

# Chapter 17

## Towards Human-Wildlife Coexistence in the Tarangire Ecosystem



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**Abstract** In this final chapter we summarize the contributions to the book “Tarangire: Human-Wildlife Coexistence in a Fragmented Ecosystem.” The 15 contributed chapters analyzed conservation and livelihoods issues from anthropocentric perspectives and from the wildlife lens, and explored aspects of human-wildlife interactions in the Tarangire Ecosystem (TE). With differing topics and perspectives, each chapter contributes in its own way to our understanding of key issues and challenges in the TE. We synthesize these multi-dimensional knowledge types according to complexity features that are characteristic of coupled social-ecological systems: non-linearity and thresholds; reciprocal interactions and feedback loops; time lags and legacy effects; resilience; heterogeneity; embedment and telecoupling; vulnerability; and surprises. Several examples highlighted in the book illustrate that planning for and managing human-wildlife coexistence remains a major and complex governance challenge. Learning from mistakes and successes of the past may offer guidance for more effective ways towards coexistence between people in wildlife in the TE and elsewhere. While our place-based analysis highlights that stakeholders and scholars differ widely in their opinions about *what* the specific solutions should be, there is overwhelming consensus about *how* such solutions

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should be planned and implemented: by employing interdisciplinary, collaborative, and equitable approaches that ensure that both people and wildlife can thrive together in the TE.

**Keywords** Complex socio-ecological systems · Stakeholder participation · Conservation conflict · Conservation solutions · EcoHealth

## 17.1 Synthesizing the Complexity of the Tarangire Ecosystem

No place on Earth is untouched by the imprint of humanity (Ellis et al. 2021), from the deepest depths of the ocean (Chiba et al. 2018) to the highest mountain tops (Napper et al. 2020). As we stated in the introduction to this book, humans interact with wild animals wherever we go, and the long history of these interactions has shaped human cultures, communities of organisms, ecosystem functioning, and evolution of both humans and wildlife. For as long as humans have existed, we have profoundly influenced and were profoundly influenced by wildlife.

Situated in the heart of East Africa, where anatomically modern humans likely evolved and supporting a remarkable diversity of large mammal species, the Tarangire Ecosystem (TE) is an excellent example of a dynamic social-ecological system, with waves of human occupation and exploitation of natural resources beginning tens of thousands of years ago and continuing to this day. The current landscape of the TE comprises small and large towns and scattered temporary homesteads, two famous national parks, game-controlled areas, a game reserve, a forest reserve, a ranch conservancy, and several community-based conservation initiatives including three Wildlife Management Areas as well as Simanjiro Conservation Easements and Certificates of Customary Rights of Occupancy, all embedded within an ecologically heterogeneous landscape. This system poses great challenges as well as great examples of and opportunities for coexistence between people and wildlife. As this book demonstrates, for several decades anthropologists have collected information about attitudes and perceptions of (mostly Maasai) people in the TE about conservation; wildlife scientists have monitored a diverse suite of wildlife species ranging from African savanna elephants (*Loxodonta africana*) and Masai giraffes (*Giraffa camelopardalis tippelskirchi*) to lions (*Panthera leo*) and antelopes; and NGOs have implemented community education programs and focused attention on resolving challenges and providing opportunities for both humans and wildlife. Insights gleaned from these studies of humans and wildlife and their interactions in the TE may have wide-reaching applications for addressing conflict in this and other coupled natural-human landscapes (Liu et al. 2007).

Conservation conflicts occur within the context of the social and cultural histories of the different people involved. A key driver of conflict is the different perceptions of reality stemming from those different histories. This is relevant to what has been termed the “Rashomon effect” (Levin et al. 2021), derived from a 1950 film in which a samurai is murdered, and four different witnesses provide four different equally believable yet contradictory stories of the murder. Levin et al. (2021) define the Rashomon effect in conservation as “the existence of multiple plausible but conflicting perceptions about the causes and underlying consequences of an urgent conservation challenge.” To wit, this is not to say that there are different *truths* (which is not possible), but rather that there are different *perceptions* of the truth—or different and equally valuable ways of knowing about the external world—based on objectively collected mechanistic data (i.e., ecology), human experiential context (i.e., sociology), and human narrative (i.e., history). These various knowledge types each provide critically important components to help address complex conservation and human livelihood challenges.

In this book, we collated different knowledge types from a broad range of scientists and advocates who have worked with humans and wildlife in the TE over relatively long periods of time. Our intention is to provide interdisciplinary analyses that link three fundamental dimensions in the TE: the human perspective/system, the wildlife perspective/system, and the human-wildlife interface. The different knowledge types can and should be integrated to craft innovative and effective solutions to complex problems (Liu et al. 2007; Levin et al. 2021). Within the field of conservation science, researchers hail from various cultures, including social and natural sciences, each of us with our own unique background, training, and interests. The contributors to this book certainly fit this mold. Consequently, we offer our stories through not only objective observations and data but also through the subjective lenses of our own personal experiences and perceptions. There has, however, traditionally been a separation between the natural and social sciences (Liu et al. 2007). The primary challenge is in coming to terms with our traditional differences, embracing and respecting the plurality of opinions, integrating the natural and social sciences to better understand how coupled human-natural systems function, and moving forward in an interdisciplinary manner to achieve real success for both human livelihoods and conservation.

In this final chapter of the book we first summarize the previous chapters. With differing topics and different viewpoints and perspectives, each chapter contributes in its own way to our understanding of key issues and challenges in the TE (Fig. 17.1). Subsequently, we synthesize these multi-dimensional knowledge types according to complexity features pertinent to coupled social-ecological systems. By employing a systems-thinking approach, we hope to not only provide a better understanding of past and current conservation and livelihood challenges in the TE but also to identify possible pathways that enable both people and wildlife to thrive together.



rangelands through Certificates of Customary Rights of Occupancy, and a community-based Wildlife Management Area. Below we review the main points from each chapter.

In Chap. 2, Jevgeniy Bluwstein argues that ideas about people and nature have changed over time, yet colonial legacies regarding conservation and management have persisted in the TE. These legacies involve the separation of humans and wildlife. This antagonism between a state-centric paradigm of land control versus use by local Maasai pastoralists underpins much of the human-wildlife conflict in the region. Furthermore, Bluwstein contends that conservation in the TE has recently expanded beyond (contested) protected area boundaries, but the growing reliance on market-based approaches to protect biodiversity in these expanded areas while providing economic benefits may not be sustainable or fully address the needs of local people. This contested past and conflicted present points to the need for ‘convivial’ conservation efforts. Bluwstein outlines a set of governing principles for convivial conservation, including (i) democratic (local) engagement in conservation decisions; (ii) replacing ‘protected areas’ with ‘promoted areas’ without set boundaries; (iii) transitioning away from a market-based approach of payment for conservation and conventional short-term tourism; and (iv) forging a different type of relationship with the Tanzanian state.

