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Is Proactive Adaptation to Climate Change Necessary in Grazed Rangelands?

Andrew Ash,[1] Philip Thornton,[2] Chris Stokes,[3] and Chuluun Togtohyn[4]

Authors are [1]Director, CSIRO Climate Adaptation Flagship, Brisbane, QLD 4001, Australia; [2]Senior Scientist, Climate Change, Agriculture and Food Security (CCAFS), International Livestock Research Institute (ILRI), Nairobi 00100, Kenya; [3]Senior Research Scientist, CSIRO Ecosystem Sciences, Townsville, QLD 4814, Australia; and [4]Professor, National University of Mongolia, and Director, Dryland Sustainability Institute, Ulaanbaatar 14250, Mongolia.

Abstract

In this article we test the notion that adaptation to climate change in grazed rangelands requires little more effort than current approaches to risk management because the inherent climate variability that characterizes rangelands provides a management environment that is preadapted to climate change. We also examine the alternative hypothesis that rangeland ecosystems and the people they support are highly vulnerable to climate change. Past climate is likely to become an increasingly poor predictor of the future, so there is a risk in relying on adaptation approaches developed solely in response to existing variability. We find incremental, autonomous adaptation will be sufficient to deal with most of the challenges provided by the gradual expression of climate change in the next decade or two. However, projections of greater climate change in the future means that the responses required are qualitatively as well as quantitatively different and are beyond the existing suite of adaptation strategies and coping range. The proactive adaptation responses required go well beyond incremental on-farm or local actions. New policies will be needed to deal with transformational changes associated with land tenure issues and challenges of some displacement and migration of people in vulnerable parts of rangelands. Even where appropriate adaptation actions can be framed, issues of when to act and how much to act in a proactive way remain a challenge for research, management, and policy. Whether incremental or transformational involving system changes, a diversity of adaptation options will be required in different rangeland regions to enhance social and ecological resilience.

Resumen

En este articulo evaluamos la idea de que la adaptación al cambio climático en pastizales pastoreados requiere un mayor esfuerzo que lo que se hace en la actualidad para manejar los riesgos debido a la inherente variabilidad climática que caracteriza a los pastizales y que provee un manejo del ambiente que está pre-adaptado al cambio climático. Examinamos la hipótesis alternativa que los ecosistemas de pastizales y la gente que mantienen es altamente vulnerable al cambio climático. El clima pasado es probable que se convierta cada vez más en un pobre predictor del futuro así que el riesgo en confiar en enfoques de adaptación desarrollados únicamente en respuesta a la variabilidad existente. Encontramos que la adaptación autónoma será suficiente para lidiar con la mayoría de los desafíos proporcionados por la expresión gradual de cambio climático en las siguientes dos décadas. Sin embargo, las proyecciones de un mayor cambio climático en el futuro significan que las respuestas requeridas son tanto cualitativa como cuantitativamente diferentes y éstas van más allá de los alcances de las estrategias adaptación y afrontamiento. La adaptación proactiva de las respuestas requiere ir más allá del incremento de la granja o de las acciones locales. Nuevas políticas serán necesarias para lidiar con los cambios transformacionales asociados con problemas de la tenencia de la tierra y los retos del desplazamiento y migración de la gente en ciertas partes vulnerable de los pastizales. Incluso donde las medidas adecuadas de adaptación se pueden enmarcar, problemas de cómo actuar y en qué medida en una manera proactiva siguen representado un reto para los investigadores, manejadores y las políticas. Ya sea envolviendo cambios sistemáticos transformacionales o incrementales, se exigirá una diversidad de opciones de adaptación en las diferentes regiones de pastizales para mejorar las resiliencia ecológica o social.

Key Words: displacement, migration, proactive approach, resilience, transformation

INTRODUCTION

By their very nature pastoralism and ranching in rangelands are adaptations to a highly variable climate that does not permit more intensified forms of agriculture at any significant scale. This adaptation is not just to the biophysical attributes of rangelands (variability and low productivity), but also to other social and economic drivers, such as distance to markets, sparse population, and remote governance (Stafford Smith 2008). In many rangelands of the world these climate-challenged and complex socio-ecological systems have been evolving for many centuries, whereas in developed nations domestic livestock production is a more recent phenomenon. Regardless of location or form of livestock use, a common feature of resilient rangeland systems (Walker and Abel 2002) is the ability to adapt to a highly variable climate and to changing social dynamics and policy objectives that together shape ecosystem responses and livelihood outcomes.

