Hum Ecol (2009) 37:441–451
DOI 10.1007/s10745-009-9253-2

A Complex-Systems Approach to Pastoral Commons

Lance W. Robinson

Published online: 2 June 2009

Abstract In recent years a new approach has begun to emerge in commons scholarship that draws on complex systems thinking and that makes use of concepts such as *fit*, *scale*, and the *adaptive renewal cycle*. This paper explores what complex systems thinking has to offer for commons scholarship by applying these concepts to the pastoral commons of the Gabra ethnic group of north-central Kenya. The concepts of fit and scale can help us to understand why some features of the institutional regime of the Gabra do not conform to mainstream principles such as clearly defined boundaries, clearly defined membership rules, and subsidiarity. The notion of the adaptive renewal cycle can help us to describe and understand some aspects of dynamics of Gabra institutions, especially those related to the management of shallow wells. Applying the adaptive renewal cycle to larger and longer scales highlights the possibility that the Gabra social–ecological system is becoming increasingly brittle, with evolving institutional arrangements putting more and more constraints on adaptation and especially on nomadic mobility. An examination of the distinctive nature of dryland pastoral commons, and in particular a complex systems approach to this examination, suggests a number of issues that relief and development organizations should consider, including how to foster novelty and innovation through all the phases of the adaptive cycle.

Keywords Adaptive renewal cycle · Common property · Complex systems · Institutions · Pastoralism

L. W. Robinson (✉)
Natural Resources Institute, University of Manitoba,
303-70 Dysart Rd.,
Winnipeg, MB R3T 2N2, Canada
e-mail: Lance@roboroz.ca

Introduction

In recent years mainstream commons scholarship has received numerous critiques, particularly from a group of perspectives that is typically referred to as either the 'entitlement school' (Johnson 2004) or the 'social-practice model' (Young 2002). While scholarship that falls under the *social-practice* heading may be a somewhat disparate group, it is united in agreement that the mainstream, rational choice perspective gives insufficient attention to questions of power, culture, meaning and history. Notwithstanding these criticisms, it must be noted that within commons scholarship, new questions are being asked and theory is being pushed in new directions. For example, one emerging concern relates to questions of dynamics, cycles of change, and ongoing adaptation in commons institutions (Wilson 2002; Dietz *et al.* 2003; Seixas and Berkes 2003; Folke *et al.* 2005; Berkes 2006).

A more fundamental problem with the image of commons scholarship as being dichotomized into these two schools of thought—the mainstream, rational choice approach and the social-practice perspectives—is the very idea that there are only two. This conception neglects the existence a third cluster of commons scholarship. This alternative position is neither the 'middle ground' between the rational choice and social-practice perspectives as described by Beck and Fajber (2006), nor is it a modified version of either of the other two perspectives. While the literature contributing to this emerging approach builds to a certain extent on earlier scholarship and while very little of it makes any explicit claim of being based on an alternative paradigm, it nevertheless draws on complex systems thinking to apply a distinct set of concepts to commons scholarship. Some of these concepts are *self-organization*, *non-linearity*, *uncertainty*, *scale*, and the notion of *linked social–ecological systems* (Berkes *et al.* 2003; Folke 2006; Berkes 2007).

Complex systems thinking is particularly relevant and particularly needed for the study of pastoral commons. It has long been recognized that pastoral tenure regimes seldom fit into the standard typology which divides property regimes into four types—private property, state property, commons and open access (Riddell 1982; Swallow 1990; Cousins 2000). Furthermore, the institutional regimes of pastoralist peoples tend to be characterized by a degree of overlap and flexibility both in territorial boundaries and in lines of authority and decision-making that does not conform to standard notions about the nature of well-functioning commons regimes (Cousins 2000).

The aim of this paper is to explore what complex systems thinking has to offer for commons scholarship by applying it to the pastoral commons of the Gabra ethnic group of north-central Kenya. The paper will show that a complex systems approach provides novel insights into institutional regimes such as that through which the Gabra manage their commons. It is based on field research that was conducted in 2007 and 2008, as well as on existing literature on the Gabra. The next section of the paper discusses some of the relevant features of a complex systems approach to commons scholarship. This is followed by a brief overview of the Gabra social–ecological system and some of its institutions. I then take two key concepts from the emerging complex systems approach to commons—*fit* and *scale*—and use them to make some sense of the nature of Gabra commons institutions. Following this, I use one of the influential concepts that derives from complex systems thinking—the *adaptive renewal cycle*—to examine the dynamics of Gabra commons institutions. I conclude by considering whether an examination of the distinctive nature of pastoral commons through the lens of complex systems thinking may produce lessons that are relevant to commons scholarship as a whole and to current issues of global environmental change.

Some Features of Complex Systems Thinking

For a number of years, and most notably in the last ten years, the concepts of *complexity* and *complex adaptive systems* have been gaining influence in scholarship on natural resources management, poverty reduction and ecology. They have influenced a number of overlapping bodies of work including resilience thinking (e.g., Holling 1973; Adger 2000; Gunderson 2000; Holling 2001; Gunderson and Holling 2002; Berkes *et al*. 2003), Ecosystem Health/Ecohealth (e.g., Rapport *et al*. 1998; Lebel 2003; Waltner-Toews 2004), and most recently the Sustainable Livelihoods Approach (Singh and Gilman 2000; Robinson and Fuller 2005; Connell 2006). These concepts have also made inroads in commons scholarship (e.g., Young 2002; Nayak 2006; Berkes 2007).

Complex systems thinking assumes that human life exists within a context of systems that are complex—that is, systems characterized by self-organization and emergent properties and in which the whole is greater than the sum of the parts. *Complexity* itself is the notion that no single theory, model or perspective can encompass or explain all of the processes, interactions, or causes and effects in the system, and a complex system can be defined as a system for which many distinct yet valid subsystem descriptions are possible (Rosen 1991). The fundamental features of complex systems are summarized in Table 1. The implications of these features, which collectively provide the basis for complex systems thinking, have been most thoroughly explored in literature on social–ecological resilience. One of the concepts prominent in the resilience literature which is relevant to commons scholarship is the idea that the social and the ecological are integrally linked. This body of literature holds that neither the ecological system nor the social system can be adequately understood without understanding the other and the linkages between them, and that essentially they function together as a *social–ecological system* (Berkes and Folke 1998; Folke 2006). Social–ecological systems, furthermore, exist in complex nested hierarchies that bridge scales—a social–ecological system is made up of smaller systems and is itself part of a larger system (Berkes *et al*. 2003).

