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Wildlife Management

Failures, Successes and Prospects

Edited by Jafari R. Kideghesho and Alfan A. Rija

WILDLIFE MANAGEMENT - FAILURES, SUCCESSES AND PROSPECTS

Edited by **Jafari R. Kideghesho** and **Alfan A. Rija**

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Meet the editors

Professor Jafari R. Kideghesho was born in Ugweno, Mwanga, in Northern Tanzania. He obtained a BSc (Agric.) from Sokoine University of Agriculture (SUA), Tanzania (1993), an MSc (Conservation Biology) from Canterbury, UK (1996), and a PhD from the Norwegian University of Science and Technology (2006). He started his career in wildlife management at the College of African Wildlife Management, Mweka, where he taught for six years before joining SUA in 1999. He served as a deputy director of the Wildlife Division in Tanzania's Ministry of Natural Resources and Tourism for two years (2012–2014). Professor Kideghesho has been an active supporter of academic efforts within and outside Tanzania through teaching and serving as an external examiner at different universities. He has published over 40 scientific papers in reputable journals and is an author of numerous books. Currently, he is the Rector at the College of African Wildlife Management in Kilimanjaro.

Dr. Alfan A. Rija was born in Kigoma Region of western Tanzania. He is a lecturer in conservation and ecology at Sokoine University of Agriculture (SUA), Tanzania. He has a PhD degree in Biology specializing in spatial patterns of illegal activities in protected areas from the University of York in the UK (2017), an MSc in Conservation Biology from Victoria University of Wellington, New Zealand (2009), and a BSc in Wildlife Management from SUA (2003). Dr. Rija's research interests span a wide range of themes focusing on understanding the intricate interactions between humans and wildlife and biodiversity, and designing appropriate strategies for sustainability. He has over 15 years of experience working at the forefront of conservation challenges in protected areas in Tanzania and has researched and published widely on related fields.

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Preface

Ensuring the survival of wildlife resources is increasingly gaining momentum and becoming a matter of priority in the face of growing challenges facing the resources. With increasing poaching, habitat destruction, introduction of alien species, wildlife diseases, overexploitation, climate change, and human–wildlife conflicts, among other threats, increasing efforts are being devoted to developing and implementing management approaches and policies considered effective in addressing these challenges. However, the approaches and policies adopted have often produced mixed outcomes, both failures and successes.

Loss of wildlife populations still persists despite the efforts devoted to address the challenges. According to the *International Union for Conservation of Nature*, approximately 23% (1130 species) of mammals and 12% (1194 species) of birds are considered as threatened. Failure to achieve effective wildlife management is often caused by numerous factors, including limited livelihood options among local communities around the protected areas, increased demand for wildlife products, insufficient financial and human resources, and poor implementation of conservation policies.

Historically, communities around the protected areas have resisted conservation policies and expressed negative attitudes towards conservation. To communities, wildlife conservation has been perceived as a liability due to social and economic costs associated with this type of land use. The costs associated with wildlife conservation, among others, include opportunity cost due to loss of land for alternative uses, livestock depredation, crop damage, wildlife-related accidents to humans, and destruction of infrastructures. Scientific studies have indicated that a widespread apathy towards wildlife among the local communities is mainly caused by economic and social costs inflicted by wildlife.

In most cases, local communities around the protected areas take part in illegal activities at the detriment of wildlife to retaliate against losses caused by problems or dangerous animals. Occasionally, violation of laws such as illegal hunting is pursued for the sake of survival. For example, in Western Serengeti, Tanzania, most of the arrested poachers were from communities that had neither livestock nor land for cultivation.

Increased demand for wildlife products and consequently the exponential increase in price have created an incentive for poaching and illegal wildlife trade globally. For example, the high demand for ivory in China tripled the price to US$2100/kg in 2014 from US$750/kg in 2010. [1] This had, consequently, exacerbated the poaching of elephants in the supply countries, where poverty, population growth, unemployment, insecurity, and corruption are widespread. [2]

Inadequate human and financial resources allocated to conservation in wildlife sectors contribute to inefficient law enforcement and this undermines the conservation efforts. Conservation efficiencies to meet the management requirements of most of the protected areas, especially in developing countries, are almost non-existent. The budgets allocated are too minimal com-

pared to the global mean budget for a protected area (at US$893 per km^2) and global mean staff input (at 27 per 1000 km^2) released by the World Commission on Protected Areas. [3]

Despite the challenges, conservation agencies in different countries are striving to ensure that wildlife resources are managed effectively to meet ecological, political, and socioeconomic goals. The management approaches have shifted from the conventional "fences and fines" to more current ones—e.g. community-based approaches. The latter has been promoted with a premise that if local communities are involved in managing wildlife and benefit from the resource, they will be motivated to align their behaviors with conservation goals and, therefore, they will refrain from activities that are destructive to wildlife.

These management approaches have, however, produced mixed results—both failures and successes. Failures are evident through increasing poaching, human–wildlife conflicts, and decreased wildlife populations, among other indicators. The success stories in some areas are manifested by increasing costs of participating in illegal wildlife activities, increasing incentives for stewardship, decreasing pressure on wildlife species and habitats, and, therefore, increasing wildlife populations.

In this book, the authors have attempted to present challenges and some achievements of managing wildlife, drawing examples from different parts of the world. Through case studies, they have also provided some options for action, which can be replicated in other areas of the world to address the existing management challenges.

We thank the authors who have willingly decided to share their experience with our readers through contributing chapters to this book. We hope that this book will be useful to conservation practitioners, researchers, students, and academicians.

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Chapter 1

Introductory Chapter: Wildlife Management - Failures, Successes, and Prospects

Jafari R. Kideghesho and Alfan A. Rija

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1. Introduction

Wildlife is a resource of ecological, economic, and cultural importance. It forms a significant component of the natural ecosystem that maintains the ecological balance of nature through regulation of populations of different species; food chain or passage of food and energy through a series of functional groups comprising of producers, consumers, and decomposers; and natural cycles or circulation of inorganic nutrients between biotic and abiotic environment. Basically, each wildlife species functions with a specific role—predator, prey, decomposer, preserver, and in this way, ecological balance is maintained. For example, annual mass mortality of wildebeest drowning in the Mara River in the Greater Serengeti Ecosystem and of whales that sink on the ocean floor and salmon that die on river and streams when they come out to spawn have recently been identified as ecological input of high nutrients into these aquatic ecosystems from their carcasses and bones [1, 2]. This influences nutrient cycling in the aquatic ecosystem and maintains food webs.

By virtue of their critical ecological importance, some wildlife species are classified as keystone species and umbrella species. A keystone species is a species that has a disproportionately large effect on its environment relative to its abundance [3]. Such species play a critical role in maintaining the structure of an ecological community, affecting many other organisms in an ecosystem and influencing the types and abundance of a variety of other species in the community. Removal of such species has a huge downstream effect in the ecosystem and can lead to disappearance of the entire community. On the other hand, the umbrella species are species whose conservation is expected to confer protection to a large number of naturally co-occurring species. In conservation-related decisions, umbrella species are accorded priority since their protection implies protection of many other species making up the ecological community of their habitats [4].

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The economic importance of wildlife is realized through its utilization to meet human needs and aspirations. The main forms of wildlife utilization are consumptive and nonconsumptive use. The former involves removal of a species from its natural habitat, while the latter involves the use of a resource which does not involve removal from its natural habitat. The main form of consumptive use of wildlife is hunting conducted to cater for subsistence or commercial needs. Photographic tourism is the main type of nonconsumptive use.

Wildlife resource contributes immensely to the economy of many countries and individuals through different avenues. In Tanzania, for example, the resource plays the biggest role in tourism sector, an industry contributing 17.2% of the GDP and 25% of foreign exchange. The revenues earned during the 2016/17 financial year through its wildlife management authorities was roughly US$180 million [5]. Citing the 2011 Report by the United States Fish and Wildlife Service, the US-based Magazine—*Outside*—indicated that approximately 90 million U.S. citizens or 38% of the population aged 16 and above spent about US$145 billion on wildlife-related activities. The hunters spent $34 billion, anglers spent $41.8 billion, and wildlife watchers spent $55 billion [6].

Besides economic importance, wildlife species have spiritual, symbolic, and ceremonial importance to many global societies. Some ethnic groups have spiritual affiliation with totemic or sacred species which are worshipped as gods, revered as ancestors and classified as kins. These species are protected through taboos and traditional beliefs [7–9]. The totemic status ascribed to a particular species guarantees its protection since killing, injuring, or consuming it is prohibited.

The ecological, economic, and cultural importance of wildlife has prompted a need for conservation to ensure the long-term sustainability of this resource. In Africa, the precolonial, colonial, and postcolonial eras have observed some conservation regulations which sought to protect wildlife habitats and species. During the precolonial era, the beliefs and taboos were used to regulate, restrict, or prohibit killing or eating of a certain wildlife species. These controls were deliberately employed to avoid overexploitation and loss of such species [8]. The habitats for wildlife were also protected by taboos and beliefs [8, 9]. The colonial governments enacted laws and gazetted protected areas of different categories to safeguard the species and other natural resources. This system was inherited by postcolonial governments which gazetted more areas for wildlife conservation and maintained the centralized model of conservation—also known as fortress or fences-and-fines model. The model is based on the belief that biodiversity protection is best achieved by creating protected areas where ecosystems can function in isolation from human disturbance.

Despite the efforts to set aside large areas of land as protected areas, challenges are growing causing a dramatic decline of wildlife populations. With rapid human population growth and increased anthropogenic activities, loss of wildlife habitats and dispersal areas is increasing following their conversion to other uses such as agriculture, settlements, and infrastructures. Likewise, wildlife migratory corridors linking protected areas are being blocked and, thus limiting the gene flow between the populations and colonization of suitable sites. Other challenges include diseases, poaching, illegal logging, human-wildlife conflicts, climate change,

pollution, and introduction of exotic species [10]. Budget allocated to carry out effective management of wildlife is also limited.

The above challenges have far-reaching consequences on wildlife species. For example, research-based literature indicates that over 50% of wild mammals have declined across several African protected areas due to illegal activities conducted inside and around the protected area borders [11]. In Asia, deforestation poses significant risks to wildlife populations in protected areas than poaching. Such risks become more severe in the partially than strictly protected areas globally [12]. Furthermore, recent surge of illegal wildlife trade and their derivatives is perhaps the most challenging threats of our time that require concerted efforts from local and international institutions [12–14].

Many governments, globally, have responded to the growing conservation challenges by adopting new or alternative conservation policies and approaches. For instance, in the past three decades, community conservation approaches have been promoted to replace or complement the "fences and fines" (also known as centralized) approach. The later was considered to have failed in conserving wildlife. Under this approach, state-led enforcement of conservation laws became inefficient due to shrinkage of conservation budgets. This was manifested by heavy poaching which threatened survival of many key species such as buffalo, elephant, rhino, and lion [15–17]. For instance, poaching of African elephants for ivory reduced its population from 1.3 million in 1979 to 625,000 individuals in 1989 while black rhino plummeted from 65,000 in 1970 to 2400 in 1995 [18]. These declines of wildlife populations were partly caused by weak economies of the countries where protected areas are located and the need to increase incomes from illegal commercial sale of ivory and horns [12, 14].

The emerging of the community-based-wildlife management (CBWM) initiatives globally was important step in implementing more inclusive policies. The initiatives were construed as more plausible and promising in ensuring the survival of wildlife populations. However, implementation of this approach has had some unexpected outcomes with limited success stories [19, 20]. For instance, most of the community-based conservation projects were established to meet donor interests and their funding was fully dependent on donors. This has, consequently, led to failure of these projects instantaneously after pull out of the donors. Some community-based projects are also faced with challenges of inadequate capacity in terms of managerial and entrepreneurial skills.

Despite the challenges and failures, some successes have been recorded following wildlife conservation efforts globally. One of the successes is the growth of wildlife reserves worldwide from one (Yellowstone National Park) in 1872 to several thousand today [21]. There is increased commitment among the governments to set aside more wildlife reserves which is expected to cover about 17% of the total global land area by 2020 [22]. Similarly, about 10% coverage is expected for marine protected [12]. Essentially, this increase in protected area coverage is expected to guarantee the survival of the remaining populations of wildlife and other natural resources. Furthermore, the expansion of protected area coverage on a global scale has been reflected locally within individual countries notably from tropical countries. For example, the national coverage of the protected area network has increased notably in

Tanzania by 6.3%, the Republic of Korea (3.6%), and Mexico (2.0%). The 2017 World Database on Protected Areas (WDPA) Report indicates existence of over 230,000 protected areas in the world covering 245 countries and territories [23].

Another success recorded is increased public awareness on importance of wildlife conservation and, therefore, improved support to conservation efforts. This is a result of conservation education and realized direct benefits from conservation, especially to communities living around the protected areas. Research-based literature demonstrates that positive attitudes and support to conservation efforts are a function of direct benefits from wildlife and reduced costs related to conservation [24–29].

Along with increased public support, local and international community plays important role in ensuring the sustainability of wildlife resource. There is increased commitment locally and globally to adopt supportive policies and enforcing laws aiming at serving the species and their habitats. Many countries have formulated or reviewed their policies and amended or enacted laws to cope with increasing and emerging conservation challenges. Besides the national laws, these countries have signed/ratified various regional and international conventions and protocols for wildlife resource conservation and protection. This shows commitment of these countries to specific principles, objectives, and course of action. Some of the main conventions relevant to management of wildlife are: Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) of 1989; Convention on Biological Diversity (CBD) of 1992; Kyoto Protocol on Climate Change (UNFCCC) of 1997; Lusaka Agreement on Co-operative Enforcement Operations directed at Illegal Trade in Wild Fauna and Flora; Convention on Migratory species and; SADC Protocol on Wildlife Conservation and Law Enforcement (1999).

This book is comprised of eight chapters presenting experiences drawn from different parts of the world on failures, successes, and prospects of wildlife conservation in the world. Chapter 1 titled "*Spatial and temporal vegetation dynamics: Opportunities and nutritional constraints behind wildlife mobility in savanna ecosystem*" by Drs Anthony Sangeda and Selemani Ismail reviews the opportunities and constraints of spatial and temporal variability of forage resources and wildlife mobility in Eastern Africa savanna ecosystem. Foraging animals normally respond to the decline in forage quality and availability by moving to other landscape with relatively higher quality and abundant forage resources. Although migration of wildlife outside protected areas is ecologically vital for breeding and survival, it foments human-wildlife conflicts. Limited ecological knowledge and nutritional requirements of wildlife coupled with rapid diminishing quality and availability of forage undermine biodiversity conservation efforts. The understanding of spatial-temporal variability of forage resources along with proper wildlife management practices as well as human-wildlife conflict management is highly required to realize high productivity in livestock industry and wildlife conservation.

Chapter 2 titled "*Emerging bacterial zoonoses in migratory birds*" by Dr. Parin Ugur presents a very critical challenge of zoonotic diseases—affecting wildlife, people, and domestic animals. The seasonal variance, global warming, and extraordinary climate conditions around the world are linked with change of the physiology and behaviors of different animal species. Free ranging birds and mammals harbor some species of potentially pathogenic bacteria.

The authors explain the mechanisms through which migratory birds contract diseases and transmit them to domestic animals and humans. The migratory birds confront numerous health risks brought on by bacterial species that affect other livestock populace and public health. The chapter provides brief reference on bird-to-bird transmission and general aspects of emerging bacterial zoonoses of migratory birds for wildlife professionals, veterinary practitioners, and students.

In Chapter 3 "*Application of attitude theory in wildlife management: A critical review of concepts and processes*", Dr. Brookes Jeffrey et al. highlight the factors influencing consistency between people's attitudes and their subsequent behaviors. The authors review a number of studies on attitudes and knowledge to understand these factors. Prior knowledge is one of such factors. Attitudes held by people with high levels of knowledge of an issue tend to be better predictors of subsequent behaviors than attitudes accompanied by low levels of knowledge. Essentially, prior knowledge moderates the relationship between attitudes and behaviors by two processes: (1) accessibility and (2) stability, or strength. Using information-processing model from social psychology, authors examine the implications of knowledge about a hypothetical predator restoration. Understanding the effects of knowledge for information processing is useful to wildlife managers and communication experts who attempt to influence, persuade, and educate public stakeholders.

Dr. Mureithi Stephen et al. in Chapter 4 titled *"Community-based conservation: An emerging land use at the livestock-wildlife interface in northern Kenya*" recognize the lands outside the protected areas as important dispersal areas for about 70% of wildlife populations. These lands are communal pastoral lands where pastoralists and wildlife have coexisted harmoniously for decades. The authors point out the land use changes taking place in the area and their impacts on pastoralism and wildlife populations. Establishment of community wildlife conservancies is construed as a strategy for decentralization of wildlife governance and halting biodiversity and habitat loss. Conservancies are promoted as an avenue for restoration of degraded grazing lands and improving pastoral livelihoods through better livestock grazing management, vegetation recovery program, and income generated from tourism-based enterprises. Authors recommend a clear land zoning, reliable market for livestock, and development of support infrastructures for success of conservancies. Climate variability and change, invasive species, unsustainable land use systems, cattle rustling, and human-wildlife conflicts are outlined as the perceived threats.

Chapter 5 by Dr. Sayuni Mariki—"*Community-based wildlife management areas in Tanzania: Benefits, constraints and future prospects*"—provides some insights on the performance of community-based wildlife management approach. The approach has been promoted as a promising and more plausible option to conservation, contrary to previous approach—"fence and fines." Using the Wami-Mbiki Wildlife Management Area as a case study, the author points out that the project excelled at the beginning but with time, it became unattractive to communities. The author attributes this change to "donor dependency syndrome," which is common to many conservation projects. Ending of the donor support cripples the projects due to lack of capacity in terms of managerial skills and financial resources. Consequently, illegal activities such as wildlife poaching, overgrazing, tree cutting, and charcoal burning

increase as the projects can barely conduct effective antipoaching patrols. Entrepreneur skills, transparency, and good relationships with stakeholders, among others, are recommended as important success factors for community-based wildlife management.

Chapter 6 titled "*Power struggles in the management of wildlife resources: A case of Burunge Wildlife Management Area (WMA), Tanzania*" by Dr. Rose Kicheleri et al. provides an analysis of powers held by different stakeholders namely—structural, institutional, and strategic power. While the central government, investors, and nongovernmental organizations have both institutional and strategic powers, the power for village councils is limited to structural. Village councils are, therefore, disadvantaged in making the strategic decisions about the management of the WMA. The chapter cites divergence of interests as a source of power struggles among the stakeholders. Power struggles are more notable on issues related to distribution of revenues, management, and access to natural resources.

Chapter 7 by Prof. Lee Sang-Go—*Marine Fish Stock Enhancement Programmes (FSEP), and Fish Stock Rebuilding Plan (FSRP) in Korea*—seeks to introduce the methods and insights of Korean ecofriendly FSEP-based FSRP and its 10 years' fisheries management policy. It presents different strategies proposed to overcome any issues related to the implementation of the FSRP plan. Finally, Dr. Theresa Talley in Chapter 8 reviews the marine finfish enhancement program in California. The purpose of the review was to assess the program's functionality and efficiency, environmental impacts, scientific accomplishments, economic costs and benefits, and contribution to the marine finfish stocks.

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Chapter 2

Spatial and Temporal Vegetation Dynamics: Opportunities and Constraints behind Wildlife Migration in Eastern Africa Savanna Ecosystem

Ismail S. Selemani and Anthony Z. Sangeda

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Abstract

The Africa's semi-arid savanna ecosystems are characterized by high spatial and temporal variation in forage resources that influence mobility of wildlife population. Rapid changes in vegetation composition in savanna have been documented. These have notably involved transformation of grasslands into denser bushes and infestation of undesirable weed plants accompanied by diminishing ecological carrying capacity of rangelands. The utilization of different landscape units is strongly correlated with the availability of forage species and their nutritional quality. Foraging animals normally respond to the decline in forage quality and availability by moving to other landscapes with relatively higher quality and abundant forage resources. Although, migration of wildlife outside protected areas is ecologically vital for breeding and survival, it foments human-wildlife conflicts. Limited ecological knowledge and nutritional requirements of wildlife coupled with rapid diminishing quality and availability of forage undermine biodiversity conservation efforts. The understanding of spatial–temporal variability of forage resources along with proper wildlife management practices as well as human-wildlife conflict management are highly needed to realize high productivity in livestock industry and wildlife conservation. This chapter reviews the opportunities and constraints of spatial and temporal variability of forage resources and wildlife mobility in Eastern Africa savanna ecosystem.

Keywords: rangeland degradation, wildlife mobility, vegetation variability, semi-arid savanna ecosystem, climate change

1. Introduction

The Africa's semi-arid savanna ecosystems are characterized by high spatial and temporal variation in forage resources that influence mobility of both wildlife and livestock population [1].

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Spatially, vegetation variability occurs ranging from very fine scale (plant level) to regional scale (landscape level), resulting into pronounced patches of quality and availability of forage. On the other hand, vegetation varies in terms of time ranging from few seconds to several years resulting into seasonal fluctuations in forage quality and availability [2]. Although, several factors (such as topography, weather and climate) influence distribution pattern of animals, the vegetation characteristics (quality, quantity, species composition, plant morphology and physiology) are the key determinant of ungulate migration [3]. The vegetation variations caused by changes in land use and climatic variability are major driving forces of wildlife migration. The preference and aversion responses of foraging animals are closely linked with both nutritional composition and nutritional requirements of feeding animals [4].

At landscape level, rangelands consist of pattern of vegetation types clustered in concurrence with climatic condition and geographical features which create mosaic of patchiness [5]. The utilization of different landscape units is strongly correlated with the availability of forage species and their nutritional quality within these patches. Foraging animals normally respond to the decline in forage quality and availability by moving to another landscape with relative higher quality [6]. For example, in Serengeti National Park, ungulate such as wildebeest and zebra have been noted to move progressively in different grazing areas [1]. This grazing succession following feeding preference has great ecological implication through reduction in interspecific competition among grazing animals. On the contrary, wildlife migration has been blamed to cause inter-conflicts between different land uses. For example, Selemani [7] observes that, migration of wildlife to residential areas escalates conflicts between local people and conservationists and, consequently, results into negative attitude towards the protected areas and conservation, in general. Incidences of crop damage are the most common indicators for human-wildlife conflicts across the Sub-Saharan Africa. For example, crop-raiding by elephant in East Africa was reported to exacerbate conflicts by damaging the farmers' livelihood and, consequently, causing retaliatory killing [8].

Limited ecological knowledge and nutritional requirements of wildlife coupled with rapid diminishing of forage quality and availability will continue to be limiting factors for wildlife conservation. Wildlife migration outside the protected areas does not only impede conservation efforts but also fuel human-wildlife conflicts. A better understanding of the drivers for wildlife migration outside protected areas and the knowledge of interactions between native species and human impacts is an important step towards wildlife conservation. It is therefore important to understand both spatial and temporal changes in vegetation. Specifically, it is crucial to know existing potentials and challenges facing wildlife conservation as well as options for management of human-wildlife conflicts.

2. Factors underpinning wildlife migration

2.1. Anthropogenic activities

Increasing human population has tremendously transformed the previously natural ecosystems used as wildlife habitats. Although natural factors such as drought, wildfire, climate change and

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unpredictable hazards contribute to modification of wildlife habitats, the key driving force for degradation of forage resources and subsequently migration of wildlife are anthropogenic activities. Wildlife habitats have become more and more fragmented as a result of increasing human activities such as crop production, livestock husbandry, infrastructure development and urbanization. For example, according to Brady [9], agriculture has more profound impact on wildlife conservation than other anthropogenic activities. Cultivated crops adjacent to conservation areas are potential source of forage for wild ungulates such as elephant (*Loxodonta africana*), buffalo (*Syncerus caffer*) and antelopes. Crops like the succulent finger millet and sweet sugarcane are not only highly palatable but contain more protein and minerals compared to the native wild grasses [9]. In addition, during the dry seasons native forage quality normally declines tremendously because natural pastures are characterized by rapidly maturing grasses which attained maturity quickly [10]. Based on Optimal Foraging Theory, which states that animals tend to select high quality diet in the manner that maximizes their nutrient intake [11], it is considered that wildlife migration to adjacent croplands is a coping strategy to survive hash condition escalated by seasonal fluctuations in quality and availability of forage resources [12].

2.2. Increased human population

A growing human population entails the increasing human needs and, consequently, need for expansion of agricultural activities to meet the demand for food and cash. Global population is currently estimated to exceed 7 billion people and is projected to rise to over 9 billion by 2050 [13]. Nearly all of this population increase will occur in developing countries (**Figure 1**). This implies that, the demand for food will increase while competition for land, water resources and energy will intensify. Agricultural production and environmental challenges are inextricably linked; whereas natural environment offers resource base on which agricultural production is completely dependent, while farming itself plays a major role in shaping the environment [13].

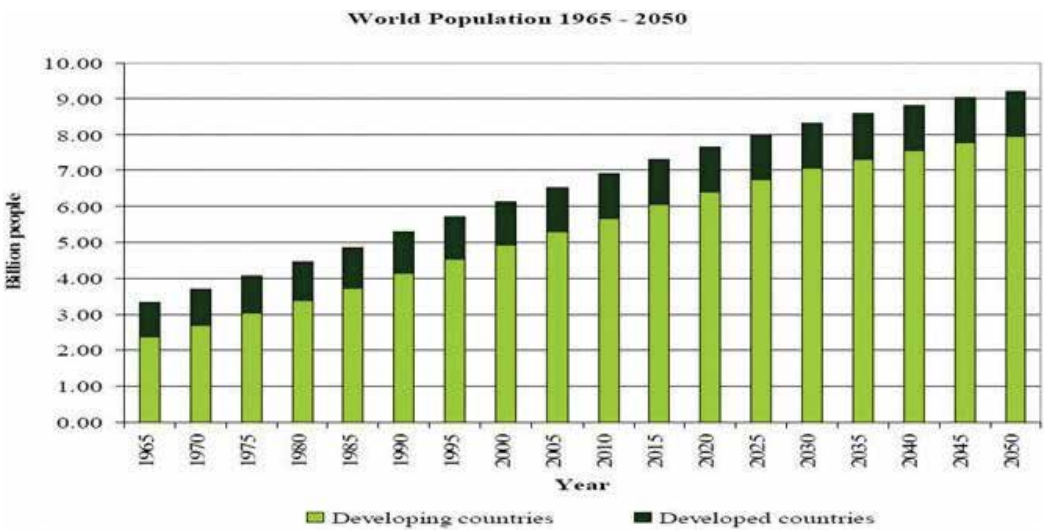

Figure 1. Projected global human population (Source RSPB 2012).

Although wildlife can tolerate agricultural land use intensification, there are thresholds beyond which tolerance is unattainable [14]. These thresholds vary with physiological and nutritional requirement of species and environmental setting. Large ungulates like elephant, zebra, giraffe, wildebeest and buffalo require vast land resources on which forage resources and water are spatially distributed. Shrinking of wildlife habitats due to agricultural expansion causes movement of wildlife to other areas where they can access quality forage resources and water.

2.3. Increased animal population

Overexploitation of forage resources in protected areas due to growing wildlife population causes changes of botanical composition and nutritional quality of vegetation. The transformation of open grassland into dense woodland known as bush encroachment is attributed to overgrazing of herbaceous vegetation. According to Walter's two layer hypothesis, decrease in grass layer following overgrazing offers opportunity for woody plants to access soil water that would otherwise be utilized by grasses [15]. Bush encroachment creates sub-habitat which differs from open grassland and thus exert different influence on grazing behavior for wildlife. Increase in woody abundance is normally accompanied by reduction in herbaceous biomass production and shift in botanical composition [16]. Change in botanical composition following overgrazing results into invasion of more unpalatable and undesirable plant species which prevents voluntary intake by foraging animals. Woody plants respond to herbivore attack through a variety of defensive mechanisms ranging from physical barriers to more complex production of secondary metabolites [17].

2.4. Infestation of invasive plant species

Invasion of noxious weeds in conservation areas largely contribute to significance loss of natural biodiversity of both fauna and flora species. Recently, invasion of alien shrubs such as *Chromolaena odorata* and *Parthenium hysterophorus* species have been observed in conserved areas such as Serengeti and Arusha National Parks in Tanzania. However, abundance and distribution of these species are inadequately documented in East Africa [18] (**Table 1**). Most of invasive weed species have been reported to pose serious threat to wildlife and biodiversity conservation with negative impact on productivity of grassland ecosystems [19]. Previous studies have shown that, the rapid spread of alien species depend on combination of reasons ranging from their high reproductive capacity, high growth rate and capacity to inhibit growth of native plants [18–20]. Allelopathy is considered as the main reason for alien species to eliminate and competitively exclude the neighboring plant species [19]. Allelopathic chemicals produced by most invasive weeds have also been reported to affect animal health by causing rhinitis, asthma, bronchitis, dermatitis, and hay fever [18, 19].

Invasive plant species in East Africa have been reported to cause environmental damaging and biodiversity loss in dry land ecosystems. Their disastrous effects include causing the death of animals (both wildlife and livestock), poisoning and destroying animal health, accelerating biodiversity loss via suppression of native plants, and increasing diseases by offering a breeding ground for mosquitoes, tsetse flies and other disease-causing insects [21] like tsetse-flies (**Table 2**). Wild animals normally respond to increasing unpalatable and noxious invasive plant species by moving to other landscapes with relative palatable and high nutritious plant

Location	Density (spp/m^2)	Frequency %	Abundance
Arusha-Kilimanjaro	4.28	96	6.79
Arusha Airport	6.52	72	5.94
Njiro	9.88	96	10.29

Source: Kilewa and Rashidi [18].

Table 1. Distribution of *Parthenium hysterophorus* in Arusha region.

Invasive plant	Occurrence		Disaster effects/impacts
	Tanzania	Kenya	
Lantana camara (Lantana)	x	x	Breeding ground for sleeping sickness & Nagana, lowers biodiversity
Prosopis juliflora (Mesquite)	x	x	Reduces livestock foliage, deep roots enhance drought, thorns poisonous
Prosopis pallida (Mesquite)		x	Reduces livestock foliage, deep roots enhance drought, thorns poisonous
Opuntia ficus indica (Prickly pear cactus)	x	x	Poisonous to wildlife in parks, affecting potential of tourism
Caesalpinia decapetala (Mauritius thorn)	x	x	Shades out grass & shrubs eaten by animals, limits animal movement
Psidium guajava (Guava)	x	x	Outcompetes native plants and lower species Biodiversity
Senna spectabilis	x	x	Suppresses growth of native park trees
Acacia farnesiana (Sweet acacia)	x	x	Suppresses growth of native trees, forms impenetrable thickets that limits access
Acacia mearnsii (Black wattle)	x	x	Outcompetes native plants lowers biodiversity & increased water loss
Acacia polyacantha	x	x	Suppresses native plant species

Source: Adopted from Obiri [21].

Table 2. Occurrence and impact of invasive species in Tanzania and Kenya.

species. The wildlife migration has socio-economic and ecological implications which are discussed in detail under the following section.

3. Ecological and economic benefits of wildlife migration

Although wildlife migration is often implicated with economic losses and degradation of environment, there are numerous potential opportunities associated with this phenomenon.

Mobility is one of the important coping strategies for animals grazing in a highly variable ecosystem with unpredictable rainfall. It is recognized that, the quality and availability of forage resources differ between parts of landscape and, therefore, foraging animals move across the landscape units searching for high quality forage [22]. In non-equilibrium condition (such as semi-arid savanna ecosystems), the appropriate management practices recommended is to focus on the process that generate spatial and temporal heterogeneity, including interaction between organisms [23]. Movement of wildlife outside protected areas, offer opportunity for interaction with livestock population (e.g. in WMA) which reduces intraspecific competition and facilitate maximum utilization of available resources distributed in time and space. In East Africa, wildlife and livestock exhibit high degree of spatial overlap or co-existence [1]. Both wildlife and livestock utilize foraging strategies based on mobility (seasonal migration and transhumance) in order to access pasture and water resources occurring in unpredictable environment.

3.1. Ecological benefits

Ecologically, seasonal migration of wildlife offer potential breeding sites to wild ungulates. A well-known example of seasonal wildlife migration in East Africa savanna ecosystem is the annual migration of around 1.3 million wildebeest (*Connochaetes taurinus)*, 0.6 million zebra (*Equus burchelli*) and Thomson gazelles (*Gazella thomsoni*) in Serengeti-Mara ecosystem (i.e. "as in Ref. [24]"). The wildlife migration (between dry and wet season) in Serengeti-Mara ecosystem is ultimately driven by the marked and strongly seasonal rainfall gradient that runs from the southeastern short-grass plains to the tall-grass woodland and savanna habitats in the north, center, and west of the ecosystem (i.e. "in [25]"). The migrant animals leave the plains during dry season and track the spatial and temporarily varying resources across the ecosystem in the wetter northern region. Different explanations have been proposed to explain this movement from the plains, to northern part of ecosystem including higher forage abundance and quality, water nutrient content and avoid risk of predation in the plains especially during breeding (i.e. "as in Ref. (i.e. "in [26]").