Jim Igoe (Chap. 3) urges readers to consider that if conservation is viewed from the perspective of local Maasai pastoralists whose people have been present in and used the landscape for generations, then formally protected areas such as Tarangire National Park are, to them, *part* of the fragmentation of the ecosystem (along with farming, mining, and human settlements) rather than the only areas *free* of fragmentation. With state-imposed zoning and boundaries separating humans (other than tourists) from wildlife, the local people are denied access to resources they argue are their heritage. Igoe discusses the need to recognize compatibilities between conservation and pastoralism, and to support approaches such as collective, local-level resource management and stewardship.

In Chap. 4, J. Terrence McCabe and Emily Woodhouse delve into the conceptualization of wellbeing among the Maasai of Simanjiro. The results of interviews underscore the differences in attitudes between younger and older men and between men and women. Younger men wanted fewer cattle, wives, and children than older men, and younger men also considered education of children—including girls—more important than did the older men (but women were overall more adamant about the importance of girls’ education than men). Women focused on the importance of livestock and cultivation not from a wealth perspective, but from the perspective of being able to provide milk and food for children, and a source of income for school fees and health care for children as well. Women valued children because they were important for their own social lives as women become dependent upon their children—especially sons. Women also believed that harmony within the household was critical for their wellbeing. Communal grazing lands were considered essential by all male respondents, and men and women all expressed distrust of the federal government, private investors, and some NGOs. Some of the respondents expressed frustration that they are encouraged to depend upon livestock and

tourism and abandon cultivation, which poses a key conservation challenge. The romanticized image of the Maasai as nomadic pastoralists living in harmony with wildlife is not always accurate and this chapter clearly depicts the changing values and livelihoods among contemporary Maasai in the ecosystem.

In Chap. 5, Peadar Brehony, Alais Morindat, and Makko Sinandei describe an innovative program to secure land tenure rights, known as Certificates of Customary Rights of Occupancy (CCROs). This is a unique program developed in the Simanjiro region, in response to changes in traditional systems of land and live-stock management among the Maasai people. CCROs cement traditional land use and governance practices with legal requirements for participatory land-use planning. The land-use plans are then overseen by village councils. This model creates a mixed-use coexistence landscape and constitutes a payment for ecosystem services model that seems to work for both people and wildlife alike.

In Chap. 6, Justin Raycraft reports high levels of community support for the Randilen Wildlife Management Area (WMA) in 2020. Furthermore, most interview respondents reported liking the WMA more than they did 5 years before. Strikingly, the vast majority of respondents stated that they trusted WMA authorities to act in their interests, and that they felt their community was included in WMA governance and management. Upwards of 90% of respondents viewed the WMA as a success and that it represented community-based conservation rather than a fortress conservation model. These results were based on structured interviews with a large, representative, randomly selected sample of men and women and quantitative analyses of the data. Perceptions of the benefits of a Wildlife Management Area adjacent to Tarangire National Park appeared to have changed over time, from negative to positive. This chapter provides strong arguments for quantitative analysis of conservation attitudes and suggests that attitudes towards conservation entities can change if people feel that they are involved in decision making and benefit from conservation efforts.

### 17.3 The Wildlife Dimension

The Tarangire Ecosystem supports one of the densest populations of African savanna elephants on the continent, one of Tanzania's most abundant populations of Masai giraffes, one of only a handful of long-distance migrations of wildebeests (*Connochaetes taurinus*) and zebras (*Equus quagga*) remaining in Africa, threatened yet ecologically still vital populations of carnivores including lions, cheetahs (*Acinonyx jubatus*), and wild dogs (*Lycaon pictus*), and a rich diversity of ungulates that shape the landscape's vegetation and provide food for predators and scavengers. The second section of the book addresses the wildlife dimension of the TE with insights gleaned from several long-term research projects whose breadth and depth rival research projects in Tarangire's more famous neighbor, the Serengeti-Ngorongoro Ecosystem. First, baselines for wildlife populations are discussed,

followed by focused chapters on a suite of eight commonly detected ungulates, giraffes, elephants, and large carnivores.

Herbert H. T. Prins and Joost de Jong's Chap. 7 focuses on the dynamic ecohistory of the TE, the shifting baseline syndrome, and whether the system has passed beyond a threshold where the natural state cannot be restored. The ecohistory is placed in context of a discussion on shifting baselines, whereby a previous reference point to measure change in a system is itself already a change from an even earlier point in time. The baseline of an ecosystem should represent its natural state, but this is difficult to establish in East Africa where humans have lived for hundreds of thousands of years. Prins and de Jong propose a reference baseline of 1935 for wildlife in the TE, when wild animal populations were likely at a zenith after recovering from rinderpest, human numbers were low, and before widespread hunting, poaching, and habitat loss began.

Ungulates are ecologically and economically significant in the TE. In Chap. 8, Monica L. Bond, Christian Kiffner, and Derek E. Lee review and discuss historical and current data on population trends of eight species of ungulate: zebra, eastern white-bearded wildebeest (*C. t. albobabatus*), common eland (*Taurotragus oryx*), common waterbuck (*Kobus ellipsiprymnus*), impala (*Aepyceros melampus*), Grant's gazelle (*Nanger granti*), Thomson's gazelle (*Eudorcas thomsonii*), and Kirk's dik-dik (*Madoqua kirkii*). The chapter flags some problems with comparing data derived using different methodologies. Despite this, recent monitoring studies in Tarangire National Park, Manyara Ranch, Wildlife Management Areas bordering Tarangire and Lake Manyara national parks, and the Simanjiro Conservation Easements suggest relatively stable ungulate populations in these protected areas over the last decade. Overall the available evidence indicates that ungulate populations in the TE are probably well below the 1935 baseline suggested by Prins and de Jong, and remaining ungulate migration routes are threatened, but populations have apparently stabilized recently. On a positive note, the chapter provides evidence that additional collaborative conservation efforts (particularly the establishment of Wildlife Management Areas) contributed to localized wildlife population increases.