Another important concept from the literature on social–ecological resilience—a concept emphasized in this paper—is

Table 1 Fundamental features of complex systems

Emergence	Complex systems behave as *systems* and cannot be adequately understood by decomposing the pieces
Hierarchical	Complex systems are usually hierarchical. The system is nested within a larger system and is itself made up of smaller systems.
Self-organization	Complex systems are characterized by self-organization. Those relationships and structures evolving within the system that are able to maintain and reproduce themselves and that help the system as a whole to process energy come to dominate and replace those relationships and structures that do not.
Non-linearity	Complex systems are characterized by non-linear dynamics.
Openness	A complex system is an open system with energy, information and causality entering and exiting the system. It cannot be adequately described by any single theory, model or perspective. As a result, boundary definition is problematic.

The above combine to create multiple quasi-stable states, threshold effects, and chaotic behaviour (adapted from: Kay *et al*. 1999; Waltner-Toews 2004; Berkes 2007)

the *adaptive renewal cycle*. Originally, the cycle was used to help make sense of the dynamics of ecosystems, including in rangeland ecosystems (e.g., Carpenter *et al.* 2001; Walker and Abel 2002). In recent years several authors (e.g., Gunderson *et al.* 2002; Holling and Gunderson 2002; Scheffer *et al.* 2002) have suggested that it can also help us to understand institutional dynamics, applying the concept especially to fishing communities (Seixas and Berkes 2003; Grant 2006). This paper takes a similar approach, applying the adaptive renewal cycle concept to institutional dynamics in pastoralist systems.

The idea of the cycle is that ecosystems, and by implication social and social–ecological systems, tend to go through cycles of four stages: exploitation, conservation, release, and reorganization. In a forest for example, the exploitation phase relates to the periods when plants are colonizing a landscape, and the conservation phase relates to a subsequent period when accumulation and storage of energy are prominent and one or more climax species becomes established. During these phases, interconnections within the system gradually increase, the resources and potential that exist in the system are increasingly locked up, and the system gradually becomes more rigid (Holling and Gunderson 2002). In social systems, these are typically the phases of *institutionalization* of solutions to problems (Scheffer *et al.* 2002). As the conservation phase extends itself and connectedness within the system increases, the system becomes more and more susceptible to a disturbance causing a 'release'—a forest fire that benefits from the accumulated energy and sweeps through the forest or a social upheaval that results when long-standing institutions are unable to deal with new stresses and problems. A release is characterized by a relatively rapid destruction and/or recycling of stored capital and by a weakening or breaking of many relationships in the system. This is followed by a reorganization of those relationships. The way that a social–ecological system evolves and the way that the cycle unfolds depend both upon the internal dynamics of the system and upon external shocks or disturbances. Externally generated shocks can occur at any point during the cycle, but it is when the system has accumulated larger amounts of capital and a higher degree of connectedness (the conservation phase) that the system is most susceptible to those shocks triggering a release and reorganization.

If disturbances and the *release* phase are suppressed and the conservation phase artificially extended, the resilience of the system can be compromised as it becomes vulnerable to a much more serious release and potentially a 'flip' into a qualitatively different state. Holling *et al.* (1998) have argued that many customary property regimes have evolved so that disturbance enters the system at small scales so that institutional renewal occurs internally while overall structure is maintained, thus avoiding flips. Scheffer and coauthors similarly suggest that as new problems emerge, in order to ensure adaptability and to allow the social system 'to incorporate new stakeholders or allow for a new definition of the situation', there may need to be a deinstitutionalization—the *release* phase of the adaptive renewal cycle (2002: 235).

Another set of concepts influenced by complex systems thinking and relevant to commons scholarship comes from the work of Oran Young (2002) and the International Human Dimensions Programme on Global Environmental Change. While Young himself does not outline a full-fledged complex systems theory of institutions, he does argue that the frontier of institutional theory—at least institutional theory for natural resources management—relates to three concepts: *fit*, *interplay*, and *scale*. *Fit* refers to how well an institutional regime matches the ecosystem in question. *Interplay* is concerned with how institutions interact with other institutions. The concept of *scale* in institutional analysis considers how institutions relate to the social–ecological environment at various spatial and temporal scales.

One other concern prominent in complex systems thinking deserves mention: dynamics. Most of commons scholarship has assumed that both ecosystems and well-designed institutions are stable; however, the recognition that societies are rarely, if ever, 'in balance' with their resources and that commons institutions are seldom stable for long has recently forced attention onto dynamics, cycles and change (Seixas and Berkes 2003; Berkes 2006). To understand dynamics, a number of factors are important, including the scale at which particular institutions operate, the drivers impacting on institutions, and institutional interplay. This concept of *interplay* reminds us that institutions are not self-contained units but are shaped by their interactions with other institutions (Young 2002). Berkes (2002) similarly affirms the relevance of examining the effects of larger scale institutions on smaller scale institutions. Examining common property institutions through the lens of resilience theory, he emphasizes adaptive change and argues that commons researchers need to look beyond the forms that institutions take and give more attention to adaptive capacity, to the role of institutions in relation to shocks and stresses that accompany social, political and environmental change, to institutional linkages across scales, and to institutional dynamics (Berkes 2002).