In addition to wildlife migration in Serengeti-Mara ecosystem [26], Simanjiro plains have also been reported as important dispersal and breeding areas for wild mammals from adjacent Tarangire National Park. The high density for zebra and wildebeest recorded in Simanjiro plains during rainy season (**Table 3**) was attributed to the seasonal migration behavior from Tarangire National Park for breeding purposes. The population of wildlife has been reported to decline during the dry season as most of wild mammals concentrate close to water points in the Tarangire National Park [27]. Therefore seasonal migration of wild animals has important ecological values; enhance population viability, sustain nutritional requirements of wildlife and preserve animals from risk of predation.

3.2. Economic benefits

Economically, wildlife migration contributes significantly to GDP for East African countries particularly Tanzania and Kenya. For example, migration of wildebeest and zebra across Serengeti-Mara ecosystem is important phenomenon for tourism attraction, resulting in the

Species	No. of herd	Head size	Density (km^2)	Abundance (n)
Zebra	105	13.28 ± 1.11	1.48 ± 0.54	11,223 ± 4216
Wildebeest	59	10.20 ± 1.79	0.89 ± 0.43	5199 ± 2670
T. gazelle	25	7.24 ± 1.31	0.34 ± 0.10	1398 ± 491
Impala	21	12.67 ± 2.66	0.63 ± 0.14	4534 ± 1393

Source: Rija and Shombe [26].

Table 3. Distribution and abundance of wild animals in Simanjiro plains.

Serengeti National Park in Tanzania being listed as a World Heritage Site [27]. It was reported that wildlife concentrations outside Serengeti National Park and wildebeest migration across Serengeti-Mara Ecosystem contribute to 30% of tourists' satisfaction [28]. Nevertheless, wildlife migration has indirect vital role in ecosystem function by providing important ecosystem services [29]. Wildlife mobility enhances vegetation diversity through pollination, seed dispersal, germination and growth induced by nutrient recycling. For example, there is direct or indirect influence of plant–animal-mutualism on flowering phenology in tropical region [30].

4. Challenges related to vegetation dynamics and wildlife migration

4.1. Climate change

Rangeland resources worldwide are commonly viewed as overstocked, overgrazed, degraded and unproductive [22]. Increasing human population pressure, encroachment of rangelands for other land uses, bush encroachment and decline in primary productivity contribute to the degradation of rangelands. The heterogeneity nature of semi-arid rangelands coupled with climatic variability, mobility and adaptive management are coping strategies for both wildlife and domestic animals [23]. Ecological evidence demonstrates that rainfall is a key factor determining rangeland productivity in East Africa [1]. The effect of climate change such as rising in temperature and changes in amount and pattern of rainfall in East Africa has affected both ecosystem and biodiversity conservation [29]. Rapid decline in nutritive value of forage species, particularly protein content, during dry season constrain nutritional requirement for wildlife species. For example, green grass intake and protein content both play a key role in determining the movement and distribution patterns of migratory wildebeest in the Serengeti National Park [25]. Quality of forage is better predictor of wildlife migration than the above ground biomass. All these important plant parameters are negatively influenced by climate variability and change.

4.2. Human-wildlife conflicts

Despite the significant importance of wildlife migration, seasonal movement of wild animals has been blamed for everlasting conflicts between different land users [9]. Increasing human population magnifies the competition for scarce grazing land and water resources which in turn increase potential for human-wildlife conflicts. Although humans and wildlife in African

rangelands have positively co-existed for many years, currently different forms of human-wildlife interactions are fuelling numerous conflicts. Migration of wild animals from protected areas such as national parks and game reserves to adjacent communal lands inflicts serious damages ranging through crop raiding, livestock depredation, and wildlife-induced accidents to humans. For example, a survey in the villages bordering the Serengeti National Park showed that the wildlife predators caused a loss of livestock equivalent to an average annual financial loss of 19.2% of their cash income [31].

In many parts of Africa, conflicts between human and wildlife are reported as the most serious problem particularly between local people surrounding natural reserves and wildlife managers [32]. Negative conservation attitudes pervade among local people adjacent to protected areas as result of frequent losses caused by wildlife [7]. Lack or inadequate direct benefits that can offset the losses communities experience from wildlife translates into negative attitudes towards conservation and wildlife authorities. For example, people are more likely and willing to support the abolishment of adjacent reserves when the benefits from protected areas are too minimal to outweigh the costs of conservation [32].

4.3. Bush encroachment

Bush encroachment is increasingly becoming a problem in many protected areas of Eastern Africa rangelands thus causing shortage of forage [33] Encroachment of woody plants is normally accompanied by reduced productivity of herbaceous layer (grasses) which are potential source of forage to many wild ungulates. The rapid transformation of grassland ecosystem to denser woodland in most African rangelands has been associated to several factors including heavy grazing pressures and effects of climate changes [15]. The encroached woody plants are normally unpalatable to grazing animals due to impenetrable thickets, suppressing palatable grasses and herbs. Although the causes of bush encroachment is still debatable [34], there is evidence that, effect of poor rangeland management such as overgrazing is the main driver of encroachment of woody species [16]. Overgrazing severely alter natural ecological processes by allowing woody plants to outcompete the grasses for water resources [35]. In addition to heavy grazing, reduction in fire regimes, above average rainfall, and elevation of atmospheric carbon dioxide levels are some of the processes that facilitate the growth and subsequent spread of shrubs and other woody vegetation [36]. Due to differences in their photosynthetic pathways, many woody plant species (i.e., C3 plants) benefit more from elevated atmospheric carbon dioxide due to climate change effects and subsequently grow faster and accumulate more biomass, compared to many grasses (i.e., C4 species) found in semiarid regions [36].

Bush encroachment alter ecosystem characteristic through alteration of vegetation resource and microclimate which subsequently affect wide range of animals including wildlife. Encroaching woody plants change the habitat structure, diversity abundance and composition with different micro-habitat compared to grassland ecosystem. Furthermore, plant and animal diversity is negatively affected through a decrease of vegetation structural diversity leading to an overall loss of ecosystem functioning. In some rangelands, woody plant encroachment is associated with a decline in wildlife grazing capacity up to 80% [35]. The decline in grazing capacity in most protected areas is linked with wildlife mobility to adjacent areas. For example,

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Research-based literature shows that over 70% of the large native ungulates in the world are found outside the formal protected areas [37].

4.4. Poaching and blockage of wildlife migratory routes

Seasonal mobility of wildlife exposes the wild animals to high risk of poaching. Poaching threatens many migratory mammals and this is intensified by human population growth, particularly around the protected areas. For example, around Serengeti National Park, number of wildebeest consumed per annum ranges from 70,000 to 129,000 [24]. Most of the animals are killed outside the protected areas during the seasonal migration. In Nairobi National Park, the wildlife migratory routes from the park to adjacent areas (**Figure 2**) were found to be more risk areas for migrant species due to poaching incidences and blockage of wildlife corridors [24].

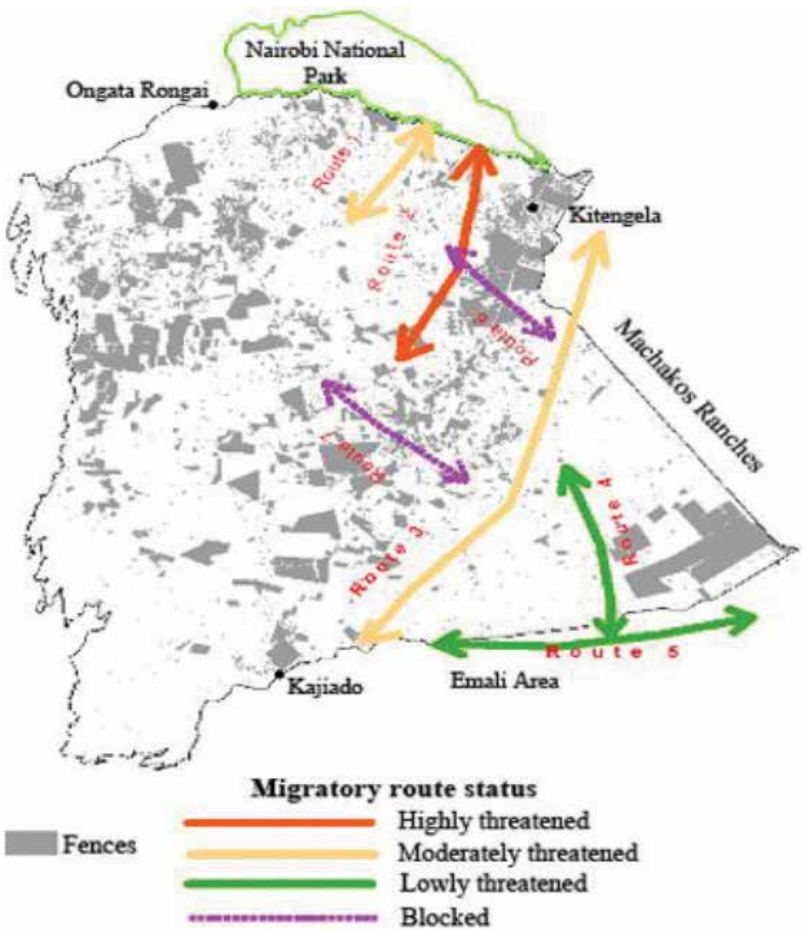

Figure 2. The map showing migratory routes of wild animals from Nairobi National Park. Source: UNEP 2013.

4.5. Diseases

Wildlife migration outside the protected area does not only cause conflicts between park management and surrounding communities, but also expose animal to health risks. The emergence of zoonotic and vector borne diseases pose considerable risks to public health, livestock and migrant wild animals. Migrant wild animals interact with both human and livestock outside the protected areas and, therefore, increase the chances for infections. In general, wild animals are susceptible to infection by the same bacteria, viruses, and parasites that infect livestock and disease transmission can occur in either direction [38]. Approximately 60% of disease causing pathogens illness in human and livestock originates from wild animals [39]. Although there is variation in wild animals and livestock on ability to respond to infections, disease transmission can occur in both directions and, therefore as the phenomenon is a two-way traffic.

5. Conclusion and recommendations

Foraging resources in Eastern Africa savanna ecosystem vary greatly in space and time. While spatial variations range from very fine scale within plant level to regional scale at landscape levels, the temporal variations range from very few seconds to several years. However, wild animals are constrained by nutritional stress, particularly in protected areas, due to seasonal fluctuations in quality and availability of forage and water resources. These animals normally respond to spatio-temporal variation in foraging resources by selecting high quality forage distributed in space and time. Seasonal migration of wildlife across different landscape units is considered as one of important coping strategies for breeding and survivability of wild ungulates. Economically, seasonal migration of wildlife is of iconic importance for tourism attraction and thus contributes to income generation. Despite the ecological and economic importance of seasonal migration of wildlife, migratory animals are implicated with losses they inflict on communities around protected areas through crop raiding, livestock depredation, accidents to humans. This exacerbates conflicts between local communities and conservationists. As a result of these losses, local communities adjacent to protected areas develop negative attitudes towards conservation efforts. In addition to human-wildlife conflicts, seasonal mobility of wild animals in Eastern Africa savanna ecosystems is also associated with climate changes, poaching, diseases and land use pressures resulting into blockage of migratory routes. It is recommended that, establishment of wildlife habitats should consider ecological and nutritional requirements of stocking animals. Migratory routes (wildlife corridors), breeding sites and dispersal areas should be designed and well protected. Most importantly, appropriate range management practices for improving range health such as bush control, prescribed fire, pasture renovation and distribution of water points are recommended. For sustainable wildlife conservation both within protected and outside protected areas and reduction of human-wildlife conflicts, we propose development of a flexible and adaptive community based conservation system involving a diverse set of stakeholders ranging from community level to region levels.

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Chapter 3

Emerging Bacterial Zoonoses in Migratory Birds

Uğur Parin, Şükrü Kirkan and Göksel Erbaş

Additional information is available at the end of the chapter

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Abstract

The seasonal variance, global warming, and extraordinary climate conditions around the world change the physiology and behaviors of different animal species. Free ranging birds and mammals harbor some species of potentially pathogenic bacteria; however, these diseases do not result in spontaneous deaths. Being significant individuals of the ecosystem, free living immigrant birds are prone to bacterial diseases. Migratory birds are accommodated in areas located on migration routes to provide rest, food, and water. During this stay, they spread the diseases they bring with them to the poultry in the region and to the poultry farms that do not take adequate biosecurity measures—especially to the free range poultry farms. The migratory birds confront numerous health risks brought on by bacterial species that affect other livestock populace and public health. This chapter provides brief reference on bird-to-bird transmission and general aspects of emerging bacterial zoonoses of migratory birds for wildlife professionals, veterinary practitioners, and students.

Keywords: migratory birds, emerging zoonoses, bacterial diseases

1. Introduction

Numerous wild bird species exist together with people and depend on anthropogenic wellsprings of environment and nutrition. Bird migration is one of the most curious topics in humans about birds' lifetime period. This behavior is one of the most important and critical turning points for birds throughout their lives. Every year more than 50 billion birds in the world migrate, depending on the seasonal change of food resources, and 5 billion birds of 187 species leave Europe and Asia each year and migrate to Africa. Migratory birds relocate a large number of kilometers all through various mainlands and convey certain pathogens. Sixty-one percent of human pathogens are zoonotic, 60.3% of all developing diseases in people are zoonoses, and 71.8% of these initiate in natural life. The recurrence of free living fowl death occasions and the assortment of

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irresistible bacterial maladies have expanded extraordinarily amid late decades. Convenient and exact identification of mortality is expected to appropriately guide disease control procedures [1–3]. This review presents brief of emerging bacterial diseases of migratory birds.

2. Emerging bacterial zoonoses in migratory birds

2.1. Avian cholera

Avian cholera is an infectious disease coming about because of contamination by *Pasteurella multocida*. A few subspecies of microscopic organisms have been proposed for *P. multocida*, and 16 distinctive strains have been described [4].

2.1.1. Transmission

Acute pasteurellosis infections are common in worldwide and they can cause bird deaths in 12 h, albeit 24–48 h is typical. Vulnerability to contamination and the formation of malady depends on various factors, including gender, age, and hereditary variety [5]. Many birds harbor the organism in nasal clefts. The presence of the bacterium is generally related to severity of upper respiratory infection in the birds. The enzootic focus of infection is healthy nasal carriers [6]. Transmission to vulnerable birds from contaminated wetlands or from direct bird-to-bird contact is the in all probability routes of transmission amid epizootics (**Figure 1**). Two field cultures were isolated from raccoons that were pathogenic for poultry. Sparrows and pigeons carried organisms without showing clinical signs, but 10% of infected rats developed acute pasteurellosis. The possibility that insects may serve as vectors of FC has been investigated. Transmission by flies, however, is probably not common, as indicated by previous studies. Although FC was maintained in two lots of chickens during the height of the fly season, no spread of the disease occurred to adjoining lots separated only by bird nesting. It was observed that larvae, nymphs, and adult ticks (*Argas persicus*) contained *P. multocida* after feeding on infected hens. A previous demonstration described that the red mite (*Dermanyssus gallinae*) became infected with *P. multocida* after feeding on infected birds, but the mite did not transmit the organism [2].

2.1.2. Clinical aspects

Birds that survive the initial acute septicemic stage may later succumb to the debilitating effects of emaciation and dehydration, may become chronically infected, or may recover. Female Common Eiders are frequently discovered dead sitting on their clutch [7]. Birds with signs suggestive of neurological involvement (unpredictable ungraceful flight, surrounding while at the same time strolling or swimming, or opisthotonos) have additionally been accounted for [8].

2.1.3. Diagnosis

Similarly as with other bacterial diseases, isolation of the causative agent is required for an authoritative identification. To isolate *P. multocida*, sear the tissue or exudate with a spatula and obtain a specimen by inserting a sterile cotton swab or wire loop through the seared surface. If birds are living, squeeze mucus from the nostril or insert a cotton swab into the nasal cleft.

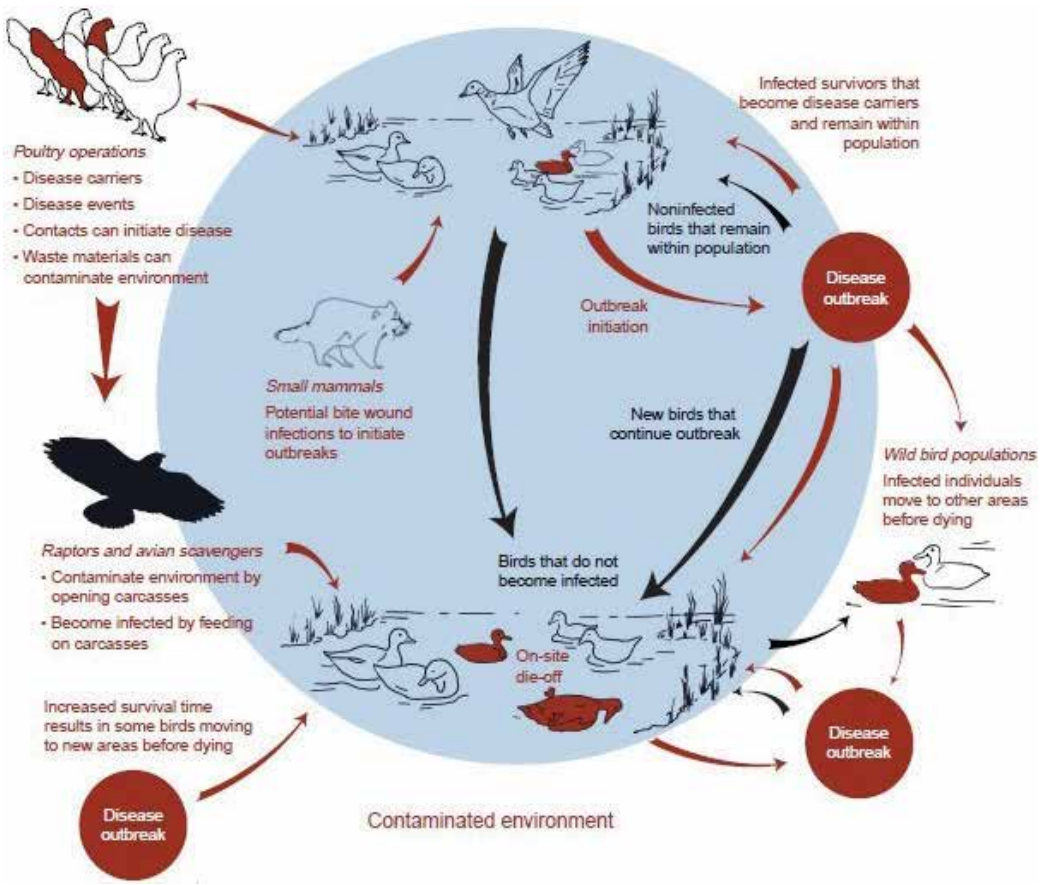

Figure 1. Disease cycle of avian pasteurellosis [1].

Specimens may also be streaked on MacConkey and blood agar media to aid in identification. Colonies characteristic of *P. multocida* are transferred to dextrose starch agar slants incubated 18–24 h. Tubes of phenol red broth base containing 1% glucose lactose, sucrose, mannitol, and maltose are then inoculated with growth from the slant. Fermentation of glucose, sucrose, and mannitol without gas is characteristic of *P. multocida*. Lactose usually is not fermented, but some avian isolates will ferment it. Inoculate 2% tryptose in 0.85% saline solution, incubate 24 h at 37°C, and test for indole (Kovac's test). Indole is almost always produced by *P. multocida*. There should be no hemolysis of blood and no growth on MacConkey agar [9, 10].

2.1.4. Treatment and prevention

Antibacterial chemotherapy has been used extensively in the treatment of FC with varying success, depending to a large extent on the promptness of treatment and drug used. Sensitivity testing is often advantageous, because strains of *P. multocida* vary in susceptibility to chemotherapeutic agents, and resistance to treatment may develop, especially during prolonged use of these agents. Prevention of FC can be effected by eliminating reservoirs of *P. multocida* or by preventing their access to poultry flocks. The choice of adjuvant for an autogenous vaccine

can be water-in-oil emulsion or aluminum hydroxide. Autogenous bacterins using aluminum hydroxide as the adjuvant are useful for the vaccination of turkey breeder or broiler breeder flocks that are in lay because the water-in-oil emulsion, in combination with the whole bacterial cell, results in a significant tissue response by the bird. The use of live FC vaccines stimulates an effective immune response but has the disadvantage of potentially resulting in mortality in the vaccinated birds. If the mortality post vaccination becomes excessive, it can be reduced by the administration of an antibiotic. This should be avoided, if possible, until at least 4 days post vaccination when there will be at least partial immunity induced by the vaccine [11].

2.2. Salmonellosis

The genus *Salmonella* has a broad range of conveyance and is a standout among the most widely recognized reasons for bacterial diarrhea of the bowels in human and animals. In terms of history, clinical signs, epizootiology, lesions, and control and eradication procedures, pullorum disease and fowl typhoid have many similarities. However, differences have been reported for these two diseases, which are caused by these two different serovars (i.e. *Salmonella* Pullorum and *S*. Gallinarum, respectively). These two bacterial taxa are generally regarded as separate serovars, namely *S. enterica* subsp. *enterica* serovar Gallinarum (*S*. Gallinarum) or *S*. Pullorum, but debate continues as to whether they are single or different taxa within the same serovar [12].

2.2.1. Transmission

Salmonellosis can be transmitted from multiple points of view. The relative contribution of vertical transmission in the two organisms is unclear because it is easy to establish persistent infections and egg transmission with *S*. Pullorum [13] but much less easy with *S*. Gallinarum, and it may be that horizontal transmission is more important in this highly virulent organism in which experimental infection generally either results in clinical disease and mortality or no infection depending on the genetic background of the host. It is known that *S*. Pullorum persists within macrophages in the spleen during the carrier state [14]. Although numbers gradually reduce, they are not eliminated [13], and at sexual maturity, the numbers increase as a result of reduced capacity of T cells to respond specifically and nonspecifically to antigens [15], probably following increases in sex hormones. The reduced immune responsiveness enables the bacteria to spread to the reproductive tract.

2.2.2. Clinical aspects

The birds can manifest somnolence, weakness, depressed appetite, poor growth, and adherence of chalky white material to the vent. Death ordinarily follows inside 24 hours. On the off chance that enteritis occurs, there might be diarrhea, making the vent pasted with liquid defecation and urates [12].

At the point when the esophagus is cut open, the nodules might be viewed as huge, diffuse plaque-like nodules or as discrete, nodular regions inside the esophagus (**Figure 2**). Occasional cases of PD can be subclinical, even though the disease may originate by egg transmission. Mortality usually peaks during the second or third week of life. In these situations, the birds exhibit lassitude and

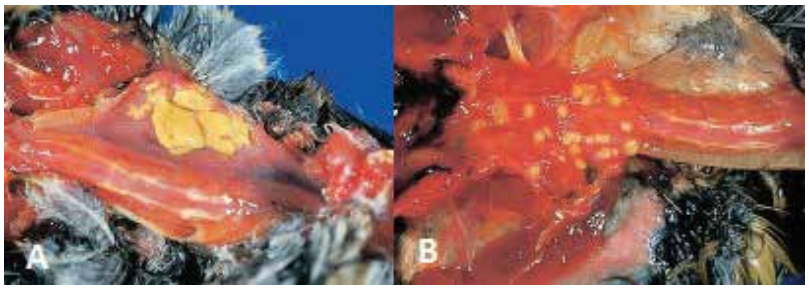

Figure 2. (A) Diffuse plaque-like nodules. (B) discrete, nodular regions inside the esophagus [1].

an inclination to huddle together under heaters, having droopy wings and distorted body appearance. Labored breathing or gasping may be observed as a result of extensive involvement of the lungs due to PD. Survivors may be greatly retarded in their growth and appear underdeveloped and poorly feathered. In certain instances, a relatively high incidence of infection in the joints, which can produce lameness and obvious joint enlargement, can occur in juveniles. In acute to subacute cases, there is multifocal necrosis of hepatocytes. In chronic cases, especially in cases in which there are large nodules in the heart, the liver will have chronic passive congestion with interstitial fibrosis. The spleen may have severe congestion or fibrin exudation of vascular sinuses in acute stages and severe hyperplasia of the mononuclear phagocytic system cells in later stages. The ceca in young chicks may have extensive necrosis of the mucosa and submucosa, with an accumulation of necrotic debris mixed with fibrin and heterophils in the lumen [1].

2.2.3. Diagnosis

The clinical signs and lesions produced by PD or FT are not pathognomonic. Other *Salmonella* infections may produce similar lesions in the liver, spleen, and intestine, which cannot be distinguished grossly or microscopically from those produced by PD or FT. Aspergillus or other fungi may produce similar lesions in the lungs. *S*. Pullorum and *S*. Gallinarum can localize in major joints and tendon sheaths of chicks. Such signs and lesions resemble those produced by organisms such as *Mycoplasma synoviae*, *Staphylococcus aureus*, *Pasteurella multocida*, or *Erysipelothrix rhusiopathiae*. Local infections with *S*. Pullorum and *S*. Gallinarum in adult carriers, particularly of the ovary, may appear identical to those produced by other bacterial infections such as coliforms, staphylococci, *P. multocida*, streptococci, and other *Salmonellae*. Birds of any age may be infected with *S*. Pullorum or *S*. Gallinarum but fail to show grossly discernible lesions. A definitive diagnosis of PD and FT can be made only following the isolation and identification of *S*. Pullorum and *S*. Gallinarum, respectively [2]. The bacteria can be identified by molecular procedures also [16, 17].

2.2.4. Treatment and prevention

The disinfection must be done daily with hypochlorite-type solutions in feeding points of free-ranging birds in consequence of sudden outbreaks. Reasonably effective prophylactic and therapeutic drugs for poultry production have been developed against PD and FT. Treatment is

generally neither feasible nor desired. Sulfonamides, in particular, frequently suppress growth and may interfere with feed and water intake and egg production. Sulfonamides that have been used in the treatment of PD and FT include sulfadiazine, sulfamerazine, sulfathiazole, sulfamethazine, and sulfaquinoxaline. Transmission through shell penetration and feed contamination by *S*. Pullorum has been reported can be partially prevented only by formaldehyde fumigation [18].

2.3. Avian botulism

Synonyms for botulism are "Limberneck" and "Western duck sickness." Free-ranging and confinement-reared poultry and feral birds can be affected. Most avian cases are caused by *C. botulinum* type C or mosaic type C/D, although outbreaks due to other toxin types have been described [19, 20]. Nonhuman primates, however, have succumbed to type C botulism [2].

2.3.1. Transmission

Laboratory examinations exhibited that decomposing flesh contaminated with botulinum cells or spores can support the production of high amounts of toxin. Waterbirds and different vertebrates unintentionally digest bacteria spores while feeding and convey them in their tissues. Upon death, the subsequent anaerobic condition and rich protein source of cadaver are ideal for vegetation of spores and toxin formation [21, 22].

Avian type C botulism can be caused by ingestion of preformed toxin or by toxico-infection. More than 2000 minimum lethal doses (MLD) of type C toxin/gram of carcass tissue of intoxicated birds have been found. Birds scavenging such carcasses can readily obtain enough toxins to become affected. Fly-blown carcasses may have maggots containing 104–105 MLD of neurotoxin. In aquatic environments, small crustaceans and insect larvae may contain *C. botulinum* in their gut. If large numbers die due to oxygen depletion, toxin can be produced within these invertebrates. Ingestion of toxin-laden invertebrates has been proposed as the cause of type C botulism in ducks [23].

2.3.2. Clinical aspects

Clinical signs of botulism in chickens, turkeys, pheasants, and ducks are similar. In chickens, flaccid paralysis of legs, wings, neck, and eyelids are predominant features of the disease. Wings droop when paralyzed. Limberneck, the original and common name for botulism, precisely describes the paralysis of the neck. Because of eyelid paralysis, birds appear comatose and may seem dead. Gasping has been reported when birds are handled. Death results from cardiac and respiratory failure. Affected chickens have ruffled feathers, which may fall out with handling. Quivering of certain feather tracts has been observed. Broiler chickens showing signs of botulism may have diarrhea with excess urates in the loose droppings [2].

2.3.3. Diagnosis

Isolation of *C. botulinum* is of little help in diagnosis. However, detection and isolation of the organism in clinical samples from animals or feed or environmental samples may prove

useful in epidemiologic studies. The organism can be cultivated anaerobically at 30–42°C in cooked meat medium or trypticase-peptone-glucose-yeast (TPGY) medium [19, 24]. After 2 days of incubation, the sample can be analyzed for the presence of the neurotoxin or the neurotoxin gene. Real-time PCR assays have been developed for detection of the BoNT gene of types A–F [25, 26].

2.3.4. Treatment and prevention

Antitoxins can be applied to sick captive birds in early stage of the malady. The most widely recognized strategy for preventing disease is by evacuation of cadavers before development of flies in order to counteract distribution of toxin to different bird populations. In problem areas, removal of contaminated litter and thorough disinfection using calcium hypochlorite or formalin may help reduce spore numbers in the environment. Disinfection of areas around poultry houses has been recommended because spores may be located in the soil outside of the poultry facility and can be transported back into houses. Fly control may be another means of reducing the risk of toxic maggots in the environment. Two cases of type C botulism were reported in commercial broilers and were associated with elevated intake of iron from water and feed sources. However, the relationship between iron and toxicoinfectious type C botulism needs to be experimentally confirmed [27].

2.4. Avian tuberculosis

Mycobacterium avium complex (MAC) which along with *M. genavense* is responsible for most cases of avian mycobacteriosis. Less generally, tuberculosis in fowls is caused by *M. intracellulare*, *M. fortuitum*, *M. tuberculosis*, *M. gordonae*, and *M. nonchromogenicum* [28, 29].

2.4.1. Transmission

Nontuberculous mycobacteria, including MAC, are ubiquitous in the environment and are commonly isolated from soil and water. Humans become infected by ingestion or inhalation of MAC organisms from the environment. Infected animals and birds commonly shed mycobacteria in their feces, but are not considered to be an important source of human infections. The contaminated environment, especially soil and litter, is the most important source for the transmission of the bacilli to uninfected animals. The longer the premises have been occupied by infected birds and the more concentrated the poultry population, the more prevalent the infection is likely to be [30, 31].

2.4.2. Clinical aspects

The liver (**Figure 3A**) generally contains similar nodules, but intestines (**Figure 3B**), spleen (**Figure 3C**), and lung can present such nodules. Aggregations of these nodules may appear as firm, fleshy, grape-like clusters. Abscesses and nodular growths (**Figure 4**) have been reported on the skin of birds in the same locations where pox lesions are frequently seen around the eyes, at the wing joints, on the legs, side of the face, and base of the beak [1].

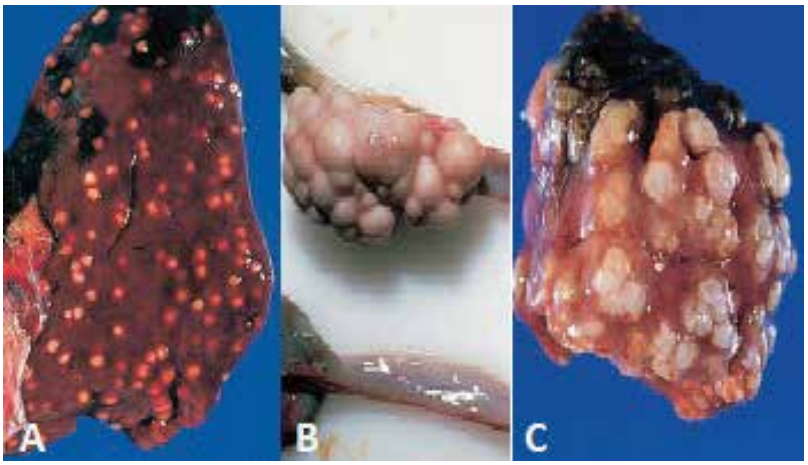

Figure 3. The raised, firm nodules in these organs are typical lesions of avian tuberculosis. (A) Liver; (B) intestine; and (C) spleen [1].

Figure 4. Nodular lesion, which was caused by avian tuberculosis, on the skin of a canvasback [1].

2.4.3. Diagnosis

Demonstration of acid-fast bacilli in smears or histologic sections of liver, spleen, or other organs strengthens the diagnosis and is sufficient for most diagnostic cases. In live, suspected infected birds, fecal smears for culture, staining, and/or PCR may be attempted but these tests are not reliable due to intermittent or no fecal shedding of bacilli [32]. Fecal positivity increases as the disease course progresses [33]. PCR has been used to detect mycobacteria, including *M. avium* and *M. genavense,* in formalin-fixed tissue, which may further aid diagnostic considerations [34]. PCR may also be used to detect mycobacteria in organ samples as well as further differentiate isolates [35].

