Received: 18 December 2020 | Revised: 24 May 2021 | Accepted: 24 June 2021

DOI: 10.1111/conl.12826

Conservation Letters
A journal of the Society for Conservation Biology
Open Access
WILEY

LETTER

# Sustainability of social–ecological systems: The difference between social rules and management rules

## 1 | INTRODUCTION

Socioecological systems are described as sustainable when people whose livelihoods depend on natural resources can meet their needs without threatening the availability of those resources for future generations (Saito et al., 2017). Common pool resource theory suggests that sustainability is most likely to be achieved when clear property regimes are established (Ostrom, 1990). Property regimes can be based around the division of resources into privately owned parts (private property regime), the administration and control of a resource by the state (state property regime), or the creation of "bottom-up" arrangements to manage resources (common property resource management regime). While these various property regimes may look rather different to one another, they all rely on of some kind of management rules that limit resource use (Galik & Jagger, 2015). Management rules, here used as a synonym of access rules (Ribot & Peluso, 2009), can be defined, in conservation science, as a group of rules that control the ability of users to extract/manage natural resources (Milner-Gulland & Rowcliffe, 2008) (Table 1). According to common pool resource theory, socioecological systems without management rules will descend into a "tragedy of the commons" scenario in which individuals overexploit natural resources, resulting in ecosystem exhaustion or collapse (Behnke et al., 2016; Hardin, 1968). However, recent empirical case studies suggest that this is not always the case and that under certain conditions, sustainability can be maintained in the absence of management rules, described by Moritz et al. (2018) as Open Property Regimes and Chiaravalloti and Dyble (2019) as Limited Open Access systems.

It is important to note that many communities will have rules around resource use that cannot be considered *management* rules insofar as their purpose is not to limit resource extraction. Rather, they are *social* rules that facilitate cooperation in resource extraction or sharing and serve to *increase* resource extraction rates. These social rules may be necessary for the viability of individual livelihoods, especially when resources are patchily or unpredictably distributed. For example, in many hunter-gatherer communities, the majority of hunting trips are unsuccessful, such that individuals rely on social rules that encourage the sharing of food among community members to maintain a regular supply of meat (Gurven, 2004). Similarly, among fishers in the Brazilian Pantanal, social rules facilitating the sharing of information about the location of productive fishing sites are essential for the viability of individual livelihoods (Chiaravalloti & Dyble, 2019). While such social rules facilitating cooperation may be advantageous, they are also vulnerable to "free-riders" who benefit from being part of a cooperative group without contributing to public goods. This vulnerability can lead to the formation of social boundaries between groups which arise not because of competition for finite resources but because individuals from outside the community might disrupt the system of cooperation within the community.

While the recent research from Moritz et al. (2018) and Chiaravalloti and Dyble (2019) describes socioecological systems that are different from classic property regimes and proposes possible driving conditions that may lead them to exist, there is no attempt understand the importance of rules controlling users' ability to extract/manage natural resources to be sustainable (management rules) and rules facilitating cooperation (social rules). This article aims to further explore these issues, articulate the difference between social and management rules, and explore how social and management rules may interact to produce different kinds of socioecological systems. To do this, we first outline a simple conceptual model and then provide three illustrative ethnographic case studies in which social rules facilitating cooperation are necessary for the viability of individual livelihoods: Pantaneiro fishers, Agta hunter-gatherers, and Maasai pastoralists.

**TABLE 1** Definitions of terms that underpin our argument that sustainability of socioecological systems is better understood when we separate management and social rules

| Term | Definition | Reference |
|---|---|---|
| Common pool resource | Natural or human-made resources where one person's use subtracts from another's use and where it is often necessary, but difficult and costly, to exclude other users outside the group from using the resource | Berkes (1985) |
| Property | Formally is considered a specific area in which an owner has the right to exclude non-owners from it. However, some consider it an evolving multiple layers of ownership best captured by the term "bundle of rights" | Chiaravalloti et al. (2017) |
| Institution | Institutions are the rules of the game of a society or more formally are the humanly devised constraints that structure human interaction. They are composed of formal rules (statute law, common law, regulations), informal constraints (conventions, norms of behaviour, and self-imposed rules of behaviour); and the enforcement characteristics of both. | North (1991) |
| Access | The ability to benefit from things—including material objects, persons, institutions, and symbols. | Ribot and Peluso (2009) |
| Rules | Broadly understood as a socially transmitted and customary normative injunction or immanently normative disposition, that in circumstances X do Y | Hodgson (2006) |
| Norms | Patterns of behaviour that give rise to "behavioural rules" internal to the individual, as opposed to the external, agreed-upon rules that constitute institutions | Wallis (2017) |