The Gabra Pastoral Commons

The traditional territory of the Gabra ethnic group is in north-central Kenya and extends into southern Ethiopia. Livestock are the foundation of the Gabra household

economy, with milk accounting for over 60% of household food consumption among those still primarily engaged in the traditional economy (McPeak 2003, 2005). Typically, a Gabra household's livestock mix is diverse, being based on camels but also including sheep, goats, donkeys and sometimes cattle (Ganya *et al.* 2004). Most respondents interviewed for this research said that livestock and food aid were the only sources of their livelihood. The diversity of livestock is part of their regular coping strategies and is related to the varying lengths of time that different animals can go without water (Ganya *et al*. 2004). This region has no permanent rivers, and throughout most of the area, precipitation is under 300 mm. per year and is highly variable, with the coefficient of variation ranging from 30% to 50% (National Environment Management Authority 2006). Movement of herds and households is a key to survival in this arid region, and even households which have established a permanent residence still rely primarily on livestock and still send some household members and their livestock long distances in search of water and pasture.

Indeed, diversity and flexibility of movement is central to this livelihood system (Robinson 1985; Ganya *et al*. 2004; Haro *et al*. 2005). As noted by Haro *et al*. (2005), this flexibility of nomadic movement functions without any strong emphasis in the culture on territorial boundaries. Each of the five *Yaa*s, the ritual nomadic camp for the traditional council of each of the five Gabra phratries (groups of clans), has defined frontiers that it does not cross, but these frontiers do not constrain the movements of members of phratry at large. Generally, particular groups are not associated with territories defined by boundaries, but rather with some specific location (Haro *et al*. 2005).

Gabra commons institutions, embedded in a clan-based social structure, include well councils and other institutions involved in governing water sources (Robinson 1985; Ganya *et al*. 2004), exclusion of outsiders from grazing in the core areas of Gabra territory (McPeak 2003), and institutionalized norms for negotiating access to water and pasture resources controlled by others (Ganya *et al*. 2004). Gabra territory also has numerous sacred sites which may be important ecologically. Because grazing and other activities are restricted at sacred sites, they tend to have a slightly different mix of flora and fauna than the surrounding territory and in this way they contribute to biodiversity across the landscape, as well as being a natural source of seeds and hence biological memory for these surrounding areas (Ganya *et al*. 2004). Gabra society has an intricate set of nested decision-making institutions, and lines of authority which, like territorial boundaries, are fuzzy, with different scales of 'communities' making competing claims on the same resources (Haro *et al*. 2005). Decision-making institutions include both permanent bodies and traditional *korra* meetings that are held for various purposes at various levels of social organization. Korra can be held very frequently, such as for planning movements or organizing rituals, but can also be organized on an ad hoc basis as the need to discuss particular matters of community interest arises (Table 2).

Commons institutions exist to govern trees, pasture and water. At sacred sites and in the vicinity of water points there are rules about cutting trees and branches. For example, around some towns and water points, branches of certain trees are to be cut only on one particular day of the week. Recently, some settlements have adopted rules governing milk herds and *foora* (dry) herds: within walking distance of the settlement and its water points only animals in the milk herd should be grazed, whereas male animals, unproductive females, and productive females beyond the number that the household needs for its daily milk consumption are to be put in foora herds and kept on more distant pastures. Generally, however, Gabra livestock owners enjoy essentially unrestricted access to pasture throughout Gabraland (McPeak 2003, 2005). An elder of one of the five *Yaa*s went so far as to say that it would be 'very shameful' for a Gabra to tell any other Gabra that they cannot use a particular pasture or that his livestock numbers should be limited.

It is water, rather, that is more tightly regulated in the traditional system, and access to water is the main factor limiting access to pasture (Robinson 1985). Shallow, hand-dug wells, for example, are governed by numerous rules and norms. The person who digs a well (with the help of friends and fellow clan members) is the *abba ela*, literally 'father of the well.' Although Gabra refer to the *abba ela* as the owner of his well, he is essentially a trustee, caring for the well on behalf of his clan. Wells and other water sources such as rock catchments may also have a *heerega*, a term that refers to both the schedule of turns for bringing livestock to the water source and to the committee of elders who oversee the schedule. When a newcomer arrives and requires water for his herd, he will typically ask permission from the *abba heerega*. On one occasion I witnessed this firsthand, when an interview with an *abba heerega* was interrupted by someone just who had just arrived in the village and who came asking permission to water his livestock. Gabra respondents explained that permission will seldom be denied initially, but if a large number of livestock are already using the well, the newcomer may be given water once but not given a regular turn in the rotation and then politely asked to find another water source. The *abba ela* is one of the members of the *heerega*, and does enjoy certain rights regarding 'his' well. For example, he usually is given the first morning slot in the watering rotation and hence does not need to spend any time waiting in a queue for others to finish watering.

Table 2 Some of the key features of the Gabra institutional environment

Biophysical context: Extreme variability in rainfall and pasture resources across time and space		
Standing institutions: Institutionalized positions and corporate institutions	Yaa councils, one for each of the five Gabra phratries (groups of clans)	
	Heerega (well council)	
	Abba heerega (head of the heerega, lit. 'father of the watering rotation')	
	Abba ela (lit. 'father of the well')	
	Water Users Associations governing boreholes	
Rules, norms and understandings regarding the use of natural resources	Water	Heerega (rotation system) governing access to wells and to water in some pans and rock catchments
		Norms for accessing wells and some other water points and for receiving a slot in the heerega
		Wells that are nominally 'owned' by the abba ela, but held in trust for his clan
		Detailed rules about what activities are permitted at and near wells
		A degree of openness or rigidity in access to shallow wells that varies with livestock population and water availability
		Access to springs is more relaxed as supply typically exceeds demand. However, in recent years committees have been emerging regarding the apportionment of spring water for horticulture.
	Territory and pasture	Rules regarding sacred sites
		Rules regarding where foora (dry) herds may be grazed
		Exclusion of outsiders from the core of Gabra territory
		Generally, however, there are few restrictions on the use of pasture
		Most territorial boundaries are ill-defined
	Other natural resources	Rules regarding sacred sites
		Rules limiting the cutting of trees and branches in particular locations
Governance	There are several levels of 'community'	
	There is flexibility in how the competing claims of these 'communities' are handled	

Ultimately, however, it is the *heerega* as a whole that determines watering turns. One *abba ela* whom I interviewed went so far as to say that, depending upon circumstances, the *abba ela* may not even get a slot at his own well. While this kind of situation may be rare, it does highlight how rights to wells are distributed among the *heeraga*, the *abba ela*, and the clan.