2.4.4. Treatment and prevention

Control of avian tuberculosis in free-living birds is not viewed as plausible on the field since the bacteria perseveres in the field, is resistant to numerous tuberculosis medications and detergents, and it is hard to isolate from sick birds. Treatment with antituberculosis drugs is impractical; however, combinations of isoniazid (30 mg/kg), ethambutol (30 mg/kg), and rifampicin (45 mg/kg) may be applied to captive birds. The recommended duration of therapy is 18 months, provided that there were no adverse side effects [36].

2.5. Avian chlamydiosis

Chlamydiosis alludes to an infection with microorganisms of the genus *Chlamydia* sp., which is a microbe that lives within animal cells. *Chlamydia psittaci* is the species generally associated with this disease in birds. Avian chlamydiosis is caused by the bacterium *Chlamydia psittaci*. Avian chlamydiosis is a respiratory disease, usually systemic and occasionally fatal. *Chlamydia psittaci* can be transmitted to humans. The disease in birds and humans originally was called psittacosis or parrot fever because it was first recognized in psittacine birds and in humans associated with psittacine birds [3].

2.5.1. Transmission

Infection usually occurs with the inhalation of bacteria that are released into the air from birds' feather patches. Contagion also develops via beak-to-beak feeding from mother bird to juveniles. Since the chlamydia is not completely eliminated, reinfection and damage to host tissues continue. In persistent infections, the inflammatory response increases, chronic inflammatory advances continue in the focal areas, and the etiologic agent is shed from the damaged tissues. Vertical transmission has been demonstrated in ducks, parakeets, seagulls, and snow geese [37, 38].

2.5.2. Clinical aspects

Fowls frequently end up noticeably feeble, quit eating, and create purulent (liquid containing discharge) releases of the eyes and nares. Birds have a tendency to wind up plainly still, stay in a settled position, and crouched up with unsettled feathers [39]. Signs of chlamydiosis in turkeys infected with virulent strains are cachexia, anorexia, elevated body temperature, conjunctivitis, and respiratory distress. Diseased birds excrete yellow-green, gelatinous droppings. Egg production of severely affected hens declines rapidly to 10–20% and may temporarily cease or remain at a very low rate until complete recovery. Disease signs in a flock infected with strains of low virulence are usually anorexia and loose, green droppings in some birds, with less effect on egg production. In overwhelming infections with virulent strains, lungs show diffuse congestion, and the pleural cavity may contain fibrinous exudate. In fatal cases, a dark transudate may fill the thoracic cavity. The pericardial membrane is thickened, congested, and coated with fibrinous exudate. The liver is enlarged and discolored and may be coated with thick fibrin in birds that survive infection with a strain of low virulence, the

lungs may not be seriously affected. However, multiplication of organisms on the epicardium may result in the formation of one or more fibrin plaques [3].

2.5.3. Diagnosis

The recommended medium for chlamydiae consists of SPG buffer. For isolation, the following samples should be preferably collected: pharyngeal/choanal slit swabs in live birds. Cloacal swabs or fresh feces are less optimal because chlamydial shedding is intermittent. In dead birds, lungs, spleen, and liver can be sampled. The specimen should be stored at −80°C if it will not be sent to laboratory immediately [40]. This methodology would be the same or comparative for migratory birds.

2.5.4. Treatment and prevention

Chlamydiosis treatment for poultry has not changed over the years. The drug of choice varies from country to country. Among tetracylines, which are the drugs of choice, chlortetracycline and doxycycline are most often used. Enrofloxacin (fluoroquinolone antibiotic) can also be used. Contact with potential reservoirs or vectors such as pet birds, rodents, arthropods, and wild and feral birds should also be prevented. General sanitation must be practiced diligently. Movement of people should be restricted so that visitors do not have free access to premises holding birds. This is easier to accomplish if birds are confined in houses and if the "all-in-all-out" principle is used on the farm [41].

2.6. Mycoplasmosis

Mycoplasma phylogeny and taxonomy continue to be re-examined by the application of molecular tools such as DNADNA hybridization DNA sequence analysis of the 16S rRNA gene, 16S rRNA PCR and denaturing gradient gel electrophoresis, and tRNA gene PCR. The complete genome sequence has been determined for MG strains Rlow, Rhigh, and F [42], and a database dedicated to the comparative genomics of Mollicutes, including MG, has been established [3].

2.6.1. Transmission

Experimental intra-crop inoculation of house finches resulted in infection, disease, and a serological response [43]. *M. gallisepticum* seldom survives for more than a few days outside of a host, so clinical or subclinical carrier birds are essential to the epidemiology of MG diseases. However, additional transmission and more widespread disease outbreaks may occur via fomites-contaminated airborne dust and droplets, or feathers, coupled with suboptimal biosecurity and personnel practices. In house finches, experimentally infected birds were demonstrated to indirectly infect naive birds through contacted bird feeders and support the possible transmission of MG by fomites. Experimental research show that transmission happens between sick grown-up house finches and their posterity [2]. Avian mycoplasmosis can happen whenever of the year however for the most part a higher commonness has in the winter [44, 45].

2.6.2. Clinical aspects

In house finches, MG causes mild-to-severe eyelid swelling, conjunctivitis, and watery discharge from one or both eyes as well as nares. Air sacs frequently contain caseous exudate that may be focal, multifocal, or diffused. Conjunctivitis with periocular swelling and inflammation are characteristics of MG in house finches and other songbirds [46].

2.6.3. Diagnosis

The gold standard for MG diagnosis is isolation and identification of the organism. In some cases, the isolation of MG in culture is impaired by the overgrowth of saprophytic mycoplasmas that inhabit the upper respiratory tract of avian species and contaminant bacteria and fungi that may not be successfully inhibited by mycoplasma-selective media. To culture MG, fluid sinus exudate should be inoculated directly to mycoplasma broth and/or agar media [47]. Swabs can also be taken from the trachea or choanal cleft (palatine fissure) for MG culture. *M. gallisepticum* may also be present in oviducts [48] and has been isolated from the cloaca of turkeys and chickens [49]. Detection of MG using DNA and ribosomal RNA gene probes has been described, but for most applications these methods have been superseded by various PCR-based procedures that are relatively less complex and more rapid, sensitive, and specific. Multiplex PCR protocols have been described, which allow for the simultaneous detection of different organisms [3]. A test based on amplification of the 16S rRNA gene with "Mycoplasma specific" primers and separation of the PCR product by denaturing gradient gel electrophoresis has been described [50]. Detection of MG-specific DNA by PCR has become the frontline approach at diagnostic and institutional laboratories using commercial conventional PCR kits or established protocols [51]. More rapid and highly specific detection by quantitative PCR methods has also been described [3]. Detection of MG DNA by PCR compared to isolation of the organism in culture provides a negative or positive result in hours instead of days, does not rely on the presence of viable organisms, and is not susceptible to saprophytic mycoplasmas and microbial contaminants. However, culture and isolation of MG organisms remain essential for further studies such as experimental infections, pathogenicity studies, and intra-species (strain) identification. An inoculated mycoplasma broth can be divided and processed for both culture and PCR. When culture and isolation of viable organisms are not necessary or possible, FTA filter paper may be used for the inactivation and storage of MG suspensions or field specimens prior to PCR or other DNA-dependent assays [52]. A positive serologic test together with history and clinical signs typical of MG disease allows a presumptive diagnosis pending isolation and/or identification of the organisms [3].

2.6.4. Treatment and prevention

M. gallisepticum is inherently resistant to penicillins or other antibiotics, which act by inhibiting cell wall biosynthesis [53]. Tylosin and tilmicosin are reported to be effective in house finches [54, 55]. Close perception of birds and prompt detailing of outbreaks to experts will give the chance to early intercession in view of convenient determination and for starting a proper disease control technique particular to the area and populace included [3].

2.7. Borreliosis

Borrelia sp. is highly motile, helical spirochetes that stain well with aniline dyes, hematologic stains, and silver impregnation. Spirochetes can be readily identified in wet smears of blood or tissues by dark-field or phase microscopy [3]. *Borrelia anserina* causes nonrelapsing, tick-borne spirochetosis in avian species, including chickens, turkeys, pheasants, geese, and ducks, in tropical and subtropical areas. Occasional outbreaks have been identified in the southwestern United States in chickens, turkeys, and pheasants [56]. Extensively reared free-range flocks are more likely to be affected than confined flocks, and indigenous breeds of chickens are generally more resistant than exotic breeds. The disease is usually an acute septicemia characterized by high morbidity and mortality, but may be mild if birds are infected with low-virulent strains [57]. Birds can also develop asymptomatic infections with *B. burgdorferi*, the cause of Lyme disease in people, and serve as hosts for ticks capable of spreading the spirochete to mammals. Wild turkeys are also hosts for *B. lonestari* and *B. miyamotoi*. No clinical disease has been recognized in birds infected with Borrelia species other than *B. anserina*. Occurrence of spirochetosis corresponds with the distribution of fowl ticks in the genus Argas, which serve as both the reservoir and primary vector. Attempts to transmit *B. anserina* with the tick *Amblyomma cajennense* were unsuccessful. In addition to ticks and other biting arthropods (mosquitoes, mites), infection can result from cannibalism; scavenging on carcasses; multiple use of syringes and needles; or ingestion of infective blood, droppings, or infected ticks. Virulent strains are capable of penetrating unbroken skin. *B. anserina* is not resistant outside of the host. Recovered birds are not carriers; organisms disappear from tissues at or shortly after they disappear from the circulation. Birds infected with virulent strains of *B. anserina* are visibly sick, with cyanosis or pallor of the comb and wattles, ruffled feathers, dehydration, inactivity, and anorexia. A marked elevation in body temperature begins shortly after infection accompanied by rapid weight loss. Affected birds pass fluid green droppings containing excess bile and urates and have increased water consumption. Late in the disease, birds develop paresis or paralysis, become anemic, and are somnolent to comatose. Body temperatures are subnormal just prior to death. Birds recovering from the disease are often emaciated and have temporary residual weakness or paralysis. Infection with low-virulent strains may be mild or inapparent. Marked enlargement and mottling of the spleen is typical of spirochetosis but may not be evident when birds are infected with low-virulent strains or early in the disease [58]. Livers are often enlarged and contain small hemorrhages, pale foci, or marginal infarcts. Kidneys are swollen and pale with excess urates distending the ureters. Green, mucoid intestinal contents are usually present, and often there are variable amounts of hemorrhage, especially at the proventriculus-ventriculus junction. Fibrinous pericarditis occurs infrequently. Extensive hemorrhage and muscle necrosis occur in naturally infected pheasants. Splenic lesions result from macrophage and lymphoid hyperplasia, erythrophagocytosis, and hemosiderin deposition. Multifocal necrosis and hyalinization of white pulp and/or extensive hemorrhage may be present in some birds. The liver is congested with increased periportal infiltrates of mixed lymphocytes, hemocytoblasts, and phagocytic cells with vacuolated cytoplasm. Erythrophagocytosis and hemosiderin are seen in Kupffer cells. Extramedullary hematopoiesis may be present. Lymphoplasmacytic infiltrates occur in kidneys and intestinal lamina propria of some birds. Occasionally, there is mild-to-moderate

lymphocytic meningoencephalitis. Spirochetosis can be tentatively diagnosed by finding characteristic lesions in birds with signs consistent with the disease. Diagnosis is confirmed by demonstrating *B. anserina* in blood or tissue sections. In chickens exposed to ticks (*Argas miniatus*) infected with *B. anserina*, spirochetes were found in blood smears prepared from the exposed birds between day 5 and day 12 post exposure, with the peak number of spirochetemic birds occurring between days 7 and 9. Spirochetes were not found in blood smears from any of the exposed birds after day 13 [59].

Borrelia sp. cannot be cultured on routine bacteriologic media but will grow in chick embryos following yolk sac inoculation or in susceptible young chicks or poults. It can be grown in liquid medium but loses virulence [60]. Bursectomy or dexamethasone treatment of chicks may be necessary to detect low-virulent strains. Isolates are usually maintained in ticks, day-old chicks, and chicken or turkey embryos or by cryopreservation (−70°C or in liquid nitrogen) in 5% glycerol or dimethylsulfoxide added to infective blood [58]. Several serologic methods have been used to detect antibodies in immune birds. Spirochetal antibodies occur in yolk of eggs from immune hens [60]. Arsenicals and most antibiotics, including penicillin, chloramphenicol, kanamycin, streptomycin, tylosin, and tetracyclines, are effective in treating infected birds. Intramuscular injections of penicillin at 20,000 IU/bird given three times in 24 h or 20 mg oxytetracycline given daily for 2 days represent current treatment regimens. Active immunity follows recovery or immunization. Immunity is serotype-specific; infection with other *B. anserina* serotypes can occur in recovered or vaccinated birds. An autogenous or polyvalent vaccine containing multiple serotypes may be necessary to provide full protection. Controlled infection followed by antibiotic treatment 3 days later has also been used to induce active immunity. Passive maternal immunity provides protection for 5–6 weeks. Preventing fowl tick infestation is the best method to control spirochetosis in endemic areas. Young chickens in dense poultry areas during the summer are more likely to be infested with fowl ticks. Adult ticks can remain alive without feeding and carry the spirochete for as long as 3 years [61].

2.8. Tularemia

Tularemia is essentially a malady of mammals, yet normal diseases by *Francisella tularensis* have caused deaths of ruffed grouse and other grouse species. An assortment of avian animal categories has been observed to be vulnerable to contamination because of serological studies that have identified counter antibody against tularemia, test concentrates to decide susceptibility, and by reason for death evaluations for birds submitted for necropsy. Ticks are responsible of disease outbreaks in birds [1].

There are no reports of the clinical course in normally infected birds, and clinical signs in wild animals are inadequately archived, principally because of the acute character of tularemia in many species [2].

The bacteria can also be identified in culture or specimens by hybridization with probes specific to the 16S rRNA gene of *F. tularensis*, and types A and B can be distinguished by this method [62].

3. Conclusion

Avian cholera has become the most important emerging bacterial disease of waterbirds and geese. The vast majority of the geographic extension and expanded recurrence of outbreaks of avian cholera has happened since 1970. The high prevalence of avian tuberculosis disease that has happened since 1982 has challenged the survival of crane populations. Salmonellosis has turned into a noteworthy source of mortality at poultry breeders all through the world, and mycoplasmosis in house finches has turned into the most quickly spreading infection at any point found in free living birds. Avian botulism has likewise extended in geographic circulation and has increased expanded noticeable prominence as a disease of waterbirds. It is, without a doubt, the most critical malady of waterbirds around the world. The geographic expansion of avian botulism has mostly occurred during the past quarter century. Of the diseases addressed in this section, chlamydiosis and tick-borne pathogens pose the greatest risk to public health and other livestock, especially poultry production. Avian tuberculosis can be a significant risk for humans who are immunocompromised. Salmonellosis is a common, but seldom fatal, human infection that can be acquired from infected wild birds. Convenient and exact identification of mortality is expected to appropriately guide disease control procedures. Keeping in mind the main scope to precisely identify which diseases are emerging and zoonotic in the field, specimen should be sent to avian research laboratories, which know about the wide assortment of conceivable diseases that may infect wild birds and domestic livestock.

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Chapter 4

Application of Attitude Theory in Wildlife Management: A Critical Review of Concepts and Processes

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Additional information is available at the end of the chapter

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Abstract

Consistency between people's attitudes and their subsequent behaviors is affected by different factors. This chapter reviewed relevant studies of attitudes and knowledge from applied fields of study. The authors focused on how prior relevant knowledge about an attitude object affects consistency between people's attitudes and their behaviors. Attitudes held by people who possess high levels of knowledge of an issue tend to be better predictors of subsequent behaviors than attitudes accompanied by low levels of knowledge. There is evidence that prior knowledge moderates the relationship between attitudes and behaviors by two processes: (1) accessibility and (2) stability, or strength. Implications of knowledge about a hypothetical predator restoration are examined using an information-processing model from social psychology. Understanding the effects of knowledge for information processing is useful to wildlife managers and communications experts who attempt to influence, persuade, and educate public stakeholders.

Keywords: attitude-behavior consistency, communication, wildlife education, information processing, moderation effects, prior relevant knowledge, social psychology

1. Introduction

Traditional attitude research in social psychology has investigated how people form overall evaluative judgments (i.e., attitudes) toward an array of entities and issues. When applied correctly, the attitude concept can be useful to researchers, studying the human cognitive and behavioral components of wildlife management issues [1–8]. The relationship between

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attitudes and people's actions is an important research topic, but why should we study attitudes if we are ultimately concerned with behaviors? If we accept (and are guided by) the assumption that cognitive structures such as beliefs, evaluations, and information in memory play a key role in determining behavior, the attitude concept becomes an important tool for understanding, predicting, and possibly modifying behaviors to better manage relationships between people and wildlife. Studying attitudes can allow access into the human mind, which is necessary to understand human behaviors, especially when we view people as rational actors.

The amount of knowledge possessed by individuals about attitude issues can be studied as a variable that affects the relationship between attitudes and behaviors [9–12]. Examining the concept of moderation, or third variable influence, is one approach to understanding potential effects of knowledge on attitude-behavior relationships. Moderators are third variables that have a long tradition in social science research [13]. Moderators are external variables (e.g., individual differences such as gender or level of education) that affect the strength and direction of the relationship between an independent variable (e.g., attitude) and a dependent variable such as intentions to act [2, 9, 13–15].

This chapter is focused on the extent to which prior knowledge about the attitude object affects or moderates attitude-behavior relationships in the context of wildlife management issues. Our objectives are to (1) discuss conceptual definitions of attitude, knowledge, and attitude-behavior consistency; (2) review findings from past moderation research on the effects of knowledge on the relationship between attitudes and behaviors; and (3) describe a linear information-based model of cognitive processing [16] to explore the implications of knowledge for attitude and behavior change. We present the model in the context of predator restoration in a national forest. Implications of knowledge are discussed relative to wildlife education programs designed to inform the public and influence attitudes and behaviors.

2. Concepts

2.1. Attitudes

Eagly and Chaiken [17] define attitude, as a psychological tendency (i.e., a state internal to a person) that is expressed by evaluating a particular object with some degree of favor or disfavor. An attitude must be toward something (e.g., an entity, an object, an issue, a person, etc.). In social psychology, entities that are evaluated are called attitude objects [17]. Individuals may hold attitudes toward a wide variety of objects, including social issues, wildlife issues, human groups, policies, specific individuals, and physical objects [18].

People's attitudes include (1) affect, or feelings and emotions; (2) cognition, or beliefs and thoughts; (3) behaviors, or actions; or (4) some combination of these elements [17, 19, 20]. It has been debated whether a behavioral component should be included in the definition of attitude because researchers tend not to use behavior in their operational measures of attitudes [21].

This is particularly the case when the research objective is to predict behaviors. The concept of attitude is often confusing because of its multiple interrelated components. An attitude is the association in memory between an object and an evaluation [22]. The core of the attitude concept is the idea of evaluation [17, 20, 23].

2.2. The attitude-behavior relationship

Attitude-behavior consistency occurs when a person's behavior is consistent with his or her attitudes. People who hold positive attitudes should engage in behaviors which mirror, enhance, or support the object, and people with negative attitudes should engage in behaviors that avoid or oppose the object [17]. Predicting and explaining human behaviors are important practical goals for attitude research [20, 24]. Social scientists do not, however, consistently find substantial correlations between attitudes and behaviors, possibly due to limitations involved with measurement of the relationship [17]. Correlations between attitude and behavior measures often are not significant if these are not measured at similar levels of specificity, or correspondence [25–29]. Inconsistent attitude-behavior correlations can occur due to the influence of moderator variables external to the attitude-behavior relationship such as differences in social or economic characteristics [8, 26]. Research suggests that attitudes can determine behavior when they are based on knowledge that a person has about the issue [20].

2.3. Knowledge

Knowledge is the amount of information about an object, in memory, and associated with a person's attitude toward it as measured by knowledge listings, self-reports, and quizzes [30]. Knowledge must be relevant to the wildlife issue under study. According to Krosnick et al., level of knowledge can differentiate stable and strong attitudes from unstable and weak attitudes [30]. We review knowledge as a moderator, because knowledge about the attitude object has been shown to predict the extent to which people will act in accordance with their attitudes [10]. Learning about wildlife issues creates knowledge about wildlife and can affect education and communication about wildlife.

We found three distinct measures of knowledge in the research literature. These included: (1) thought listings [12, 31–33], (2) self-reports [10, 12, 33], and (3) objective quiz questions [3, 11, 15, 34]. Thought listings involve giving subjects a brief period to recall and list characteristics and facts they believe to be true about the issue and previous experiences they have had with the issue [35]. Self-reports involve asking people how knowledgeable or familiar they feel they are about an issue [12, 33, 35]. Researchers should not assume these two measures capture the same concept. Knowledge measured by thought listings, for instance, has been found to be weakly related to self-reported knowledge [30]. Quiz questions, which can be open-ended, multiple-choice, or true and false, measure accuracy of subjects' factual or objective knowledge about an attitude object or issue [35]. Accuracy of information (i.e., measured by quizzes) and amount of information (i.e., measured by thought listings) are most likely distinct dimensions of knowledge. Davidson indicated that both amount and accuracy of knowledge contribute to attitude strength, but data have demonstrated weak to moderate

relationships between these dimensions [36]. Furthermore, a person's objective factual knowledge about an attitude object is distinct from his/her subjective beliefs about it [16].

Moderation researchers should pay close attention to ensure that the intended type of knowledge is actually measured. We recommend measuring more than one type of knowledge, which allows for comparisons. Teel et al. measured two types of knowledge in their experiment of biased processing of natural resource information [33]. Alternatively, composite measures of knowledge such as Wood's measure of working knowledge should prove useful for testing moderator effects [12].

3. Moderating effects of knowledge

Researchers believe there are two processes by which knowledge about an attitude object can moderate the relationship between attitudes and behavior, namely accessibility and stability [10, 17, 36]. Attitude accessibility refers to the likelihood that the attitude will be activated automatically, or effortlessly and uncontrollably, from memory when the object is encountered [18]. More accessible attitudes are more highly correlated with behaviors and intentions than those that are not accessible [7, 17, 18, 37]. Attitudes accompanied by knowledge and experience are more likely to be readily accessed from memory than attitudes unaccompanied by knowledge and experience. Therefore, attitudes supported by knowledge tend to guide behaviors. In the accessibility process, high levels of knowledge tend to increase attitude accessibility, and attitude accessibility tends to enhance attitude-behavior consistency [14, 18]. Stability relates to two features of strong attitudes: resistance to change and persistence over time [16]. In the stability process, high levels of relevant knowledge increase attitude strength, and strong attitudes tend to guide behaviors more than weak attitudes because strong attitudes are resistant to change in the face of new information [36]. For a detailed explanation of attitude strength, see [38].

3.1. Accessibility

People with relatively high access to knowledge tend to act in a manner consistent with their attitudes [12, 32]. Wood et al. defined working knowledge as beliefs and prior experiences that spontaneously come to mind when a person is confronted with an attitude object [16]. Working knowledge was measured using two tasks [32]. First, subjects listed facts and characteristics they believed to be true about environmental preservation (i.e., the attitude object). Secondly, subjects listed past behaviors they had engaged in related to environmental preservation. Subjects were given a two-minute time limit to complete each task. This was done to ensure measurement of access to the most salient knowledge, not subjects' entire storehouse of relevant knowledge [12, 16]. Two weeks later, subjects were asked to sign and circulate pro-environmental petitions and participate in a recycling project. Subjects' responses to the petition requests and the amount of time they participated in the recycling project served as the behavioral measure. Subjects with relatively high levels of working knowledge tended to act in a manner congruent with their attitudes [32]. Subjects originally in favor

of environmental preservation recycled, signed, and agreed to circulate petitions, whereas subjects with less favorable attitudes were not as likely to do so. Subjects with relatively low levels of knowledge about environmental preservation demonstrated little attitude-behavior consistency [32]. This work supports a moderation effect for knowledge about an attitude object on attitude-behavior consistency. More knowledge resulted in greater behavioral prediction from attitudes.

Although Kallgren and Wood did not explicitly test the accessibility process of moderation, by adding the variable prior experience to their operational measure of working knowledge, they may have indirectly initiated the accessibility process [32]. The argument behind the accessibility process is that direct prior experience (versus indirect or no experience) with an attitude object increases the likelihood that an attitude will be accessed upon encountering an object [7, 14, 22]. Accessible, prior, and direct experience with an attitude object tends to be remembered by people, while they think about how to behave toward (or respond to messages about) an object or issue [14]. Direct experience provides information that is relevant to attitudes and can be accessed from memory to increase attitude-behavior consistency. In contrast, when a person has had only indirect experience with an attitude object, highly accessible attitudes do not develop, and the subsequent effect on behavior is relatively small [14].

Wood compared subjects having high access to knowledge about environmental preservation with those having little access to knowledge regarding subjects' susceptibility to persuasion. Subjects read a counter attitudinal message before completing the opinion questionnaire [12]. Subjects with little access to knowledge were more likely to change their attitudes to be more consistent with the message than subjects with high access to knowledge [12]. Subjects then completed a second questionnaire to elicit thoughts about the counter attitudinal message. It was concluded subjects with access to knowledge about environmental preservation produced arguments counter to the persuasive message. People who produced counter arguments tended toward less attitude change [12]. These findings suggested that attitude change was a function of retrieval of attitude-relevant information (i.e., counter arguments), rather than general access to working knowledge.

Working knowledge indirectly increased attitude-behavior consistency, possibly by increasing attitude accessibility [12]. Working knowledge, conversely, may have directly moderated attitude-behavior consistency via the stability route. Attitudes based on relatively greater knowledge are resistant to change upon encountering new information contrary to a person's attitude [36]. This alternative hypothesis highlights the need for research that more specifically investigates processes by which knowledge affects relationships between attitudes and behavior.

3.2. Stability

Researchers examined the effects of amount of information and beliefs about an attitude object (i.e., subjective knowledge) on intention-behavior and attitude-behavior consistency independent of prior experience with the attitude object. This approach is consistent with the definition of knowledge used in this chapter (i.e., the amount of information about an

object or issue, in memory, that accompanies a person's attitude). This conceptual definition of knowledge is different from the concept of working knowledge as used by Wood et al., which includes amount of direct experience with an attitude object or issue [16]. Future research could examine the extent of overlap between the two knowledge concepts because part of a person's overall relevant knowledge stored in memory could have been acquired through direct experience with the issue.

In a study regarding voting for political candidates, Davidson et al. investigated people's knowledge about candidates as a possible determinant of congruency between their intentions to vote and actual voting behaviors [36]. Knowledge was measured by asking subjects to list all the information and beliefs they possessed about each candidate. They found a significant interaction between intention and knowledge (i.e., moderation effect); as knowledge relevant to the behavior increased, so did the correlation between intention and behavior. Knowledge moderated intention-behavior consistency independent of prior experience and attitude certainty, which are two other established determinants of attitude-behavior consistency [36].

Two replications investigated potential effects of knowledge in the context of voting for social policy initiatives and having an influenza vaccination [10]. Procedures were similar to those used in the previous (i.e., political candidate) study except knowledge about the attitude object was measured using self-reports instead of thought listings. Results showed knowledge increased attitude/intention-behavior consistency. Davidson et al. concluded strong attitudes (i.e., those capable of guiding behaviors) are reinforced by greater knowledge, and attitudes lacking supportive knowledge are less likely to guide subsequent behaviors [10]. Based on the idea that strong attitudes are stable (i.e., resistant to change and persistent over time), knowledge appeared to moderate attitude-behavior consistency via the stability process.

Knowledge can indirectly affect attitude-behavior consistency by moderating the effects of thinking about reasons underlying attitudes. Researchers found analyzing underlying reasons for attitudes reduced the correlation between attitudes toward a political candidate and number of fliers that people were willing to distribute for that candidate for subjects with low knowledge about the candidate [11]. They used a quiz with 15 questions about candidates and issues to measure subjects' objective, or factual, knowledge. Subjects were then assigned to high or low knowledge groups via a median split of scores on the knowledge test [11]. The main finding was that thinking about reasons for attitudes lowered attitude-behavior consistency for subjects with low objective knowledge, but not for subjects who possessed high objective knowledge. According to the stability hypothesis, attitudes based on greater knowledge are more likely to withstand effects of new information produced by thinking about underlying reasons for attitudes than attitudes based on lower levels of knowledge [36].

Tarrant et al. studied moderating effects of objective knowledge about wildlife on the relationship between environmental values and attitudes toward wildlife protection (i.e., value-attitude consistency) [15]. Consistent with methodology in the Wilson et al. study, objective knowledge was measured using true and false quizzes [11]. Subjects were divided into high and low knowledge categories based on a median split of knowledge scores. A significant moderation effect was found for factual wildlife knowledge on the value-attitude relationship

for two of the four groups under study [15]. In the hunter and angler groups, higher levels of knowledge were consistently associated with value-attitude consistency. For the combined user-group (i.e., those who both bird watched and hunted or fished) higher knowledge levels significantly decreased value-attitude consistency. Perhaps the combined group relied on knowledge to form attitudes toward wildlife preservation instead of underlying values to reduce cognitive dissonance; this condition could be produced by internal conflict involved with thinking about competing values associated with consumptive and non-consumptive activities [15]. The negative finding for the combined group suggests that generalizations about direction of knowledge effects for value-attitude consistency should be made with caution. Further investigation of the influence of both objective and subjective knowledge on the value-attitude relationship should be addressed in future research.

The studies reviewed above indicate that knowledge about an attitude object tends to function as a moderator in a cognitive hierarchy [39] involving values, attitudes, intentions, and behaviors. These studies provide support for the hypothesis that attitudes based on greater amounts of knowledge are stronger and tend to guide subsequent behavior [36]. These findings support the stability hypothesis, and objective factual knowledge was found to moderate cognitive consistency [15].

4. Implications for wildlife education and communication

Persuasive communication involves use of messages to influence attitudes and behaviors, and its primary goal is to sway the hearts and minds of the audience; through a process of reasoning, the message exerts its influence by force of its arguments [40]. Presumably, it is the information, presented as arguments in the messages, that influences attitudes and behavior. When people encounter new information contained in a persuasive, or educational, message about a certain natural resource topic, they typically will either change their attitudes to be consistent with the message or maintain (i.e., reinforce) their initial attitudes toward the attitude object. What occurs cognitively between encountering the message and changing or maintaining attitudes is a complex process referred to by psychologists as information processing. A persuasive message can be viewed as incoming information, which requires active processing in some manner by the recipient of the message. How knowledgeable versus unknowledgeable people process incoming information is important for understanding the implications of prior, issue-relevant knowledge for wildlife communication and education.

Attitude change or stability often are outcomes of the influence of knowledge and emotion on reception of new information and on evaluation of what was received, not necessarily in this order [16]. Reception includes both attention to and comprehension of detailed information. Wood et al. presented a model that included both information processing and attitude change as functions of knowledge about an attitude object. The model employed the concept of working knowledge, which is defined as information, beliefs, and prior experiences that spontaneously come to mind when a person is confronted with an attitude object [12, 16]. We present hypothetical examples within this framework to demonstrate the effects of prior

relevant knowledge on information processing and attitude change (**Figure 1**). The model and examples are simplified to concretely illustrate the literature reviewed and to demonstrate implications of knowledge for communication and education.

The hypothetical issue we examine is wolf restoration in a national forest. The first example takes the perspective of an individual with high knowledge and minimal emotion toward the attitude object. For this condition (high knowledge/low emotion), Wood et al. posited that knowledge would enhance reception of valid information [16]. The high knowledge/low emotion person will evaluate whether information contained in the persuasive message is valid. The persuasive message contained arguments that supported wolf restoration, claiming restoration would benefit the ecological function of the national forest.

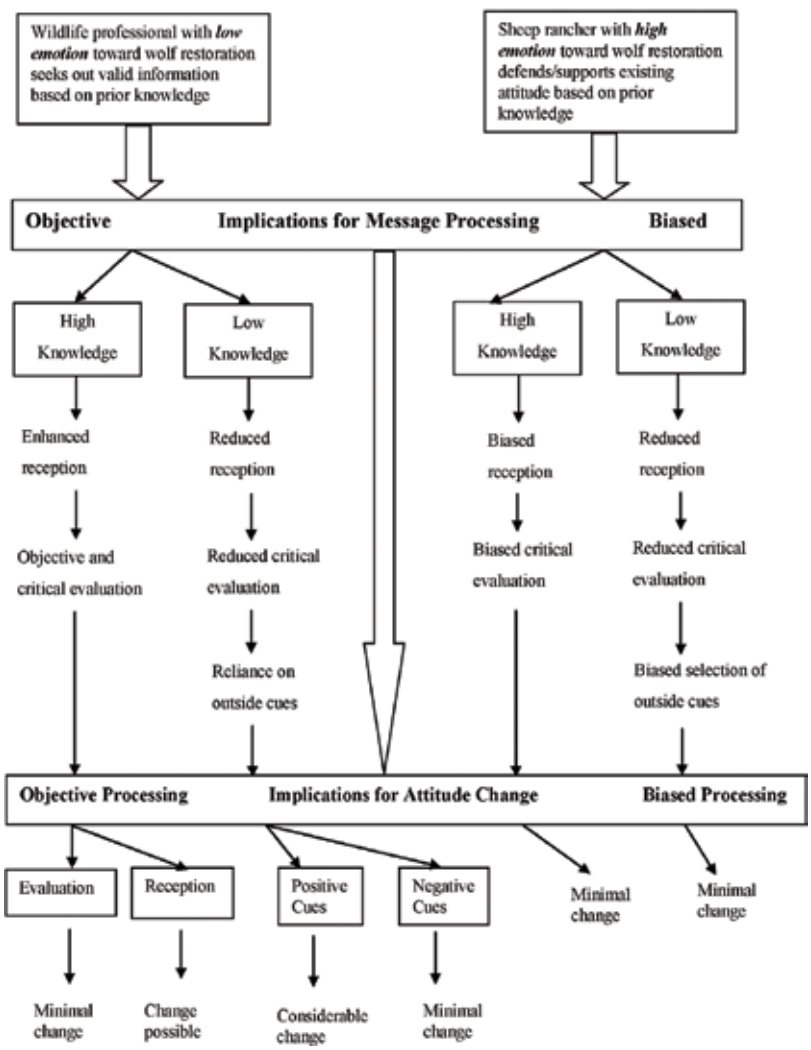

Figure 1. Information-based model of attitude change as a function of prior knowledge and emotion about wolf restoration, adapted from [16].