The Masai giraffe is the national animal of Tanzania and a globally iconic megaherbivore. Chapter 9 describes the population structure, social structure, and demography of Masai giraffes in the TE based on almost a decade of research. The long-term study was designed to understand the influence of humans on giraffe demography and social relationships in a coupled human-natural landscape. Using photographic identification to monitor individual giraffes over time, Derek E. Lee and Monica L. Bond quantified demography (survival, reproduction, and movements) of subpopulations defined by either administrative boundaries (national parks, Manyara Ranch, Wildlife Management Areas) or by social relationships among the giraffes. Results revealed that natural factors such as predation and season as well as humans influence survival, reproduction, and sociality of giraffes in complex ways. For example, female giraffes have lower survival if they live near to towns that are densely populated by people (some who poach giraffes for meat) and surrounded by farms. On the other hand, although female giraffes have weaker and more exclusive relationships with each other near Maasai bomas, they aggregate

near bomas to reduce natural predation risk on their calves. Thus, the presence of pastoralists appears to be compatible with giraffe population persistence. Volcanic soils in northern Tarangire National Park and Manyara Ranch are good quality habitats for giraffes, with high calf and adult survival despite proximity to people, suggesting that giraffe conservation in the TE could be facilitated by protecting habitats on volcanic soils and maintaining connectivity. The Lake Manyara National Park giraffe subpopulation is isolated and has low calf and adult survival, but the size of the subpopulation has remained stable over many decades. Finally, similar to other ungulates, Wildlife Management Areas show greater giraffe densities as well as improved survival rates, indicating community conservation success. This bodes well for human-giraffe coexistence in the TE.

Charles A. H. and Lara S. Foley's Chap. 10 covers the history of the iconic African savanna elephant population in the TE from the early 1900s until today. The population suffered greatly during the 1970s when ivory poaching soared, which dramatically altered the movements and ranges of the elephants for two decades as they crowded within Tarangire National Park for safety. Government anti-poaching efforts and an international trade ban on ivory in 1989 alleviated much of the poaching and subsequently the elephant population expanded rapidly from 1990 to 2020. During this period of high population growth, the age structure of the population changed substantially, with more older males and females, and ranges expanded into Manyara Ranch, Burunge and Randilen Wildlife Management Areas, and beyond. Long-term individual-based elephant research by the Foleys revealed three subpopulations in the TE based on wet season ranging and association patterns. In the 1990s and early 2000s, the southern subpopulation had a significantly lower infant-to-mother ratio and congregated in significantly larger aggregations than the northern subpopulation, which was attributed to higher levels of human-induced stress from continuous, albeit low, levels of poaching in the south. However, since 2002 evidence suggests that the southern subpopulation is reverting to traditional grouping patterns, possibly due to a reduction in poaching. The increase in elephant movements outside Tarangire National Park into adjacent community lands has resulted in increased conflicts with people—especially crop raiding—thus necessitating the implementation of mitigation/conflict-reduction measures. With the amelioration of poaching and population expansion, Tarangire's elephants represent a true conservation success story, but the consequent increase in conflicts points to the critical importance of cooperation between wildlife authorities and local communities to ensure the safety and wellbeing of both humans and elephants.

Large carnivores evoke strong emotions among humans, being admired and feared alike. These top predators exert influential effects on their prey and as such they shape ecosystem processes. In Chap. 11, the last of the wildlife dimension chapters, Christian Kiffner, Charles A. H. and Lara S. Foley, Robert A. Montgomery, and Bernard M. Kissui synthesize available data on distribution and abundance of six species of large carnivores across the conservation gradient in the TE: lion, spotted hyena (*Crocuta crocuta*), striped hyena (*Hyena hyena*), leopard (*Panthera pardus*), cheetah, and wild dog. All but the cheetah and wild dog were widely detected throughout the ecosystem, and densities of these rarest of carnivores were relatively



low. Spotted hyenas reached the highest densities of all the species, followed by leopards and striped hyenas. Tarangire National Park supported the highest densities of lions, followed by Makame Wildlife Management Area, with other protected areas supporting low densities of the largest carnivore species. Interestingly, species-specific densities were not strongly or clearly correlated with conservation status of an area. Most carnivore species moved outside Tarangire National Park during the rainy season, bringing them into greater contact with humans. Essentially, these species follow their prey, occupying areas with higher prey density and catchability but being less frequently detected in human-dominated areas. The lion population is particularly dependent on conservation efforts. The spotted hyena stands out from the other species in that occupancy of areas is positively associated with human population densities—and is responsible for most livestock predation events in the TE. The chapter concludes with two key elements that must be addressed to achieve human-carnivore coexistence: negative interactions with large carnivores such as livestock depredation and subsequent retaliatory killing of carnivores must be reduced using sustainable, cost-effective, and socially accepted non-lethal methods, and conservation measures must protect essential habitats for prey species.

## 17.4 Human-Wildlife Interactions

Exploring patterns, causes, and consequences of interactions between humans and wildlife can help guide appropriate policy and management decisions that consider the needs of both. The last section of the book focuses on a variety of issues dealing with the human-wildlife interface, from wildlife movements through human-dominated landscapes and coexistence between people and elephants as well as people and large carnivores, to strategies for using a results-based system of payments for ecosystem services and community education to inspire conservation ethics and promote effective solutions to coexistence.

A growing human population and associated land-use changes in the TE contribute to a lack of habitat connectivity which can hamper dispersal, gene flow, and the ability of wildlife populations to respond to climate change. In Chap. 12, George G. Lohay, Jason Riggio, Alex L. Lobora, Bernard M. Kissui, and Thomas A. Morrison describe movement patterns of wildlife among key habitat areas, from the core Tarangire and Lake Manyara national parks and Manyara Ranch to the Wildlife Management Areas, Game Controlled Areas, and Game Reserves. Data from telemetry, photo mark-recapture identification, aerial and ground count surveys, and DNA analyses can elucidate past connectivity, recently used movement paths, and movement probabilities. Early descriptions of wildlife movements across the TE indicate a vast wet season dispersal of ungulates in all directions from the dry season ranges in Tarangire and Lake Manyara national parks. However, by the 1980s movement routes west of Tarangire were largely blocked by agriculture, and linkages to the north and northwest were diminishing rapidly. By the 2000s only seven wildlife corridors remained in the TE, with the majority in critical danger of

being lost. Recent data show large mammals including elephants, giraffes, wildebeests, and lions still make long-distance movements throughout the ecosystem and functional and genetic connectivity remains, but Lake Manyara National Park exhibits troubling signs of isolation. Wildlife populations are threatened by continued habitat loss, poaching, vehicle collisions, and conflicts with humans. Thoughtful, science-based land-use planning to protect safe movement corridors for wildlife—planning that is driven by community conservation efforts—could maintain connectivity and sustain these wildlife populations well into the future.