It can be argued that current approaches to dealing with climatic variability in some regions do not build resilience because they are constrained by a lack of flexibility and options in management or by policies that are designed for more static conditions. Solving this issue will require a greater emphasis on

Correspondence: Andrew Ash, CSIRO Climate Adaptation Flagship, Brisbane, QLD 4001, Australia. Email: Andrew.Ash@csiro.au

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adaptive management (Gunderson et al. 2008) across scales from individual to communities to institutions.

Making progress in this area of rangeland management is important because the challenges faced by livestock managers today in highly variable rangelands will only be exacerbated by climate change. The impacts of climate change will be multidimensional. Not only will temperatures increase, but rainfall patterns are projected to alter, with some areas set to received increased rainfall, whereas other regions will experience a drier future. Importantly, rainfall variability is likely to increase in all regions, further heightening the need to balance forage supply and demand effectively (O'Reagain et al. 2011).

Given their experience in managing climatic variability, albeit not always successfully, some range managers may already be preadapted to deal with these future climate impacts. If so, they should be able to respond to these impacts as they unfold, building on their ability to manage variability, i.e., autonomous adaptation. Adding strength to this approach is that many rangeland systems around the world are under growing pressure from population growth, land use, and land tenure change and declining terms of trade (Blench 2001). Climate change over and above existing climate variability is likely to be a relatively minor driver in their sustainability and viability in the coming decades.

An alternative argument is that rangeland ecosystems and the people they support are already highly vulnerable to a range of environmental, social, and economic stresses, and climate change will provide sufficient additional pressure such that transitions to undesirable ecological and social states will be unavoidable.

Therefore, a more proactive approach to adaptation to climate change is likely to be needed for planning and policy decisions, particularly where actions will be required sooner rather than later. In this article we explore these two different perspectives of autonomous and proactive adaptation to identify some pathways forward in managing rangelands in the context of climate change and other socioeconomic, management, and policy pressures.

IMPACTS OF CLIMATE CHANGE ON GRAZED RANGELANDS

Climate change will impact rangelands in a number of ways. Increasing concentrations of carbon dioxide will generally increase the productivity of rangelands, alter vegetation composition, particularly the balance between woody plants and the herbaceous layer, and decrease forage quality (Wand et al. 1999; Morgan et al. 2008; Stokes et al. 2008a). Increasing temperatures will affect the length of the growing season, plant productivity, and animal production through both reduced cold stress in temperate climates and increased heat loads in summer and in tropical climates. Livestock diseases are also likely to be affected by climate change through changes in pathogen behavior, host vulnerability, distribution of insect and other vectors, and epidemiology of diseases (Thornton et al. 2009).

Rainfall projections are highly uncertain, though there is a general trend for midlatitudes to become drier while higher latitudes and tropical regions are more likely to experience increasing rainfall (IPCC 2007). A combined impact of increasing temperature and even slightly decreasing precipitation in the early growing season may increase dryness, reducing plant productivity in midlatitudes. Indeed, even though projected declines in mean rainfall may seem small compared with interannual variability, they have the potential to greatly reduce forage production (McKeon et al. 2009).

In most environments it is expected that rainfall will become more variable, with extreme events becoming more intense in many regions (IPCC 2012). Even small changes in the frequency of extreme events may have a disproportionately large impact on rangeland ecosystems (Allen-Diaz 1995), because extreme events are a key driver of the ecology and functioning of rangeland systems.

In addition to increased temporal variability, there is evidence that spatial variability of extreme events will increase, e.g., medium confidence that droughts will become more severe in many regions (IPCC 2012). The increased spatial heterogeneity of extreme events has been assessed mostly at regional scales. However, there is evidence from regional climate modeling that local phenomena such as thunderstorms will be enhanced under increasing greenhouse gas concentrations (Trapp et al. 2007). This has implications for management of spatial variability in rangelands, particularly in forage availability and mobility of livestock.

RESPONDING TO CLIMATE CHANGE IMPACTS

A special issue of *Rangelands* summarizes the impacts of climate change in most continents (e.g., Chambers and Pellant 2008; Hoffman and Vogel 2008; Stokes et al. 2008b; Yahdjian and Sala 2008). A number of these articles indicate that climate-change impacts should not be considered in isolation from other rangeland dynamics, which include grazing, weed and fire management, and policy changes relating to land tenure and land use. Although the merits of this view are obvious, it is also useful to examine whether the direct impacts of climate change are likely to be significant enough to warrant adaptation strategies beyond incremental responses. It is also important to identify what the limits to adaptation might be in managed rangeland ecosystems. Table 1 summarizes the impacts and the degree to which current strategies are likely to be sufficient in dealing with the projected climate changes.