The first individual (i.e., hypothetical subject) to receive the communication is a visiting wildlife professional who has experience working with wolves and wolf restorations in Canada, but she has no strong emotional feelings toward wolf restoration in this particular national forest. Researchers found that she has a negative attitude toward wolf restoration for this forest. According to the model, when she encounters the pro-restoration message, her prior knowledge would tend to enhance reception (i.e., attention and comprehension) of the arguments, especially if she found the information therein to be valid. Her issue-relevant knowledge would enhance objective, critical evaluation of the new information contained in the message [16].

High knowledge is typically associated with minimal attitude change because of critical evaluation of the message. The model predicts no attitude change if the professional processed the information based on evaluation. This is because she should have used her knowledge to detect any weaknesses in the message's arguments, thereby supporting her initial attitude [16]. If, however, the message was processed based on reception rather than evaluation, her knowledge would tend to produce attitude change. In other words, she would have been persuaded because she attended to and comprehended technical details contained in the pro-restoration arguments. Persuasion tends to occur when high knowledge/low emotion individuals find arguments to be valid [16]. When there is little or no emotion involved with the attitude, knowledgeable people tend to objectively process information in messages better than unknowledgeable people. In the high-knowledge/low-emotion condition, knowledge has different implications for attitude change, depending on whether the basis for processing is reception (i.e., favoring change) or evaluation (i.e., resisting change).

In the second example, the individual receiving the pro-restoration message is a sheep rancher, who lives on and operates a ranch near the national forest boundary. Researchers found the rancher to hold a negative attitude toward wolf restoration, be highly emotional about wolf restoration, and have high knowledge about wolf restoration because he had represented a rancher's association during public meetings on the issue 5 years earlier at a similar national forest. According to Wood et al., this rancher's knowledge would enhance his ability to defend his existing attitude. The highly emotional rancher would have received the message in a biased fashion. The model predicts that he should give greater attention to and comprehension of information that supports his initial attitude and will discount any information that challenges his attitude about wolf restoration. The rancher's critical evaluations of the message would be biased because he would tend to favor information that supported his attitude over information that opposed his position [16]. Pro-restoration arguments contained in the message would tend not to change his initial, anti-wolf restoration attitude because of biased reception and evaluation (i.e., biased processing).

People whose attitudes are grounded in emotion and prior relevant knowledge tend to process incoming information in a way that protects and strengthens their initial attitudes [16]. Strong, emotionally grounded attitudes, which are reinforced by relevant knowledge about the issue, are resistant to change and persistent over time. In the example of the rancher, strong attitudes in opposition to restoration would tend not to guide behaviors that support wolf restoration. Strong attitudes would be more likely to guide anti-restoration behaviors because they were stable and backed by high knowledge [36].

The two hypothetical examples presented are extreme cases, which can approximate reality for controversial wildlife issues like predator restoration. We chose these for clarity and to allow the reader to better understand the complex model of information processing. In terms of emotion and knowledge about wolf restoration, middle-of-the-road people are probably more vulnerable to persuasion attempts of this nature than are people at the extremes [41]. On the other hand, people who lack knowledge about a particular issue of interest, such as wolf restoration, will tend to have less ability to attend to, comprehend, and critically evaluate arguments contained in a persuasive message [16]. Message recipients who possess minimal knowledge and emotion about wolf restoration tend to experience attitude change (assuming that they have formed an attitude toward restoration) when exposed to positive (pro-message) outside sources, or cues, such as credibility of the source [16]. The content of the persuasive message itself is not, however, likely to produce lasting attitude change because of a lack of clear reception and critical evaluation. Finally, recipients of the pro-restoration message who possessed high emotion and minimal knowledge would experience minimal attitude change because they would tend to selectively rely on outside cues or peripheral information that supported their initial, highly emotional attitudes [16].

Less knowledgeable people, who feel emotional about an issue, are probably less proficient at selectively receiving new information; their lack of issue relevant knowledge leaves them without an informed guide to negotiate information they encounter that attacks or supports their attitude during persuasion attempts [16]. For highly specific attitude objects, such as predator restoration, members of the general public will tend not to possess high levels of knowledge [3]. Persuasive messages, therefore, will tend not to be critically evaluated by members of the general public when narrow or technical issues are concerned, due to lack of issue-relevant prior knowledge. If however, outside cues or short-cut information (i.e., not contained in the message) are highly favorable (i.e., pro-message), then some attitude and behavior modification might occur. For example, attitude change could occur if the source of the communication was found to be highly credible.

People holding strong attitudes linked with high levels of knowledge and emotion are less likely to be persuaded. Similar to our hypothetical case study, forest management agencies, which may favor predator restoration for ecological reasons, tend to develop pro-restoration messages. Consider the sheep rancher who has a strong negative attitude and who is emotional toward wolf restoration, but who is also knowledgeable about wolf restoration. Other sheep ranchers in the vicinity of this national forest may share similar opinions and feelings. Bath found over 90% of members of the Wyoming Stock Growers Association to be against wolf restoration in Yellowstone National Park [1]. It is likely, however, that the majority of ranchers do not possess similarly high levels of knowledge as the individual rancher who had participated in earlier public debates over restoration. Despite lower knowledge, the model predicts minimal attitude change for the rancher group as a whole. These ranchers have stable and strong attitudes, which tend to resist change. It would be ineffective for forest managers to attempt to educate the ranchers about the benefits of having wolves in the national forest. Attempts to increase knowledge for unknowledgeable stakeholders, who are not emotionally involved, about wolf restoration could increase their ability to objectively

process pro-restoration information, thereby increasing the likelihood of producing supportive attitudes and behaviors [16].

The amount of issue-relevant knowledge possessed by user-groups, park visitors, and other members of the public, affected by wildlife management issues, influences the effectiveness of persuasion. Manfredo and Bright found that use of persuasive brochures specifying appropriate human behavior in bear country, in a northern Minnesota wilderness area, were effective for recipients possessing low knowledge about bears [42]. In contrast, the greater the self-reported prior knowledge about bears, the less effective the brochures were for changing behaviors in bear country [42]. Roggenbuck reviewed applications of persuasion and their effectiveness in natural resource and recreation management settings [43].

Figure 1 provides a tool for understanding the effects of knowledge on information processing and attitude change. Similar models and theories exist, which are appropriate in wildlife management settings [19, 44]. Additional models of information processing should be explored. The core of persuasion is the informational message [40]. Examining the manner in which people process information provided in messages is important for understanding the outcomes of persuasion attempts such as attitude and behavior change or attitude stability. Understanding the effects of knowledge for information processing provides useful information to wildlife managers when they attempt to influence and educate their stakeholders.

5. Recommendations for research and management

Researchers studying knowledge, attitudes, and behavior should carefully consider conceptual definitions and measures of knowledge. Thought listings, self-reports, and objective knowledge tests do not measure the same concepts. Additionally, it is important to know whether the knowledge measure employed includes direct experience with the issue, because knowledge and direct experience are separate dimensions of attitude strength [30]. Finally, moderator variables should be tested as continuous variables and not dichotomous variables to avoid range restriction [45, 46]. Careful consideration of these methodological issues can substantially improve attitude and moderation research in the wildlife management arena.

Educators and managers should identify levels of direct experience for visitor groups relative to wildlife management issues. Specific education programs should focus on increasing direct experience for people who visit and recreate in protected areas and other natural resource settings, especially for those who are inexperienced and unfamiliar with particular wildlife policies [3].

When designing communication and education programs, wildlife educators, interpreters, and managers should consider knowledge levels of their audiences. Prior and relevant knowledge about the issue, problem, or resource affects how people process messages and information. Training programs should be conducted by attitude theory experts to help managers and interpreters use information about knowledge and attitudes more effectively. Published literature in human dimensions has provided useful examples that should be reviewed to increase understanding of how people process information.

Educators and communicators should attempt to increase memory and enhance information processing abilities for visitors and user-groups, as opposed to simply imparting facts [47, 48]. Knowledge cannot strengthen attitudes and consistently guide wildlife behaviors unless it is retained in memory and recalled upon exposure to a management issue. Managers should encourage first-time users to think about and discuss resource issues to repeatedly pair attitudes with objects to increase attitude accessibility [7]. Repeated communication efforts using multiple sources should be used to increase visitors' awareness of issues [22]. When developing information campaigns, environmental communicators should consider not only the repetition of the message and number of sources but also the presentation style and format [49, 50]. Natural resources professionals should investigate which types of educational approaches are most effective for increasing retention and unbiased processing. Persuasion that is effective and unbiased requires information that is both understandable and unrestrictive to the public's processing abilities; wildlife managers should tailor messages to the educational levels and reading abilities of their target audiences and present messages in a context in which audience members are most likely to pay attention [51].

Wildlife managers must learn under what conditions do what kinds of attitudes held by what kinds of people predict what kinds of behavior because the attitude-behavior relationship is not universally strong [14, 52]. In addition to knowledge, socioeconomics, situational factors, and individual differences may influence attitude-behavior consistency [53]. Prediction of behaviors will be most effective when knowledge, attitudes, and behaviors are measured at comparable levels of specificity. The correspondence rule is indispensable when attempting to predict human behavior from attitudes [25]. General behaviors usually result from general attitudes and specific behaviors from specific attitudes.

6. Conclusion

We explored implications of knowledge for changing attitudes and behaviors and addressed concerns among researchers and managers about the utility of assessing human attitudes and quality of attitudinal data [2]. Our review revealed that prior knowledge about an attitude object affects consistency between peoples' attitudes and their subsequent behaviors toward wildlife management decisions. Attitudes of people who possess relatively high levels of relevant knowledge about a wildlife issue better predict subsequent behaviors than attitudes accompanied by low levels of knowledge. Past research indicates that knowledge about an attitude object is a reliable determinant of attitude-behavior consistency and can influence value-attitude relationships. The processes by which knowledge moderates attitude-behavior relationships deserve further study. Two proposed processes include stability and accessibility [36]. Understanding how these processes influence attitudes and behaviors will increase the utility of attitudinal information. Wildlife managers need to know when, why, and for whom attitudes will or will not predict behaviors to improve their public communication and education programs.

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Chapter 5

Community-Based Conservation: An Emerging Land Use at the Livestock-Wildlife Interface in Northern Kenya

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Additional information is available at the end of the chapter

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Abstract

In East Africa, an estimated 70% of wildlife populations are dispersed outside protected areas on community land. The way of life of the pastoralists, essentially support the thriving of wildlife. However, pastoralism is slowly transiting to more sedentary forms of livestock production. The region's wildlife populations future now largely depends on the conservation of habitats and migratory corridors on private and communally owned lands with competing land uses. Community wildlife conservancies are one of the approaches of decentralizing wildlife management and curbing biodiversity and habitat loss at the livestock-wildlife interface environments. Further, conservancies present an avenue for restoration of degraded grazing lands and improving pastoral livelihoods. This paper reviews the community-based conservation unfolding in northern Kenya using the case of Naibung'a Wildlife Conservancy in Laikipia County. Conservancies through land zoning and range rehabilitation have contributed to improved security of wildlife, people and their livestock. Conservancies' success depends on continued investment in vegetation recovery, grazing management, livestock marketing and benefit sharing. The perceived threats facing conservancies are pasture scarcity, cattle rustling and human-wildlife conflicts. Conservation objectives and human livelihoods in Africa are closely interlinked and lessons learnt in Naibung'a Wildlife Conservancy could particularly be useful to other similar initiatives in Africa.

Keywords: Naibung'a wildlife conservancy, conservation planning, Ewaso Nyiro ecosystem, community wildlife conservancies, livestock, pastoralism, wildlife, paper reviews

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1. Introduction

In East Africa, an estimated 70% of wildlife populations are dispersed outside protected areas (PAs) on community land where pastoralism is practiced [1–3]. Unfenced and uncultivated rangelands adjacent to PAs increase the total available range resources to wildlife and enhances its long-term survival (see island bio-geographic theory by [4]. The region has several endemic species, some of which are vulnerable, threatened or endangered. Maintaining wildlife habitats on the communally owned lands is key to the conservation of region's migratory wildlife populations [5, 6]. In Kenya, more than half of the wildlife habitats are outside the protected areas and are dispersed in private and communal grazing lands. In these areas, wildlife, people, and livestock all interact and compete for the same natural resources [1–3]. The traditional pastoral approach to livestock husbandry is considered compatible with and complementary to wildlife conservation [7]. Human population increase is associated with agricultural expansion into more marginal areas that were formerly used as open communal grazing lands [8]. Consequently, these areas have been transformed into high-density rural settlements of small-scale farmers [8] engaging in cultivation and livestock grazing [8, 9]. Further exclusion of pastoralist and wildlife use is resulting from, progressive conversion of these lands into large-scale flower and horticultural farms. Open pastoral rangelands are under increasing pressure and unprecedented environmental degradation. Pastoralists' rangeland has become too restricted for traditional livestock grazing practices, forcing them to diversify livestock-based economies and agriculture [10, 11]. There is a widely acknowledged decline of African pastoral lands [10–14]. As the pressure on land intensifies, there is potential for conflicts between wildlife and people, over grazing land characterized by predation on domestic livestock and diseases transmission. Wildlife populations and their habitats have been adversely affected by these changes. In the internationally renowned Maasai Mara ecosystem, for example, populations of some herbivores were reported to have declined by nearly 60% over the last three decades [15–17].

The situation is grave across East Africa and if solutions are not sought, wildlife will disappear in the very near future. One way that wildlife can be conserved in shrinking pastoral areas is by improving the socioeconomic benefits accrued from wildlife to pastoral communities, and minimizing negative wildlife-related impacts such as livestock diseases and predation. Ashley and Eliott [18] showed that benefits from integrated wildlife and livestock production can be higher than those from either enterprise on its own. In order to maintain or, in most cases, restore a healthy ecosystem, economically attractive solutions must be developed and implemented.

One of the approaches of arresting the imminent problem of habitat, biodiversity and livelihoods loss in Africa has been the establishment of wildlife conservancies on communal lands. Community-based conservation (CBC) seeks to stretch conservation efforts beyond PAs, and bring communities into conservation initiatives through benefit sharing and participatory planning [19]. It presents an evolving set of economic, social, and institutional tools that seek to limit activities detrimental to wildlife, while providing economic benefits to communities. These benefits seek to balance the costs of living with wildlife [19, 20]. CBC model has strongly challenged the view of community areas as mere buffer zones of the state owned

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protected areas. It has a potential for effective conservation and development contrary to the top-down approaches of protectionist conservation [21]. That calls for state and conservation agencies to reconsider how they engage the communal land owners in conservation policies.

A community wildlife conservancy is a constitution of one or several adjacent communal ranches. It represents an effort to leverage more communal land at the livestock-wildlife interface in Africa for conservation [1]. Over the last decade, an international conservation organization, African Wildlife Foundation (AWF) has developed and applied a landscape-scale conservation model, constituting land units under individual, communal and state protection [22]. African Wildlife Foundation has applied this model in eight priority conservation landscapes in 11 countries of Africa, areas referred as African Heartlands [22]. Intervention strategies AWF applies across the various Heartlands are protection of critical habitats and corridors by bringing land under 'conservancy' management, development of conservation-based enterprises, applied research and species conservation, development of capacity and leadership for conservation and, where necessary, engagement in policy and legislation work with partner governments [23]. The AWF's African Heartland program augments protected areas and helps to manage the surrounding areas, considering the needs of native species, ecosystem processes and local stakeholders [22, 23]. Such landscapes have the potential to provide economic benefits and ecosystem services that strengthen livelihoods of local people.

This review focuses on the establishment of community-based conservancies in northern Kenya, where the pastoral communities have adopted wildlife conservation as a land use, in addition to pastoralism. Naibung'a Community Conservancy in Laikipia County within the Ewaso ecosystem is used as a case study to highlight pillars of success and potential threats to conservancies in northern Kenya. Naibung'a conservancy straddles five administrative locations (Mumonyot, Ildigiri, Oloibosoit, Ilpolei and Ilmotiok).

2. Methods

This review was motivated by the paucity of published information on the growing trend of community wildlife conservancies' establishment in northern Kenya region. A lot of work has been done but most of the findings lie in consultancy reports and are not accessible to international audience. The study adopted a qualitative approach for data gathering and analyses. First, a literature review was conducted on the topic in context of the study area. Second, detailed field-notes from direct field observations were revised and similar information consolidated with the use of a summary table. All this information was harmonized during the write up, in order to glean out the impacts of conservancies on natural resources, pastoral livelihoods, security, their threats, and key pillars of the initiatives success.

2.1. Study area—the Ewaso ecosystem in northern Kenya

The Ewaso Nyiro Basin (**Figure 1**) is an area spanning over 30,000 km^2 with variable topography ranging from 200 to over 3000 m. Two major physical features influence the climatic and drainage

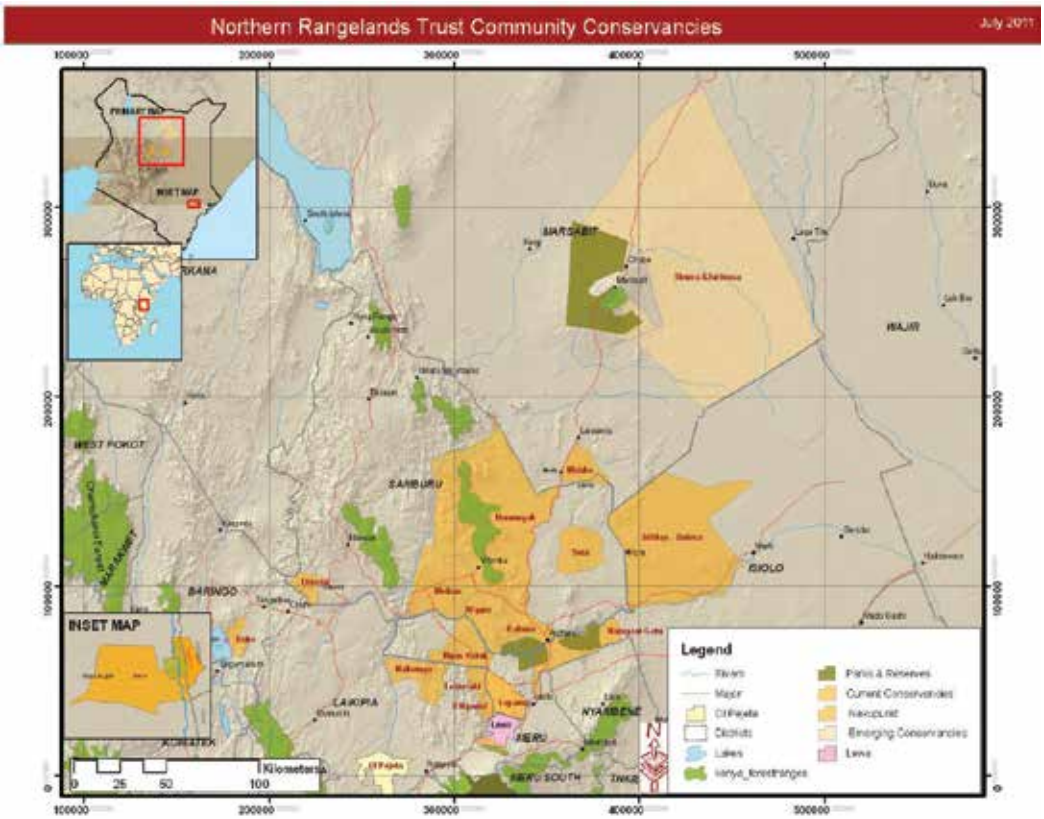

Figure 1. Spatial distribution of wildlife conservancies* in northern Kenya (courtesy of Dr. Juliet king, northern rangelands trust).

patterns within this landscape: the Aberdare ranges system to the southwest that forms the source of Ewaso Nyiro River and Mt. Kenya to the east that provides many tributaries. The Mathews Range to the north is a source of a few ephemeral rivers [24]. The basin has a tropical wet and dry climate with warm and stable temperatures throughout the year, averaging to a daily maximum of 32°C. Seasonal changes in wind patterns result in distinct wet and dry seasons. There is a wide range in the total rainfall across the basin, from a minimum of 200 mm in the dry savannah to slightly over 650 mm per year near the mountain ranges. This climate, coupled with shallow and nutrient poor rocky soils render much of this area unsuitable for arable agriculture.

The basin is characterized by semi-arid vegetation systems apart from the Ewaso Nyiro river watershed draining from Mt. Kenya and the Aberdare ranges. These systems include savannah mosaic, acacia-grasslands, and *Acacia-Commiphora* scrubs [25]. These ecological conditions are mostly suited to livestock production, either in the form of commercial ranching or traditional pastoralism, which are the two main economic activities in the area. Species of livestock reared are mainly cattle, camel, donkeys, sheep and goats. The Ewaso Nyiro River remains the most important water source for human, livestock, and wildlife in the basin, up to Lorian swamp.

The basin is diverse in wildlife habitats, livestock, wildlife and culture. It is home to a growing population of elephants (*Loxodonta africana*) and the endangered African wild dogs (*Lycaon pictus*) [26]. It is also habitat to many endangered and semi-endemic mammalian species such as the Grevy's zebra (*Equus grevyi*). The specialist species in northern Kenya are the endangered Grevy's zebra, reticulated giraffe (*Giraffa camelopardalis reticulate*) and Somali ostrich (*Struthio camelus molybdophanes*) and Beisa Oryx (*Oryx beisa*), all of which are of distinct conservation interest. Other important large mammals are the endangered black rhino (*Diceros bicornis*), lion (*Panthera leo*), stripped hyena (*Hyena hyena*) and spotted hyena (*Crocuta crocuta*), leopard (*Panthera pardus*), cheetah (*Acinonyx jubatus*), Gemsbok oryx (*Oryx gazella*) and plains zebra (*Equus quagga*). The area has one of the highest concentrations of large mammal biomass in Kenya [26].

Although Kenya is renowned for its national parks and reserves, only three protected areas (PAs) are found in Ewaso Nyiro Basin (Buffalo Springs, Samburu and Shaba National Reserves). These areas account for 1.5% (455 km^2) of this vast and biodiversity rich landscape [24]. Private (e.g. Lewa) and community-based (e.g. Il Ngwesi, Kalama, Lekurruki, Naibung'a, Namunyak, Kalama, Sera and West Gate) conservation initiatives (**Figure 1**) are gaining credence as the sustainable solution for both wildlife and local communities. These would add over 200,000 ha (> 2000 km^2), about 7.5% of land to conservation activities. Consequently, they effectively increase area under wildlife-based enterprises by a factor of five. In all the pastoral rangelands of northern Kenya, there are no fences. It is one of the few places left in Africa that allow for the free movement of wildlife and livestock across a vast area that is protected by communities [1, 2]. Tolerance for wildlife is generally high even among the locals, and is increasing mainly because of increase in tourism-based enterprises in the region's communal ranches. Since cultivation is not a feasible option in northern Kenya, the system of land use adopted by communities in the conservancies and associated communal ranches must derive from livestock keeping and wildlife conservation.

3. Community-based conservation initiatives in Ewaso Nyiro basin

In Kenya, CBC initiatives have their origin from the United States Agency for International Development (USAID) funded Conservation of Resources through Enterprise (CORE) project in early 1990s. Its goal was to improve benefits to communities and landowners in areas critical to parks and reserves and in that way achieve better conservation and management of natural resources. It involved development of community conservancies with tourism infrastructure, for example eco-lodges, tented camps and cultural manyattas [27]. Il Ngwesi, Lekurukki and Namunyak were the first such conservancies to be set in northern Kenya, between 1996 and 1999 (**Figure 1**). More than 15 other conservancies (e.g. Kalama, Naibung'a, Sera, Ishaqbini) have been established after apparent successes of the pilot and increased cohesiveness among the communities. These conservancies have changed substantially the land use face of this region (**Figure 1**) [1]. Such CBCs have in various programmes and projects established collaborations and strong working partnerships with various governmental and non-governmental institutions. These partnerships have enabled the stakeholders to combine their resources to

ensure the development and success of the CBCs. Some of the key partners include African Conservation Center, Arid Land Resource Management Programme, AWF, Government of Kenya (through various Ministries), Kenya Wildlife Service, Lewa Wildlife Conservancy, Laikipia Wildlife Forum, Ol Pejeta Conservancy and Northern Rangelands Trust (NRT), among others. This collaboration and partnership is an incentive towards improved natural resources management. As wildlife is more and more accepted as a land use, community participation is critical in wildlife management and pastoral livestock production enterprises in efforts to enhance positive economic and ecological change.

3.1. The Naibung'a wildlife conservancy

Naibung'a Conservation Trust was established in 2001 by Laikipia Wildlife Forum through the collective effort of nine Maasai communal ranches in the western part of the Mukogodo Division in Laikipia County (**Figure 2**). These nine communal ranches are part of the large Mukogodo pastoral system that includes Tiamamut, Kijabe, Koija, Ilmotiok, Musul, Nkiloriti, Morupusi, Ilpolei and Munishoi (**Table 1**). The ranches are communally owned within the provisions of the community-representative, land tenure system found in CAP 287 of the Laws of Kenya. The communities of neighboring ranches (**Table 2**) came together and combined

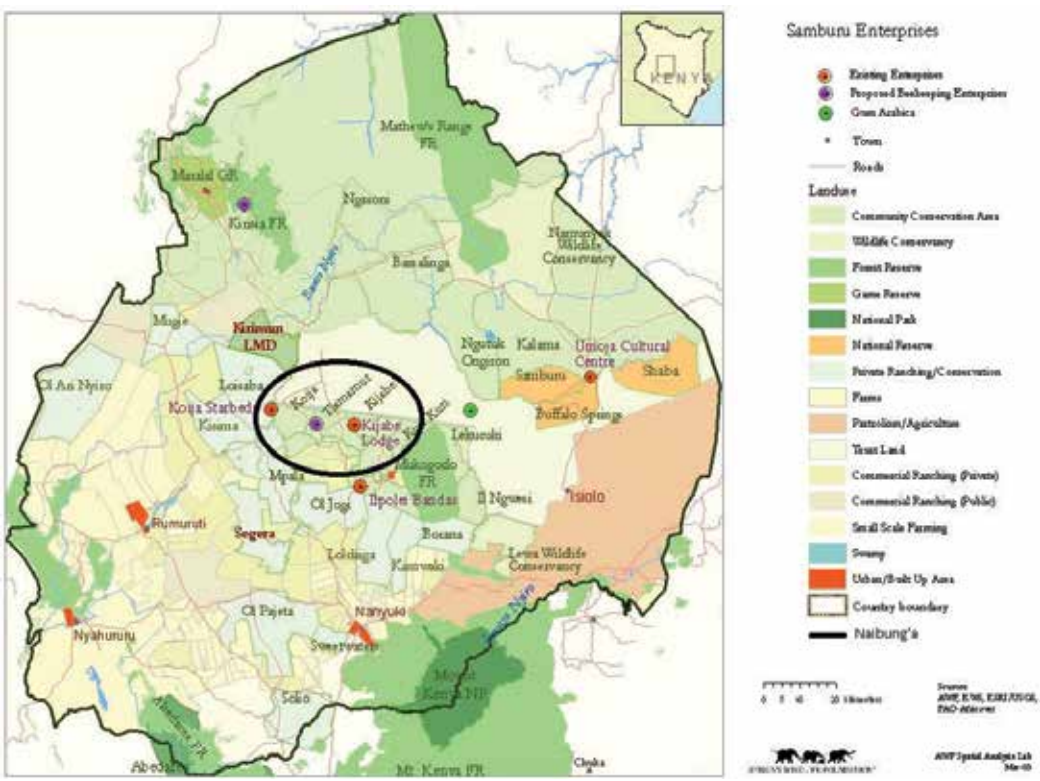

Figure 2. African wildlife Foundation's Samburu heartland showing location of Naibung'a community conservancy, circled. Courtesy of African wildlife foundation (AWF).

Location	Mukogodo Division, Laikipia District in Ewaso Nyiro Basin
Constituents community ranches	Koija, Il Motiok, Tiamamut, Kijabe, Nkiloriti, Musul, Il Polei, Munishoi and Morupusi
Ethnicity	Mukogodo Maasai
Population	14,256 people (2009 Census)
Land ownership	Community ranches with and without title
Core conservation area	75,947 ha
Main livelihood	Pastoralism (Livestock-keeping)
Key wildlife species	Elephant, Zebras (Plains and Grevy's), lion, leopard, giraffe, African Wild dog, Gerenuk, Impala, Gazelles (Thomson's and Grant's)
Year of registration	2001
Staff employed from the community	21
Annual operating budget	US$ 44,500

Table 1. Facts about Naibung'a wildlife conservancy in northern Laikipia (source: NRT [1]).

their lands and resources into one large community conservancy. However, constituent community ranches still have some level of autonomy. Community members accepted the need for conservation efforts in the area in order to address the challenges of increasing human and livestock population and high environmental degradation. The high diversity of wildlife in the area also presented an opportunity for the community to tap from the booming tourism industry in Kenya. However, they could only do so if they got organized. The conservancy,

Location	Sub-location	Community Ranch(es)	Area (km^2)	2009 population size					
				Male	Female	Total	House holds	Density	Persons/HH
Mumonyot	Mumonyot	Morupusi	75.9	958	987	1945	350	25.6	5.6
Ildigiri	Tura	Musul II, Kijabe, Ilkiloriti	118.1	1562	1429	2991	478	25.3	6.3
Oloibosoit	Ewaso	Koija	81.3	1366	1321	2687	549	33.1	4.9
Ilpolei	Ilpolei	Ilpolei Munishoi, Musul I	383.8	1820	1647	3467	793	9.0	4.4
Ilmotiok	Ilmotiok	Ilmotiok, Tiamamut	100.3	1558	1608	3166	473	31.6	6.7

The sex ratio for of the area is 1:1 for male to female (Source: [28]).

Table 2. Population distribution among community ranches constituting the Naibung'a wildlife conservancy and for various administrative areas within Mukogodo division.

therefore, works as a catalyst for wildlife conservation, environmental rehabilitation, resource conflict resolution and sustainable enterprise development for members of the nine communal ranches. Its mission is to conserve the integrity of the natural and cultural resources of the Laikipia Maasai area, while promoting the sustainable use of these resources in eco-tourism development to provide economic benefits to conservancy members.

Although most of the wildlife populations in Laikipia County are concentrated in private ranches, a substantial number is found in Naibung'a [29]. Wildlife dispersal into community ranches is more common in the wet season –when grazing and foraging is not a limitation. The conservancy is home to populations of elephant, zebras (plains and Grevy's), gerenuk, warthogs, dik-diks, impalas, gazelles, hippos, buffaloes, African wild dog, hyenas and lions. Other small animals include Granos, Clip, rabbit and tortoise among other wildlife species [30].

Naibung'a conservancy straddles five administrative locations (Mumonyot, Ildigiri, Oloibosoit, Ilpolei and Ilmotiok) in Laikipia Sub-county. The 2009 National Census shows it has a population of 14,256 over an area of 759.47 km^2, a density of 24.92 persons km^{-2} [28] (**Table 1**). This density of settlement is categorized as low, and is not dissimilar to population distribution in other dryland areas in the country [31]. However, the high population growth rate has caused a lot of pressure on the available infrastructure and natural resources, especially grazing and water resources, at times degenerated into community conflicts.

Mukogodo Division in which Naibung'a is found is mainly inhabited by the Laikipia Maasai community, who practice and depend on pastoralism for their livelihoods [32]. As the area is semi-arid, livestock keeping is the most viable economic practice. Mukogodo is considered as the poorest division in Laikipia County, as pastoralism which is most prevalence yields generally low income levels. The high levels of poverty among the Mukogodo pastoralists has been attributed to; the loss of livestock due to drought, diseases, extensive land degradation, poor management of the community ranches, high illiteracy levels, lack of employment opportunities, banditry and cattle rustling and the general inability to exploit the available natural resources such as sand and wildlife that can be a source of supplementary income for the community's benefit [32]. Drought and insecurity are the most critical challenges facing the Mukogodo pastoralists. Long-term investment and sustainable drought management and mitigation programme need to be developed.