Applying Complex Systems Thinking to Analysis of the Gabra Pastoral Commons

In any analytical approach based on complex systems thinking, an implicit early step is to consider just what constitutes the system in question (or, in the case of multiple scales, the nested *set of systems* in question). Social–ecological systems can be defined according to watershed boundaries, ecosystem boundaries, political or other kinds of social boundaries, or combinations thereof. How the system is demarcated for analytical purposes depends to a great extent on the kinds of questions being asked (Waltner-Toews 2004). In the case of natural resources held in common, institutions are of paramount importance, and with the Gabra most of the key commons institutions are locally culturally defined rather than having been designed by the state. Furthermore, there are many aspects of decision-making, interaction, management of resources, and the construction of livelihoods that are connected to Gabra identity and to traditional Gabra institutions. Thus, for studying the pastoral commons in this part of Kenya, an important scale of the nested social–ecological system can be defined according to the territory in which the Gabra normally live and move. I refer to this as the Gabra social–ecological system. It is these institutions and patterns of nomadic mobility, and the linkages that they create, more than a sense of collective ethnic identity per se, that make this kind of delineation appropriate.

Fit and Scale

The concepts *fit* and *scale* help to explain why the institutional regimes of the Gabra and of other dryland pastoralists tend to look different from that of many other customary property regimes. The extreme variability of the climate in which the Gabra live and the resulting nomadic lifestyle mean that the relevant social–ecological system

exists in a territory that covers tens of thousands of square kilometres. The need for mobility and to access pastures wherever the rain has fallen produce an imperative for keeping territorial boundaries porous and ill-defined. For those still living the traditional life, the notion of a village and its surrounding territory as a 'community' is largely irrelevant. This accords with Scoones' (1999, 2004) discussion of the implication of the new ecology and non-equilibrium systems and seems to contradict the mainstream commons view that clearly defined boundaries are key to well-functioning commons regimes (Ostrom 1990, 1992).

Thus, the Gabra case provides a specific illustration of the relevance of the concepts of *fit*, *scale*, and linked *social–ecological systems*, all of which direct attention to the biophysical constraints that impose themselves on the range of institutional possibilities, constraints that have not always received adequate attention in commons scholarship. One implication of the existence of such constraints is that the pursuit of universal principles of effective commons governance is probably doomed. The variability of rainfall and pasture, the size of the territory used by a Gabra household and the scale of the social–ecological system in which a household operates are such that some 'principles' of effective common property regimes, such as clearly defined boundaries, clearly defined membership rules, and subsidiarity, cannot easily be applied. Young argues that because various social and ecological scales each have their own unique characteristics, the pursuit of design principles for institutions of the sort advocated by Ostrom (e.g., Ostrom *et al*. 1999) must be undertaken very carefully and that the principles that apply at one scale may not apply at another. For example, the principle of *subsidiarity*—the idea that decision-making should be relegated to the lowest capable level of social organization—is not easily implemented for large-scale ecosystems (Young 2002). Berkes (2007) similarly asserts that concepts and principles that apply at different levels of social–ecological organization overlap and are linked, but that each level also requires new concepts and principles.

Gabra Institutions and the Adaptive Renewal Cycle

This section uses the notion of the *adaptive renewal cycle* to describe and understand a few aspects of the dynamics of Gabra institutions. In studying Gabra institutions the utility of the adaptive renewal cycle is most obvious at a time-scale of a few years and in relation to livestock and to the institutions that govern the use of shallow wells. The *exploitation* and *conservation* phases of the cycle relate to times when rainfall is adequate and herds are expanding (points A and B in Fig. 1). During the conservation phase, capital is accumulated as herds become larger. Having a

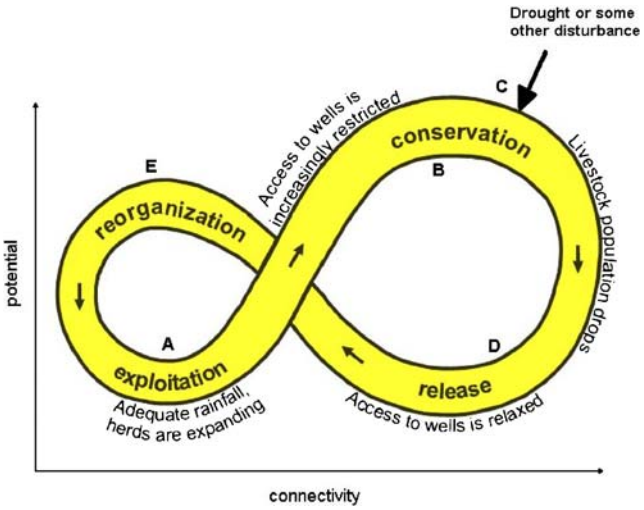

Fig. 1 The dynamics of livestock population and access to shallow wells

growing number of camels helps the Gabra household exploit more remote pastures more successfully, not only because camels can go for 7–14 days without water but also because they can haul water long distances thereby relieving the nomadic camp from the need to locate in areas near permanent water which typically have very poor grazing. Also, herd splitting strategies become more common as herds grow, since someone who has a larger herd has more scope for dividing that herd into various units. In abstract terms, mechanisms for capturing energy are becoming more intricate.

Eventually a disturbance upsets the system: typically a drought, but occasionally loss of livestock because of disease or theft (C). In response to drought, numerous coping strategies are employed, most notably moving herds to distant locations in search of water and pasture. The release phase of the cycle corresponds to a drop in the livestock population (D): in response to the drought, some animals will be sold or slaughtered, and in severe droughts many more will die of thirst and hunger despite the coping strategies that are employed. Some households and even entire nomadic camps will relocate to a new range. A well owner will typically return to 'his' well for part of each year, but sometimes with only part of his herd if his herd is divided. But some of those herd owners who were using someone else's well, once they have relocated, may not return for many years. This represents the system reorganizing after the shock, with new relationships and new linkages being established (E): some households and camps have relocated, many water points thereafter have a slightly different set of people using them, and through traditional forms of restocking new social relationships are being created and old ones renewed.