Elephants are one of the primary ‘conflict’ animals in the TE, given their propensity to move outside of protected areas and the danger posed by their massive size. Typically, studies of the human-elephant interface focus on farmers, as elephants often raid crops, but these pachyderms also inhabit rangelands utilized by pastoralists. In Chap. 13, John Kioko, Sophie Moore, Kathleen Moshofsky, Anne Nonnamaker, Blaise Ebanietti, Katharine Thompson, and Christian Kiffner characterize the pastoralist-elephant interface in Manyara Ranch. The authors interviewed cattle herders in Manyara Ranch about their perceptions of elephants, and observed elephant reactions to sound playbacks of humans, cattle, and other wildlife species. The vast majority of herders (nearly 90%) supported the presence of elephants in the ranch and generally perceived elephants as a minor threat to their cattle and themselves, compared to other wildlife species such as lions, buffalos, and hyenas. Elephants—especially groups with calves—reacted most to sounds of herders and domestic dogs, typically fleeing into nearby closed habitats. The relatively positive herder perceptions of elephants suggest that interactions with cattle are not based in conflict, and indeed herders often allowed their cattle to intermix with elephants (although they personally kept a distance), demonstrating potential for coexistence in rangelands. Overall, focus should remain on mitigating crop raiding by elephants.

Large carnivores are another major ‘conflict’ taxa in the TE. In Chap. 14, Bernard M. Kissui, Elvis L. Kisimir, Laly L. Lichtenfeld, Elizabeth M. Naro, Robert A. Montgomery, and Christian Kiffner summarize information on incidences of human-carnivore interactions in the TE based on surveys and reports dated back to 1943. Data included type of interaction (attack on human or livestock), carnivore species involved, where the interaction occurred (which village, in a boma, in the bush), and the human activities at the time of the interaction. The number of reported interactions increased from the early 1980s to the 2000s, possibly due to increase of the human population and decrease in natural prey populations. Nearly all large carnivore attacks on humans were on males, especially younger males ( $\leq 30$  years of age), and most were by lions. Older people were particularly susceptible to attacks by hyenas which most often occurred at night in the home. Carnivore attacks on humans were concentrated in just a few villages over the 66-year timespan, and most people were attacked during retaliatory lion or leopard hunts during the day, and to a lesser extent when livestock herding in the field—these two activities are likely to pose the highest risks to humans. In contrast, the majority of livestock predation events were caused by hyenas, and to a lesser extent by lions and leopards. Records indicate decreasing livestock attack events from 2004 to 2017, for various possible reasons. People’s perceptions of the frequency of human-carnivore

conflicts were much greater than observed levels of conflicts, possibly indicating the fear of extreme damage events (e.g. loss of livestock and associated economic and social losses; loss of human life) and deep-rooted conflicts and mistrust between pastoralists and management authorities. Key behavioral co-adaptations in carnivores, such as increased nocturnal behavior in human-dominated areas, as well as in humans, for example adoption of fortified bomas and improved livestock guarding methods, can facilitate coexistence.

In Chap. 15, Marc Baker, St. John Anderson, and Christian Kiffner profile a results-based model of payments for ecosystem services—the purchase of verified emission reductions for use as carbon offsets in the REDD+ project of Makame Wildlife Management Area in the southern TE. REDD+ (Reducing Emissions from Deforestation and forest Degradation) is a framework to curb carbon emissions by encouraging communities to preserve forests. Emission reductions from a REDD+ project are issued only after verification, thus climate, human, and biodiversity benefits are completed before the emission reductions are monetized. The Makame Savannah REDD project meets the standards of the Verified Carbon Standard and the Climate Community Biodiversity Alliance and was developed by Carbon Tanzania, a Tanzanian NGO, to protect the WMA's forests from conversion to agriculture. The project's targets for community and biodiversity co-benefits were developed during community workshops and thus were inclusive of the needs of the local people to the extent possible. The targets were also designed to meet global standards, and a monitoring framework was developed to systematically collect, analyze, and report on social and wildlife indicators. This approach follows a business strategy for conservation rather than reliance on donor funding and thus represents a long-term investment that can provide significant economic benefits to rural communities.

In Chap. 16, the last of the human-wildlife interaction chapters, Monica L. Bond, Karakai Barisha, Krissie Clark, Ferdinand D. Chugu, James M. Madeli, Revocatus Magayane, Alejandrina Ocañas, Anna Sustersic, and James Danoff-Burg outline ways to promote positive behavioral changes and foster support among human communities for conservation in the TE through environmental education programs. Behavioral changes that benefit conservation require effective communication that assesses the targeted audience, elicits emotions, activates involvement, and incorporates redundancy of the message. Education programs must include impact evaluations to assess effectiveness at changing knowledge, attitudes, and behaviors. The chapter describes three innovative long-running primary and secondary school education programs operating in the TE: Wild Nature Institute's 'Celebrating Africa's Giants', Tanzania People and Wildlife's 'Youth Environmental Education', and PAMS Foundation's 'Living in Harmony with your Natural Surroundings'. These programs use specially designed curricula and materials relevant to the local area and people, fun hands-on activities such as tree plantings and community events, and visits to Tarangire and Lake Manyara national parks. They have reached thousands of schoolchildren in the TE and have had positive impacts on attitudes towards local wildlife according to impact evaluations. Media such as animated videos on television and songs on the radio are sharing wildlife conservation messages in

creative ways. With carefully crafted messaging, active engagement with students and communities through participatory experiences, and rigorous assessments of impacts on knowledge, attitudes, and behaviors, environmental education can result in positive attitudes, a growth in knowledge and quality education, and investment in the future that improves conservation of nature.

## **17.5 Assessing Sustainability in the Tarangire Ecosystem**

Ostrom (2009) noted that resources used by humans are embedded in complex social-ecological systems, composed of subsystems such as resource systems (e.g. rangeland or national park), resource units (grasses, trees, wildlife, water), users (pastoralists, farmers, tourism operators), and governance systems (institutions and laws that govern resource use). These subsystems interact to produce emergent outcomes at the social-ecological systems level. These outcomes can be measured with social and ecological performance measures, but as Ostrom noted, “ecological and social sciences have developed independently and do not combine easily.” Indeed, often vastly different frameworks, theories, and models are used by the different disciplines to explain the parts of the complex whole. The various contributions to this book underscore the diversity of narratives and opinions from both social and natural scientists about the origins and history of human-wildlife—and human-human—conflicts in the TE; about the measures proposed and implemented to reduce conflicts and conserve the biodiversity of this ecosystem; and about the (perceived) successes and failures of these measures. Using a common framework enables variables to be identified and quantified to study a particular social-ecological system in an interdisciplinary manner. Such a common framework also enables comparison with similar systems in other places.