3.2. Conservation planning within Naibung'a wildlife conservancy

One of the objectives of the wildlife conservancies is to promote the ecosystem recovery and sustainable use of natural resources. This is viewed as an important pillar for the success of conservation efforts both at the conservancy and constituents ranches level. As part of a landscape level conservation planning, the natural resource management (NRM) plans for the Naibung'a Wildlife Conservancy were developed in 1999 by African Wildlife Foundation (AWF) and The Northern Rangelands Trust (NRT) together with a number of other conservation supporters and the communities [22]. This involved a landscape-scale systematic conservation planning including developing strategies to help the local communities to benefit from nature tourism and resources on their land [29], and to prevent further habitat loss in community ranches. The NRM planning encompassed participatory land zoning designating

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zones for core conservation, livestock grazing and settlement according to ecological capacity and the most beneficial economic activity of a particular area [33]. Zoning is undertaken during sustainable resource use planning, and is key to successful management of livestock-wildlife interface areas, and reflects a commitment by the communities to conservation. Community members participate in a joint PRA exercise to demarcate zones for conservation, multiple uses and settlement. The zoning provided a means for actualizing a systematic, landscape-scale conservation planning and budgeting for the utilization of natural resources [34]. The NRM planning also targeted strengthening of local governance institutions by setting up two new thematic management committees, Conservation committee and Grazing and Settlement committee under the legally recognized Group Ranch Committee. In each zone, specific management strategies are employed by the conservancy aiming to sustain wildlife population numbers within the wider context of NRM Plans as follows:

a. *Core conservation (preservation) zone* - low intensity use zone, areas with good wildlife habitats, water, and are usually the best places to find wildlife. Core conservation zone where livestock and human traffic is removed through a process of monitoring by community scouts. The monitoring is required to reduce incidences of poaching and illegal grazing that allow the rangeland vegetation to recover and to track wildlife trends by recording citing and signs (dung, footmarks or audio signals). Use of community scouts also provides employment opportunities to some of the youths contributing to the economic benefits of the conservancy. The scouts are also being trained to promote strategies geared towards reducing human-wildlife conflicts. For example, warning herders of predator species like the presence wild dogs and hyenas reduces livestock depredation. These strategies have increased the numbers of resident wildlife in Koija, Tiamamut, Kijabe and Nkiroliti community ranches over the past few years.

b. *Buffer grazing zone (low intensity, multiple use zone for grazing and conservation)* - is the transition zone between the core conservation zone and the high use or settlement zone. The grazing zone is also a wildlife dispersal area and is further demarcated into wet and dry season grazing areas that allow for rotational grazing management aimed at optimizing the use of grazing resources within the community ranches. A study by Mureithi et al. [35] reported that increased grazing pressure in the grazing zones has led to reduced herbaceous cover, species diversity and biomass production. He emphasized on the role of regulated grazing in maintaining productivity of semi-arid rangelands.

c. *High intensity use zone (for all other activities including settlements)* - Settlement zone where the communities put up their *Manyattas* and *bomas* (homesteads and cattle corrals, respectively), and other people oriented ranch infrastructure such as health clinic, nursery school for children and the community ranch office. The proximity of such installations to each other increase security for the people and make relief accessible.

Currently only four of the nine community ranches in Naibung'a conservancy have established land use zones with clearly mapped geo-referenced boundaries. These are Koija, Tiamamut, Kijabe and Nkiroliti community ranches (**Figure 3**). The boundaries have been documented by NRT and AWF which have been working closely with the four community ranches within the Naibung'a Wildlife Conservancy.

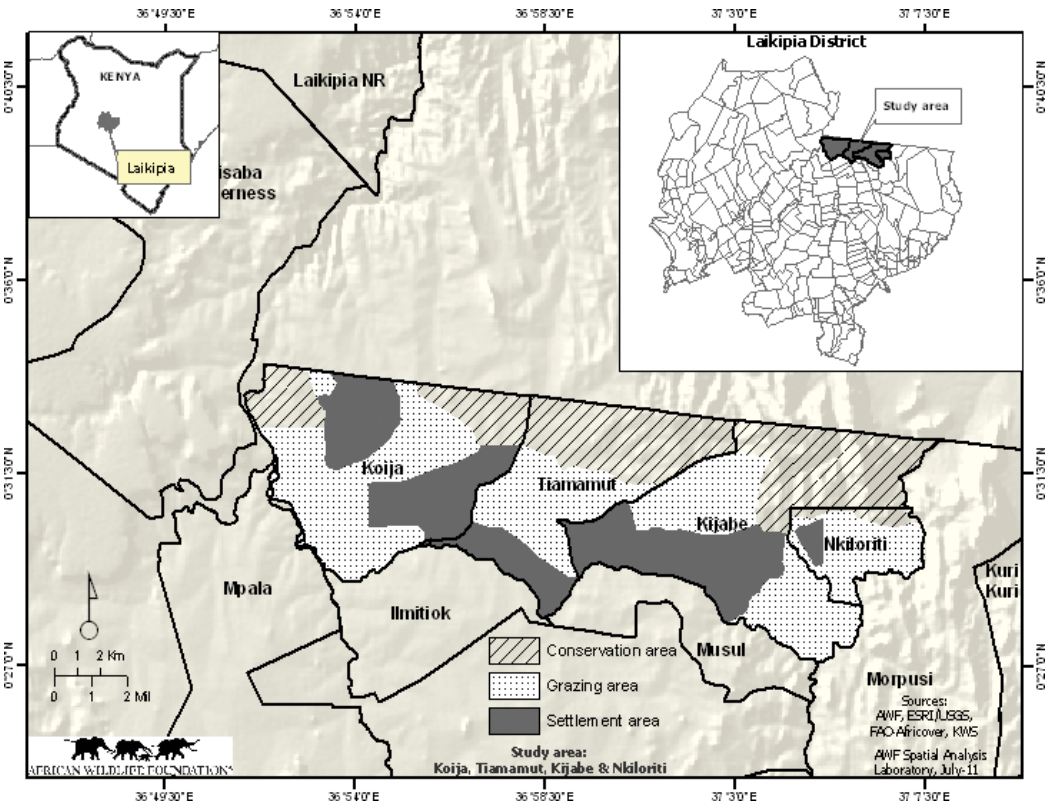

Figure 3. Land use zone for Koija, Tiamamut Kijabe and Nkiloriti community ranches. Courtesy of African wildlife foundation (AWF).

4. Discussions

4.1. Impacts of conservancies on natural resources

Panoramic satellite imageries show most community areas in northern Kenya in very poor range condition [36]. Presently the pastoralists have to move their livestock out of the community ranches in normal dry seasons in search of pasture, unlike in the past when such migrations only occurred during protracted droughts. Environmental degradation has resulted into loss of wildlife habitats, biodiversity, communities' grazing land and water resources and thus eroding pastoral livelihoods base. Poverty and insecurity is on the increase as the natural resource base, and especially pasture and water resources are degraded. In the biodiversity-rich Ewaso Nyiro Basin, conservation strategies aimed towards environmental rehabilitation and improved grazing management are critically needed. A review of effectiveness of the NRM planning on ecosystem health was carried out in 1999 for Koija, Tiamamut and Kijabe community ranches in Naibung'a Wildlife Conservancy. An analysis of normalized difference vegetation index (NDVI) between years 2000 and 2004 by Oguge [24] showed a significant increase in NDVI in the core conservation zones of Kijabe and Koija community ranches. This indicated an increase in vegetation

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biomass suggesting an improvement in ecosystem health. Only modest increase in NDVI was noted in the conservation zone of Tiamamut community ranch. Conversely, the settlement and grazing zones showed significant decrease to no change across most of the landscape. Exceptions were small grazing areas bordering conservation areas in Kijabe and Koija, respectively [24].

Desirable vegetation change is the best indicator of improved range condition in semi-arid ecosystems. The significant increase in plant cover over a 5-year period (1999 - 2004) suggests modest success in the role of NRM planning in reversing the trends in ecosystem degradation. Satellite imagery analyses by Oguge [24] were corroborated by vegetation data from ground truthing. Results of vegetation data showed high species richness and diversity in the conservation area of Kijabe community ranch indicating that the NRM planning had to a reasonable extent had led to the slowing of ecosystem degradation. Ten years after the NRM planning began in Kijabe conservation zone, herbaceous vegetation (mainly grasses) has fully recovered, to the extent that the management is weighing options to open up the area for guided high intensity grazing of livestock. The Kijabe conservation zone is hilly and rugged and is not preferred by zebra for grazing as the plains. Zebra is an avid grazer that opens up grass, enhancing further regeneration (AWF, Zebra fact file). Small game such as the Grant's and Thomson's Gazelles are observed to have moved out of the conservation zone due to the tall vegetation, a behavioral change to avoid predation. They are now commonly found on the open plains of the Kijabe grazing zones. Other options like mowing and burning are least desirable in the conservation area setting. If left unattended, the range condition would decline due to the growth of shrubs and bush replacing the grasses in absence of grazers. *Themeda triandra*, an important forage species that had locally disappeared is presently abundant in Kijabe conservation area indicating the NRM planning effectiveness in restoring the biodiversity.

4.2. Impacts on the pastoral socio-economic status

The long-term conservation of wildlife in Kenya's northern rangelands is inextricably linked to the fate of the local pastoral communities. These communities are politically and economically marginalized, and opportunities for economic growth have been hindered by insecurity and by longstanding ethnic rivalries and resource use conflicts in the region. The increasing trend in the uptake of community-based conservation in northern Kenya shows acceptability of the initiative by the communities. More new conservancies are in the process of being established in Samburu and Isiolo Districts. Olesarioyo [30] showed that the communities in Ewaso Nyiro Basin benefit, both directly and indirectly, by having wildlife on their land. However, trade-offs cannot be avoided between the existing community best management practices that promote the use of pastureland for livestock production, in co-existence with high numbers and diversity of wildlife. Benefits associated with the initiative include; secure resource rights and strong local institutions, eco-tourism enterprises revenue sharing and incentives, strengthening resource access and tenure rights, conservation-friendly cultural and spiritual values and improved human security [30]. Costs include competition for pasture and water, and livestock losses from predation and diseases.

Other indirect benefits derived from conservation management include linkages to livestock marketing opportunities. For instance, in 2009, the NRT and AWF together with Ol Pejeta Conservancy (OPC) initiated a community livestock outreach component 'linking livestock markets to wildlife conservation'. The initiative purchased a total of 580 heads of

cattle from seven community ranches paying KES 16,770.96 per head, 30% higher than the market price [37]. The aim was to reduce the stock density on the community ranches while increasing income to the households. Reduced stocking density hastens rangeland vegetation recovery [38].

Wildlife conservancies also present a better opportunity of institutionalizing the communal land ownership in northern Kenya. Owning land as a community is vital for provision of key resources such and grazing and wooded lands in arid and semi-arid areas [39]. Significantly, such ownership arrangement protects the land from sub-division and secures it for the future generations of the pastoral communities [40]. The conservancies present avenue for planning, implementing and re-orienting natural resource management and conservation efforts in a way that all the four segments in the conservation complex (people, land, wildlife and livestock) are at a balance. The ecotourism infrastructure in the conservancies is also expected to improve the general regional development.

4.3. Impacts on insecurity on wildlife, livestock and people

Historically, northern Kenya region is volatile, characterized by frequent incidents of insecurity, aggravated by its proximity to Somalia and Ethiopia. In the last decade, efforts by the Kenyan Government and local communities have significantly reduced the human insecurity problems. However, wildlife has not been so fortunate. In some areas poachers present a serious threat over the remaining wildlife populations [1]. Establishment of security systems is integral to the overall protection of wildlife in the region. Once a community wildlife conservancy is formed, it institutes its security operations as a matter of priority. The operations aim at improving stability to residents, wildlife, and visitors to the area. Without security, other activities related to conservation and community development cannot effectively operate. NRT has an integrated security network which operates across the region with robust radio communications, professionally trained security staff and Conservancy Security Scouts. Conservancy security teams are networked and closely linked to the Kenya Wildlife Service and Kenya Police. Additional support in the form of aerial back-up, tracker dogs and armed security is available from the Lewa Wildlife Conservancy as required. Effective communication and rapid response initiatives have significantly improved the security of the region.

4.4. Threats facing natural resources and livestock management

The community wildlife conservancies in northern Kenya are threatened by numerous factors. These factors are briefly discussed below:

4.4.1. Climate variability and change

Declining annual rainfall and prolonged droughts affects plant regeneration posing a serious threat to pasture availability and range rehabilitation initiatives in arid and semi-arid rangelands. The higher frequency of prolonged droughts in northern Kenya is encouraging the influx of immigrant pastoral communities within the region. The increased pressure on the limited vegetation resources from the immigrants encourages resource use conflicts. Communities are forced into negotiated grazing arrangement with the private ranchers at a fee. Those who

cannot afford the fees to trek with their animals to Mt. Kenya forest blocks. Implication of such movement is that large herds of animals are lost because of cold climate and associated diseases around the Mountain. Climate variability and change may also increase the prevalence of vector-borne and zoonotic diseases.

4.4.2. Invasive species

Acacia mellifera, A. reficiens, Opuntia spp. Datura sp., Propopsis juliflora, Sanseviera intamida are the most widespread invasive species in the conservancies undermining the quality and quantity of forage species. These invasive species suppress the growth of pasture grasses for livestock and wildlife. *Datura sp.* and *Prosopis juliflora* if ingested have poisoning effect on animals [30]. Control of weeds is imperative to the restoration and maintaining of healthy and productive pasturelands. Attempt to mechanically control *Sanseviera intamida* from rehabilitated sites in Tiamamut Community Ranch by uprooting, heaping to dry or dumping in deep gullies have been going on with some success. *Acacia mellifera* and *A. reficiens* is being controlled through de-branching and using the cut branches to erect fences around enclosures [41].

4.4.3. Unsustainable and competing land uses

Practices such as overstocking (in absence of livestock marketing links and/or presence of quarantines), dry land agriculture, deforestation, unmanaged sand and stone harvesting, charcoal production and unplanned human settlement have negative impact on conservancies. These practices threaten the sustainability of the community wildlife conservation efforts prompting the need of good land use plans to accommodate different uses. Enforcing of the community enacted by-laws to govern the land use zones is being applied in Naibung'a to tackle this problem.

4.4.4. Cattle rustling

This problem is propagated by factors such as, drought, diseases and ethnic cultures leading to losses of livestock and human lives: This problem is particularly common in dryland areas of East Africa where pastoralism is practiced [1, 2, 42]. It is deemed as a cultural adaptive strategy to restock after losses due droughts and diseases. The result is ethnic clashes and rivalry that hamper conservation and development.

4.4.5. Predation of livestock

The most common predators in the conservancies are lions, leopard, cheetah, hyenas and the African wild dog. According to NRT [1], STE [2] and Frank [43], each year, carnivores kill approximately 0.8% of cattle and 2.1% of sheep on private commercial ranches, and 0.7% of cattle and 1.4% of sheep and goats on pastoral community ranches in Laikipia County. The slightly lower loss rates of predation in pastoral community ranches are probably a reflection of the higher numbers of livestock and lower numbers of predators on these lands. The impact of predation is fairly small in comparison with that of diseases and drought. Nevertheless, losses to predation are serious, and may have an important impact on the livelihoods of pastoralists, and on incomes of commercial ranches [1, 2, 43].

4.4.6. Human-wildlife conflicts

The human-wildlife conflicts take various forms, including - carnivores attacking and killing livestock, herbivores raiding crop, attacks on humans, competition for pasture and water and transmission of zoonotic diseases [44–46]. In northern Kenya, competition for pasture and water is the most serious form of human-wildlife conflicts [30]. Authorities of Samburu, Buffalo Springs and Shaba National Reserves have to deal with constant pushing of livestock outside parks and reserves. Competition for limited pasture and water intensifies during the dry season. The main wild competitors for pasture are the elephants and zebras. Wildlife uses various tactics to compete for the resources to the advantage of livestock. For example, elephants and baboons become violent in the face of water scarcity resulting in destruction of property and life. Grevy zebras contaminate the watering point with their urine, which livestock cannot drink. In most cases, elephants destroy watering point, thus lowering water quality for domestic and livestock uses [30].

4.5. Roadmap for conservancies success

4.5.1. Clear and effective land zonation

There are various weaknesses related to land zonation that has been done in most conservancies and their constituent ranches. Limitations of the zones are not well understood, hence there is abuse of the zoning system. There is no clear demarcation of the core conservation area. The objectives of the zoning should be clearly defined and the communities should be actively involved in the zoning exercise. For the conservancies to succeed, the boundaries of the zones should be clearly established in a participatory manner and geo-referenced for monitoring, followed by by-laws and drawing up of specific management strategies applicable for each zone. An inventory of resources and other decision making tools for the zones need to be applied.

4.5.2. Water resources management

Water is a resource causing frequent conflicts because of high demand exacerbated by drought, destruction of catchment and pollution. It is one of the critically threatened resources in the conservancy and therefore requires proper management. Strategies for rain-water harvesting and storage are needed. For example, a rock infrastructure for rain water harvesting has been established at Nkiloriti community ranch with support from AWF and is now functional. In the low lying areas desilting water pans and shallow dams can help in harvesting flood water during storms.

4.5.3. Livestock management and marketing

The economy of pastoral communities in northern Kenya is primarily livestock-based. Being an integral component of land use, livestock production should be a key component in the conservancies' NRM plans and in any other development initiative in the region. Improved livestock management can be enhanced by strengthening the grazing committees through awareness and leadership training, logistical and other support systems for livestock marketing, use participatory grazing by-laws; education to local communities on benefits of correct stocking and

shunning from negative cultural practices such as cattle rustling. Rangeland improvement through reseeding degraded patches in the grazing zones can improve the grazing resources. Key grass species that are reported as suitable for the rehabilitation of grazing lands in the region include *Cenchrus ciliaris*, *Eragrostis superba* and *Enteropogon macrostachyus* [47].

4.5.4. Development of human support infrastructure

Support infrastructure for transport, communication security system, information, health, education, governance and other basic support services are key for the implementation of NRM plans. The conservancies need to mobilize more resources to rehabilitate existing pastures and to develop necessary support infrastructure for the implementation of NRM plans.

5. Conclusions and recommendations

Community-based conservation is a new conservation approach unfolding across Africa, based on a premise to maintain and improve wildlife habitats on areas outside the parks and reserves. The approach as applied in wildlife conservancies in northern Kenya attempts to engage the local people in conservation initiatives through participatory planning of their land and natural resources and benefit sharing. The case of Naibung'a Wildlife Conservancy presented in this review demonstrate that community conservancies are a viable avenue for conserving the biodiversity and habitats while promoting human development through improvement of pastoral livelihoods. The approach could uphold the way of life for pastoral communities and their economy, and prevent threats from land sub-division that dismantles pastoralism. Ecological and socio-economic benefits are projected following the leveraging of expansive areas under conservancies, improving their management, and addressing people's attitude to foster wildlife conservation. This notwithstanding, addressing threats facing the conservancies and the costs of sharing resources with a diverse wildlife species is core to sustainability of the initiatives.

Recommendations made here for effective mitigation of threats and conflicts facing natural resources, and to ensure success and sustainability of Naibung'a and other community wildlife conservancies in northern Kenya are: (a) continued capacity building among members of the conservancy on sustainable use and management of their natural resources, (b) improvement of land zoning systems that will enable better and expand the wildlife management programmes in the conservancy, (c) develop better and improve existing security and rapid response systems, (d) devoting more efforts to reduce the costs and risks, while contributing to the communities' benefits for keeping wildlife on their land, and (e) building stronger and more equitable governance institutions at community levels, that secure property rights of the pastoralists communities, promote active community participation and promote equitable benefit sharing, partnerships and distributed development. Communities must not only benefit but must be part of, if not drivers of the change. Conservation will thereby need to be people centered and address the real and diverse livelihoods needs of communities, and provide sufficient benefits and incentives for the people to sustain the initiatives in the long term.

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Chapter 6

Successes, Threats, and Factors Influencing the Performance of a Community-Based Wildlife Management Approach: The Case of Wami Mbiki WMA, Tanzania

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Additional information is available at the end of the chapter

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Abstract

Over three decades, community-based wildlife management (CBWM) has been promoted as a promising option for achieving biodiversity conservation and community development. From the outset, different development partners have facilitated implementation of this process. However, studies on its effectiveness are limited, and the reported outcomes are mixed. In this study, I used qualitative methods (interviews, focus group discussion, informal interviews, direct observations, and secondary data) to assess the performance of the CWBM approach in Tanzania in view of its contribution to sustainable natural resource management and enhanced local livelihoods. The study used the Wami Mbiki Wildlife Management Area (WMA) as a case study. While the CBWM scheme was designed to achieve dual objectives, this study found that the resultant efforts, in this case, were largely unsuccessful following the end of donor support in 2011. The WMA lacks effective anti-poaching patrols, leading to increased illegal activities, such as poaching, overgrazing, tree cutting, and charcoal burning. Although the community-based organization was successfully established as an institution to provide leadership in natural resource management and tourism development, some key actors still lack necessary entrepreneurship and managerial skills, transparency, and good relationships to ensure its success and sustainability.

Keywords: community-based, natural resources management, threats, Wami Mbiki, wildlife management area

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1. Introduction

1.1. Background

Over the past 3 decades, in most developing countries, there has been a paradigm shift in the management of natural resources from a top-down, state-centered approach to more decentralized approaches [1–3]. The new approach has been driven by factors such as constrained resources for conservation, biodiversity loss, and burgeoning rural populations [4, 5]. This alternative approach, which seeks to integrate wildlife conservation and rural development objectives, has been widely promoted as a strategy across the developing world that aims to conserve biodiversity, while simultaneously enhancing the rural livelihoods [6]. Moreover, this strategy provides an arena for other conservation strategies, for instance payment for ecosystem services, on which to build [7, 8]. The proponents of community-based wildlife management (CBWM) argue that devolving control of natural resources to local communities increases local participation, improves management of those resources, reduces conflicts, thereby improving the resource base and provision of benefits to communities [9–12]. Since its inception, many international conservation and development agencies and partners have supported the CWBM approach [13, 14].

However, several studies from different parts of the world have revealed unexpected outcomes, mixed results in performance, and some degree of disillusionment with the CBWM approach [9, 10, 15]. Some studies show that, despite its popularity, CBWM has not met expectations of halting biodiversity depletion and poverty reduction among the local communities that have implemented it (e.g., [16–19]). However, a few successful and convincing reports have demonstrated a positive correlation between livelihood improvement and conservation. For instance, Communal Area Wildlife Conservancies in Namibia are considered a major success story as the result of reduced illegal wildlife use and recovery of game populations [20]. Elsewhere, the impact of CBWM is harder to discern as many studies focus on the area of land conserved rather than effectiveness of the program [5]. Mixed factors have been reported to affect CBWM performance, such as the type of communities involved in CBWM, resource governance, effectiveness of the institutional framework, availability of skilled personnel, stakeholders' capacity, reinvestment of CBWM projects, revenue sharing, and community cohesion [21, 22].

This chapter examines the performance of Wami Mbiki Wildlife Management Area (WMA) in Tanzania. WMAs are community-run protected areas, where several villages come together and set aside land for wildlife conservation. In return, these villages generate income mainly through sport hunting and photographic tourism [23]. Under this arrangement, the wildlife resource remains the property of the state although the villagers acquire the user rights of this resource. This chapter seeks to answer three main questions: (a) To what extent has the Wami Mbiki WMA contributed to sustainable natural resource conservation and enhanced rural livelihoods? (b) What are the threats facing this particular WMA? and (c) Which factors influence the performance of this WMA?

This study adopts the World Conservation Union's (IUCN) definition of a "protected area" as a clearly defined geographical space, recognized, dedicated, and managed, through legal or

other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values [24]. I proceed by first presenting the CBRNM framework; thereafter, I describe briefly the history of WMAs before outlining the methodology of the study, then presenting the results and providing a discussion. Generally, I conclude that more anti-poaching effort is needed to save the remaining wildlife because of the multiple threats to the survival of wildlife in the study area.

1.2. The CBNRM framework

Community-based natural resource management (CBNRM) is the management strategy of natural resources aiming to reduce poverty, conserve natural resources, and promote good governance and decentralization [25]. It requires some degree of devolution of decision-making power and authority over natural resources to communities and community-based organizations [26]. The CBNRM approach is built upon common property theory which argues that common pool resources can be utilized sustainably provided certain principles are applied [27]. These principles include the autonomy and recognition of the community as an institution, proprietorship, and tenurial rights, rights to make the rules and viable mechanisms to enforce them, and on-going incentives in the form of benefits that exceed costs [27, 28]. CBNRM is based on three key assumptions: (a) local people are better placed to conserve natural resources; (b) people will conserve a resource only if the benefits exceed the costs of conservation; and (c) people will conserve a resource that is directly linked to their quality of life [55, 56].

The local communities living with natural resources are best placed to conserve and manage them as they have sufficient knowledge and experience. A community in this context is defined as a group of people living within a legally defined geographic area with diverse socio-economic interests and capabilities with a shared interest in conserving natural resources [29]. Before colonialism, traditional institutions existed in local communities which had developed systems and practices for natural resource management [30–33]. Other studies point out that local communities share an interest in conservation of natural resources as their livelihoods are intricately connected to these resources (e.g., [34]). Thus, people will conserve and manage resources that they perceive to contribute positively to their livelihoods [35]. Also, people living closest to natural resources have more to lose from depletion and degradation of these resources [36]. If given proper support and incentives, they will be most likely to effectively conserve them. Such an approach is also a cost-effective alternative to the fortress (fences and fines) approach to natural resource management.

In order to ensure sustainable and effective management of natural resources, the benefits must outweigh the costs [37–39]. Ostrom et al. [40] demonstrate this by pointing out that "an individual's choice of strategy in any particular situation depends on how he/she perceives and weighs the benefits and costs of various strategies and their likely outcomes." Therefore, communities will only embrace a participatory approach as a long-term livelihood strategy if it proves attractive to them [41]. For sustainable management of natural resources, participation of local communities is imperative. Participation can best be achieved through decentralization of authority over the resources and promotion of good governance. Governance, in simple terms, means the process of decision-making and the process by which decisions are implemented (or

not implemented) [42]. However, good governance includes several key elements, that is, participation, rule of law, transparency, responsiveness, consensus-orientation, equity and inclusiveness, effectiveness and efficiency, and accountability. Based on this premise, this chapter considers these issues in theory and in practice by exploring the case of the Wami Mbiki Wildlife Management Area.

1.3. The wildlife management areas in Tanzania

In the 1980s, Tanzania experienced a wildlife crisis where almost half of its elephant population and entire black rhino population were wiped out through poaching [33]. Learning from the past failures, the government of Tanzania formulated the first comprehensive wildlife policy in 1998 advocating the devolution of natural resources governance to local communities. This policy provided opportunities that linked sustainable natural resource conservation and rural development [23]. The policy recognized the establishment of Wildlife Management Areas (WMAs) as one of the strategies for devolving management responsibilities and rights to local communities. WMA regulations were formulated in 2002 alongside the establishment of 16 pilot WMAs. The policy encouraged wildlife management at the local level by allowing local landholders to "manage wildlife on their land for their own benefit" ([23]: 13) in order to enhance conservation and alleviate poverty through sustainable utilization of natural resources [23]. The main assumption was that if local people acquire ownership of wildlife resources and obtain tangible benefits from them they are likely to manage the resources sustainably. This required a shift from state-centered control of natural resources to local communities, which also, maximized the value of wildlife-rich land compared to alternative land use so as to improve the standard of living and in turn provide incentives for communities to support conservation efforts.

The first pilot WMAs were established in 2003 and user rights granted in 2006 and 2007. Additional WMAs were created subsequently [43]. Currently, there are 17 WMAs that have attained authorized association (AA) status while 22 are in various stages of development. The number of villages in each WMA can range from 2 to 30. The WMAs cover over 23,000 km^2 of Tanzania's land surface. In designating a WMA, several villages have to set aside portions of their land for wildlife conservation and develop management plans and regulations for managing the land. Government approval is required for the plans to become operational and for formal ownership to be given to the communities. To be able to manage the WMA, an authorized association (AA), that is, a Community-based Organization (CBO) representing the member villages must be established and granted user rights by the Minister of Natural Resources and Tourism. Virtually all WMAs have been developed with external support (e.g., USAID, GTZ, DFID, UNDP, GEF, DANIDA, WWF, AWF, WCS, and ADAP). The costs of establishing a WMA are far beyond community affordability and are estimated to range between US$250,000 and $300,000 [44].

There has been considerable criticism of the concept of WMAs, facilitation, and devolution of management responsibilities. In practice, the government has retained considerable residual control of WMAs and has attempted to recentralize control of natural resources [45]. Administrative processes to establish WMAs have been criticized as bureaucratic, excessively

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complex, and with many hurdles hindering their development [46]. Although some WMAs generate revenue for their member villages, there is insufficient evidence that benefits exceed income received prior to the WMAs establishment [47]. The Wildlife policy was revised in 2007 and "Non-Consumptive Utilization of Wildlife Regulations" were formulated in 2008 which recentralized many powers and benefits to the government [46]. However, new regulations issued in 2012 have afforded more control and benefits to communities [48].

2. Research methodology

2.1. Study area: the Wami Mbiki Wildlife Management Area

The study was conducted in the Wami Mbiki Wildlife Management Area located in the central eastern part of Tanzania between latitudes 06°10′00″ and 06°30′00″ S and longitudes 37° 50′00′ and 38°15′40″ E. The WMA's core wilderness area covers 2500 km[21], combining land from 24 villages. The WMA was first identified in 1995 in a joint effort between local elders and tourist hunters who were concerned about unsustainable utilization of natural resources that threatened the future of the area and the livelihoods of the surrounding communities. It therefore started as a pilot project in 1997 with support from the Danish Hunters Association (DHA) and funding from DANIDA. The CBO named the Wami Mbiki Society (WMS) was registered on 15 July 2002 under the Societies Ordinance Act, with registration no. 11491. It became an authorized association in January 2007 and received user rights in April 2007 [49]. The WMS comprises representatives from member villages.

Facilitation of the Wami Mbiki WMA through DHA took place in three phases. The first phase (1998–2001) aimed at developing the WMA, sending Village Game Scouts (VGS) for training and building guard stations. The second phase (2002–2006) was mainly for building staff capacity, delegate training, and development activities in the surrounding villages. The third phase (2006–2011) focused mostly on business to attract investors. Generally, the funds received from DHA supported data collection for the development of land use plans (LUPs), business plans, and the legal establishment of the Society, formalizing a constitution, a general management plan, bylaws, community education and capacity building, protection of the natural resources as well as operational and technical expenses for the WMS.

The Wami Mbiki WMA has abundant flora and fauna. Wildlife species found in the WMA include lion, leopard, elephant, hartebeest, waterbuck, greater and lesser kudu, giraffe, buffalo, yellow baboon, hyena, wild dog, cheetah, bush pig, hippopotamus, and zebra among others. The area is also rich in birdlife, including varieties of miombo specialties such as the racket-tailed roller, pale-billed hornbill, rufous-bellied tit, and miombo wren-warbler, as well as many other birds. The primary vegetation type inside the WMA is open and closed woodlands, bushland, and inundated grasslands. The WMA has both rivers and natural ponds that serve

[1]The size is given as 63,000 ha (630 km^2) by the WMA Authorized Association Consortium (AAC) website (www.twma.co.tz), and 250,000 ha (2500 km^2) by the Wami Mbiki Society website (makingithappentz.blogspot.dk).

as sources of water for wildlife. The Wami River divides the WMA into two segments (north and south) (**Figure 1**).

The climate of the area is warm tropical with short rains from October to December and long rains from March to May, ranging between 600 and 1200 mm per annum. The average annual temperature ranges between 26 and 28°C. The altitude ranges between 350 and 400 m above the sea level. The area is interspersed with rocky hillsides of thin soil cover and valleys with deep clay or alluvial soils.