It is clear from this analysis that many of the impacts of climate change play out gradually with modest levels of climate change. Incremental adaptation will be sufficient to deal with many of the challenges through management options such as altering stocking rates and grazing systems, changing livestock genetics or breeds, adjusting fire management practices, and use of technologies such as increased shade or water points, etc. These responses will occur autonomously but they will be much more effective if they are framed systematically in the context of risk management (Thornton et al. 2009) and are well planned. Desirable adaptation outcomes will be further enhanced if these responses are brought together in a toolbox of adaptation options developed in partnership with rangeland managers.

Table 1. Typology of impacts of climate change on rangelands and the nature of the adaptation response required.

Change variable	Nature of impact	Gradual or threshold change	Can current strategies manage the impact and limits to adaptation
Increasing CO_2	Increased plant productivity, altered species composition, decreased forage quality	Largely gradual change, but there are likely to be some threshold changes in species composition (woody–grassy balance, weeds, sufficient fuel loads for fire)	Enhanced fire and weed management strategies may help manage vegetation change for some time, but it is likely unavoidable transitions will occur. Declining forage quality could be managed through nutritional supplements and grazing management strategies.
2°C temperature increase (increasingly unavoidable)	Longer growing seasons in cold climates, some reduction in plant growth in dry climates, some heat stress in animals, contraction of grazing zones around water sources, species shifts in C3/C4 mid-latitudes	Gradual change	Animal breeding for heat tolerance, altered herd and grazing management, additional shade, altered fire regimes, more efficient use of water resources, enhanced opportunities in temperate climates
4°C temp increase (likelihood increasing)	Likely to be beyond the coping range of animals (and possibly humans) in some environments, significantly reduced plant production in hot climates	Thresholds likely to be crossed where production systems in hot climates fail	Limit to adaptation reached in some hot environments—change to seasonal use of resources
Decreasing rainfall (midlatitudes)	Increased exposure to drought, water resources less reliable especially where year-round stream flows become seasonal	Gradual change in many environments but thresholds might be crossed where water resources reach critical levels, particularly systems that are dependent on seasonally available key resources	Improved use of seasonal climate forecasts and increased effort on improving their skill, increased use of water storages, recalculation of safe stocking rates, increased mobility or availability of other forage resources, cropping land becomes marginal with conversion to pasture
Increasing rainfall (high latitudes, tropics)	Increased water availability for other uses, potentially more flooding in some areas	Gradual change	Opportunities for diversified agricultural use, pressure on pastoral land conversion to agriculture where soil quality permits
Increase in extremes/ variability	Direct impacts (which may be catastrophic, e.g., dzuds in Mongolia) on vegetation and herd viability; on the vectors, extent, and severity of livestock diseases	Likely to be threshold changes	Support from policy to help deal with extreme events (e.g., drought relief, flexibility in land tenure arrangements); limits to adaptation will be tested by extreme events recurring frequently

The analysis in Table 1 also suggests incremental, autonomous adaptation will on its own be insufficient under scenarios of more significant climate change. This is because the adaptation responses required are qualitatively as well as quantitatively different and are beyond the existing suite of adaptation strategies and coping range. Indeed, more significant levels of climate change by the middle of this century may cause considerable displacement and migration of people in vulnerable parts of the globe (New et al. 2011). This suggests that planned adaptation is required and that simply relying on incremental, autonomous adaptation will be inadequate in preparing rangeland managers for more transformational change (Howden et al. 2007). In this context, incremental change means that the actions taken maintain the existing system while transformational change infers a fundamental, but not necessarily irreversible, change in the biophysical, social, or economic components of a system (Park et al. 2011).

Historical evidence further supports the argument that planned adaptation will be necessary to cope with the challenges of climate change. Episodes of degradation during drought events have been recurring across rangelands (Fredrickson et al. 1998; Stafford Smith et al. 2007) over many decades, and even in relatively recent history when lessons from earlier episodes were broadly understood (McKeon et al. 2004). Planning for drought at the individual enterprise level is still variable because of overly optimistic expectations of future climate coupled with economic and drought policy drivers. This has led to livestock being retained beyond limits of economic viability and ecological sustainability. The consequences can be long-lasting ecological damage and production losses that are not easily reversible.