## **17.6 Key Challenges and Opportunities for Human-Wildlife Coexistence in the Tarangire Ecosystem**

The chapters of this book highlight numerous interdependencies within social and ecological systems as well as couplings between the two systems. Here we summarize current circumstances and challenges in the TE according to some of the key features of complex systems in the framework outlined by Liu et al. (2007) and Carter et al. (2016). These features include nonlinear dynamics and thresholds, reciprocal feedback loops, time lags, resilience, heterogeneity, embedment and telecoupling, and surprises. Feedback loops, legacy effects, and embedment among social and ecological components are, by definition, fundamental aspects of “coupled” social-ecological systems, whereas understanding thresholds, resilience, heterogeneity, and surprises can provide additional insights into addressing some of the challenges associated with human-wildlife and human-human interactions.

### 17.6.1 *Non-linearity and Thresholds*

It is critical to identify when relationships are nonlinear or when there is a threshold of collapse, to understand when conditions may be permanently altered beyond historical conditions. One of the most obvious examples may be the substantially altered mammal species composition in areas that have been subject to human development. While elephants, hippopotamus (*Hippopotamus amphibius*) and other large mammal species reportedly thrived just north of Lake Manyara National Park 50 years ago, these areas are now occupied by irrigated agriculture and settlement (Kiffner et al. 2015b). While some wildlife species persist in these areas, other species only occasionally visit those areas and then typically come into conflict with people. Certainly, some areas in the TE have been lost as wildlife habitat for at least the next few generations (**Prins and de Jong** Chap. 7). In contrast, pastoral areas such as Manyara Ranch and Wildlife Management Areas support mammal species communities that are similar to those observed in adjacent national parks. Thus, mammal community structure seems resilient to some degree of human impact but beyond a threshold of human impact, the mammal community becomes impoverished.

One of the most devastating conservation thresholds is extinction of a species from an ecosystem. Fortunately, the TE supports most native species of larger mammals, yet excessive poaching during the 1970s and 1990s has caused the eradication of black rhinoceros (*Diceros bicornis*) across the entire TE; during earlier times, other species had been lost from the TE already, and it is currently unlikely that any of these species will be restored anytime soon (**Prins and de Jong** Chap. 7).

In the TE, barriers to wildlife and livestock movements may have exceeded thresholds and historical movement patterns may now be fundamentally altered. For example, Bond et al. (Chap. 8) documented changing patterns of use of areas by wildebeests, with more animals in Burunge WMA and Manyara Ranch than in Tarangire National Park during the dry season, and Prins and de Jong (Chap. 7) noted that African buffaloes (*Syncerus caffer*) no longer move between Lake Manyara and Tarangire national parks as they had historically.

Furthermore, connectivity of elephants between the Tarangire Game Reserve and Lake Manyara National Park that was observed in the 1960s (**Foley and Foley** Chap. 10) has been lost today (**Lohay et al.** Chap. 12). Similar isolation of Lake Manyara National Park has likely affected giraffes as well (**Lee and Bond** Chap. 9, **Lohay et al.** Chap. 12). It remains to be seen whether removing recently created anthropogenic barriers and re-establishing connectivity will facilitate historical movement patterns again, but these barriers are probably permanent, at least in the foreseeable future. Likewise, the establishment of protected areas fundamentally altered movement and grazing regimes of agro-pastoralists and their livestock (**Bluwstein** Chap. 2, **Igoe** Chap. 3) and it is currently unlikely that national park policies will be adjusted to reverse this.

## 17.6.2 *Reciprocal Interactions and Feedback Loops*

In East Africa, feedbacks between tsetse flies (*Glossina* spp.), bush vegetation, fire, livestock, people, and wildlife fundamentally shape savanna ecosystems (Sinclair et al. 2015). Tsetse flies can transmit *Trypanosoma brucei* parasites that cause Trypanosomiasis (sleeping sickness) in humans and livestock, a fatal disease if left untreated. The flies thrive in areas with thick bush cover (Nnko et al. 2021), and these areas are typically avoided by pastoralists. Flies therefore act as protectors against overgrazing by livestock. More than a century ago, human settlements and cultivation and associated activities such as lighting fires and grazing livestock had reduced bushlands and kept the tsetse fly at bay. Epidemics of rinderpest, smallpox, and cholera in the late 1800s and early 1900s devastated human and livestock populations and enabled bushlands to expand, thus increasing tsetse flies, and colonial campaigns continued to separate people from the tsetse-dominated areas (**Bluwstein** Chap. 2, **Prins and de Jong** Chap. 7).

Dynamics among ungulates, large carnivores, humans, and livestock are also reciprocal and subject to feedback mechanisms. The observed decline in ungulate populations is likely associated with multiple underlying reasons: illegal hunting to satisfy the demand for bushmeat (Kiffner et al. 2015a), habitat loss due to conversion to agriculture (Msoffe et al. 2011b), and restricted access to key resources such as surface water and grass are likely operating in concert (**Bond et al.** Chap. 8). These losses were compounded by the previous large scale culling of zebra and wildebeest populations at the end of the 1990s (Foley and Foley 2014). In turn, the reduction of wild ungulate populations may also be partially responsible for a greater frequency of livestock depredation events by large carnivores (**Kissui et al.** Chap. 14) possibly because some large carnivores now rarely encounter wild prey (Khorozyan et al. 2015).

In contrast, increases in wildlife populations could also mediate the spatial distribution and frequency of human-wildlife interactions. After the TE elephant population was released from severe poaching-related mortality, the population growth and associated spatial expansion into previously unoccupied habitats (**Foley and Foley** Chap. 10) caused increases of human-elephant conflicts (in particular crop raiding by elephants) in many areas of the TE, especially in areas of Burunge and Randilen WMAs and villages bordering Manyara Ranch (**Kioko et al.** Chap. 13). Thus, what can be labelled a success from a conservation perspective may be a serious livelihood issue from an anthropocentric angle.

Another example of reciprocal human-human interactions in the TE is when people moved closer to Tarangire National Park and developed farms out of concerns the park boundaries would be expanded (**McCabe and Woodhouse** Chap. 4). The local communities reacted in response to the federal government's delineation of the national park boundaries by further exacerbating loss of wildlife habitat, which has resulted in ongoing conflict with both the government and wildlife (**Igoe** Chap. 3).

### ***17.6.3 Time Lags and Legacy Effects***

Impacts of prior couplings on later conditions are a result of time lags or legacy effects. For example, massive poaching during the 1980s in Lake Manyara National Park (**Prins and de Jong** Chap. 7) may have driven some expansion of bushlands, which still affects the ecology of the park to this day (**Bond et al.** Chap. 8).