### 1.1 | A conceptual framework to differentiate social and management rules in socioecological systems

Let us imagine a simple socioecological system in which a population of people, in the absence of any kind of management rules or collaboration with other agents, will extract resources at a level defined by $P$. Let us also imagine that there is an ecological threshold $T$, below which an average individual's resource extraction must remain for the system to be ecologically sustainable. As such, if $P > T$, management rules are needed to avoid a tragedy of the commons (Olsson & Folke, 2004). Let us say that management rules may be able to limit individual resource extraction by some amount called $M$. Where $P > T$ but $P - M < T$, management rules can successfully reduce resource extraction to sustainable levels resulting in a successful property regime (Holt, 2005). For purposes of this model, $M$ could be a product of "top down" rules imposed by governments, the incentives to limit resource extraction resulting from private ownership of resources or "bottom-up" rules created by communities themselves (Behnke, 2018). Examples of successful property regimes can be seen all around the globe and are the stock-in-trade of classic socioecological work (Ostrom, 1990). In the Amazon floodplains, for example, communities implemented an *arapaima* fishing management system by using their traditional skills to balance and adjust the number of fish they harvest in a common property resource management regime (Campos-Silva & Peres, 2016). Among lobster fishers in Maine, rules exist about rotating fishing localities and imposing restrictions on the number and size of lobsters one can take (Waring & Acheson, 2018). In each case, management rules limit personal resource extraction, allowing ecological sustainability: where $P > T$ but $P - M < T$; management rules facilitate sustainability.

As mentioned above, resource extraction does not always need to be limited by management rules for ecological sustainability to be maintained (Moritz et al., 2018). Such systems are likely to be those in which ecological dynamics keep the system in a nonequilibrium state and/or a significant proportion of key resources remain unexploitable (Moritz et al., 2018). In the Pantanal wetlands, for instance, fishers can access between 31% and 50% of the local fish stock at any one time, reducing their capacity for resource extraction (Chiaravalloti et al., 2021). Similarly, in Cameroonian floodplains, at least two-thirds of the grassland is stored under water and cannot be accessed by mobile pastoralists for much of the year (Scholte, 2007). In these cases, where individual resource extraction ($P$) is limited by ecological and/or technological constraints such that $P < T$; ecological sustainability does not require the creation or imposition of management rules (Moritz et al., 2018).

While some socioecological systems may not need management rules, they may need social rules to guarantee economic sustainability. To clarify what we mean by this, we must introduce a second threshold called $I$, which is the minimum amount of resources that an individual needs to survive or to maintain his/her livelihood. In most

**TABLE 2** Conditions favoring common property regimes, cooperative open access, and open access

| Situation | Possible solution | Result if solved | Ethnographic examples |
|---|---|---|---|
| $I < P$ and $P > T$ Individuals can survive Ecologically unsustainable | Introduction of management rules so that $P - M < T$ | Common property regime: bounded groups with management rules | Mamirauá Amazon fisheries Campos-Silva and Peres (2016) |
| $P < I < T$ Individuals cannot survive Ecologically sustainable | Introduction of social rules so that $P + S > I$ | Cooperative open access: bounded groups with social rules | The Agta, Pantaneiro fishers Chiaravalloti and Dyble (2019) |
| $I < P < T$ Individuals can survive Ecologically sustainable | No rules required | Open access regime | Turkmenistan pastoralist Behnke et al. (2016) |

$P$ is the level at which an individual will extract resources in the absence of either management or social rules, $T$ is the ecological threshold, $I$ is the minimum amount of resources that an individual needs to maintain their livelihood, $M$ is the amount that resource extraction is reduced by as a result of management rules, and $S$ is the amount that resource extraction is increased by as a result of social rules.

systems where property regimes are described, it is assumed that lone individuals can successfully survive (i.e., that $P > I$) (Galik & Jagger, 2015). However, in some ecosystems, this is not the case—lone individuals cannot survive and so rely on cooperation with others to increase their return rates (Monk et al., 2018). For example, among many hunter-gatherers, foraging returns are too stochastic for individuals to have a reliable foraging income on their own and to counter this, they rely on extensive food sharing within the community (Dyble et al., 2016). A similar situation exists for the Pantanal fisheries– information sharing, supported by social rules, is necessary for survival. Where cooperation is necessary for survival $P < I$ but $P + S > I$, where $S$ is the improvement to return rates through cooperation.