The dynamics of the institutions governing wells follow this same cycle. As mentioned above, the notion of the adaptive renewal cycle suggests that as the conservation phase progresses, relationships become more rigid; institutions, as those human relationships that have become structured and legitimized, are no exception. Early in the exploitation phase, when herds are small, access to water sources is relaxed as the heerega has no need to exclude anyone who wants to water their herd (A). Herd owners, furthermore, have several options open to them: a number of different water points that could accommodate their herds, and green pastures in between. But respondents in this research explained that as livestock numbers and the competition for water increase, the *abba ela* or the *heerega* will apply rules more rigidly and begin to restrict usage of the well, and livestock owners find fewer options available for watering their herds (B). Eventually, drought or some other disturbance (C) triggers the release phase of the cycle which is signified by a reduction in livestock numbers (D). Sooner or later the rains return, and with livestock numbers greatly reduced the rules for accessing wells are once again relaxed (A).

The above discussion should not be understood as arguing that all temporal features of any particular institutional environment can be explained according to the adaptive renewal cycle. For example, Gabra tradition has numerous ceremonies some of which occur on an annual basis and some of which occur in relation to the Gabra's 7-year cyclical calendar. The adaptive renewal cycle on the other hand does not repeat itself according to a regular and predictable pattern. Droughts and other disturbances occur at varying intervals and with varying durations and degrees of intensity. Essentially though, it could be said that the cycle as described above tends to occur over a period of between 3 and 10 years.

At larger and longer scales external drivers play a strong role, so the pattern is not quite as clear as at smaller scales; nevertheless, the adaptive renewal cycle does seem to play itself out over longer time frames. The social–ecological system in Gabraland underwent a major reorganization in the late 1800s in response to a series of shocks: an outbreak of rinderpest in 1889, outbreaks of malaria in 1890 and smallpox in 1891, conflict with neighbouring ethnic groups from 1894 to 1897, the virtually simultaneous arrival of Ethiopian and British colonialism in 1897–1898, and drought through most of the decade (Robinson 1985). With the exception of interethnic conflict, these factors were largely or wholly external to the system and obviously were not a *result* of the state of that system. But taken together they were enough to induce a 'release' (the destruction of stored capital, in the form of livestock) followed by a 'reorganization'. Two main facets stand out as characterizing the reorganization: Gabra territory shifted slightly southward into more arid land, and the prominence of cattle in the livestock mix was greatly reduced in favour of camels (Robinson 1985). The process of reaccumulating capital then began, and in this connection it is noteworthy that both 1899 and 1902 are remembered by Gabra oral historians as years when the Gabra were restocking by raiding neighbouring ethnic groups (Robinson 1985).

Another critical time occurred during the 1920s and 1930s when the colonial administration began to restructure the governance of the area, facilitated the settlement of Mount Marsabit by Burji agriculturalists (Robinson 1985), and permanently reduced the military strength of the Gabra by prohibiting them from owning horses (Torry 1973). During both of these periods, Gabra institutions proved to be quite flexible, and this was a key component in their adaptation to new situations (Robinson 1985). Since then, none of the shocks and disturbances that the Gabra have faced seem to have been on the same magnitude as these two episodes, and the organization of nomadic Gabra society, although undergoing new stresses now, seems to be quite similar to what it was in the 1930s.

There are some signs, however, that the social–ecological system is currently near the peak of a conservation phase. The human population has grown from about 11,000 in 1969 to over 45,000 at present (Ganya *et al.* 2004), resulting in increased competition for scarce resources. Droughts and theft of livestock function to keep livestock numbers within certain limits, but the ever-increasing human population means that in per capita terms the system is tighter.[1] One institutional response to this in Gabra communities has been the adoption of rules to restrict grazing near settlements and to require *foora* herds to be sent to distant pastures. A number of Gabra elders explained to me that the growing importance of such rules is a recent development, a departure from the more open and permissive grazing regime that has existed since Kenyan independence. Another ongoing institutional development is the delineation of new, smaller local government units, an action which typically receives strong political support at the local level. New local government boundaries, especially District boundaries, have a tendency to become de facto ethnic boundaries defining clearly marked grazing territories for various ethnic groups, as happened with the creation of Moyale District, when the Moyale–Marsabit border became one of the de facto dividing lines between the Gabra and the Borana.

[1] Some livestock theft that takes place in Kenya is for purposes of restocking, some is done on a more commercial basis with the livestock being sent to market. Looking at a scale larger than the Gabra social–ecological system, say all of northern Kenya and southern Ethiopia, an interesting question beyond the scope of this research is whether livestock theft is in some ways adaptive—whether it is a system response to increasing pressure on the environment.

As the marginal cost of securing scarce resources increases, so too does competition for those resources. This is leading to new mechanisms for distributing access and laying claim to resources, new rules, new institutions. As mentioned above, this is the stage of the adaptive cycle that sees the *institutionalization* of solutions to problems. In the case of the Gabra social–ecological system, this entails the tightening of rules for access to grazing land, such as the rules for foora herds mentioned above, and the ever-stricter demarcation of boundaries between ethnic groups. This is not to say that ethnically defined identities and territorial boundaries are necessarily desirable or that they represent a sustainable adaptation to increasing competition. Rather, ethnically based responses to this situation tend to emerge because ethnic identities and ethnically based institutions are already strong and often represent the most convenient way to draw both territorial and conceptual dividing lines. The concept of the adaptive cycle implies, however, that increasing institutionalization and increasing competition for resources go hand in hand with increasing brittleness. Whereas the rainfall regime remains as variable and unpredictable as it always was, these recent developments, while adding to the ability of the social ecological system to manage competition, also restrict the primary means of dealing with the climatic variability: nomadism. The result can be an overall loss of resilience.