The legacy impacts of colonialism included the introduction of rinderpest and smallpox epidemics that killed many local people who had previously kept tsetse flies at bay through their land management activities. The loss of local people resulted in the expansion of bushlands and tsetse flies which then kept pastoralists out of the infested areas. This led to continued separation of people and wildlife in the habitat reserves, as a result of both tsetse flies and government separation policies. Thus, the current tsetse fly distribution and even national park boundaries can be considered legacy effects of past colonialism.

### ***17.6.4 Resilience***

Some species are highly resilient to human disturbances, one example being spotted hyenas which are more abundant closer to human settlements (**Kiffner et al.** Chap. 11). Giraffes (**Lee and Bond** Chap. 9) are resilient to low-impact human settlements such as Maasai bomas, but not high-impact areas such as the towns of Mto wa Mbu, Makuyuni, Kibaoni, and others in the TE. Elephants are resilient when poaching is curbed, as evidenced by rapidly rebounding elephant numbers (**Foley and Foley** Chap. 10). Wildlife populations can begin to recover once protected from poaching and released from competition with livestock, as demonstrated by wildlife monitoring efforts in the TE's WMAs (**Lee and Bond** Chap. 9, **Kiffner et al.** Chap. 11, **Baker et al.** Chap. 14).

People in the TE can be highly resilient and survive despite the sometimes harsh environmental conditions such as drought and even though they have been pushed out of historical ranges (**Igoe** Chap. 3). Economic resilience of conservation efforts is important to sustainability for both people and wildlife. CCROs allow resilience because income is not tied to tourism or foreign investment (**Brehony et al.** Chap. 4). The Makame Savannah REDD+ project is an example of a long-term business strategy that is also resilient to the need for tourism dollars. WMAs were considered controversial previously, but operations have also proven to be less dependent upon income from tourism than national parks (Damien Bell, pers. comm). Furthermore, Raycraft (Chap. 6) showed that people's attitudes shifted from earlier distrust towards support of Randilen WMA.

### ***17.6.5 Heterogeneity***

Not surprisingly, heterogeneity is a primary feature in complex systems, and can be expressed in many ways, such as the dynamic seasonal distribution of resources and wildlife, differences in people's incomes or use of the land, even the diversity of opinions on a subject.

The dominant driver of vegetation heterogeneity in savanna ecosystems such as Tarangire is rainfall (Lehmann et al. 2011), with wildlife and humans also playing important roles (Msoffe et al. 2011a). Precipitation ultimately determines whether an area is mostly covered by trees, bushes, or grasslands (Lehmann et al. 2011). Savanna ecosystems are inherently dynamic with annual, decadal, and millennial changes in rainfall, along with fire, wildlife, and human actions pushing the system towards or away from a more woody or grass-dominated state (Higgins et al. 2000; Grady and Hoffmann 2012). These factors must be acknowledged and dynamism embraced in this era of rapid climate change.

Spatial heterogeneity in soil nutrient concentrations, along with protected areas that primarily cover only dry season ranges rather than the year-round requirements of migratory wildlife, is possibly the key underlying reason for most human-wildlife interactions in the TE. Further, heterogeneity in large carnivore behaviors influences human-carnivore interactions: most livestock depredations are caused by hyenas, but most large carnivore attacks on humans are by lions and leopards (Kissui et al. Chap. 14).

There can also be strong differences of opinion among people, such as between Maasai men and women residing in Simanjiro about concepts of wellbeing, in that women tend to focus more importance on the needs of children (McCabe and Woodhouse Chap. 4). How interactions with wildlife are perceived differs widely depending on the wildlife species considered (Kiffner et al. Chap. 1). From a human perspective, coexisting with giraffes is unproblematic, but coexisting with large carnivores and elephants is challenging and outcomes of interactions are strongly mediated by human behavior (Kioko et al. Chap. 13, Kissui et al. Chap. 14).

### ***17.6.6 Embedment and Telecoupling***

Another facet is the degree to which coupled systems are embedded within other systems or connected with distant systems. For instance, Wildlife Management Areas are coupled systems that are embedded in village structures and local governance. Protected areas are embedded in national protected area policies, and Lake Manyara is a UNESCO biosphere reserve—a global designation.

One of the major telecoupling aspects is the disproportionate distribution of wildlife-related costs and benefits. The costs of living with wildlife mainly accrue in poor, rural segments of the society whereas most benefits are realized in government treasuries, the bank accounts of people investing and working in the tourism



sector (who often live in urban centers), and the pleasure of foreign tourists who enjoy the wildlife from the safety and comfort of luxury safaris (**Igoe** Chap. 3).

Another major telecoupling is climate change which is primarily driven by unsustainable economies of a few industrial countries and whose impacts will likely cause many impacts on human livelihoods and wildlife in the TE. On that note, REDD+ projects (projects designed to mitigate the effects of climate change) are telecoupled to foreigners who wish to offset carbon emissions (**Baker et al.** Chap. 15). Sedimentation of Lake Manyara is influenced by land-use decisions made in the Karatu highlands (de Bisthoven et al. 2020). Further, the catchment of the Tarangire River is located in the Kondoa highlands; therefore the dry season concentration of wildlife in the TE is dependent upon the protection of forests in that area. Thus, the TE is not an insular area unaffected by decisions made beyond its borders.

### ***17.6.7 Vulnerability***

Vulnerability is the likelihood the coupled system experiences harm from changes due to internal or external forces. For example, as outlined in Prins and de Jong (Chap. 7) and Foley and Foley (Chap. 10), market forces driving demand for ivory strongly influenced the Tarangire elephant population. Pastoralists can no longer access several wetlands in the TE because they are located in protected areas or have been converted to agriculture. During times of severe droughts, livestock populations typically decline with cascading effects on peoples' nutrition, wealth, and wellbeing (**Bluwstein** Chap. 2, **Igoe** Chap. 3, **McCabe and Woodhouse** Chap. 4).

Another particularly relevant example of vulnerability in the TE is how the COVID-19 pandemic substantially reduced income from tourism, which in turn reduced income to national parks, anti-poaching programs, and local people who are directly and indirectly benefitting from tourism. Concomitantly, the pandemic also abruptly stopped some wildlife monitoring efforts so that potential impacts can possibly only be detected well after this book has been published.

### ***17.6.8 Surprises***

When complexity is not well understood, people may be surprised at the outcomes. Such surprises include unintended consequences or perverse results. An example of an unintended consequence in the delineation of protected areas in the TE was that the fear of exclusion drove Maasai to shift towards agriculture, as plowing a piece of land is a way to secure land in the Tanzanian context. Surprisingly, human-wildlife conflicts—although obvious in the case of large carnivores and elephants—do not represent the core issues of concern to many of the people who were questioned in interviews throughout the TE. Primary issues for people seem to be

land tenure and security (McCabe and Woodhouse Chap. 4). Indeed, most herders in Manyara Ranch expressed support for elephant presence despite frequently coming into contact with them (Kioko et al. Chap. 13).

