied to agriculture have been effective mainly in contexts where stability can be secured (eg in temperate climates and large-scale industrial-agriculture settings), and where most or all the produced value is captured in monetary transactions (eg where the non-formal economy is negligible or non-existent).[74] Although most of the world's agriculture consists of small producers, the need to include these rural households in processes of appraisal continues to be seen as a challenge; especially when the producers operate under conditions dominated by variability, as in the case of pastoral systems.[75]

That information on pastoral systems is rarely generated by the sources of livestock data, means that pastoralism is both under-represented and misrepresented in agricultural statistics. It is good that a global methodological revision is picking this up, but how are pastoral systems to be represented *within the new generation* of integrated and standardised agricultural data? Were mechanisms of appraisal to be successfully improved to match principles and indicators in line with the *Global Strategy*, would the information on pastoral systems improve simply as a consequence of this process?

[71] The 2007 *Guide to Designing a National Strategy for the Development of Statistics*; the 2007 *Wye Group Handbook on Rural Households Livelihood and Well-Being* (with a second edition already on the way in 2011), the 2008 World Bank's *Global Strategy* refers to earlier efforts: *Tracking Results in Agriculture and Rural Development in Less than Ideal Conditions: A Sourcebook of Indicators for Monitoring and Evaluation, and the* FAO's *World Programme for the Census of Agriculture 2010* – all cited in Pica-Ciamarra *et al.* 2014.

[72] The invisibility of pastoral economic contribution in the mechanisms of appraisal is a long-recognised problem. The consequent impression that such a contribution is negligible was listed as one of the 'myths' of pastoral development (UNDP-GDI 2003). Hesse and McGregor (2006) proposed utilising a 'Total Economic Valuation' approach. This led to a series of studies and is now being revived; for a recent overview from a methodological perspective, see Krätli (2014).

[73] Also Pica-Ciamarra *et al.* (2014: iii), in the preface signed by the Director of the Agriculture and Environmental Services Department at the World Bank, the Director of the Animal Production and Health Division at FAO, and the Director General of the International Livestock Research Institute (ILRI): 'This Sourcebook represents a first step towards a demand-driven and sustainable approach to enhance the livestock information available to decision makers'.

[74] Cf. Porter (1995), looking at early statistics and cost-and-benefit analysis. In a closely-related field of research, James Scott outlines four main causes of the frequent failure of programmes of scientific agriculture outside their conditions of origin: i. a legacy of unexamined fundamental assumptions about productive processes, following from the origin of the discipline in temperate, industrialising West; ii. a structural inclination towards serving the interests of the power-that-be, (an identification with the power is embedded into the presumption of expertise); iii. that 'rigorous attention to productionist goals [which] casts into relative obscurity all the outcomes lying outside the immediate relationship between farm inputs and yields' (eg long term outcomes on soil structure, water quality, land-tenure relations and 'externalities'); iv. the [methodological] strength of scientific agriculture, its ability to narrow the analysis down to 'the impact of a single variable on total production' [which] gets in the way of grasping 'agricultural practices that are not assimilable to its techniques' (Scott, 1998: 264).

[75] For example: '[Limited access to quality data] is overwhelmingly the case for agriculture, where output is generated by a series of inputs directly controlled by the producer, which are often difficult to measure, but also influenced by a series of variables beyond his control, such as temperature and rainfall […] Measuring [production systems] is challenging when rural households – rather than commercial enterprises – keep animals, as these do not regularly record inputs and outputs along the production process' (Pica-Ciamarra *et al.* 2014: iii, 9).

The *Sourcebook* by Pica-Ciamarra *et al.* (2014) is ambiguous on this point. The work highlights some interesting issues but does not really go beyond saying that measuring pastoral economies is challenging, starting from the fact that 'there is no standard definition of pastoralism' (*ibid*: 56).[76] The difficulties are mostly framed as rooted in the discontinuity associated with these systems of production: variability in livelihood strategies (eg along a farming-pastoralism continuum), in the use of the rangeland (mobility), or in the use of water points (many of which are seasonal and subject to weather fluctuations).