NGO personnel and other development agents working with the Gabra and other pastoralist populations in Africa, whether or not they are aware of Holling's adaptive renewal cycle, are well aware that when a social–ecological system undergoes a 'release' and 'reorganization', a great deal of human suffering can result. Among the Gabra this applies at both scales that were discussed: people suffer through every revolution of the drought cycle, and they have suffered during the larger scale reorganizations of the entire Gabra social–ecological system, as happened in response to the confluence of shocks and stresses of the 1890s. Externally generated shocks and disturbances to the system are inevitable, but if when they come resilience has been greatly eroded, people may not recover from the 'release' at all, as testified to recently by the number of Gabra who have been ejected from the pastoral economy and now live in permanent settlements relying on food aid. This may represent the beginning of what can be called an 'exit' from the cycle (Holling and Gunderson 2002) and a 'flip' into an alternate state in which many households are never able to rebuild their herds. The alternate state is potentially perversely resilient, being characterized by a vicious circle of loss of livestock leading to loss of mobility and overgrazing around permanent settlements and permanent water sources, resulting in reduced ability to rebuild herds. Factors contributing to this loss of resilience in the Gabra case probably include the growing human population, an increasingly dry and less predictable climate, and growing restrictions on mobility brought about by local rules, interethnic conflict and bolstered by ever-smaller local government areas.[2]

So the question arises of what governments, NGOs and other agencies might best do to limit the kind of suffering that accompanies a 'release' and 'reorganization' and that can become permanent if such a vicious circle takes hold. Clearly, policies and programmes that merely extend the conservation phase of the cycle are to be avoided, as this just opens up the possibility of a bigger collapse. Programmes for the distribution of relief food to Kenyan pastoralists, to the extent that they reduce the need for reorganization and for local institutions to adapt to changing circumstances, may be doing exactly that.

However, this should not be taken to mean that human beings are trapped and at the mercy of such cycles. Nor should the concept of the adaptive renewal cycle and other concepts associated with complex systems thinking be understood as a form of environmental determinism. The cycle indicates tendencies, not rigid, predetermined paths and trajectories (Holling and Gunderson 2002). Strategic policy and programming interventions can affect the dynamics of a social–ecological system and potentially reduce the amount of suffering that can accompany a release and reorganization, whether at the level of an individual community or ecosystem or on a larger scale. For example, novelty and innovation—the emergence of new elements and new relationships in the system—are most prominent in the reorganization phase of the cycle. Development agencies might consider how institutional novelty and innovation can be fostered throughout the cycle (before a disturbance triggers a release/collapse) so that less drastic reorganizations can take place. One sort of innovation that would be beneficial in north-central Kenya would be new and additional institutional mechanisms for managing increasing competition for scarce resources while still maintaining maximum flexibility for movement of herds. Table 3 presents a summary of ways in which the Gabra case illustrates how the concepts of fit, scale and the adaptive renewal cycle can be applied to an analysis of commons and institutions.

Conclusion

This paper represents an attempt to incorporate elements of complex systems thinking into commons scholarship, in particular the concepts of *fit*, *scale*, and the *adaptive renewal cycle*. One of the motivations for doing this has

[2] I hope in a future paper to explore in greater detail the resilience of the Gabra social–ecological system, and the loss of that resilience.

Table 3 Applying concepts from complex systems thinking to institutions and management of commons: Some Gabra illustrations

Concept	Gabra illustration
Fit and scale	Extreme variability in climate behoves a livelihood based on mobility and flexibility. The implications for institutions include territorial boundaries that are ill-defined, several levels of 'community', and flexibility in how the competing claims of these 'communities' are handled.
Adaptive renewal cycle	At a time scale of a few years (the drought cycle), the adaptive renewal cycle is reflected in some of the dynamics surrounding access to shallow wells
Exploitation phase	Times when rainfall is adequate and herds are expanding. Access to water is relaxed.
Conservation phase	Times when herds have grown and competition for scarce resources has increased. Rules for access to water are applied more rigidly.
Release phase	Drought or some other disturbance leads to the loss of livestock.
Reorganization phase	Some people relocate and begin using different water sources, and some people begin to receive livestock through traditional restocking mechanisms. Thus relationships shift.

been an awareness of the still-unresolved tension between 'mainstream' commons scholarship and social-practice perspectives. Those adopting a social-practice perspective correctly argue that mainstream commons scholarship has given insufficient attention to questions of power, culture, meaning and history. Furthermore, until recently, the bulk of commons scholarship has assumed that community-level institutions are relatively stable and has focused on the kinds of natural resources that community-level institutions can effectively manage, and hence on relatively small scales. But for dryland pastoralists such as the Gabra, 'community' exists at several scales, as do their institutions and the natural resources they rely upon, and the communities, furthermore, are mobile; as a result, the contribution made by mainstream commons scholarship towards understanding the institutions of nomadic peoples has been modest.

Nevertheless, it must be noted that commons scholarship has not stood still over the past decade. Increasing attention is being directed towards questions of dynamics, cycles of change, and ongoing adaptation in commons institutions, and dryland pastoral commons present an ideal subject for the study of such questions. Dryland ecosystems are usually non-equilibrium systems, and the pastoral institutional regimes that relate to such ecosystems tend to be very different from the regimes that commons scholarship has until recently focused on. While the observation that pastoral tenure regimes seldom fit into the standard fourfold typology of property regimes (private property, state property, commons and open access) is not new, this has not been fully explored by commons scholarship. Now, however, that commons scholarship is directing more attention to questions of dynamics, adaptation, and scale, the study of pastoral commons may have a great deal to offer to the field as a whole.