If cooperation ($S$) were easy to achieve then the above scenario in which $P + S > I$ would be little more than a highly cooperative version of an open property regime. In practice, however, the cooperation assumed by $S$ requires communities to introduce social rules and social arrangements in order to overcome the "free rider" problem described above. Solving this free-rider problem is rarely straightforward—it requires a range of mechanisms including indirect reciprocity, gossip, ostracism, and punishment that are often facilitated by the formation of well-defined social groups with shared social norms, as is the case in the Pantanal (Chiaravalloti & Dyble, 2019). This is what we describe as a cooperative open access socioecological system, defined as a system in which communities do not require management rules to ensure ecological sustainability but do require the formation of bounded social groups with rules facilitating cooperation in order to survive. Superficially, it may appear similar to a common property regime in that it results in groups with rules. However, these rules are entirely different, aimed at facilitating cooperation to increase return rates rather than management rules to reduce return rates. Cooperative open access is a consequence of a fundamentally different social–ecological challenge—that of individual resource extraction being below the level required for survival (Table 2). Below, we explore the importance of social rules in three socioecological systems.

## 1.2 | *Pantaneiros* fishers in Brazil

The *Pantaneiro* fisher communities live in the western border of the Pantanal wetland, Brazil. Fishing is the main livelihood for over 70% of local people (Chiaravalloti, 2019) (Figure 1). Extended families occupy different sites throughout the floodplain. Groups of four or five extended families, normally bounded through kinship, form a community.

The main ecological challenge facing the *Pantaneiro* communities is the temporal and spatial unpredictability in the distribution of fish. This is largely a result of the north-south flood pulse in the Pantanal. Due to the slight gradient of the terrain in the Pantanal, the flood pulse takes 3–4 months to pass through and is highly variable from year to year (Junk et al., 2006). Additionally, large quantities of floating vegetation mats move freely throughout the floodplain, continually blocking and opening different water bodies (Pott et al., 2011). For small-scale *Pantaneiro* fishers, this results in a system that is highly unpredictable: on average, fishing grounds stay available and profitable for no longer than 5 days. Fishers survive by sharing information about productive fishing grounds with one another and by moving to fish in the same place (Chiaravalloti & Dyble, 2019). The information is shared and discussed during ice-tea drinking sessions, of which several are held each day. However, the openness and reciprocity shown among people from the same community does not extend to people from outside their community, with whom neither information nor fishing grounds are shared (Chiaravalloti, 2019). To avoid any kind of contact (e.g., outsiders seeing where they are going), the community has a clear territory which they will defend if those fishers from other communities trespass its limits.

**FIGURE 1** Our three ethnographic case studies: Pantanal fishers (left), Agta foragers (centre), and Maasai pastoralists (right). Maasai photograph courtesy of Aidan Keane.

Ethnographic research has recorded several knife fights related to such conflicts (Chiaravalloti, 2019).

The system we see in the Pantanal involves social rules but not management rules and includes some features that are typical of an *open* property regime such as high levels of mobility and a lack of clear boundaries between community members (Chiaravalloti, 2019). However, we also see bounded social groups within which individuals cooperate extensively according to a shared set of social norms.

## 1.3 | Agta foragers in the Philippines

The Agta live along the northeastern coast of Luzon in the northern Philippines and have an economy that includes a mix of foraging, agriculture, and wage labor, with some groups still engaged almost entirely in foraging (Dyble et al., 2019). The Agta live in small but mobile groups within which they cooperate extensively in foraging, childcare, and food sharing (Dyble et al., 2016). As for many foragers (Gurven, 2004), cooperation in food sharing is essential to mitigate against day-to-day shortfalls in hunting or fishing success and it is highly likely that a single family would be unable to survive without this cooperative food sharing that is reflected by a general ethic of egalitarianism and maintained through social norms that promote sharing (Smith et al., 2017). While these *social* rules promoting cooperation are an important part of life, *management* rules limiting foraging returns are not. However, the fragility of cooperation within groups means that group membership is still controlled (largely through kinship ties) and there is a kind of social boundary defense among the Agta similar to that described among other small-scale foraging groups (Cashdan et al., 1983) in which permission is sought before foraging in another group's territory. The necessity to share food also means that it is logistically difficult to forage in an area without joining the nearest group—exclusion from this group therefore, in effect, maintains a territory. This system is an example of a cooperative open access system insofar as the formation of bounded social groups with clear social norms is necessary for survival but ecological factors and low population density mean that management rules are not necessary for sustainability.