APPROACHES TO PLANNED ADAPTATION

Building on the concept that adaptation to climate change in rangelands requires more than autonomous adaptation, it is worth considering in what areas a more planned approach to adaptation could be most beneficial. Both the magnitude of the response (incremental, system changes, transformational) and the timing of the response (immediate, delayed until impacts are nearer) are important framing questions in discussing various adaptation responses, which we address below in three key areas.

BETTER USE OF CLIMATE INFORMATION

Improving the skill of seasonal climate forecasts and broadening their application is an area that will help prepare ranchers and pastoralists to cope better with existing climate variability and future climate change. Although seasonal climate forecasts have been in use for a couple of decades now, their widespread use is limited both by the relatively low reliability of current forecasts and approaches to delivery and application that are not well suited to management needs (Ash et al. 2007; Marshall et al. 2011). However, overcoming this challenge is important, as it has been argued persuasively in an African context (Washington et al. 2006) that strengthening management responses to existing variability will be the best means of addressing longer term climate change. The use of climate information to manage climate variability better extends beyond influencing on-farm management decisions to include financial instruments such as weather-index related insurance schemes that can be put in place to buffer livestock producers against extreme events (Mude 2009).

Although there are limits to predictability, seasonal and shorter-term forecasts also would benefit from additional framing to link them with the challenges and opportunities of responding to climate change. This framing needs to demonstrate how underlying climate change trends will, over time, move outside the bounds of existing variability. This approach will help deal with the real challenges in getting people to focus on climate impacts decades away, when the natural human behavior is to discount the future.

Despite these cognitive challenges there is increasing awareness and use of projections and scenarios of future climate. This has led to an increased desire by many stakeholders for more accurate and precise projections to inform adaptation. This need is often based on the erroneous assumption that more precise projections equate to more accurate projections and that it is more appropriate to delay thinking on adaptation until these advances in climate modeling can be achieved. However, some uncertainties in our understanding of the climate system and its representation in models are irreducible (Dessai et al. 2009), and these uncertainties cascade through to impacts (Jones 2000). The response by many decision makers is to argue delaying adaptation responses until these uncertainties are resolved. Yet in many nonclimate areas of rangeland management there are considerable uncertainties, e.g., future markets, but that does not delay decision making. Adopting a risk-management, problem-oriented approach to climate change scenarios would appear to be more useful than one driven solely by climate change projections (Thornton et al. 2009; Wilby et al. 2009), especially in systems like rangelands, where climate is usually just one of many drivers of change.

TECHNOLOGY AND MANAGEMENT SYSTEM ADAPTATION RESPONSES

There is a range of technology and management options that can be deployed in rangelands to manage the impacts of climate change. Some of these can be applied now in the context of current risk management, whereas other options require longer lead times.

Herd management and stocking-rate strategies can be applied now to deal with a climate that is either changing and/or becoming more variable (Crimp et al. 2010). For example, increased use of shade trees or artificial shelter or greater deployment of water points to reduce distance to water and evenness of utilization are adaptations to a warming climate that can be implemented as the effects of warming unfold (Stokes et al. 2010). Shelters can also be a useful adaptation in winter in temperate rangelands. For example, in Mongolia climate change is being experienced through extended summer droughts and the cold winter dzuds that follow are having an impact on livestock in a weakened state from the summer drought (Batimaa et al. 2006).

Livestock breeding for improved heat and disease tolerance has delivered some significant gains to pastoralists and ranchers, particularly in the subtropical and tropical rangelands with the use of Brahman cattle (Landsberg et al. 1998). However, much of the low-hanging fruit in developing heat tolerance through traditional breeding practices has already been harvested. New research needs to be put in place to develop solutions for rangeland environments that may be 1–5°C hotter by the latter part of this century and where vector-borne diseases may be more prevalent. New approaches to livestock breeding and genetics will take many years to come to fruition, so research effort should be increased in the near future.

Fire management strategies may need to be altered to manage vegetation better. Increasing carbon dioxide concentrations have the potential to alter vegetation composition in arid and semiarid rangelands significantly, with the grass–woody balance likely to be particularly sensitive (Morgan et al. 2007; Stokes et al. 2008b). Fire is an adaptation option that could be used to manage vegetation composition in a carbon-dioxide–enriched world (Morgan et al. 2008). However, work in South African savannas suggests that the fire and herbivore regimes that have been practiced to control tree increases in grassy ecosystems may not be effective in managing the extra vigor of woody species in response to increasing carbon dioxide concentrations (Kgope et al. 2010).