Also, I would suggest that an examination of the distinctive nature of dryland pastoral commons, and in particular, a complex systems approach to this examination, can provide insights for those studying and working on problems associated with global commons. There are at least a couple of features of dryland pastoral commons regimes like that of the Gabra that make them relevant to global-level questions. Unlike community-level institutional regimes, such as might pertain to a village forest, it seems that the Gabra never developed overarching, tight controls on the use of pasture. Rather, like some global scale commons such as the atmosphere, there has been little need for tight controls until recently: the frequency of droughts functioned to limit livestock numbers; this, combined with limitations of technology for harvesting and storing water, functioned to limit overuse of pasture; and the extreme variability of rainfall functioned to limit the appropriateness of clear boundaries. Furthermore, just as the Gabra social–ecological system may be reaching the peak of a conservation phase, there is concern that the human race as a whole is pushing our global ecosystem dangerously close to critical thresholds. As is the case with other dryland pastoralist peoples, one feature of the Gabra institutional regime is that territorial boundaries and lines of authority and decision-making are fuzzy, with territories and spheres of influence that overlap. This mirrors more general observations that social–ecological systems with institutions that have modest overlaps in authority and function may be more resilient than those that do not (Folke *et al*. 2003; Low *et al*. 2003; Folke *et al*. 2005). Those involved in shaping global environmental regimes might consider whether a similar level of fuzziness, overlap, and institutional plurality may in some cases actually be preferable to neat, unitary accords.

While this paper has focused on only a few of the consequences of complex systems thinking for commons scholarship, based on the concepts of *fit*, *scale*, and especially the *adaptive renewal cycle*, the complex systems perspective certainly has further insights to offer. Other

concepts that are relevant include *self-organization*, *uncertainty*, *institutional interplay*, and *cross-level interactions*, among others. More importantly, this perspective seems to be based on a number of fundamental assumptions that are distinct both from those of the mainstream rational choice approach and from those of social-practice perspectives. While a consideration of these fundamental assumptions, including the ontology, epistemology, and approach to human agency of the complex systems perspective, is beyond the scope of this paper, I would argue that this perspective is gradually crystallizing as a distinct paradigm, one that puts dynamics and adaptation at the centre of inquiry.

Acknowledgements The research on which this paper was based was carried out with financial and in-kind support from the Canadian Social Sciences and Humanities Research Council, the International Development Research Centre, the Canada Research Chair in Community Based Resource Management, the Pastoralist Integrated Support Programme, and the International Livestock Research Institute.

References

Adger, W. N. (2000). Social and Ecological Resilience: Are they Related? Progress in Human Geography 24: 347–364.

Beck, T., and Fajber, L. (2006). Exclusive, moi? Natural resource management, poverty, inequality and gender in Asia. In Tyler, S. R. (ed.), Communities, Livelihoods and Natural Resources: Action Research and Policy Change in Asia. ITDG Publishing/IDRC, Warwickshire, pp. 297–320.

Berkes, F. (2002). Cross-Scale Institutional Linkages: Perspectives from the Bottom Up. In Ostrom, E., Dietz, T., Dolšak, N., Stern, P. C., Stonich, S., and Weber, E. U. (eds.), The Drama of the Commons. National Academy Press, Washington, D.C., pp. 293–321.

Berkes, F. (2006). From Community-Based Resource Management to Complex Systems: The Scale Issue and Marine Commons. Ecology and Society 11: 45. [online] URL: http://www.ecologyandsociety.org/vol11/iss1/art45/.

Berkes, F. (2007). Community-Based Conservation in a Globalized World. Proceedings of the National Academy of Sciences of the United States of America 104: 15188–15193.

Berkes, F., and Folke, C. (eds.) (1998). Linking Social and Ecological Systems: Management Practices and Social Mechanisms for Building Resilience. Cambridge University Press, Cambridge.

Berkes, F., Colding, J., and Folke, C. (eds.) (2003). Navigating Social-Ecological Systems: Building Resilience for Complexity and Change. Cambridge University Press, Cambridge.

Carpenter, S., Walker, B., Anderies, J. M., and Abel, N. (2001). From Metaphor to Measurement: Resilience of what to what? Ecosystems 4: 765–781.

Connell, D. J. (2006). Sustainable Livelihoods and Ecosystem Health: Understanding Similarities and Reconciling Differences. Paper presented at the Sustainable Livelihoods & Ecosystem Health: Informing Policy, Practice and Research Conference, Guelph, Canada, 4–7 June 2006.

Cousins, B. (2000). Tenure and common property resources in Africa. In Toulmin, C., and Quan, J. F. (eds.), Evolving Land Rights, Policy and Tenure in Africa. DFID, IIED, NRI, London, pp. 151–179.

Dietz, T., Ostrom, E., and Stern, P. C. (2003). The Struggle to Govern the Commons. Science 302: 1907–1912.

Folke, C. (2006). Resilience: The Emergence of a Perspective for Social–Ecological Systems Analyses. Global Environmental Change 16: 253–267.

Folke, C., Colding, J., and Berkes, F. (2003). Synthesis: Building Resilience and Adaptive Capacity in Social-Ecological Systems. In Berkes, F., Colding, J., and Folke, C. (eds.), Navigating Social-Ecological Systems. Cambridge University Press, Cambridge, pp. 352–387.

Folke, C., Hahn, T., Olsson, P., and Norberg, J. (2005). Adaptive Governance of Social-Ecological Systems. Annual Review of Environment and Resources 30: 441–473.

Ganya, C., Haro, G. O., and Borrini-Feyerabend, G. (2004). Conservation of Dryland Biodiversity by Mobile Indigenous people—the Case of the Gabbra of Northern Kenya. Policy Matters 13: 61–71.

Grant, S. (2006). Managing Small-Scale Fisheries in the Caribbean: The Surface Longline Fishery in Gouyave, Grenada. Unpublished PhD thesis, University of Manitoba, Winnipeg, Canada.

Gunderson, L. H. (2000). Ecological Resilience: In Theory and Application. Annual Review of Ecological Systems 31: 425–439.

Gunderson, L. H., and Holling, C. S. (eds.) (2002). Panarchy: Understanding Transformations in Systems of Humans and Nature. Island Press, Washington, D.C.

Gunderson, L. H., Holling, C. S., and Peterson, G. D. (2002). Surprises and Sustainability: Cycles of Renewal in the Everglades. In Gunderson, L. H., and Holling, C. S. (eds.), Panarchy: Understanding Transformations in Systems of Humans and Nature. Island Press, Washington, D.C., pp. 315–332.