On a few occasions though, the authors do touch upon the issue of *qualitative* alternatives in data collection looking at pastoral systems, and the consequences of ignoring them (ie by dealing with the poor quality of data as solely a matter of *degree*). For example, when they say that: 'Given the multiple roles of livestock in pastoral economies, and the oftentimes opportunistic use of markets by pastoral peoples, using standard production or profit functions to identify key constraints affecting their livelihoods may lead to biased conclusions and policy indications' (*ibid.*).[77] In other words, standard processes of appraisal, *even when executed by the book*, would still lead to a misrepresentation of particular systems of production. In the case of pastoral systems, this situation is further complicated by the mismatch between theoretical framework and analytical tools (cf. section 1.1 above).

Therefore, improving livestock data for public use must also first of all engage with a reflection on the methodological infrastructure beneath the processes of appraisal, and the challenge of re-qualifying the sets of items to be measured and their relationships when dealing with the drylands. There is strong demand for more authoritative data, but the authority of data should come from being representative of the people and practices they refer to, as authority without representation is risky for policies – no less than for politics.

The case of 'standard production and profit functions' highlighted above is but one example of methodological misrepresentation. The more general lesson is that if processes of appraisal are to generate any knowledge at all, their definitions and indicators, and the functions used to operationalise them, must embed qualitative assumptions about the functioning of the world: assumptions about *what is what* and *what needs to be measured* (see 1.3 above).

Measuring tools 'presume' their own purpose in the environment they are applied to, just like any other tool (for example, like a hammer presumes nails). As when applying standard production and profit functions to pastoral economies, assumptions or tools that serve well their purpose in some contexts can be off the mark in others. It follows that a globalisation of processes of appraisal in agriculture – as it unavoidably cuts across a great variety of contexts of production, many of which remain poorly understood – is a delicate and complex matter with important trade offs in terms of knowledge and representation. In any such a plan for global improvement, these trade offs should be carefully balanced or, at the very least, should be accounted for.

Pastoral systems are not an isolated case. In a world increasingly dominated by variability (not only weather volatility from global climate change, but volatility in food prices, financial and political instability, insecurity, frequent disasters and large-scale displacements of people), the legacy of assumptions embedded in agricultural appraisals can be expected to be often off the mark, especially assumptions of linearity and uniformity. Indeed, this issue is a core concern in the research on resilience, and closely relates to the challenge of measuring it in adaptive systems of food production.[78]

When reflecting on the implications and limitations of the inherited methodological infrastructure in agricultural appraisal, production systems that have developed in adaptation to environments defined by variability, such as pastoral systems, can offer an entry point with an unusually clear and contrasted view.

Finally, quantitative data are aggregative, both by virtue of being numbers, and for the way they are used to make a case, as bigger numbers carry more power of persuasion (Gitelman and Jackson 2013). Once they are produced it is difficult, if even at all possible, to control or monitor the ways they are combined. It is therefore essential to direct all possible efforts to address the known issues in the processes of data generation *before* the data are produced.

[76] The only recommendations specifically addressing pastoral systems are 'remote sensing surveys to count animals in pastoral areas at regular year interval' and 'transparent dialogue and collaboration with livestock stakeholders […] to effectively formulate livestock survey questionnaires, particularly those targeting sub-segments of the population, such as pastoralists' (Pica-Ciamarra ***et al.*** 2014: 7, 51). On the other hand, there is acknowledgement that 'aerial or satellite surveys are powerful instruments to measure livestock populations in vast arid and semi-arid areas, but they produce little information on the pastoral economy, ie on their own they are an ineffective tool for designing programs and investments' (***ibid***: 56).
[77] Another case, is when the authors highlight the differences in the generation of data ***from the same questions***, when using a standard definition of household (which presumes a nuclear family) in a polygamous pastoral context, compared with using an definition from the local language (Pica-Ciamarra ***et al.*** 2014: 57).
[78] For example, cf. the work of the Resilience Alliance (Folke ***et al.*** 2002) and the STEPS Centre at IDS (Leach ***et al.*** 2010).