The major land uses are agriculture, wildlife and forest conservation, livestock grazing, and human settlements [50]. Subsistence farming is the major economic activity (95%) followed by

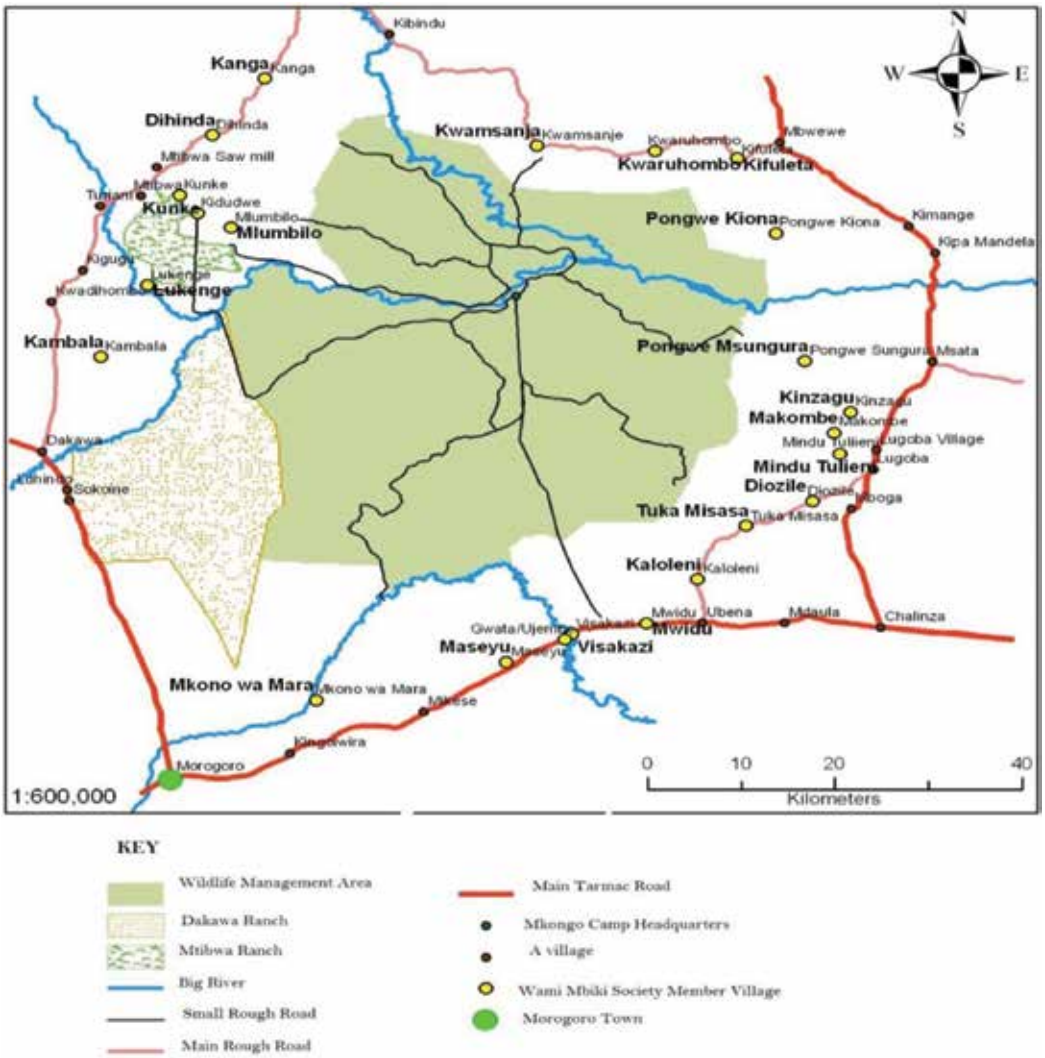

Figure 1. Map showing the Wami Mbiki Wildlife Management Area.

livestock grazing [51]. The main food crops include sweet potatoes, beans, cow peas, bambara nuts, tomatoes, pumpkins, and finger millet among others. Cash crops include pineapples, pumpkins, tomatoes, cashew nuts, and cow peas. Other income-generating activities for local communities include beekeeping, masonry, and small-scale business. Moreover, a few residents are employed as teachers, hospital staff, and prison staff. The population of member villages in 2006 was over 65,935. The main ethnic groups are Wakwere, Wazigua, Wamasai, and Wagogo.

2.2. Data collection

Data were collected using interviews, focus group discussions, direct observation, and informal discussions. Fifty-one interviews were conducted with people who were purposively selected and key informants. Interviewing was terminated when further data added no new insights to the research questions. Interviews lasted between 1 and 2 hours. Participants were encouraged to express themselves freely, and they were guaranteed anonymity and confidentiality. Interviews were conducted in Kiswahili, a common language in the study area. Moreover, four focus group discussions with generally 8–12 people were held to gather various viewpoints on the success and constraints of the WMA.

Finally, I reviewed relevant documents such as government policy documents, reports, and several existing published and unpublished studies conducted in the area. I used a tape recorder to record the data. Soon after data collection, the information was transcribed, organized into categories, and grouped into themes. The identified core themes were linked to the aims of the study, and these served as the basis for my findings and discussion presented below. Statements supported by appropriate quotations from the interviews are provided where necessary to elucidate a theme.

3. Results and discussion

3.1. Contribution of the WMA to biodiversity conservation and community welfare

3.1.1. Contribution of the WMA to biodiversity conservation

The study showed a notable improvement in biodiversity conservation in Wami Mbiki between 1997 and 2011. This improvement is attributed to the efforts of the DHA through funding support from DANIDA. The funds facilitated patrol activities, payment of staff salaries, and support for community development projects. The wildlife numbers increased notably as shown in **Table 1** below. Information from the Bagamoyo District Game Officer also indicated that wildlife killed by poachers decreased from 40 animals in 2006 to 14 in 2011.

Despite the impressive increase over almost a decade, the 7 years that followed this success experienced a decline of about two thirds of the wildlife population, coinciding with the ending of donor support in 2011. This is manifested by infrequent and low sightings of some species such as lion, leopard, eland, sable antelope, giraffe, elephant, zebra, and reedbuck.

Year	Number of large mammals
1997	5000
2004	12,578
2009	20,000
2010	31,900

Source: Refs. [44, 50].

Table 1. Number of wildlife from 1997 to 2010.

Wild dogs and cheetahs are not seen in the area anymore, suggesting the possibility of local extinction. Field estimates by the VGS (see **Table 2** below) show that all animals (except crocodiles and hippos) have decreased significantly. The respondents acknowledged an increase of crocodiles. This is partly because they are not hunted and have abundant food (i.e., livestock and wildlife).

Interviews show that elephant sightings are rare, but elephant signs such as dung, foot prints, and carcasses are observed in the area. The carnivores (lions and leopards) are decreasing partly because some are killed by pastoralists in retaliation for predation on livestock.

3.1.2. Contribution of the WMA to community welfare

3.1.2.1. Development projects

During phase 1 (1998–2001), DHA supported development projects in 14 villages—Dihinda, Kwamsanja, Lukenge, Kunke, Kanga, Kidudwe, Maseyu, Mwidu, Kaloleni, Tukamisasa, Diozile, Ponwekiona, Kwaruhombo, and Kifuleta. In the second phase (2002–2006), DHA distributed 1M TZS (2,000US$) to each member village per annum. Furthermore, from 2008 to 2011, the WMA earned 20M TZS (about 17,000 US$) annually from investment in photographic tourism. Half of the revenue was disbursed to the villages.

Several projects were implemented using DHA support and revenue collected from the WMA (see **Table 3**). These projects were implemented under the supervision of DHA staff.

3.1.2.2. Employment

The DHA employed 47 people; most of them were from the member villages. Following the termination of support and the concession fee, the number of staff decreased by more than a half, partly due to the lack of income to pay staff (see **Table 4** below).

In June 2011, the WWF started supporting WMA. The VGS were given an allowance of 5000 TZS (2USD) per day. The allowance stopped in February 2012 as WWF ceased its activities in the area. The patrol activities continued as VGS expected payment from WWF once it resumed its activities. However, when WWF re-commenced its activities in July 2013, it did not pay the VGS their arrears of salary. Consequently, the VGS sued the WMS in the labor court. Since January 2014, the VGS have received no pay apart from a portion of fines imposed on

Animal species	2010	2017
Hippopotamus	500	350
Elephant	500	About 100
Impala	18,000	Less than 1000
Sable antelope	1000	Less than 60
Hartebeest	About 700	Less than 100
Eland	About 600	Less than 100
Giraffe	About 500–600	Less than 50
Zebra	About 800	Less than 70
Grysbok	About 300	Less than 50
Reedbuck	About 200	Less than 20
Buffalo	About 2000	less than 300
Kudu	About 500	Less than 100
Warthog	About 2000	Less than 200

Source: Game scouts report.

Table 2. Field estimates of wildlife populations in 2010 and 2017.

Type of project	Number
Construction of classrooms	35
Construction of doctor's house	1
Construction of teachers' offices	2
Construction of teachers' houses	10
Construction of water pond	1
Construction of culvert	1
Construction of meeting hall	1
Construction of dispensaries	3 (of 14, 12. and 3 rooms)
Construction of pit latrines	2 latrines (of 4, 2, and 4 holes)
Drilling of water well	2
Renovation of classrooms	23
Renovation of teachers' office	1
Renovation of dispensaries	2
Finishing of village government office	1
Making of desks	40

Table 3. Projects supported by DHA and WMA revenue.

Staff	Number	
	2007	2016
Game scouts	26	20
Protection officer	1	0
Drivers	5 (4 for patrol cars, 1 for tractor at Mkongo Camp)	1
Community workers	4	0
Cashier	1	1
Messenger	6 (4 at Mkongo Camp, 2 at Morogoro Office)	0
Secretary	2	0
Accountant	1	0
Manager	1	0
Total	**47**	**21**

Table 4. Number of staff in 2007 and 2016.

apprehended offenders. Due to the lack of payment and work equipment, the WMA has retained few VGS. Currently, the VGS conducts occasional foot patrols near the WMA headquarters and a few areas under severe threat (see **Table 5**).

3.2. Threats facing the Wami Mbiki Wildlife Management Area

The study revealed numerous threats facing the WMA. These include agriculture, settlements, illegal logging and fishing (particularly the use of poisons), charcoal burning, uncontrolled grazing, and bushfires. Also, the wildlife faces unrelenting pressure from poaching, retaliatory killings, and habitat loss. These threats are discussed below:

3.2.1. Uncontrolled cattle grazing

Wami Mbiki was set aside for conservation. Human activity was prohibited in the area. An uncontrolled number of livestock (from within and outside member villages) has caused

2007	2017
Work equipment	**Number (s)**
Cars–4	1 car is used occasionally, 3 are not working
Motorcycles—6	Motorcycles—3
Tractor—1	Not working
Boats—2	Not working
Weapons—13	Working—8, fell into the river—2, held at a police station—2, broken by poachers—1
Mkongo camp buildings	Totally ruined

Table 5. The WMA work equipment in 2007 and 2017.

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overgrazing in the area following the end of donor support in 2011. The livestock grazing in the area comes from Arusha and Manyara (Mang'ati and Mbulu tribes), Mwanza and Shinyanga (Sukuma tribe), Kilosa (Maasai tribe), and Kilimanjaro (Pare tribe). Many of these have entered the WMA through Kwamsanja, Mindutulieni, Pongwemsungura, and Bwawani areas. Some pastoralists obtain permits from the village government to enter the WMA. Some villages have registered them as villagers but other villages have denied them registration. Those without a permit force entry and allow their livestock to graze inside the WMA. Regardless of the size of the herd, the village authorities impose a fine of 50,000 TZS. These pastoralists have built settlements and livestock stockades inside the WMA.

Moreover, pastoralists from WMA member villages (Kambala, Mindutulieni, Visakazi, Kaloleni, and Tukamisasa) also graze their cattle in the WMA in drought seasons but do not build stockades *(bomas)*. Due to overgrazing, the potential breeding sites and hiding places for wildlife have been degraded. For instance, one VGS stated "*on routine patrol, we have found two impala calves who had been trampled to death by a herd of cattle because the impala fled leaving the calves behind.*"

In the process of keeping tsetse flies and dangerous wildlife away, pastoralists use chemicals and burn fires which can cause wild fires. Moreover, they cut down trees to build *bomas* and settlements and litter the area with plastic bags and bottles. Due to continued degradation, most water pans have dried up. This situation is likely to increase competition for space and resources (food and water) between the livestock and wildlife, resulting in increasing stress for the wildlife. Also, it increases the possibility of poaching, leading to the migratory wildlife escaping to other relatively well-protected areas such as Saadani National Park. Efforts by the VGS to remove pastoralists from the WMA led to attacks on two occasions leaving two VGS severely injured. The expansion of livestock numbers and degraded habitat has discouraged the development of Wami Mbiki WMA as a tourist site since tourists visiting the area see more livestock than wildlife (Interview no. 5, June 2016).

In 2014, with support from KDU and Tanzania Forest Services (TFS), the VGS conducted an operation to remove livestock from the WMA. About 2400 cattle, 125 goats, 76 sheep, and 13 donkeys were removed from the WMA. Using the Mvomero District bylaws, a fine for one cow from WMA member villages was 15,000 TZS (8.7 US$) while non-member village was charged 25,000 TZS (14.5 US$). The Regional Commissioner's call on WMA invaders to vacate the area by September 1, 2017 appeared to be largely successful.

3.2.2. Farming and settlement

The study revealed that farmers from Kanga and Mziha villages lived inside the WMA before the area was proclaimed a WMA. When protection of the area weakened, people from other villages such as Dihinda (Masimbani), Kunke (Pagani), Kidudwe (Sungwindala), and Mhumbilo invaded the area. They constructed block houses and cattle enclosures (*bomas)* leading to felling many trees. Due to the presence of large numbers of people living inside the WMA, some political parties, that is, CCM (2010) and CUF, opened branches inside the area (at Kwalubendo and Pagale Forest Reserve) at Kunke Village.

3.2.3. Poaching

The study showed that poaching is a serious issue in the area despite its designation and VGS patrols. In 2008, the VGS retrieved two elephants' tusks and weapons. The elephant carcasses had been burnt after removal of the ivory so as to destroy evidence. Kikoti [52] also observed poaching signs such as meat racks near Wami River, bullets wounds, trunks cut by snares on four collared elephants, and a burnt elephant skull. It was reported that elephant poachers now not only take the ivory but also collect elephant meat to sell. This renders it impossible to identify the numbers of elephants killed in the area. Two different kinds of poaching occur in the area—commercial (for meat and/or ivory) and subsistence. Commercial poachers mostly kill elephants, hippopotamus, giraffe, buffaloes, hartebeest, and eland using cars or motorcycles, shotguns, and rifles. Subsistence poachers use muzzle loaders, rifles and shotguns, snares, fires, dogs, machetes, torches. and motorcycle horns and sell surplus meat. One respondent stated "*Strong light on animals makes them confused and motionless, thus making it easy for poachers to kill them. Through this method, a poacher can kill up to 20 impalas in a day for business purposes. These poachers usually walk on foot or use a bicycle.*" The study also showed that some pastoralists who graze livestock in the WMA also poach themselves and/or collaborate with poachers. For instance in 2010, pastoralists killed an elephant at Kwamsanja Village. A study which collared 17 elephants (5 in Saadani NP and 12 in Wami Mbiki WMA) found that 3 of the 12 elephants in the WMA had bullet wounds and 1 had a cut trunk [52]. Among the 24 villages, most poaching is organized from Kunke Village. The meat collected is sold at Madizini (Turiani). One piece of meat can be sold for about 5000 to 7000 TZS (2–3 US$). Meat from one impala can yield 60,000–70,000 TZS (27–31 US$).

Fish are also poached. One VGS stated *"in 2014, we caught poachers (men and women) who used insecticide (Thiodan) and dynamite to harvest fish in the Wami River. Many fish died and were spoiled."* Water from the Wami River is used by many people for drinking and cooking. The use of insecticides and dynamite fishing can make water unsafe for human consumption.

Some cases of poaching in the Wami Mbiki WMA are linked with government officials. For instance, the Wami Mbiki Newsletter of June 2009 reported that in 2008 three poachers were arrested with hundreds of kilograms of bush meat carried in a government vehicle. The VGS and WMS face many difficulties dealing with these kinds of cases because the poachers are protected. For instance, one respondent stated *"when some notorious poachers are arrested, they get released without any punishment. There are cases when poachers are arrested with all evidence such as guns and wildlife products but after some time they are released without any form of explanations and given back the evidence. After a few days, the same poachers can be found poaching in the same area. This situation makes it very difficult to stop poaching in Wami Mbiki."* The same respondent stated *"the current trend of poaching in Wami Mbiki makes the WMA increasingly unlikely to secure an investor."*

3.2.4. Tree cutting

The study revealed overharvesting of trees in the area for firewood (cooking at home, selling, baking bread, and hardening bricks) and construction (houses and toilets). The main tree species used by the community are *Acacia mellifera* and *Spirostachys Africana.* Poles and logs

from *Acacia mellifera* (also called black thorn/hook thorn or mkambala) are good for bee hives, building material (termite resistant), domestic uses (pestles), fencing, firewood, fodder, land improvement (nitrogen fixing), and medicine. The *Spirostachys Africana* (called micharaka) is used because it is not damaged by termites and is thus good for construction of toilets and wood houses.

Tree cutting is undertaken by people from within and outside the WMA. More than 11 cases of the confiscation of illegal logs from the WMA area have been reported. The main destination for logs was Dar es Salaam and Morogoro. Some apprehended culprits were fined, and others were taken to the court. The normal fine for a lorry of more than 3 tones is 1MTZS and a lorry of less than 3 tones is between 500,000 and 700,000 TZS.

The study also showed that the WMA does not have a permit to sell the confiscated logs. One respondent stated: *"…seized logs at Pongwekiona, Kwamsanja, and Superdoll (Mtibwa) areas were sold by TFS. The money was deposited with the central government…. The same thing happened in other incidents involving logs and charcoal…."* The WMA did not receive any share of the revenue even though the trees were harvested in the WMA. This situation created tension and conflict between the Wami Mbiki Society and TFS officials.

3.2.5. Charcoal burning

Charcoal is burnt along the WMA borders and inside the WMA. There is a growing market for charcoal in some WMA member villages, a situation which threatens the existence of the WMA. Most of the charcoal is sold along the Dar es Salaam— Morogoro road. Few of those committing illegal activities in the WMA are caught. For instance, in 2015, there were 20 court cases related to charcoal burning and 8 cases related to wildlife killing/poaching. In 2016, there were few court cases because many of those caught were willing to pay a fine. Presently, 22 motorcycles and 31 bicycles have been confiscated because offenders have failed to pay the fine.

3.3. Human/Wildlife conflicts

3.3.1. Crop raiding

The study showed that elephants, impalas, and monkeys are primarily responsible for invading farms. The areas mostly affected are Mwidu, Kwansanja, Makombe, Pongwemsungura, and Diozile villages and Mtibwa Sugar Plantation. The types of crops affected are sugarcane, maize, and banana. Elephants are most destructive because they eat crops and trample over them. In 2015 in Mwidu Village, about 18 acres were destroyed. The elephants' seasonal movements, expansion of agricultural land, and the proximity of human settlements and agriculture to elephant habitats increase the possibility for crop damage. Large tracts of land for example from Kambala Village have been allocated to sugarcane, a situation that triggers human-wildlife conflicts. The study revealed that the VGS do not respond on time when called in cases of problem wildlife. Due to this, the villagers take matters in their own hands and local hunters kill the offending animal.

3.3.2. Livestock depredation

The study showed that the villages most affected by predators are Mwidu, Tukamisasa, Diozile, Kwamsanja, and Pongwekiona. The most destructive animals are leopard, lion, and hyena. In 2015, at Mwidu Village, two goats were killed by a hyena, and near Pongwemsungura Village, a cow was killed by a lion.

3.3.3. Killing of humans

The study showed that wildlife also kill/injure people in villages adjacent to the Wami Mbiki WMA. For instance, in 2015, hyena injured two people at Maseyu Village. Elephants have also attacked people inside the WMA, especially livestock keepers and poachers. The total number of victims is unknown because most cases of wild animal attacks on human are not reported because it is illegal to enter the WMA without permission. The reasons given for attack were: (a) some people are killed in the process of trying to kill elephants (poaching), (b) some are attacked while grazing livestock in the area, and (c) some are killed because of making a noise that disturbs the elephants. Crocodiles also attack and kill fishermen/women. For instance, in 2016, three pastoralists and two fishermen were killed by crocodiles. In 2015, four pastoralists, two fishermen, and one poacher were killed by crocodiles. Due to frequent attacks from crocodiles, people have ceased to swim in the river.

It is not only the case that wildlife kills people but also humans kill wildlife in retaliation. For instance in 2015, two lions were killed by villagers at Pongwekiona Village.

3.4. Factors contributing to poor performance of the Wami Mbiki WMA

3.4.1. Termination of donor funding and lack of a reliable source of income

When donor funding ended in June 2011, the Wami Mbiki WMA was left without any source of income. At this time, no contract for alternative investment had been secured. In 2012, the Wami Mbiki WMA took the initiative to attract investors in photographic tourism and four applications were received. However, before an agreement could be reached, the negotiations failed. The possible reasons for this failure could be the required annual investment fee of TZS 45 million (US$ 28,125), which was too high considering the low tourism potential and the investment required to develop photographic tourism in the area [44].

Apart from that, the investment agreement was for only for 3 years, which is considered too short a period for an investor to recover their costs. One investor, Safari Legacy, spent about US $300,000 setting up camp between 2008 and 2011. The company discontinued their investment because of the complexity of operating in the WMA which made it impossible to sustain a profitable business [44]. Since 2011, patrol activities in the WMA decreased leading to an increase in illegal activities.

3.4.2. Lack of benefits to local people

A major challenge facing the Wami Mbiki WMA is the ability to generate sufficient benefits for the community to create incentives for them to maintain, manage, and support conservation. There has been no income at household/community level or other benefits from small business (e.g., handicrafts) or other wildlife-related activities. Many respondents felt that the WMA benefits only a few individuals and do not see the importance of keeping it—as one respondent stated *"we see no benefits from Wami Mbiki…so it is better for our land to be returned back to us…"* WMA records indicate that the WMS collected 689,000 TZS; 1,585,300 TZS; and 2,274,300 TZS in 2004, 2005, and 2006, respectively [53]. Also, interviews show that between 2008 and 2012, some tourists visited the WMA, but now there are none. Some of the revenue collected was distributed to member villages.

3.4.3. Politics

Some political leaders, such as ward councillors, partly contribute to the increase in illegal activities in the WMA because they defend encroachers and people involved in illegal activities. For instance in 2017, the ward councillors for Mtibwa led a demonstration to protest against the dislocation of people from Wami Mbiki (in Pagale Nature Reserve).

3.4.4. Lack of commitment by village leaders

The study showed that village leaders sometimes mislead villagers concerning the formal boundary of the WMA and encourage them to oppose the WMA. This encourages people to continue with illegal activities inside the WMA. Due to this, there has been occasional shifting of the WMA boundary. For instance one respondent stated *"The efforts to protect natural resources in the WMA are weakened by many people…leaders, young, and old… people do not like enhanced protection of the WMA so that they can continue with illegal activities…"*

3.4.5. Lack of commitment by the village game scouts

The field data showed that most VGS collaborate with poachers and other people who engage in illegal activities inside the WMA. For instance, the WMS leader said "*in 2015, a poacher was apprehended with elephant ivory, two guns (rifle and muzzle loader), and a bicycle. …the responsible game scouts employed delaying tactics and released the poacher…."* The study also revealed that VGS allow illegal activities inside the WMA (e.g., ruby, rose garnet gemstone extraction, and gold sieving from the Wami River; hunting, etc.) with the intention of receiving financial gain from the perpetrators.

3.4.6. Lack of communication

The study showed that villagers do not receive information and updates from WMS leaders on matters pertaining to the WMA. Since 2011, no meetings have been conducted for village representatives to share information with villagers on the performance of the WMA. The lack

of communication between WMS management and local communities has made it difficult to secure full support from local people on conservation issues. The WMS council meetings are primarily financed by revenues from fines.

3.4.7. Mismanagement of WMS properties and double standards

The study showed that in 2015/2016, the WMA in collaboration with KDU, TANAPA (Mikumi, Udzungwa and Sadani NPs), and TFS removed livestock from the WMA. More than 2000 cattle were rounder up, and their owners paid about 37M TZS in fines. Apart from these fines, 8M TZS was collected from seized cars, motorcycles, and apprehended poachers. The revenue was used to pay the VGS, repair a car, and buy food for the VGS. However, there are claims that the WMS mismanaged the money accruing from this exercise.

The study further revealed that there are double standards in deciding the amount of fines, a situation which encourages corruption as one respondent reported: "*in 2016, we conducted a joint patrol and confiscated a lorry with charcoal. Instead of paying a set fine of 12Mas, we received 3M …in a similar incident a lorry was charged 1M instead of 7M.*"

Since 2002, there have been five changes in WMS leadership. Some leaders were fired due to mismanagement of money and misuse of WMS property. Also, some were accused of showing partiality in handling cases related to illegal activities in the WMA and for defending and protecting those who were illegally harvesting resources in the WMA.

3.4.8. Interests of the facilitator

The DHA interest was to acquire a tourist hunting block for business purpose. This is reflected in the article in WFSA where they stated that an increase in the wildlife populations in the WMA could tolerate controlled hunting "…populations of most game species … can tolerate controlled harvesting through tourist hunting. … but it is of the utmost importance to attain the block allocation as to diversify the economic activities of the WMS" ([54], p 211). However, for ecological reasons, the Ministry of Natural Resources and Tourism (MNRT) revoked user rights for consumptive tourism in the WMA.

3.4.9. Lack of technical personnel

The WMA lacks creative and competent personnel who are able to assist the WMA in business terms to increase income. This situation enforces the dependency of the WMA on fines paid by apprehended poachers and other offenders for its operations.

3.4.10. Conflicts

There have been conflicts among the WMS leaders. Also, there have been cases of VGS being fired without enough evidence, which creates enmity and promotes illegal activities in the WMA. Several meetings have been held to discuss internal conflicts instead of discussing the development of the WMA. There are also conflicts between WMS leaders and government staff (TFS offices in Mvomero and Bagamoyo) in relation to revenue collected from fines and selling confiscated logs. This leads to the lack of cooperation in dealing with illegal activities in the WMA.

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3.5. People's perception of the WMA

People perceive the WMA to benefit WMS leaders but not the community. This is because since 2011, they have not received any benefit from the WMA. The villages heard that the WMA received 37 M TZS, but none of this found its way to the local communities. The expenditure of money was not transparent, and the board of trustees was not involved. For different reasons, some villages, for example Mziha, declined to send a representative to the WMS and wished to leave the WMA. Villages like Tukamisasa, Kwamsanja, and Kunke demanded the return of their land so that they could utilize it for agriculture, charcoal burning, etc. Some people were of the opinion that a new donor and/or investor should be sought soon to avoid the complete disappearance of wildlife in the area.

3.6. Proposed possible ways to improve the current situation

The community proposed the following so as to improve the current situation:

a. The efforts of the Regional Commissioner, especially those requiring people to vacate the area, together with frequent patrols, are crucial. For instance, the operations conducted in the area reduced the number of cattle in the WMA.

b. Maintenance of roads is important for people to be able to access the area. Currently, the WMA has poor roads and some areas are not accessible by car.

c. The WMA leaders should resolve their differences and work as a team. This is important as it will enhance the success of the WMA.

d. The WMA leadership should use the constitution and regulations to guide WMA operations. The study showed that WMA leaders do not follow procedures on issues pertaining to WMA activities, for example, handling issues related to WMA property and revenue, and hiring and firing WMS staff. Most VGS have been fired in a perfunctory manner without adequate justification. For example, up to 2017, 40 VGS had been fired without any investigation of their behavior. These procedures should be transparent and proper investigation must be undertaken before firing staff.

e. A way should be found for sharing income derived from logs or timber harvested in the WMA. The current situation whereby the TFS takes all the money collected is discouraging. Since the WMA comprises village land and villagers have protected the trees they consider they deserve a share of the proceeds. The money accrued could help pay patrol activities and VGS salaries.

f. WMA leaders should follow the procedures for handling WMA income, for example, depositing money in the bank first before incurring any expenditure. The study showed that money collected from fines has been used without depositing it in the bank. This situation encourages mismanagement of WMA income. Moreover, since periods of office for WMA leaders are relatively short, newly-elected leaders should receive training.

g. The government should give special considerations to the interests of WMA facilitators because experience shows that they have contributed to the success of most WMAs.

h. The government should strengthen the WMA in terms of protection and leadership because it is a guardian of all WMAs.

4. Conclusion

The findings of this study showed that following the end of donor support in 2011, almost all activities in the Wami Mbiki WMA ceased. As a result of inadequate protection, the area is severely affected by environmentally unfriendly activities such as poaching, illegal timber harvesting, charcoal burning, overgrazing, and overfishing. The population increase in the area has demanded large tracts of land for agriculture, thereby increasing pressure on the Wami Mbiki WMA. Several factors have been identified that contribute to the poor performance of the WMA. Although the government has tried to improve the situation by removing the livestock inside the area, more effort is still needed to save the remaining wildlife in the area.

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Chapter 7

Power Struggles in the Management of Wildlife Resources: The Case of Burunge Wildlife Management Area, Tanzania

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Additional information is available at the end of the chapter

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Abstract

Through a cross-sectional research design, this study examined power struggles in Burunge Wildlife Management Area (WMA) in Tanzania. Four out of ten villages comprising the WMA were purposively selected, and data were collected via focus group discussions, key informant interviews, questionnaires to household heads, and a literature review. Results showed that the central government, investors and non-government organisations held institutional and strategic powers, while the democratically elected Village Councils held structural powers and lost most of their pre-WMA institutional powers to a legally required new institution, the Authorised Association. Therefore, Village Councils lost influence on strategic, institutional and management decisions pertinent to the WMA and their constituencies' livelihoods. Accordingly, Burunge WMA democratised wildlife management by eroding the relevance of Village Councils to their constituencies. The study also found power struggles over revenues, land management and access to resources among the stakeholders, mainly due to a divergence of interests. However, there was no conflict management mechanism in place. Hence, we recommend that the institutional powers to establish, govern and dissolve WMAs should go back to Village Councils. The purpose is to establish economic incentive structures that promote (i) wildlife conservation, (ii) an equitable distribution of associated costs and benefits between Village Councils forming WMAs and (iii) an equitable distribution of costs and benefits between WMAs and higher levels of government as well as international conservation NGOs.

Keywords: wildlife management areas, power struggles, actors, resource conflicts

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1. Introduction

'Power' in the context of natural resource management has no single universally accepted definition. For instance, some scholars characterise power as the relationship between people [1], while others relate it to coercion, constraint, consent, social relationship and interaction [2]. However, power occurs in various forms including structural, strategic and institutional [3–5]. Structural power, or domination, is asymmetrical, hierarchical, hard to challenge and difficult to reverse [3]. The subordinate actors in structural power arrangements have little room for manoeuvre because their margin of liberty is extremely limited [5]. Strategic power involves structuring possible fields of action of others, and it is expressed through daily interactions between individuals and groups [3]. Accordingly, strategic power has many expressions, including economic ability, rational and ideological argumentation or manipulation [4]. Officialised institutional power is systematised, regulated and involves mandates that are legally defined [3, 5].

Furthermore, power is often exercised through multiple, intertwined institutions[1] following what is socially possible or acceptable [5]. Power analysis must involve observation of actors in decision-making [2, 3, 5, 6]. Therefore, stakeholders' power can be understood as the extent to which they can persuade or coerce others to accept decisions and follow certain courses of action [7, 8]. This may also involve actors resisting the management actions over resources. Counterpower such as foot-dragging occurs in situations where the less powerful try to express their concerns. For example, Scott [9] revealed that in developing countries, communities rarely choose open confrontations against onerous new laws but instead resort to more subtle actions of everyday resistance including foot-dragging and hidden non-compliance, that is, by using the weapons of the weak. When this happens, it is usually a sign of great desperation [9].

In Tanzania, power struggles among actors over decision-making related to wildlife management have lasted for decades [10]. For example, the lucrative nature of wildlife resources has created strong incentives and vested interests for the central government and the associated bureaucracy to maintain control over the resource [11]. As a result, institutional reforms or legal adjustments officially intended to enhance local communities' rights to benefit from wildlife have often been circumscribed to reassert the state's ultimate power in matters of wildlife governance [8]. Over time, these reforms and legislative adjustments have produced asymmetrical power relations in the way decisions are made about wildlife resources and how benefits from wildlife are shared among the actors (*ibid.*).

The United Republic of Tanzania (URT) has decentralised wildlife management through the introduction of Wildlife Management Areas (WMAs) [12]. The Wildlife Policy of Tanzania defines WMAs as a new category of protected areas for community-based wildlife management. WMAs can be established when a group of Village Councils agree to set aside adjacent parts of their respective village lands to form a WMA [12]. However, the process that leads to a fully functioning WMA is long and bureaucratic. It begins with the formation of a community-based

[1]For the purpose of this study, institutions are defined as rules including policies, legislations, regulations, guidelines, bylaws, constitution and other long established patterns of conduct or customs through which people interact with one another.

organisation among the involved villages, which among others must prepare a draft so-named Management Zone Plan for the WMA area. When the Director of the Wildlife Division endorses the Management Zone Plan, the community-based organisation is granted wildlife user rights and becomes a legally recognised institution, called an Authorised Association[2], which is authorised to manage its WMA [13]. With decentralisation by devolution as envisioned in the 1998 Wildlife Policy [12], the Authorised Association is expected to be accountable to the local communities. However, empirical evidence has revealed that Authorised Associations are more accountable to the central government ([14, 15], see also below). This contradicts Ribot's definition of devolution, which 'involves transfers of power to elected local authorities and enables local people to make decisions for themselves through their representative local authorities' [9, 16].