Haro, G. O., Doyo, G. J., and McPeak, J. G. (2005). Linkages between Community, Environmental, and Conflict Management: Experiences from Northern Kenya. World Development 33: 285–299.

Holling, C. S. (1973). Resilience and Stability of Ecological Systems. Annual Review of Ecological Systems 4: 1–23.

Holling, C. S. (2001). Understanding the Complexity of Economic, Ecological and Social Systems. Ecosystems 4: 390–405.

Holling, C. S., and Gunderson, L. H. (2002). Resilience and Adaptive Cycles. In Gunderson, L. H., and Holling, C. S. (eds.), Panarchy: Understanding Transformations in Systems of Humans and Nature. Island, Washington, D.C., pp. 25–62.

Holling, C. S., Berkes, F., and Folke, C. (1998). Science, Sustainability and Resource Management. In Berkes, F., and Folke, C. (eds.), Linking Social and Ecological Systems. Cambridge University Press, Cambridge, pp. 342–362.

Johnson, C. (2004). Uncommon Ground: The 'Poverty of History' in Common Property Discourse. Development and Change 35: 407–433.

Kay, J. J., Regier, H. A., Boyle, M., and Francis, G. (1999). An Ecosystem Approach for Sustainability: Addressing the Challenge of Complexity. Futures 31: 721–742.

Lebel, J. (2003). In Focus: Health—An Ecosystem Approach. International Development Research Centre, Ottawa.

Low, B., Ostrom, E., Simon, C., and Wilson, J. (2003). Redundancy and diversity: do they influence optimal management? In Berkes, F., Colding, J., and Folke, C. (eds.), Navigating Social-Ecological Systems. Cambridge University Press, Cambridge, pp. 83–114.

McPeak, J. G. (2005). Individual and Collective Rationality in Pastoral Production: Evidence from Northern Kenya. Human Ecology 33: 171–197.

McPeak, J. G. (2003). Analyzing and Addressing Localized Degradation in the Commons. Land Economics 79: 515–536.

National Environment Management Authority (2006). Climate Change Impacts/Vulnerability Assessments and Adaptation Options. Accessed 1 May 2006. http://www.nema.go.ke/CCADAPASSESS.pdf

Nayak, P. K. (2006). Access and Entitlements: A Complexity Approach. Paper presented at the Property and Access to Resources: Fuzzy Concepts; Fuzzy Realities. Bornholm, Denmark.

Ostrom, E., Burger, J., Field, C. B., Norgaard, R. B., and Policansky, D. (1999). Revisiting the Commons: Local Lessons, Global Challenges. Science 284: 278–282.

Ostrom, E. (1990). Governing the Commons: The Evolution of Institutions for Collective Action. Cambridge University Press, Cambridge.

Ostrom, E. (1992). Crafting Institutions for Self-governing Irrigation Systems. Institute of Contemporary Studies, San Francisco.

Rapport, D. J., Epstein, P. R., Levins, R., Costanza, R., and Gaudet, C. (1998). Ecosystem Health. Blackwell, Malden.

Riddell, J. C. (1982). Land Tenure Issues in West African Livestock Range Development Projects. Land Tenure Center, University of Wisconsin, Madison.

Robinson, P. W. (1985). Gabbra Nomadic Pastoralism in Nineteenth and Twentieth Century Northern Kenya: Strategies for Survival in a Marginal Environment.

Robinson, L. W., and Fuller, A. M. (2005). Taking Complexity Seriously in Rural Development Policy: Insights from Ecosystem Health and Sustainable Livelihoods Approaches. Paper presented at the Fourth International Rural Network Conference, Abingdon, pp. 19–24.

Rosen, R. (1991). Life Itself: A Comprehensive Inquiry into the Nature, Origin and Fabrication of Life. Columbia University Press, New York.

Scheffer, M., Westley, F., Brock, W. A., and Holmgren, M. (2002). Dynamic Interaction of Societies and Ecosystems—Linking Theories from Ecology, Economy, and Sociology. In Gunderson, L. H., and Holling, C. S. (eds.), Panarchy: Understanding Transformations in Systems of Humans and Nature. Island, Washington, D.C., pp. 195–239.

Scoones, I. (1999). New Ecology and the Social Sciences: What Prospects for a Fruitful Engagement? Annual Review of Anthropology 28: 479–507.

Scoones, I. (2004). Climate Change and the Challenge of Non-Equilibrium Thinking. Institute of Development Studies Bulletin 35: 114–119.

Seixas, C. S., and Berkes, F. (2003). Dynamics of social–ecological changes in a lagoon fishery in southern Brazil. In Berkes, F., Colding, J., and Folke, C. (eds.), Navigating Social Ecology Systems. Cambridge University Press, Cambridge, pp. 271–298.

Singh, N., and Gilman, J. (2000). Embracing the Complexity of SL Systems. Paper presented at the Sustainable Livelihoods Seminar, Guelph.

Swallow, B. M. (1990). Strategies and Tenure in African Livestock Development. Land Tenure Center paper no. 140. Land Tenure Center, University of Wisconsin, Madison.

Torry, W. I. (1973). Subsistence Ecology among the Gabra: Nomads of the Kenya/Ethiopia Frontier.

Walker, B., and Abel, N. (2002). Resilient Rangelands: Adaptation in Complex Systems. In Gunderson, L. H., and Holling, C. S. (eds.), Panarchy: Understanding Transformations in Systems of Humans and Nature. Island, Washington, D.C., pp. 293–314.

Waltner-Toews, D. (2004). Ecosystem Sustainability and Health: A Practical Approach. Cambridge University Press, Cambridge.

Wilson, J. (2002). Scientific Uncertainty, Complex Systems, and the Design of Common-Pool Institutions. In Ostrom, E., Dietz, T., Dolšak, N., Stern, P. C., Stonich, S., and Weber, E. U. (eds.), The Drama of the Commons. National Academy Press, Washington, D.C., pp. 327–360.

Young, O. R. (2002). The Institutional Dimensions of Environmental Change: Fit, Interplay and Scale. MIT, Cambridge.