In another positive surprise outcome, giraffe calves and their mothers were more likely to be detected near Maasai bomas, likely due to the lower risk of natural predation afforded by being near to pastoralists. This unintended consequence of pastoralists disrupting lion behaviors outside protected areas has helped giraffes and people to coexist (Lee and Bond Chap. 9).

## 17.7 Solutions for Human-Wildlife Coexistence

Understanding the complex features of coupled systems allows stakeholders to look to the past to develop better solutions for the future. As evidenced by the contributions to this book, a common theme is that the roots of conservation conflict in the TE stem largely from historical delineations of protected areas which did not consider seasonal movements of either wildlife or pastoralists, so-called ‘colonialist’ mentalities of separating people from wildlife rather than promoting coexistence, expansion of land uses such as large-scale agriculture that are incompatible with the needs of wide-ranging wildlife species and livestock, failures to involve local communities in land-use decisions, and dangerous active interactions with wildlife such as retaliatory killing of large carnivores. The examples in our book illustrate the manifold impacts of human-wildlife conflicts on wildlife populations, on food security, and on the physical and emotional wellbeing of residents of the TE, and how these conflicts reflect issues of inequity and are a source of social conflict between stakeholders.

Finding the middle ground for coexistence between humans and wildlife is a global challenge and “as much a humanitarian concern and an issue for social and economic development as it is a conservation issue” (Gross et al. 2021). Simple solutions to complex systems are unlikely to work for such deeply enmeshed problems. We believe that a first necessary step towards solutions is to move the discussion away from whether wildlife or human needs should come first, towards identifying solutions that work for both people and wildlife by quantifying the tradeoffs among wildlife-related ecosystem services (Kareiva et al. 2007).

As the different contributions to this book demonstrate, scholars disagree on the challenges that different elements of the system face and suggest different ways to address these challenges. It is not unusual to disagree about potential solutions to conservation problems (Lute et al. 2018) but we need to come to terms with such differences (Levin et al. 2021). The antidote to the Rashomon effect is to develop a shared logical framework so stakeholders can better understand the various points of view, all of which are valuable but which can be merged to offer the most effective ideas.

We can begin by agreeing about that which we disagree: for instance, the extent that the presence of livestock aligns with wildlife conservation goals is a matter of

dispute. Whereas some scholars claim that livestock is largely beneficial to wildlife, the scientific literature rather suggests that wildlife-livestock interactions can be both facilitative and competitive and these relationships are strongly dependent on season (Odadi et al. 2011) and densities of livestock (Kowal et al. 2019). There is also disagreement that allowing people unrestricted use of land and resources is compatible with wildlife conservation, and fundamental disagreement on hard boundaries separating people and wildlife. The debate over benefits and costs of separating people from wildlife is not confined to the TE alone, but is a global disagreement. For example, some scholars have called for fencing around protected areas, both in the TE (Prins and de Jong Chap. 7) and throughout Africa (Packer et al. 2013; Di Minin et al. 2021). However, what fencing would do in the TE can be anticipated by the fate of declining wildlife populations in Lake Manyara National Park, and some scientists have predicted that fencing Tarangire National Park might cause the collapse of one of the world's last remaining migrations of wildebeests (Voeten et al. 2010; Morrison et al. 2016).

We can also define areas of agreement. Both social and natural scientists appeared to agree that rangelands can support both people and wildlife, provided that people have a low ecological footprint. Wildlife and people mostly avoid each other at appropriate spatio-temporal scales as evidenced by: elephants and herders avoiding each other in rangelands (Kioko et al. Chap. 13), pastoralists keeping their livestock in safe pens at night (Kissui et al. Chap. 14), and Maasai herding their cattle distant from calving grounds of wildebeest to avoid transmission of malignant catarrhal fever virus (Lankester et al. 2015). There is a broad agreement that the Simanjiro Conservation Easements, and now Certificates of Customary Rights of Occupancy, work for both wildlife and people. Some authors noted disapproval of Wildlife Management Areas in earlier studies, but a recent study suggests that attitudes among people residing in WMAs became supportive over time—and all research in the TE indicates that wildlife populations in WMAs can rebound once conservation measures are in place. Social and natural scientists agree that previous top-down decisions were inadequate to cater to the needs of people and wildlife in the TE. Some parts of the TE have been lost as habitat for large mammal species and livestock grazing, and now serve other human uses such as for settlement or agriculture. While the human population in the TE is still growing (National Bureau of Statistics 2013), it would be too simplistic to blame the historical decline of rangelands and wildlife populations on this alone (Bluwstein et al. 2021): various examples in this book point to drivers outside of the TE (e.g. poaching driven by international demand for ivory, large-scale agriculture driven by international food markets, and international development policies). One thing is certain: the health of humans, animals (domestic and wild), and ecosystems are inextricably linked. This was clearly demonstrated to the world by the COVID-19 pandemic, which likely stemmed from human interference with wild animals that host coronaviruses. EcoHealth (see Box 17.1) is a concept that uses interdisciplinary research and practices to understand and promote health and wellbeing for all levels of the system—from humans and their livestock to wildlife and plants to the entire ecosystem. If we fail to adopt such interdisciplinary approaches, we may all suffer the consequences.

**Box 17.1: EcoHealth: An Interdisciplinary Approach**

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Prior to the European colonial period and big game hunting of the nineteenth and twentieth centuries, native peoples of Tanzania lived in dynamic harmony with nature. Big game hunting of large mammals with firearms marked the beginning of the decline of this harmony. Although big game hunting in Tanzania is now highly restricted, the rapid human population growth and accompanied agricultural and pastoral expansion occurring in the past 50 years coupled with climate change now pose a much more serious and persistent challenge to the health of the ecosystem. Where once hundreds of millions of wild large mammals lived in harmony with a few million people, now nearly 60 million people and 50 million livestock dwarf the remaining few million wild large mammals. Ironically, these remaining wild animals—which include the charismatic giraffe, elephant, zebra, chimpanzee, lion, leopard, and cheetah—are responsible for the lion's share of Tanzania's economy through tourism. For Tanzania to survive and thrive as a nation of people and as one of the most important ecosystems on the planet, it will need to embrace and promote the health of the entire ecosystem including humans, wildlife, livestock, land, and water. Two key interdisciplinary concepts, One Health and EcoHealth, describe the underlying principles and the key role that people must play to achieve the goal of humans and nature living in harmony.