Conclusions

This paper has made the case that there is a strong and urgent need to engage with the methodological dimension of the appraisal of pastoral systems and related resilient-dryland development.[79] We have shown how key elements of the methodological infrastructure of mainstream agricultural appraisal, commonly applied to the structurally variable drylands and pastoral production, retain underlying assumptions about stability and uniformity in the context of observation.

The important advancement in the understanding of pastoralism and the drylands, that has taken place at the theoretical level with the revision of the equilibrium model in ecology, will not materialise in the practice of representing and learning about pastoral systems unless accompanied by a corresponding reconsideration of the methodological infrastructure of dryland development. Combining the new theoretical development with the old underlying assumptions developed to serve the equilibrium model, means remaining locked, in practice, into the old world of problems and solutions.

We have shown that in the appraisal of pastoral systems the production context cannot be abstracted from it, as is done in the appraisal of mainstream agriculture. This is also the case for most smallholder crop-farming and mixed crop-livestock systems. Meaningful appraisals of pastoral systems cannot be done exclusively at animal or even herd level, but need to include higher scales, from extended-family herd level up, taking into account temporal and spatial as well as other relationships.

With regard to the necessary changes in the methodological infrastructure, it is clear that the qualitative assumptions that underlie definitions, categorisations and the choice of proxies and indicators need to reflect the differences that matter in the pastoral systems. If this remains ignored, even specialist analysis of drylands economies will not be sufficient to inform policies and interventions. It also misses out on dryland pastoralism as a vantage point for seeing important lessons on the opportunities for food production harbouring in the rule of discontinuity. Finally, it undermines the analysis of the relationship between drylands and international security: a dimension that has now become central to the concerns for developing of climate-resilient rangelands (cf. the Declaration de N'Diaména 2013; Agir 2013; De Haan *et al.* 2014).

[79] A similar argument has also just made with regard to environmental change and land degradation in the Sahel, where the authors analyse divergent positions against different sets of conceptualizations, definitions and choice of indicators; as well as against different methodological choices: Rasmussen ***et al.*** 2015.

Way forward

With the reflections presented in chapter 1, we hope to motivate other scientists and development practitioners to share their experience resulting from a mismatch between formal theoretical understanding of small-scale dryland food production – particularly pastoral systems – and the theory embedded in the analytical tools and methodology of drylands development.

We are therefore setting up an online participatory platform on 'pastoralism methodologies' with two main objectives:

1. Collect a critical mass of examples of 'barriers' to resilient dryland development embedded in off-the-shelf methodological tools and procedures from a variety of disciplines, and organise them into a searchable database to bring the problem out into the light.
2. Mobilise interest and debate around the challenge of revising and updating the methodological infrastructure of drylands development, sharing knowledge of existing options for quantitative analysis in contexts dominated by variability, and ideas for innovative approaches to capture relevant data in the drylands.

The benefit expected from an online platform would be to harness the expertise of a critical mass of people from several disciplines, starting from the initial group of specialists who participated in the workshop, expanded through word-of-mouth as well as targeted advertising on the networks concerned with resilient drylands development and pastoral systems (eg CELEP, WISP, the IUAES Commission on Nomadic Peoples, the recently created Pastoralism Knowledge Hub at FAO, amongst many others).

This platform should run for six months, plus an additional six months if the volume of traffic is high. At the end of this period, we expect to have enough material (i) to make a strong case about the issue of barriers embedded in methodologies in the context of resilient drylands development; and (ii) offer substantial solutions and alternatives. The analysis of this material would enter the public domain in the form of a book (conditional to securing funding).

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The theoretical framework for the scientific understanding of the drylands is almost the opposite today of what was mainstream in the 1970s, but the methodological infrastructure of analytical tools and practices is still catching up. As researchers and practitioners involved in dryland development depend on such infrastructure, they are often in danger of silently reproducing the old theoretical horizon even when manifestly operating in the new one. This is the issue this paper sets out to discuss.

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International Institute for Environment and Development
80-86 Gray's Inn Road, London WC1X 8NH, UK
Tel: +44 (0)20 3463 7399
Fax: +44 (0)20 3514 9055
email: info@iied.org
www.iied.org

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