Before the introduction of WMAs, other functionally protected areas included National Parks and Game Reserves where no human settlement is allowed and Game Controlled Areas as well as the Ngorongoro Conservation Area—where settlement is allowed albeit under tight regulation [17]. National parks are managed by the Tanzania National Park Authority (TANAPA); game reserves and game controlled areas are managed by the Tanzania Wildlife Management Authority (TAWA); and WMAs are managed by communities through Authorised Associations, which, except for the secretary and trustee of each Authorised Association, are democratically elected community-based organisations. Therefore, WMAs are a form of common property regimes (CPR), whereby communities are expected to sustainably manage and benefit from wildlife [18, 19]. However, decentralisation usually threatens some actors' powers and interests. As a result, official power transfers from the central government to local actors are often resisted overtly and covertly by different actors [20].

Currently, Tanzania has 38 WMAs at different stages of development [21]. Burunge WMA was among the first nine pilot WMAs in Tanzania. It was launched in 2003 and granted official status in 2006 [22, 23]. Burunge WMA has great significance to Tanzania's protected area network given its function as a wildlife corridor linking Tarangire National Park, Lake Manyara National Park and Ngorongoro Conservation Area [22, 23]. The importance of Burunge WMA has attracted numerous actors to participate in its management. Divergent roles, interests and expectations of these actors are, however, major causes of power struggles, which unfortunately is not unique. For example, Shilereyo [24] reported a situation where local people had no power to influence management decisions in a WMA, while Manyika et al. [25] reported power struggles over forest governance. Also, Bluwstein et al. [14] showed how the process of rule-making and rule-changing in WMAs generated power struggles. However, analyses addressing issues of interests, power disparity and power struggles among the actors in community-based conservation are relatively few. Thus, our understanding of the outcomes including the management of such power struggles is inadequate.

This study examines power struggles among the key actors in Burunge WMA, specifically by attempting to answer the following questions: who are the actors and what are their roles and interests in the management of Burunge WMA? What powers (structural, strategic and institutional) do these actors possess and how do they affect the management of the WMA?

[2]Authorised Association means 'a community based organisation, whose primary objective is to conserve wildlife resources for the benefit of local community members ordinarily residing in that particular area' (URT, 2012:5).

How do these powers determine the outcome of struggles among the actors? And how are these power struggle conflicts managed?

1.1. Theoretical framework

Drawing on Raik et al. [2], Nuijten [3], Kajembe et al. [5] and Manyika et al. [25], this study focuses on identifying actors including their roles, interests and powers to understand power struggles and their outcomes in natural resource governance. The emergence of conflicts is an important indicator of power struggles among actors [2, 25]. In this study, power means the relationship among the actors, while power struggle denotes a negative situation in the course of decision-making where certain actors at the expense of other legitimate actors push forward their interests in the management of WMAs. Also, the study draws on common property theory dealing with the governance of common pool resources. The theory is expounded by the principles of subtractability/rivalry (that one person's resource use diminishes what is available for others) and excludability (that people are divided into 'insiders' who have rights to a defined resource and 'outsiders' who do not have rights) [19, 26].

2. Methodology

2.1. Description of the study area

The study was carried out in Burunge WMA located in Babati District in Northern Tanzania (**Figure 1**). The H-shaped WMA was established in 2003 and covers about 283 km^2. It is formed among 10 villages, namely Mwada, Sangaiwe, Ngoley, Vilima Vitatu, Kakoi, Olasit, Manyara, Magara, Maweni and Minjingu. The residents in these villages practice livestock keeping and small-scale farming as their main economic activities. Their main food crops are maize, beans, bananas, paddy rice, potatoes and millets. Sesame is the major cash crop. The area experiences a bimodal rainfall: short rains from May to June and long rains between November and January. The annual rainfall ranges between 400 and 500 mm, while the temperature ranges between 18 and 33°C [27, 28].

2.2. Research design and data collection methods

The research was carried out between 2014 and 2016 using a cross-sectional design. Four villages, Mwada, Vilima Vitatu, Minjingu and Kakoi, were purposely selected for this study. The main criterion for selection of the study villages was residents' level of acceptance of Burunge WMA and associated arrangements of access to resources (i.e., satisfied or dissatisfied). For example, preliminary survey results showed that Mwada villagers were fairly satisfied with the WMA, while villagers in Minjingu, Vilima Vitatu and Kakoi (a relatively newly formed village separated from Minjingu) were dissatisfied and wanted to withdraw from the WMA.

For triangulation purposes, the study applied several methods of data collection including focus group discussions, key informant interviews and a questionnaire. Focus group discussions were conducted with Village Council members, with youths, women and senior men from each village. Selection for the focus group discussions was conducted so that each group had

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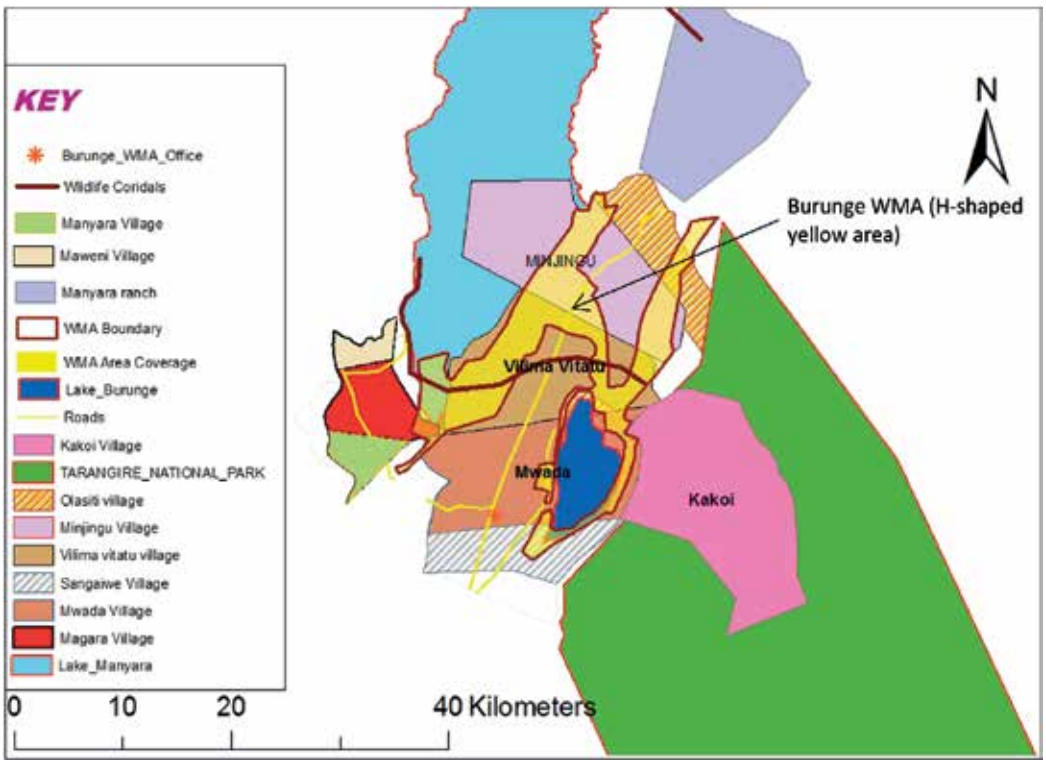

Figure 1. Map of the study area. Source: [15].

different interests, positions and roles in the management of natural resources [29]. Key informant interviews were conducted up to the point at which no new information was obtained, that is, the data saturation point [30]. Informants involved were respondents who had specific knowledge about Burunge WMA including the village chairpersons, senior men and women, the Burunge Authorised Association and Babati District and Wildlife Division officials.

Focus group discussions and key informant interviews sought to identify powers held by the key actors and uncover emerging struggles originating from these power differences. The powers of different actors in the WMA were identified through a stakeholder analysis that uncovered stakeholders with vested interests in the current situation and stakeholders who were likely to be affected, either positively or negatively, in case conditions change or remain the same. The questionnaire survey involved respondents drawn randomly from the village registers (n = 140 households in total) [31]. The questionnaire had both closed-ended and open-ended questions. Along with key informant interviews and focus group discussions, the questionnaire survey was used to assess the existing resource use conflicts. Secondary data, mainly law texts that related to actors, powers of actors, power struggles and conflicts were reviewed.

2.3. Data analysis

Content analysis was used to analyse data related to the institutional and different categories of power possessed by different actors. In this case, all qualitative data from focus group

discussions, the questionnaire and key informant interviews were categorised into related themes [32]. Underlying themes in the categories of words were identified, explained, clarified and interpreted [33].

3. Results and discussion

3.1. Key actors in the management of the WMA

The study revealed various actors with different roles and interests in the WMA (**Table 1**). The interests were both overlapping and divergent. However, all actors supported the objective of wildlife conservation. The local communities viewed conservation as an opportunity to improve their livelihoods, while the central government, through the Wildlife Division, enjoyed the expansion of conservation territory as well as improved revenue collection

Actor	Roles	Interests
Village Assembly	Collective decision-making such as approving the size of land to be allocated for WMA establishment.	Conservation of wildlife; accruing benefits from the WMA and improvement of livelihoods.
Village Councils	Representing villagers in all matters about the villagers' well-being.	Protecting their fellow villagers' rights and promoting their interests.
Authorised Association	Managing the WMA on behalf of the villagers.	Ensuring the conservation of wildlife and that associated benefits are realised at WMA level.
	Act as a power broker between the villagers and the central government agencies and local government.	
District Council	Oversee management of the WMA.	Making sure wildlife is conserved. Generating benefits from the WMA.
Wildlife Division	Making rules for WMA management.	Increasing the area of protected landscapes including wildlife corridors where most WMAs are located.
		Collecting revenues from tourism investments in the WMA.
Non-Governmental Organisations (World Wildlife Fund for Nature, African Wildlife Foundation)	Facilitating WMA establishment.	Conserving wildlife and ensuring the increase of protected landscapes including wildlife corridors between otherwise protected areas.
Investors (Maramboi and Burunge tented camps)	Entering into contracts with the Authorised Association to undertake business ventures in the gazetted WMA.	Generating profits through wildlife conservation.
Tanzania National Parks Authority (TANAPA)	Conserving Wildlife	Ensuring that Burunge WMA acts as a buffer zone and corridor.

Source: field data.

Table 1. Actors, their roles and interests in Burunge WMA.

because the Wildlife Division, by law, has substituted the Village Councils' role as a revenue collector from tourism businesses within the WMA (see below).

The Wildlife Division has three major roles: policy formulation, regulation and coordination. Until recently when Tanzania Wildlife Management Authority was established by government order, the Wildlife Division was responsible for overseeing the management of wildlife outside national parks and the Ngorongoro Conservation Area. However, since the formation of WMAs was based on the promise of enabling people to manage wildlife on their lands and benefit from this resource, the role of revenue collection assumed by the Wildlife Division contradicted expectations of the local communities, whom government officials during the sensitization process verbally promised full control over the WMA and a say over the revenues and other benefits. By assuming the role of revenue collection, our respondents felt that the Wildlife Division had grabbed an intended power of the Authorised Association—defined in the WMA Regulations as 'a community-based organisation, whose primary objective is to conserve wildlife resources for the benefit of local community members ordinarily residing in that particular area' [13].

Besides its conservation role, the Authorised Association is intended to act as a power broker between the local communities and the central/local government agencies. However, the Authorised Association was found mostly to represent the interests of the central government. These findings are similar to another study in the area by Kicheleri et al. [15] where the Authorised Association was found to be accountable to the central government, quite in contradiction to the WMA Regulations, which require Authorised Associations to be accountable to the local communities. Accordingly, the interests of the central government take precedence over those of the local communities. The Tanzania National Park Authority's (TANAPA's) interests are that Burunge WMA serves as a buffer zone to and a corridor between 'its' national parks.

Kajembe et al. [5] contend that in the management of natural resources, triangles of actors including state agencies, NGOs (Non-Governmental Organisations) and local communities are created where power struggles take place. This happened in this case as well where procedural flaws have clouded the Burunge WMA establishment process during which some actors pushed forward their interests without due regard to other actors' interests or formal democratic procedures. For instance, the conflicting interests and power differences among communities, donors, the central government and the African Wildlife Foundation (AWF) negatively affected the AWF's work with communities in Burunge WMA [15, 34]. Instead of acting as a power broker between the central government and local communities, the AWF found itself in conflict with the local communities because it sided with representatives of the Wildlife Division who allegedly manipulated and misled Village Councils to push for their acceptance of the WMA [15]. Accordingly, proper identification of actors, their roles and interests from the very beginning of a conservation-through-decentralisation project is quite vital. The reason being that this allows other actors and stakeholders to assess the likely consequences (for them) when the kind of decentralisation they are asked to support entails a transfer of specific bundles of powers from the centre to particular institutions that are more or less downwardly accountable [16].

3.2. Powers of key actors in Burunge WMA

From these results, the key actors, that is, Village Councils, the Authorised Association, District and Wildlife Division officials, NGOs and TANAPA, and investors exercised different types of powers (**Table 2**). Essentially, there were three types of powers possessed by these actors. The Village Councils had structural power, while investors possessed strategic power. The Authorised Association, District Council, TANAPA, NGOs and the Wildlife Division had both institutional and strategic powers. The structural power relates to cultural or social positions such as being an elder in the society, while strategic power relates to level of education and/or wealth. The institutional power relates to positions in the government, organisations or associations [2–4, 6].

The communities that collectively make decisions at the Village Assemblies are represented by the Village Councils, that is, the democratically elected Village Governments. Therefore, the structural power possessed by the Village Councils is in line with the findings of Kajembe et al. [5] who assert that structural power is widespread in traditional societies. This is because structural power is associated with social position such as being a household, clan or tribal head. It is further associated with a cultural position such as being a traditional healer in a village [6]. However, in this context, the village's liberty to influence the WMA management decisions was limited. Structural power cannot override strategic or institutional powers unless full discretionary powers are devolved [18]. Therefore, to influence multiple levels of governance, structural power needs the backing and support of institutional or strategic powers. Unfortunately, the exact opposite tends to happen, which increasingly restricts those holding structural powers to realms of cultural and religious rather than socio-economic significance.

With democratic decentralisation, it was expected that institutional power over decision-making in the WMAs would be shifted to the Village Councils whose members are democratically elected and thus downwardly accountable to the local communities. However, contrary to this expectation, the Authorised Association, District Council and Wildlife Division have the institutional power to make most decisions regarding the WMA management at the village level. These findings suggest that the rights of local communities to exercise institutional power and manage the WMA were undermined. Thus, a Village Council's ability to influence WMA management

Actor	Type of power
Village Councils	Structural and institutional
Investors	Strategic
Authorised Association	Institutional/governmental, strategic
District Council	Institutional/governmental, strategic
TANAPA	Institutional/governmental, strategic
NGOs	Institutional/governmental, strategic
Wildlife Division	Institutional/governmental, strategic

Source: field data.

Table 2. Actors' powers to influence Burunge WMA management decisions.

decisions was limited by the institutional setup of the WMA. This may be associated with the lack of enforcement of rules that are centrally enacted on the ground together with central government interests to re-centralise (while decentralising) WMA management. In support of this argument, Kicheleri et al. [15] found that WMA related meetings were not conducted in the villages to communicate WMA management performance and progress.

The WMA Regulations Section 17 describes the responsibilities of the Village Council in the management of Wildlife Management Areas [13]. Section 17 (g) states that the Village Council shall 'monitor the activities of the Authorised Association and report to the Village Assembly and District Council'. Section 17 (i) states that the Village Council shall 'ensure that the Authorised Association implements sectoral policies while entering into agreements on the management of a Wildlife Management Area'. Contrary to these statements, however, the WMA Regulations' Section 24 excludes Village Councils as members of the District Natural Resources Advisory Board (DNRAB) [13]. We argue that excluding Village Councils from this Board attenuates their ability to influence Authorised Associations' governance of WMAs.

Investors hold strategic power, which gives them access to investment opportunities in the WMA. Mbeyale [4] identifies wealth among the sources of strategic power, whereas Kelly [35] sees the market value of tourism business as high and, therefore, a key area of investment by actors with strategic power. Essentially, tourism investors want to stay in the market; hence, they employ their strategic powers to stay in business and pay taxes to the Wildlife Division rather than to Village Governments as they did before the WMA was established. Hence, tourism investors often find themselves hijacked in a struggle over tourism-based revenues between the central government and Village Councils.

The NGOs, namely the AWF and the World Wide Fund (WWF) for nature both held institutional as well as strategic powers. In the establishment of WMAs, NGOs are claimed to have used their position to manipulate local communities to accept WMAs [15]. Comparable observations are apparent for REDD+ projects in Tanzania where financial resources were used to earn NGOs higher bargaining power [25]. Similarly, instead of facilitating the process of establishing Burunge WMA through meaningful public participation, the AWF alienated local communities by favouring interests of the central government and donors in expanding the area for nature conservation [34].

3.3. Power struggles in Burunge WMA

3.3.1. Struggles over revenues from the WMA investments

In the WMA, benefits stem from non-consumptive utilisation such as tourist lodges, photographic tourism and consumptive tourist hunting. When Burunge WMA initiated operations in 2006, the Authorised Association collected and distributed non-consumptive utilisation revenues from tourist investors among Village Councils. That practice changed in 2012 when the Wildlife Division took over the role as revenue collector from the Authorised Association. This change emerged following the release of the Non-Consumptive Wildlife Utilisation Regulations of 2008 (revised 2016) in which Section 16 (3) states that 'the Director shall collect the fees prescribed under these Regulations on behalf of the Authorised Association' [36].

According to one of the Wildlife Division officials, this change was instituted after learning that the Authorised Associations had inadequate capacity to collect the revenues. Allegedly, this deficiency resulted in minimal revenue collection from investors. These observations are in line with those of Ribot et al. [20] on how governments justify re-centralisation control over revenue streams from community-based programmes. Whether the alleged poor capacity of the Authorised Association to collect revenue is true or not, an effective community-based programme must include fiscal devolution, otherwise, the discretionary powers of locally elected leaders become irrelevant to their constituency's livelihoods [16]. The changes in revenue collection also provoked complaints from the Village Councils who claimed that their share of revenue had decreased, which indeed was the case from 2011/12 to 2012/13, c.f. **Table 3**.

However, the most important messages from and related to **Table 3** are that: (i) it was difficult to get access to the data, which is held at the Authorised Association's office, (ii) in most years, the Authorised Association seemed to accumulate substantially larger amounts of cash from the WMA than what any Village Council received and (iii) during Burunge WMA's 12-year history, the Authorised Association appears to have accumulated a surplus of more than TZS 833 million or on average just above TZS 69 million per year, which is more than three times the average annual amount received by the individual villages. Accordingly, the first author attempted to access the Authorised Association's audited accounts to verify its bank balance, but that was promptly stopped. Her subsequent requests to access the books of the Authorised Association were categorically denied.

After 2012/13, when the central government had re-centralised WMA revenue collection, official revenues going to the Village Councils picked up. Although positive in a narrow sense, this fiscal re-centralisation is problematic, c.f. above. Further, our respondents generally agreed that the Authorised Association's capacity to govern the WMA and associated revenue flows needs improvement as does public access to scrutinise the Authorised Association's accounts.

The re-centralisation of WMA revenue governance is evident in the WMA Regulations and associated legislation, which specify how revenues from a WMA must be shared. The Non-Consumptive Wildlife Utilisation Regulations Section 19 (b) stipulates a sharing mechanism of revenues from the non-consumptive operations in WMAs, stating that '5% shall be directed to the District Council, 25% to the Director of Wildlife and 70% to Authorised Associations' [36]. Non-consumptive utilisation includes game viewing and other ecotourism investments in WMAs including tourist lodges and hotels. Likewise, the WMA Regulations Section 48 (8) states that 'the income generated from resident hunting in WMAs shall be shared as follows: (a) Authorised Association 40%; (b) responsible District Council 60%' [13, 31]. Moreover, the Twelfth Schedule of the WMA Regulations provides a table showing how benefits from tourist hunting in the WMAs should be shared. The benefits are shared between the Tanzania Wildlife Protection Fund (TWPF) unit in the Wildlife Division, the Wildlife Management Area (WMA), the District Council (DC) and the Treasury (TR) as shown in **Table 4**.

Furthermore, the 2012 WMA Regulations Section17 (e) [13] authorises the central government to determine the level of benefits local communities get from WMAs. The Regulations state that Village Councils will be responsible for 'approving the mechanism for benefit sharing among the villages forming the Wildlife Management Area in accordance with guidelines

Fiscal Year	WMA gross revenue[1]	Village Councils' share[2]	WMA expenses	Authorised Association's surplus	Each Village Council	Number of villages[3]
2006/7	37,496,988	18,748,494	8,296,411	10,452,083	2,083,166	9
2007/8	75,256,890	37,628,445	24,243,022	13,385,423	4,703,556	8
2008/9	64,595,376	32,297,688	34,211,010	−1,913,322	3,588,632	9
2009/10	227,618,815	113,809,407	101,338,183	12,471,224	11,380,941	10
2010/11	391,459,764	195,729,882	150,325,192	45,404,690	19,572,988	10
2011/12	473,738,860	236,869,429	175,940,789	60,928,640	26,318,825	9
2012/13	275,430,040	137,715,020	163,041,379	−25,326,359	13,771,502	10
2013/14	412,593,089	206,296,544	175,515,558	30,780,987	20,629,654	10
2014/15	820,954,000	410,472,500	290,810,232	119,662,268	41,047,250	10
2015/16	795,272,230	397,636,115	383,923,203	13,712,912	39,763,611	10
2016/17	1,268,810,655	634,405,327	460,869,316	173,536,011	63,440,533	10
2017/18	2,071,861,968	1,035,930,984	655,882,294	380,048,690	103,593,098	10
Sum	6,915,088,674	3,457,539,835	2,624,396,589	833,143,246		
Average per year				69,428,604	29,157,813	

[1]After the deduction of shares to the Tanzania Wildlife Protection Fund, the District Council and the Treasury (see below).

[2]Village Councils are entitled to 50% of the WMA gross revenue as per legal regulation.

[3]In 2006/7–2008/9, the total number of villages was nine as Kakoi village was formed in 2009/10. As part of Minjingu village's struggle to pull out of Burunge WMA, its share in 2007/8 and 2011/12 was used by the Authorised Association to fund a secondary school project.

Source: field data.

Table 3. Burunge WMA revenue collection and distribution (current TZS).

Fee	TWPF	WMA	DC	TR
Block fee	25%	75%	0	0
Game fee	25%	45%	15%	15%
Conservation fee	25%	45%	0	30%
Observers fee	25%	45%	0	30%
Permit fee	25%	15%	0	60%

Source: [13]

Table 4. Distribution of income generated from tourist hunting activities in a WMA.

issued by the Government from time to time' [12, 13]. Section 66 (1 and 2) further elaborates on benefit sharing mechanisms at the Authorised Association and village level: '(1) benefit-sharing in Wildlife Management Areas shall comply with circulars issued by the government from time to time. (2) Authorised Association shall ensure that: (a) at least 15% of its annual gross revenue is re-invested for resource development; (b) at least 50% of its annual gross revenue is directed to villages forming part of the Wildlife Management Area and (c) at least 25% of its annual gross revenue is used to strengthen the Authorised Association'. This distribution leaves out 10% of the revenues. Interviews with the Authorised Association officials revealed that 50% of the gross revenues stay with the Authorised Association, while 50% goes to the villages forming the WMA, c.f. **Table 3**. According to local Wildlife Division officials, the missing 10% from the WMA Regulations is an error in the Regulations and that revenues should be divided equally between the WMA forming Village Councils and the Authorised Association.

Villagers in Burunge WMA knew that their Village Councils' share of the WMA revenue originated from their land. However, they did not know how much this amounted to in percentage of the total WMA revenue, and they were unaware that all Village Councils got equal shares irrespective of the fact that each village had contributed different areas of land to the WMA and some hosted tourist lodges or camps while others did not. As noted above, the group of Village Councils do get their minimum share, that is, 50% of the WMA revenues. However, this share is entirely top-down defined and then imposed on Village Councils who did not seem to have foreseen this loss of authority over village land revenues when they joined Burunge WMA.

Power struggles over revenue-sharing were also observed between the Village Councils and the Authorised Association. For example, Village Councils complained about the 50-50 share of revenues between them and the Authorised Association. Further, Village Council members argued that regardless of the amount received by the Authorised Association they did not see the necessity or legitimacy of dividing those revenues equally between them. For example, Village Council members in Minjingu and Vilima Vitatu villages claimed that since they had supplied more resources and land to the WMA, other villages did not deserve equally high shares of the WMA revenues. The size of land contributed to the WMA was 3746 ha from Minjingu, 12,829 ha from Vilima Vitatu, 3039 ha from Mwada, 2445 ha from Sangaiwe and 2257 ha from Magara [27, 28].

Dissatisfaction over the rule specifying that revenues must be divided into arithmetically equal shares among the participating villages figures among the reasons why Minjingu village wants

to withdraw from the WMA. Before the formation of Burunge WMA, Minjingu village had signed a contract with the investor who operates Maramboi Tented Camp on their village land. The investor started operations in September 2006, and in 2008, Minjingu village was forced to share that revenue with the other villages. **Table 5** shows the revenues received by Minjingu village from Maramboi Tented Camp in 2006 and 2007 before the investor was required to pay the Authorised Association instead of Minjingu village. Due to this and claims by Minjingu village that it did not willingly accept joining the WMA, Minjingu Village Council sued the investor and the Authorised Association in 2014. During the conflict, Minjingu village continued to demand its revenues from the investor who was paying first to the Authorised Association, and since 2012, to the Wildlife Division, c.f. above. At the same time, Minjingu occasionally refused to accept its shares of revenues from the Authorised Association, c.f. **Table 3**. Therefore, to prevent anger and frustration among villagers, the investor had to renegotiate his position and contribute to village development activities in Minjingu over and above previously agreed annual payments that went to the Authorised Association and subsequently to the central government. This enabled the investor to stay in business but reduced his profit margin.

Benefit-sharing programmes that do not address problems at the household level are likely to become unpopular no matter how much money is injected into them [38]. Unfortunately, costs in the form of wildlife causing crop damages and restrictions on traditional uses of resources within areas set aside for the WMA rather than benefits have materialised at the household level in Burunge WMA [39]. Nevertheless, the WMA Regulations Section 17 (e) specifies that the central government is mandated to determine the share of generated benefits that local communities are to receive from village land investments [13]. This clearly contradicts Section 26 of the Local Government District Authorities Act No. 7 of 1982 that mandates Village Councils to be corporate bodies, which are free to earn benefits from investments on their land and to determine how to use the revenues for their own development [40]. In this context, however, the structural power of the Village Councils cannot override the strategic and institutional powers possessed by the Authorised Association, the District Council and the Wildlife Division. This imbalance is bound to cause conflicts.

3.3.2. Power struggles over the management of Burunge WMA

The general narrative presented to Village Councils in Burunge WMA suggested that the decision to set aside part of their village lands for conservation under a WMA would not affect their control over these lands. However, the strategic powers that the Authorised Association

Year	Revenue from Maramboi Tented Camp directly to Minjingu village	WMA revenue to each of the other villages
2006	11,198,479	2,083,166
2007	40,511,101	4,703,556

Sources: [37]

Table 5. Revenues received by Minjingu and the other WMA villages in 2006 and 2007 before the investor was required to pay the Authorised Association in current TZS.

share with the District Council and the Wildlife Division has largely made it the, de facto, governing body of the WMA area. Even though the villagers officially form it, the Authorised Association distanced itself from the communities and acted mostly in the interest of outsiders. The WMA Regulations' Section 17(a) states that village councils shall 'provide land for the designation and establishment of a Wildlife Management Area' [13]. Accordingly, Vilima Vitatu's Village Council committed 65% of its village land to the WMA during the WMA initiation process, that is, 12,830 ha out of 19,800 ha. Simultaneously, the village population increased from 1,323 in 2003 to 3,281 people in 2014. Therefore, the village wanted to reclaim part of its land from the WMA to offer livelihood opportunities to its citizens. That, however, proved to be far from straightforward. The WMA Regulations Section 37(a) states that a WMA will cease to exist when there is 'a change of use in the Village Land Use Plan' [13, 26]. However, since WMAs are formed by many villages, one or several of these are not free to independently change the status of the part of their land that falls within the WMA. The WMA Regulations are silent on what should happen in a situation where one or several villages change their land use plan and continues to be party to the WMA, but Kicheleri et al. [15] found that when a WMA is gazetted, the land within the WMA appears to change legal status from village land to reserved land. Thus, if Village Councils like that of Vilima Vitatu want to modify their land-use plan, they wake up to a realisation that they have lost control over, the part that falls within the WMA. Meanwhile, the WMAs generate substantial revenues from different investment ventures. As mentioned, 50% of these revenues are controlled by the Authorised Association, not the Village Councils. Hence, although Village Councils hold *de jure* institutional power, the WMA institutional arrangement severely limits their control over WMA revenues (strategic power), thereby undermining their relevance to their constituencies among whom many feel under-compensated for losses they have suffered because of Burunge WMA. Adding pain to injury, the Authorised Association leaders are, in comparison to Village Council leaders, paid generous allowances to attend meetings and workshops in different parts of the country which makes their positions more prestigious and financially attractive than those of Village Council leaders.

An interview with the Wildlife Division officials regarding the management of WMAs revealed that the central government's approach was to progressively build the capacity of Authorised Associations to fill their roles. Nevertheless, Village Council members from the study villages claimed that the Authorised Association had thus far failed to communicate its mandate and obligations to local communities. These findings correspond with those of Kicheleri et al. [15] who found noncompliance with WMA Regulations by Burunge Authorised Association, which failed to hold meetings with villagers. Village Councils and the Authorised Association both hold institutional power, but they differ in the sense that Village Councils have structural power over the people, while the Authorised Association has strategic power (money). Hence, including Village Councils in Authorised Association meetings could challenge the latter's strategic power. Formally, nothing prevents Village Councils from seeking such influence, but information gaps and lack of clear communication channels among the WMA actors have thus far prevented this from happening in a structured manner, which is a major cause of frustrations and conflicts [41].

In short, Burunge WMA has, contrary to its official objective, attenuated the democratically elected Village Councils' powers over their village lands *as well as* their power over revenue

streams from such lands. Village Councils lost their original authority over land and revenue to a newly created and supposedly democratic institution, the Authorised Association, which has subsequently lost part of its authority over WMA revenues to the Wildlife Division and District Councils. Notably, this followed a 'rule through law' process the dangers and consequences of which Village Councils did not realise before it was too late. Intended or not, this looks like 'divide and rule' tactics by the central government to re-centralise while decentralising wildlife governance. Following Ribot's [16] definition of democratic decentralisation: *The transfer of meaningful powers over resources and associated revenue streams from the centre to responsive, representative, and downwardly accountable local institutions*, Burunge WMA has done the exact opposite vis á vis Village Councils.

3.3.3. Power struggles over accessing and using resources

The establishment of Burunge WMA has imposed opportunity costs on local communities by prohibiting their access to natural resources such as water, thatching grasses, building poles, dry season grazing areas, firewood and Doum Palm (*Hyphaene compressa*). However, extraction of some resources such as firewood was allowed on special occasions such as burial ceremonies. Bluwstein et al. [14] reported a similar situation as well as the resulting resistance from local communities within Burunge. In this respect, Kakoi village is a good example. Here, people applauded the idea of establishing the WMA following a verbal promise by the Wildlife Division's representative that the villagers' access to dry season fodders within the WMA area would be maintained. However, unknown to the villagers at that time, plans for tourist hunting in the very same area were also under development. This may explain villagers' subsequent claim that they were hardly involved in the detailed and formalised processes of developing a management plan to legally establish Burunge WMA, c.f. Kicheleri et al. [15]. Village Assemblies and Councils were involved during the sensitisation process but excluded during the preparation of the Management Zone Plan and General Management Plan for the WMA. As mentioned, the official recognition of the WMA area as well as the Authorised Association's authority to manage it is contingent on the Wildlife Director's official endorsement of the Management Zone Plan, which identifies areas for specific uses and set limitations on other forms of use depending on the purpose and sensitivity of the resources. Unsurprisingly, tourist hunting turned out to be incompatible with local resource uses due to risks of accidental injuries or casualties and disturbance of the wildlife targeted for hunting. Accordingly, when the investor complained to the Authorised Association that villagers' collection of fodder and grazing of livestock impacted his tourist hunting business negatively, the Authorised Association decided to criminalise these activities through a revision of the WMA Management Zone Plan. So, on the (verbal) promise of continued access to key resources, the people of Kakoi village were mobilised to support the establishment of Burunge Authorised Association, which subsequently used its legally defined authority to deny people access to these very resources.

3.4. Conflict management in Burunge WMA

Power struggles have fuelled numerous conflicts in Burunge WMA. However, our respondents in the four case villages distinguished between 'conflicts', which they identified as situations where conflicts of interests led to open confrontations and 'problems', which they

identified as circumstances that had made villagers' lives harder but not led to open confrontations. Rules on rights to land and environmental resource use were identified as the source of conflicts among pastoralists, the investor (Maramboi and Burunge Tented Camps) and the Authorised Association (**Table 6**). The conflicts were primarily over access to grazing areas and fodder. Frequently these conflicts were associated with problems of access to (potential) agricultural land, water, building poles, firewood, and thatching grass as grazing lands provide these opportunities and environmental products too.