A third adaptation strategy is adjusting use of nitrogen or protein supplements. The increased photosynthesis, and improved water- and nitrogen-use efficiency of plants under increased carbon dioxide concentrations stimulates growth, and this might provide some options for improved management of forage availability. A negative effect of this increased plant growth is reduced protein concentrations of forage (Stokes et al. 2008b). Seasonal protein deficiency is already a constraint in many pastoral environments, particularly in the subtropics and tropics. Nitrogen (e.g., urea) or protein supplements are often used to correct these deficiencies, and it is likely that the use of such supplements will need to be extended in response to declining forage quality. An additional option is to manage forage quality better through grazing strategies and systems that aim to keep a leafy, higher-quality sward available to livestock.

Better management of grazing pressure is a fourth adaptation strategy. Increased temporal and spatial variability in rainfall in the future will pose additional challenges to pastoralists' and ranchers' ability to manage forage availability. Current strategies for coping with a highly variable forage resource include being prepared to stock conservatively so that there is a good buffer of forage during droughts, buying and selling animals on a frequent basis, growing or purchasing fodder to supplement animals during drought, or being able to shift animals to areas where forage is available. There may be only limited scope for enhancing these current strategies to deal with increased variability in forage supply. For example, kinship and friendship networks can offer a useful adaptation response to a spatially heterogeneous climate for individual ranchers or pastoralists. This can be achieved through temporary relocation of cattle via reciprocal grazing arrangements (McAllister et al. 2006) or by exchanges of labor, food, or cash (Osbahr et al. 2010). However, these same networks are tightly bound, with a high proportion of weak links, and they lack a culture of innovation, so they may not be helpful in coping with new challenges associated with climate change (McAllister et al. 2008). Large-scale commercial operations can also achieve spatial diversification via geographically dispersed properties or ranches that help spread the risk in the forage availability. This strategy may become more important in a future climate with more extremes.

INSTITUTIONAL, POLICY, AND BEHAVIORAL RESPONSES

Relying on autonomous adaptation rather than a more systemic planned approach is likely to be inadequate to deal with the impacts of climate change where policy change is required. For example, institutional and policy reform will be required in land access and tenure as climate change impacts unfold. Pastoralists' ability to manage climate variability has been restricted by successive policies of fragmentation in many rangeland regions of the world. This has limited the mobility of livestock and severely restricted pastoralists being able to exploit spatial heterogeneity as a means of managing temporal variability (Hobbs et al. 2008). As climate change will likely exacerbate climate variability in many parts of the world, this will demand some attention be given to reforming land use and tenure policies as a form of climate adaptation. Although top-down policies are required, restoration of traditional landscape management practices to reduce fragmentation and adapt to climate change may be best achieved at the administrative-unit level (Chuluun and Ojima 2011).

Changes in policies relating to drought, subsidies, and opportunities for diversification will also need to be considered (Thornton et al. 2009) in the context of climate change, but as yet this area is receiving little attention. There is also a risk that the wrong policy solutions will be developed if they are formulated just through the lens of climate change. An alternative is to adopt an adaptive governance approach to climate-adaptation policy reforms in the rangelands, as there is a greater opportunity to balance and harness synergies between multiple and changing drivers and interests (Nelson et al. 2008).

It is in the area of structural adjustment and institutional and policy reform where transformational change will most likely be needed in the rangelands. One of the challenges in the context of transformational change and an uncertain future is deciding when to act and how much response is needed, and having a good understanding of the system consequences of what might be irreversible changes (Leary et al. 2007).

Transformational adaptation also needs to be put in the context of other drivers of change that may prove to be more significant than climate change in some regions. For example, we live in a rapidly urbanizing world, where 80% of the planet's population will be living in cities by 2050. Rangeland societies are already marginalized by distance and remote governance, and this will be further exacerbated in the coming decades. The question remains whether our increasingly urban-based society, itself having to cope with the impacts of climate change, will care enough about livestock production in rangelands to act.

MANAGEMENT IMPLICATIONS

We argue that adopting an approach that relies solely on autonomous adaptation to climate change in rangeland environments will not be sufficient to maintain the viability and sustainability of livestock systems in the coming decades. Extending existing approaches to risk management and better managing climate variability in a planned way will be an appropriate adaptation strategy in the early stages of climate change. However, more transformative approaches to adaptation also need to be considered, particularly in the policy areas of land tenure and land use and flexible governance arrangements, because there are limits to technological transformation in rangelands. Issues of when to act and how much to act in a proactive and transformative way remain a challenge for research, management, and policy. Whether incremental or transformational, a diversity of adaptation options will be required in different rangeland regions to enhance the development of sustainable livelihoods with both social and ecological resilience.

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