## 1.4 | Maasai pastoralists in East Africa

Maasai pastoralists manage livestock in a highly unpredictable East African savanna rangeland environment (Figure 1). They have customarily dealt with drought and disease by moving to access forage and to avoid seasonally high disease vector populations threatening livestock health (Miller et al., 2014). Though Kenya Maasai land is largely privatized, in Tanzania (and in parts of Kenya where land is still held in common) Maasai livestock management hinges on common property rules, with communal dry season grazing clearly delineated and set aside, timing of access controlled, and penalties imposed for infringement. This corresponds to the top row of Table 2. But at the start of the wet season, with animals at their most depleted, new growth grazing is increasingly available but patchy, unpredictable, of variable quality. Many other drivers of herding decisions are similarly unpredictable: seasonal eruptions of disease vector populations, market price fluctuations and differentials, security hazards presented by human or wild predators (Homewood, 2008). To navigate these complexities, herders rely on cooperative information sharing, through channels built into social structure and process, corresponding to the middle row of Table 2. With good rains though, good grazing is temporarily superabundant, and where there is no security or disease threat people's herding decisions correspond to the bottom row of Table 2 (Homewood, 2017). With conditions continually shifting across time and space, and with no single overriding driver of ecological dynamics or social need, Maasai pastoralists manage a hybrid system with a mix of cooperative open access within an overtly common property regime framework.

The two different sets of rules described above—for management or for cooperation—are distinct but not necessarily mutually exclusive. Complex cases where both occur side by side, applying respectively to different dimensions of the resource base, may arise (cf. the "complex mosaic" system historically prevalent among the Borana of East Africa: Robinson, 2019).

## 2 | Conclusion

Developing a clear understanding of how different communities deal with their ecological dynamics is critical for conservation science and practice. Based on standard property regime principles, most conservation and development initiatives currently focus their actions on management rules that aim to restrict humans' natural resource extraction (van Laerhoven et al., 2020). For instance, the creation of national parks and other strictly protected areas is underpinned by an assumption that large areas should be set aside from human use or contact in order to protect the environment (Neumann, 2004). Indeed, most socioecological systems do require some form of management rules for sustainability to be ensured. However, this is not the case for all systems and adopting a one-size-fits-all approach may be detrimental or unnecessary where the ecology and technology is such that open property regime or cooperative open access systems are sustainable (Chiaravalloti & Dyble, 2019; Moritz et al., 2018). The theoretical model we present opens the possibility for new or optimized conservation strategies.

We argue that in some cases, it is the social rules for cooperation that make social–ecological systems sustainable, especially where unpredictable ecosystem dynamics and limited exploitation technologies make people unlikely to overstep ecological thresholds. In these cases, the primary conservation focus should be on social (rather than ecological) sustainability. Serious threat presented by existing users shifting to exploitation technology that is not sustainable, or new users coming in with such technology, would be all the more likely where social or cooperative systems are weak or collapse. It is important therefore not just to enforce against trespassing or freeriding, but to strengthen social systems that sustain social cooperation. For instance, financial resources for community reserves governed by cooperative open access or open property regimes may be better allocated in avoiding trespassing than biodiversity monitoring, since there is no need for management rules to guarantee sustainability. Where local resource use practices are demonstrably sustainable, but social /cooperative systems are vulnerable—for example, to external commercial pressures—conservation should acknowledge that sustainability and promote those customary practices; support indigenous peoples' and local communities' (IPLC) land rights against state and corporate resource grab; ensure government enforces exclusion against trespass and illegal extraction; and ensure returns to IPLC from, for example, ecotourism are realistic and equitably distributed. Where unpredictable ecosystem dynamics make social cooperation key to social–ecological sustainability, conservation must acknowledge that unpredictably fluctuating conditions require flexible access which will necessarily change across seasons and years and acknowledge the consequent need for mobility as a key dimension of community resource use. Conservation should acknowledge community expertise in responding to changing conditions and allow for fuzzy social and spatial boundaries in resource access and use, under IPLC management, as exemplified by dynamic conservation areas or seasonal protected areas (D'Aiola et al., 2019; Chiaravalloti, 2017).

## ACKNOWLEDGMENTS

The authors are grateful to Agta, Pantaeiro, and Maasai communities for their hospitality during field trips.

## CONFLICT OF INTEREST

The authors have no conflict of interest.

## AUTHOR CONTRIBUTIONS

RC and MD wrote the main manuscript text and prepared Figure 1. KH contributed the Maasai case study. All authors contributed to the discussion and reviewed the manuscript.

## ETHICS STATEMENT

Data for this study were collected by authors referred throughout the paper.

## DATA ACCESSIBILITY STATEMENT

The data that support this study are available in the references provided through the paper.

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**KEYWORDS**
Agta hunter-gatherers, conservation initiatives, limited open access, Maasai pastoralists, open property regime, Pantaneiro fishers, socioecological systems, sustainability

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**How to cite this article:** Chiaravalloti RM, Homewood K, Dyble M. Sustainability of social–ecological systems: The difference between social rules and management rules. *Conservation Letters*. 2021;e12826. https://doi.org/10.1111/conl.12826