One Health is a biomedical approach focusing on animal and human health and includes both veterinary and human medicine (Lerner and Berg 2017). Lerner and Berg (2017) noted that the core values of the One Health concept relate somewhat narrowly to human health and the health of animals that directly influence human health. An expanded concept is EcoHealth, which encompasses the health of humans, animals, and ecosystems synergistically. EcoHealth has been defined as “a field of research, education, and practice that adopts systems approaches to promote the health of people, animals, and ecosystems in the context of social and ecological interactions” (Parkes et al. 2014). Importantly, EcoHealth embraces wellbeing and not merely the absence of disease. As such, the EcoHealth approach includes more social science and humanities—including local and indigenous knowledge—than the One Health approach. The core values of EcoHealth are population health (of humans, animals, and ecosystems) as well as biodiversity and sustainability (Lerner and Berg 2017).

Such core values underscore the importance of interdisciplinary approaches to health and wellbeing of not only humans but animals, plants, and the ecosystems in which we are all embedded. How might the concept of EcoHealth be applied in the Tarangire Ecosystem? Traditional health studies might report the incidence of malignant catharral fever in domestic cattle, which is spread by calving wildebeests (Lankester et al. 2015). But what are the human social/economic impacts, and potential solutions? Pastoralists either avoid

(continued)

**Box 17.1** (continued)

wildebeest calving areas and shift their livestock elsewhere or chase off wildebeests from desirable rangelands. These actions can cause problems for people, wildlife, and the ecosystem. Integrating research disciplines can reveal potentially successful means of maintaining the wellbeing of pastoralists and their cattle, thriving populations of wildebeests, and the critical ecosystem services provided by thousands of migratory large mammals.

As much as coexisting with wildlife creates many challenges, it also provides opportunities. In the TE, many steps, most notably the establishment of conservation easements, CCROs, and WMAs, have been taken to conserve and restore wildlife populations during the last decades. To make full use of these opportunities we need to learn from our past mistakes.

These interventions have likely contributed to stopping wildlife declines, and wildlife populations slowly show signs of recovery in these areas (**Bond et al.** Chap. 8), but wildlife populations in the TE are likely well below their historical baselines (**Prins and de Jong** Chap. 7). While it may not be possible to restore the full community and abundance of wildlife across the entire TE, we believe that there is still substantial potential for ecosystem restoration provided that such attempts take into account the coupled social-ecological complexities (Fischer et al. 2021). Ecological restoration efforts in the TE also resulted in income-generating mechanisms and provided opportunities for employment and for communities to invest in infrastructure such as schools or dispensaries that contribute to the wellbeing of people and sustainable development of the region. Several scholars object that such monetary contributions are insufficient and we agree that there are multiple ways to make sure that benefits associated with wildlife accrue to people who actually live with wildlife. Since grazing rights are so important for Maasai (**McCabe and Woodhouse** Chap. 4) and limited grazing may be compatible with long-term persistence of wildlife populations (exemplified by Manyara Ranch; **Bond et al.** Chap. 8), restoration efforts in the TE are likely most effective if they take into account the needs of pastoralists as well as the needs of wildlife.

For coexistence to work, we anticipate that participatory and consensus-based approaches for planning and managing human-wildlife coexistence are a suitable way to find integrated and holistic solutions for people and wildlife to coexist in the TE (König et al. 2020, 2021). The establishment of conservation easements, CCROs, and WMAs during the last decades is a step in this direction, yet there are many areas where managing the different aspects of the human-wildlife interface could be done in a more holistic way. Tanzania is one of the first countries to enact national legislation on protecting wildlife corridors (**Lohay et al.** Chap. 12)—a laudable effort that hopefully contributes to maintaining seasonal wildlife and livestock movements and to facilitate anticipated range shifts of wildlife (Payne and Bro-Jørgensen 2020). This national legislation implicitly recognizes that humans and

non-humans alike depend upon a healthy environment for both to thrive and fosters a land-sharing approach in Tanzanian landscapes. Specifically, strong and immediate efforts must be made to secure two key remaining wildlife migration corridors in the TE: from the dry season range in the national parks and Manyara Ranch north to Lossimngore and the Gelai plains, and east to the Simanjiro Plains. The large majority of these two corridors is already covered by CCROs, and several NGOs are working to fill in the remaining conservation gaps, most of which are now quite small, through additional CCROs or other means. Protecting these critical wildlife movement corridors will go a long way towards safeguarding the integrity and function of the TE as a whole, which benefits both wildlife and humans. Without this step, there may be sequential faunal collapse over the next decades.

For human-wildlife coexistence to work in the sense of Carter and Linnell (2016), effective institutions are required to ensure “population persistence, social legitimacy, and tolerable levels of risk”. Several contributions of this book point to the idea that approaches to govern human-wildlife interactions have not always been effective in the past due to inadequate spatial scales of administrative responsibilities for wildlife, lack of resources for implementing effective technical solutions to prevent or reduce negative human-wildlife interactions at scale, and often also due to lack of trust between stakeholders. Thus, we anticipate that national endeavors to conserve connectivity (one of the key prerequisites for abundant wildlife populations and associated ecosystem services in the TE) will be most successful if they are accompanied by a national and collaborative human-wildlife coexistence program that could possibly be funded through income generated from ecotourism or payments for ecosystem services. Such a program could ensure that methods to prevent wildlife damages are developed, refined, and made available at scale. Empowering people to reduce human-wildlife conflict, by using cost-effective, socially acceptable, sustainable, and scalable methods such as predator-proof bomas to protect livestock and chili pepper fences to protect crops from elephants, would be a key component of such a program (Kissui et al. 2019; Kiffner et al. 2021). Foremost, however, such a program would need to make sure that land tenure issues are effectively addressed and that stakeholders are adequately involved in decision-making and adaptive management of wildlife corridors and human-wildlife interactions (Carter et al. 2021).

In this synthesis, we have outlined the issues affecting this human-dominated landscape, and the disparate opinions on the challenges affecting both people and wildlife. Too many other ecosystems have lost long-distance migrations or the vast majority of their large wild mammals; one only needs to think of the fenced reserves of South Africa and Kenya where wildlife migrations are now only distant memories of past ecosystem processes. Thus, we cannot stress enough the uniqueness of the TE. Despite all of the human development in the landscape, it is remarkable that this ecosystem is still ecologically functional. It hosts hundreds of thousands of people, millions of livestock, large mines, booming towns, two major tarmac roads, and a patchwork of agricultural fields—and yet still supports one of the most significant long-distance migrations of wildlife remaining in the world, much of it taking place on community land. Wildlife numbers have declined historically, but the mere

fact that many populations are stable, and some are increasing, despite all the odds, is testament to the singularity of the place, and demonstrates that humans and wildlife can indeed coexist.

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