Table 6 illustrates that most (74%) of the interviewed households stated that conflicts existed within the WMA all of which were over land-use and involved pastoralists, investors and the Authorised Association. The Authorised Association was involved in all conflicts because, since the establishment of the WMA, all investors are answerable to it and not to the respective Village Councils.

Kakoi, which is a rather new village established in 2009, has had land use conflicts over fodder with the Authorised Association since its initiation. On many occasions, villagers from Kakoi cited the separation of Kakoi from Minjingu Village, which wants to pull out of the WMA, as equal to the *German divide and rule tactics during the colonial era.* With the assistance of district officials, it was possible to establish Kakoi village and persuade villagers to join the WMA. Although this tactic was successful, it has not ended land use conflicts. These findings support Neumann [42] and Fairhead [43] who assert that land use conflicts are ubiquitous in CBNRM in Africa. However, this was not expected in the WMA context as CBNRM programme principles aim at giving local communities more rights to resources and associated revenues as well as rights and opportunities to manage conflicts, compared to 'fence-and-fine' conservation approaches [44].

This study also uncovered several problems that villagers perceived were directly related to the WMA and the Authorised Association. Villagers claimed that crop raiding had increased since the WMA was established. As described by a man in Kakoi village: '… *the elephants come in a herd at night before raiding a pumpkin farm. A few would come close to the farm and walk around. When they realise there is no danger, they will give a trumpeting that will call the rest of the herd into the farm'*. Villagers complained about lack of compensation following crop raids. Likewise, fishermen claimed that the Authorised Association had taken over the responsibility of the Beach Management Unit (BMU) [45] denying them their livelihoods, where in reality the BMU should have been run by the communities. They further accused the Authorised Association of assuming control over Burunge Lake.

Villagers also accused investors of fuelling conflicts in Burunge WMA, presumably due to the inherent conflict potential of their conflicting land-use interests. Thus far, none of the

Village				Total	Mean	Percentage
Mwada	**Vilima Vitatu**	**Minjingu**	**Kakoi**			
15	25	30	34	104	26	74

Source: household interviews (n = 140).

Table 6. Land-use conflicts involving pastoralists, investors and the Authorised Association.

identified conflicts between the District Council, the Wildlife Division, Village Councils and the Authorised Association have been resolved. The strategic power (money) possessed by investors in the WMA made villagers claim that the investors bribed officials of the Authorised Association and the District Council to disregard villagers' interests in their village land. For instance, respondents claimed that when they report an incident to the said officials, they tend to team up and visit the investors before calling a resolution meeting with the villagers. The District Council and Authorised Association officials denied these allegations.

No specific participatory and transparent mechanisms to manage and resolve conflicts within Burunge WMA exist. Instead, actors use different means and ways to push their agendas. For example, villagers report conflicts to the Village Councils or the Village Executive Secretary. The Village Councils report conflicts to the Authorised Association or the Babati District Council. The Authorised Association reports conflicts to the Babati District Police and Wildlife Division, while the investors report conflicts to the Authorised Association, District Council and the Police. Also, some villagers deal with problems simply by extracting products in contravention of the WMA rules, that is, through everyday forms of resistance. This multitude of approaches to deal with conflicts and diverging interests is rather bewildering and contrary to the recommendations of, for example, FAO [46], according to which participatory mechanisms for conflict management are critical for successful natural resources management.

4. Conclusion and recommendations

In the management of Burunge WMA, actors had different types of power and to some degree diverging interests, which features among the major causes of resource conflicts and power struggle between the key actors: the Village Assemblies, Village Councils, Babati District Council, NGOs, TANAPA and the Wildlife Division [47, 48]. Overall, Village Councils, the pre-WMA existing village-level democratic institutions, lost powers over their village lands and associated revenue streams-mainly to the Authorised Association but also to the Wildlife Division. All other actors held and gained, via legislative and management rule revisions (rule *through* rather than the rule *of* law), strategic and institutional powers that enabled them to influence WMA management decisions and dominate village citizens' interests. Thus, and quite contrary to its official objectives, Burunge WMA has de-democratised wildlife governance by undermining the importance and relevance of Village Councils to their constituencies. Investors had strategic powers (money) that enabled them to survive amid struggles and conflicts that inevitably involved their business interests. NGOs' strategic and institutional powers enabled them to promote their conservation interests. Specifically, power struggles among the actors were about the generation and distribution of costs and benefits, which resulted from the WMA rules and regulations. Due to power struggles, conflicts emerged over the access to and use of WMA resources. However, conflict management mechanisms pertinent to the WMA were absent.

Consequently, this study recommends that institutional powers must be returned to the Village Councils, whose responsibilities include all aspects of their constituencies' livelihoods. Accordingly, Authorised Associations must be formed *by*, not *in addition to*, the group of Village Councils that have set aside parts of their village lands to form a WMA. Based on

the fundamental principle that WMAs should always be more profitable to Village Councils than realistic alternative uses of their village lands, such new Associations (authorised by the Village Councils as well as the Wildlife Division) should collect and redistribute WMA revenues. Relevant district-level and state-level actors should also get a share if and only if this does not violate the above principle. Accordingly, legislative amendments must secure individual Village Councils permanent and widely defined rights to withdraw from WMAs. Also, the group of Village Councils that contribute land to a WMA should hold legal rights to dissolve the WMA. Both instances must result in the reinstatement of Village Councils' pre-WMA rights to their village lands and related resources. Such legal rights of Village Councils to pull out of or dissolve a WMA would fundamentally change the current economic incentive structure. First, if the WMA yields an overall income that surpasses the sum of perceived net benefits from realistic alternatives, then the group of Village Councils would face a strong incentive to negotiate viable short- and long-term compromises for governing the WMA including how to spend and share common funds among them. Second, the central government, conservation NGOs and potential donors would face a compelling incentive to uphold the moral justification for WMAs: that they remain the most attractive land use for rural communities—in practice, not just potentially or in theory.

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Chapter 8

Marine Stock Enhancement, Restocking, and Sea Ranching in Korea

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Additional information is available at the end of the chapter

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Abstract

The Fish Stock Enhancement Programs (FSEPs)-based Fish Stock Rebuilding Plan (FSRP) have been established and operated from 2006 and is expanded to 16 species in 2016. While the current FSEPs-based FSRP is operated by species if the FSEPs-based FSRP be expanded to encompass the whole coastal ecosystem, it will greatly contribute to more effective FSEPs-based FSRP for all overfished species in coastal and offshore fisheries in Korea. This study is intended to introduce the processes and the contents of the Korea's FSEPs-based FSRP and its fisheries resources management policies in more details. It is also to reveal any current issues in the socio-bioeconomics to achieve the effectiveness of the FSEPs-based FSRP. Objective recovery amounts of catch for each step were configured and a 10-year FSEPs-based FSRP was simply analyzed by catch data. The 10 year results of the FSEPs-based FSRP show that the amount of catch was increased in 8 species among 10 species.

Keywords: Fish Stock Enhancement Programs (FSEPs), Fish Stock Rebuilding Plan (FSRP), fish catch recovery

1. Introduction

The world's fishing has contributed to human welfare, income, augmenting employment and meeting raised food demand. On the other hand, it has also imposed a firm threat on fishery resources and marine ecosystems by diminishing stock abundance and biodiversity, and compromising the economic viability of the fishing industry [1, 2]. The present situation compels the United Nations to draw attention toward sustainable resource management in the oceans [3]. In this regard, a reduction in only fishing effort should counteract the increase in global per

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capita fish intake registered over the last five decades [4, 5]. South Korea has increased the fishing pressure on many marine resources in a sustainable way in a short period [6, 7]. This situation compelled the whole nation and experts to think about exploited stock rebuilding to make sound marine ecosystem. Though conditions vary from species to species, stock assessment carried out in coastal and offshore areas in Korea revealed that the total fish harvest dropped consistently from 1.7 million tons in 1986 to 1.0 million tons in 2004 [8]. Remained fishing pressure can be one of the potential causes to deplete fish stocks by 3.5 million tons in a decade [6]. In addition, in the 2000s, the proportion of adult fish in the catches was lower than 20% [8]. This highlights that the reproductive capacity of fish stocks has been sharply decreased, which not only resulted in the decline of fishery resources but also increased the percentage of immature fish.

Besides fishing pressure, climatic variations, unbalanced catch composition, environmental contamination, and habitat destruction are other factors contributing to the decline in the biomass of marine resources [7]. Moreover, co-management of fishing grounds with neighboring countries has not been effectively carried out due to territorial conflicts. Some of the fishing management strategies conventionally adopted by the Korean Government include closures in fishing time, area closures, mesh size regulations, and mesh as well as input control. Conventional fisheries management strategies had solely focused on arbitrating within fisheries and maintaining fishing industry rather than on rebuilding stocks. Besides, management policies also were implemented ineffectively in accordance with stock data. In particular, the characteristics of coastal and offshore multi-species fisheries put the ultimate challenges in implementing management policies for each fish species. Likewise, another potential reason of depletion in fisheries resources is the failure of effectively refrain fishers from overfishing of juvenile fishes due to mix fishing [6]. As a result, the Korean government has taken step to rebuild fish stocks as the core objective of fisheries policy. The government launched the Fish Stock Rebuilding Plan (FSRP) including traditional management measures and Fish Stock Enhancement Programs (FSEP) in 2005 to effectively achieve this objective.

This study introduces the methods and insights of the Korean eco-friendly FSEP-based FSRP and its 10-year fisheries management policy. It presents different strategies proposed to overcome any issues related to the implementation of the FSRP plan.

2. FSEP-based FSRP's legislative policy and scientific structure

2.1. FSRP's legal framework

Understanding fisheries law is not easy to Korean fishermen due to its complex structure with 3 presidential decrees and 15 ministerial ordinances. Still, the 1960s law standards are applied even though some measures are contradictory to current fisheries management plans.

In this context, the "Fisheries Resources Management Act" was announced and established by the government on April 22, 2009, to conduct "broad and methodical fisheries resource management and to establish and implement fisheries resources recovery plan" [6]. The sole goal/

purpose of this law is to enhance fish stocks by conserving and managing marine resources through strengthening research and assessment. Some key features of the law are as follows:

1. Fisheries resources research and assessment shall be conducted each year.
2. Plan to recover fisheries resources shall be established every 5 years.
3. Institutional ground for co-management to settlement of dispute was established.
4. International rules like promoting international cooperation, eco-friendly fishing method, sharing data on resources management, and precautionary approach are also incorporated into the law.

Then, the Ministry for Food, Agriculture, Forest and Fisheries initiated the Fishery Resources and Environment Division to develop and implement FSRP. In addition, the Fishery Resource Recovery Team (FRCT) was established to conduct research, implement resource enhancement programs, and management. For working effectively with FRCT, fishermen, academics, governmental officers, and researchers were encouraged to participate in developing, implementing, and assessing FSRP. A newly organized Science Committee (SC) and the Fishery Resource Management Committee (FRMC) will also take part in decision making for FSRP implementation [9].

2.2. FSRP's scientific background

Depending upon the status of the fish species, efforts are directed toward the recovery and management of the target fish under specific ecosystem-based FSRP. A Fish Stock Rebuilding plan was set up for drastically depleted species. By contrast, fisheries management plan was taken into consideration for overexploited species. Intensive management on total allowable catch (TAC) was provided where TAC target species were key staples. To understand the situation of selected target species in offshore and coastal seas, the decision was made on the basis of three steps such as (1) investigating applicable materials and recovery of target fish; (2) classifying fish to manage and recover target species; and (3) setting target quantity at each stage for recovery.

In most cases, the only data available to assess the state of fish stocks were the annual catch data, except for a few species. Based on the method used by Garibaldi and Caddy [10], 3-year moving average fishery data were analyzed to evaluate the condition of fish stocks by using the species catch data. When catch level was less than 20% of the maximum moving average value, it was grouped as depleted stock. From an analysis at the beginning, 30% catch reduction of some fish species were targeted to recover.

By 1990s, several stocks had depleted significantly; therefore, data could not depict absolute state of stock by species. To include species for recovery, fluctuation trends of catch by species were analyzed. Hence, considering the features of fluctuation trends of catch, they were grouped into (1) very low, (2) low, (3) decreasing, (4) decreasing trend after increasing, (5) fluctuation, (6) stable, and (7) increasing. Then, the species that were within (1), (2), and (3)

conditions were grouped as recovery targeted species at last. The rest of the fish species were considered as management target species.

Meanwhile, stock biomass and maximum sustainable yield, MSY, for 10 targeted species was estimated. Among those species are Sand Fish (*Arctoscopus japonicus*), Blue Crab/Swimming Crab (*Portunus pelagicus*), Octopus (*Octopus vulgaris*), Tokobushi Abalone (*Haliotis discus*), Skate/Ray (*Hongeo koreana*), Cod (*Gadus macrocephalus*), Yellow Croaker (*Larimichthys polyactis*), File Fish (*Stephanolepis cirrhifer*), Korean flounder (*Paralichthys olivaceus*), and Purplish Washington Clam (*Saxidomus purpuratus* Sowerby). On the basis of the results of assessment, recovery target for every phase and recovery tenures were set.

In addition, fishery resources that required systematic and broad management were found through conducting research and assessment. FSRP, TAC, and Marine Protected Areas were also implemented after the assessment plans. A "total fishery resources information database" was created and then operated to manage systematically for implementing FSRP. Fishery resources information like fishing status, habitat, and ecological information were collected under the "total fishery resources information database." A useful scientific research assessment system was built on the basis of this database.

Furthermore, the central and local governments divided the role in research and assessment considering features of every species and strengthening human resources on stock assessment and research. It was aimed to construct a more effective scientific research and assessment system for better management and improvement of FSRP. Thus, research, assessment manuals, and model fully based on the characteristics of each species were made. Moreover, ecological changes including climate change were taken into consideration when stock assessment by species was done. To develop and implement the FSRP, the stock assessment by species was supplied as basic data [6].

3. FSEP-based Fish Stock Rebuilding Plan

3.1. Fish Stock Enhancement Programs

Fish Stock Enhancement Program (FSEP) is one of the major tools of rebuilding fishery stocks carried out by the Korean Fisheries Resources Agency (FIRA). FIRA is involved in Fish Stock Enhancement Programs including the construction and installation of artificial reefs, production and release of fish seeds, and building and managing marine ranches and marine forest (marine reforestation) to restore and recover fish stocks in Korea's coastal and offshore fisheries. In Korea, the main goal of Fish Stock Enhancement Programs is to increase fish stocks and fishermen's income by improving the marine environment and restoring productivity for natural population of fish [11]. The artificial reef program was implemented in 1971 to increase fisheries resources by creating habitats and spawning grounds. The fry stocking program has been operating since 1976 in order to complement and enhance the recruitment of fishery resources by directional fry releases of Jumbo Shrimp, Blue Crab, Flat Fish, Kuruma Prawns, Jacopevers, and Abalone. The marine ranching program was conducted in four main coastal

areas since 1998 (**Figure 1**). This program is conducted by using multiple networks, based on the industry-university-institute model, to establish optimum technical and model development. Since 2009, the marine seaweeds forest program has been playing an important role in the spawning, breeding, and feeding grounds for many kinds of marine organisms including fishes. The program focuses on the reestablishment of marine seaweed forests destroyed by some factors such as sea temperature rise, marine pollution, and algae-eating animals.

3.1.1. Artificial reefs program

Artificial reefs are man-made structures placed in the sea to attract, protect, and cultivate marine organisms. It is one of the main methods of creating and enhancing marine resources, utilizing the environment of marine life. Selective artificial coral reefs have been used to enhance specific fish populations. Improved rugged-type reef and round reefs were used for

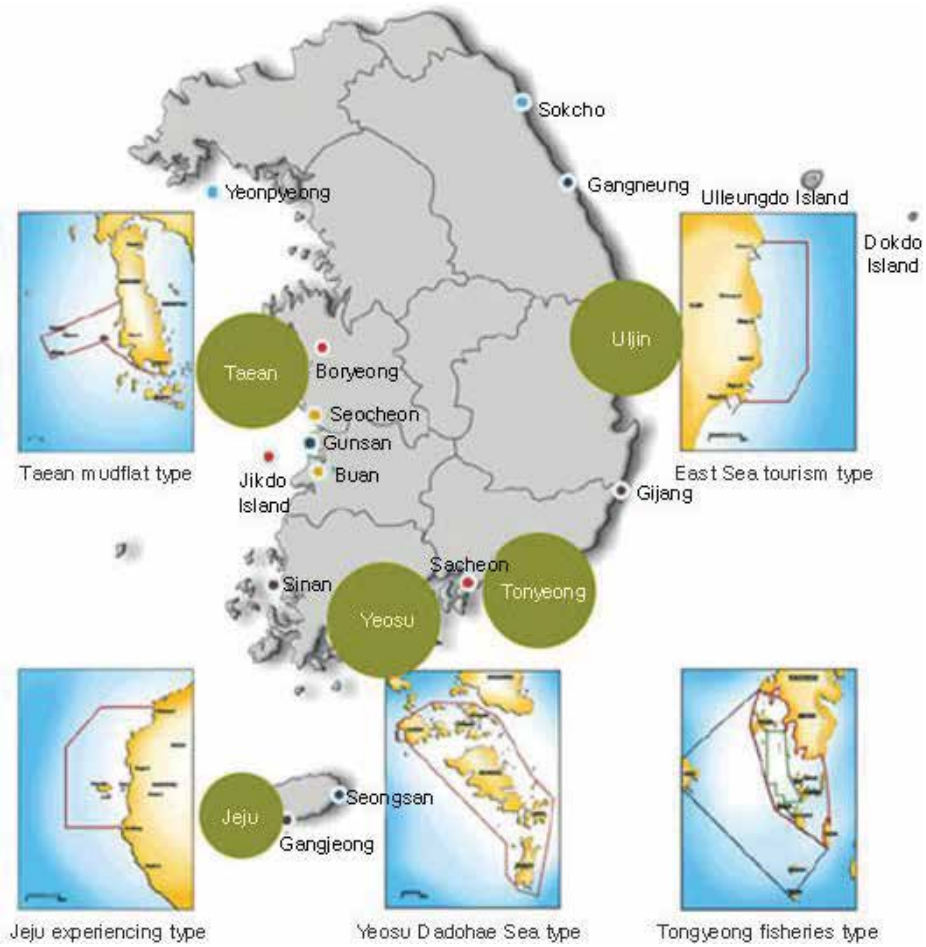

Figure 1. Map of coastal marine ranches in 2014. Source: Fisheries resources agency (FIRA), homepage, business FIRA, 2015.

shellfish and algae while large octagonal dams and cube and box shape reefs were used for small and medium fishes. In addition, for large fishes, composite steel fishing vessel reefs and large octagonal dome-shaped reefs were used. The installing process of artificial reefs is related to site suitability assessment, structure of reefs, and follow-up management.

3.1.2. Fish seed-releasing program

Young healthy artificially produced fish and shellfish are selected and released in a suitable environment with the purpose of increasing marine resource abundances. Afterwards, continuous research is conducted in order to determine releasing efficiency and investigate any effect associated to seedling releases, including monitoring the genetic diversity and the preservation of a healthy environment after the releases. The total seedling released accounted for 4.85 billion, including government (1.58 billion), laboratories (2.5 billion), and local government (770 million) [12]. Ninety percent of the total quantity is from major species including jumbo shrimps, Blue Crabs, Flat Fish, Kuruma Prawns, Jacopevers, and Abalones. Eighty-one percent of the total expenses are from major species including Abalones, Flatfish, Blue Crabs, Sea Cucumbers, and Jacopevers. By continuing disease screening and genetic diversity evaluation, healthy fish seed was produced for fruitful operation of fish seed-releasing program.

3.1.3. Marine ranching program

The marine ranching programs were conducted in the coastal and sea areas of Tongyeong, followed by Jeonnam (Yeosu) Dadohae Sea in 2001, and East Sea (Uljin), Yellow Sea (Taean), and Jeju starting from 2002 (**Figure 1**). The Jeonnam marine ranching was completed in 2011, and the marine ranches of the East Sea, Yellow Sea, and Jeju were completed by the end of 2014. With the purpose of increasing stock biomass of fish stocks in coastal fisheries in a short period of time, the technology and experience attained from the marine ranching were applied throughout the entire program. The technology and experience acquired through the marine ranching program can also be used to develop marine ranching models that suit each specific sea environment. In order to maximize the effects of the resource enhancement, the program was implemented by a marine ranching utilization management system through mutual cooperation with research institutes and academic regional organizations and established in an efficient model for the local government and local organizations, bringing direct impacts to the fish stock rebuilding.

3.1.4. Marine seaweeds forest program

Destruction of spawning grounds and nursery habitats often lead to the reduction in fish stock biomass and productivity of the marine ecosystem. Marine forest creation programs were intended to restore the fish stock biomass and the ecological functioning. A total of 47 marine forests were created between 2009 and 2013 (3334 ha, KRW 72.2 billion). Fisheries authorities have raised awareness of the importance of promoting sea forest for enhancing fish stock biomass and the necessity of building a national rebuilding program to restore the fisheries stocks and ocean ecosystem in the territorial waters of Korea (approximately 8 million ha).

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3.2. Fish Stock Rebuilding Plan

Korean Government established the fundamental plan for the FSRP in 2005. Its fisheries management strategies aim to mitigate the challenges of the existing fisheries management policies and to attain an expected recovery of fishery resources across EEZ territory. At national level, this ecosystem-based FSRP has been established as a comprehensive plan to enhance fish stock from the current level to a target level within a rebuilding period by choosing appropriate FSEPs.

Korea's FSRP was primarily aimed to marine fish stock recovery by eliminating the challenges from traditional management strategies with a view to improving conventional policies in the following ways:

1. FSRP focuses on specific fish stock for recovering. It contrasts to the lack of goals found in traditional fisheries management policies.
2. Conventional fisheries management policy was implemented without scientific research and estimation. By contrast, FSRP took into consideration the condition of fish stocks and required time of recovery with pragmatic goals.
3. Conventional fisheries management policies were established on the initiative of central government. On the other hand, FSRP ensures voluntary fishermen participation to execute plans and making them responsible for the results.
4. An analysis neither before application of fisheries management measure nor after its execution regarding conventional fisheries management policies was performed. However, FSRP ensures an analysis on fisheries management measures by fishery types, sea area and species before and after operation for effective utilization.

The main objective of FSRP and its policy was to enhance the total fish stock to 8 million tons by 2017 in order to maintain a consistent catch level at 1.3 million tons annually within coastal and offshore fisheries. Hence, it is anticipated that to reach fishery resources at an optimum quantity level, Korea's coastal and offshore sea ecosystem should break a vicious cycle chain of resource exploitation and aggravated fishery business condition and to keep a stable fishery production.

FSRP was performed by dividing the operational plan into three potential phases with mid-term and long-term plans. To establish system for operating FSRP, at first, the mid-term goals will get preference to achieve, and then long-term objectives will be attained by settling and spreading the management plans nationwide. To promote and operate each phase of FSRP, strategies and objectives were constructed as Phase 1—Institutional update and basic mid- and long-term FSRP's foundation (2005); Phase 2—FSRP implementation by species (2006–2012); Phase 3—FSRP-based fisheries management system settlement (2013–2017) (**Table 1**).

Traditionally, Korean fisheries were managed by considering input control depend on licensing system of fishing vessels and some technical measures like gear mesh size regulation, area closure, and time closures. Besides, since 1994, vessel buyback plan has been implemented.

Phase	Objectives	Policy enforcement
Phase 1 (2005)	Institutional update and basic mid- and long-term FSRP's foundation	(Master Plan Establishment) • Update Institution to implement FSRP • Mid- and long-term FSRP Establishment on yearly basis • New "Fisheries Resource Management Act" enactment • Set up Teams for Fish Stock Rebuilding to implement FSRPs fully • Species Selection for pilot projects to establish FSRPs in 2006
Phase 2 (2006–2012)	FSRP implementation by species	(Plans for Mid-term) • Fixed targets to maintain a total catch at 1.2 million tons • Pilot projects execution for 7 species by 2007 • FSRPs execution and establishment for 20 species by 2012 • Basic and bio-ecological research implementation on yearly basis
Phase 3 (2013–2017)	FSRP-based fisheries management system settlement	(Plans for Long-term) • Achievement of sustainable target at a total catch of 1.3 million tons • FSRPs execution annually to recover target species • Shift species-based FSRPs to establish ecosystem-based FSRPs • Review FSRPs for revising

Table 1. Phases to operate FSRP plans.

Thereafter, the total allowable catch (TAC) as an output control measure has been implemented since 1999 to reduce excess catch of fish.

In addition, FSEP plans such as artificial reef installation, fry releasing, and seaweed forest programs also have been implemented to enhance fish stocks for coastal and offshore fisheries. Moreover, to trigger participation and encourage playing a vital role of the fisheries personnel, both Science Committee (SC) and Fishery Resource Management Committee (FRMC) were formed. Experts from various disciplines (ecology, fisheries stock assessment, statistics, etc.) were included in the Science Committee to create and improve a fish stock recovery plan exclusively relying on Fish Stock Enhancement Programs and to make pragmatic advice for considering measures to rebuild fish stocks by analyzing data from scientific researches and critical reviews. Likewise, a scientific research on fish stock is conducted by NFRDI to recover desired species and subsequently FFRMC makes action plans to rebuild fish stock. FFRMC determines the measures to manage fishery effectively by judging

the comments made by academics, governmental, and nongovernmental participants. Basically, resources are managed by applying measures not only giving importance on individual species but also for refraining from using unbalanced fishing efforts and techniques. Accordingly, management took steps to install artificial coral reef and release fish fry to increase the overall fish stock in the coastal zone of Korea. In light of recovering individual fish stock, many policies and programs were taken into consideration to enforce them for the durability of fishery resources through FSEP. However, Korea's entire fishery was not shut down for a faster fish stock recovery as in other nations [13]. Hence, ecosystem-based fisheries management was implemented though some restriction was present on individual fisheries resource exploitation for effective and quick recovery of stocks. Consequently, the minimization of overall compromised revenue due to stop fish harvest could be possible to overcome undesirable situation. Besides, Korean fishery sector also could maintain stable business during the resource recovery period [14].

One interesting attribute of FSEP-based FSRP is promising the voluntary participation of fishermen to promote community-based fisheries management. In this manner, fishermen can make decision to manage resources as efficiently as possible and take part in developing plans for FSRP. In addition, voluntary self-control management can be implemented by fishermen to avoid unregulated fishing to promote efficient FSRP for rebuilding fish stocks effectively.

4. Classic and sustainable dimensions in FSEP-based FSRP

4.1. Environmental friendliness of FSEP-based FSRP

Although it is difficult to evaluate a comprehensive fisheries management policy FSRP based on FSEP within only 10 years, some vivid emerging improvements were depicted at the level of biodiversity. Vital FSEP tools not only enhanced biological components in the marine ecosystem but also encouraged physical and biological manipulation to make sound habitat for lifting up the stock size.

Until now, a total of 16 FSRPs have been established, including the special programs on sandfish, swimming crab, octopus (East Sea), skate ray (Yellow Sea), cod, yellow croaker, filefish, Korean flounder (East Sea) but rest FSRPs were considered for nationwide. In 2008, 10 species were considered to reach a target level of recovery based on their stock biomass from catch data. Fish Stock Enhancement Programs were acted in supporting with stock rebuilding plans to progress fish stock level. The amount of gained biomass was computed on a yearly basis by subtracting harvested amounts in 2005 from the total harvest in each subsequent year up to 2016. Once the gain in stock biomass of each targeted species is calculated for 10 consecutive years, from 2005 to 2016, the total recovery amount was estimated by adding all values of recovered stock amount of each targeted fish. As a result, the estimated 10 targeted fish stocks recovery amounts accounted for 469,827 million tons (**Table 2**).

Year	Sandfish	Blue Crab*	Octopus	Tokobushi Abalone	Skate ray	Cod	Yellow Croaker	File fish	Korean Flounder	Purplish W-Clam**
2004	2472	2683	5953	19	259	2641	17,570	1267	5345	5380
2005	2401	3714	7637	66	255	4272	15,272	1055	5472	6534
2006	2647	6894	7894	54	392	6810	21,428	1071	5218	3399
2007	3769	13,606	12,033	62	375	7533	34,221	2998	7326	3422
2008	2720	17,596	11,838	102	1343	5395	33,200	2631	5175	2672
2009	3939	31,302	15,386	34	3254	6870	34,033	8280	5107	1918
2010	4236	33,193	10,813	27	4131	7289	31,931	3475	6671	1950
2011	3834	26,608	10,421	3	2925	8585	59,226	1606	6709	2314
2012	5836	26,861	10,080	5	2123	8682	36,840	1419	6488	2037
2013	6306	30,448	9109	5	1651	9133	35,280	1295	18,171	2199
2014	4678	25,310	9881	10	1889	13,402	27,638	2418	18,804	2335
2015	4762	16,374	8753	4	2349	7820	33,254	2040	17,753	1828
2016	7593	13,558	9683	5	2000	4994	19,271	1805	15,977	1741
Total increase catch amount (M/T)	23,909	200,896	31,884	36	18,137	14,834	132,771	5959	41,401	0
Price (2016) ($/MT)	1241	11,954	14,113	55,706	5350	5015	8022	6163	7460	4956
Increase revenue (million US$)	29.7	2329.2	450.1	2.0	97.0	74.4	1065.1	36.7	308.9	0

Source: 2017 Korean Fisheries Yearbook, www.fips.go.kr*Swimming Crab.
**Purplish Washington Clam, Butter Clam.

Table 2. FSEP-based FSRP's economic effectiveness by target species.

4.2. Economic viability of FSEP-based FSRP

FSRP has contributed to rebuild fishery stocks in a relatively short period. Observations indicate a positive change in fish stock biomass during FSRP project operation. Likewise, an increment of catches triggered more revenues from targeted individual fisheries. The total revenue was computed by multiplying market price with the total recovery amount of fish over a 10-year period to evaluate the economic contribution of FSRP. Between 2005 and 2016, fishing earning increased by 4393.1 million USD (**Table 2**). Besides, an average yearly basis increment was seen in the fishing income of million USD 206.3 million amid FSRP operation [15]. In

10 years, the total increased 0.55 million tones fish contributed to the domestic fish market. This is an important fact taking into consideration that 70% of the food supply is imported from overseas, with the value of imported fish and seafood estimated in 3.8 billion USD [16].

A bioeconomic analysis was conducted to predict the economic impact for each species. In particular, biological and economical uncertainties were considered fully during analyzing the bioeconomic modeling. After performing this analysis, the results were used to make best policies for effectively maintaining FSEP-based Fisheries Stock Rebuilding Plans.

4.3. Social acceptability of FSEP-based FSRP

Effective and voluntary participation of fishermen community in promoting self-regulatory fishery is one of the main objectives of FSRP. As a novel concept in Korean fisheries management, community-based fishery allows fishermen to deliver unique ideas to manage resources as effectively as possible through improving awareness and understanding on current situation to implement FSRP. Effectiveness of community-based FSRP can be maximized by ensuring active participation of fishermen.

Before selecting the stock of a target species for enhancing, an agreement was made between the fishery resource management committee and the fishermen's organizations. The purpose of this agreement was to stimulate voluntary and active participation of fishermen to maximize the effectiveness of FSRP in connection with community-based management associations. Tasks were made voluntarily by fishermen to refrain themselves from roaming for fishing beyond limits, using excess gears by vessels and disturbing in spawning grounds. The Science Committee arranged conferences to make a fruitful avenue to ensure active participation of fishermen. Eventually, many fisheries restrictions were watched and found limited unlawful fishing.

Korean fisheries rebuilding relies on the voluntary participation of fishermen community for effective stock enhancement through notable stock enhancement programs. Besides, many strategies were taken to ensure better participation in providing opinion, managing resources, and stopping illegal fishing. Accordingly, strengthen community-based fisheries management imposes losses upon fishermen during rebuilding stock for accepting to reduce the amount of catch from fishermen organizations.

During the entire FSRP period, the government supported fishermen by taking some fruitful steps to stabilize the market for ensuring active participation. For example, some specific support was made to fix losses such as support on reducing fishing days, improvement of habitat for small fish, and also avoidance of by-catches. Expenditure to displace fishing gear and training of fishermen was aided for minimizing losses [17].

Socially accepted FSRP also provided time-demanding education and counseling to fishermen by experts having in-depth knowledge on fisheries. In addition, a fisheries management committee was set up as a system to manage and operate FSRP. To build up awareness of fishermen, the fisheries management committee worked on strengthening public relations on rebuilding stocks of targeted fish [18].

5. Limitations of FSEP-based FSRP

The Science Committee, the regional fishery management committee, and the fishermen have a significant contribution to the overall monitoring of ecosystem-based stock rebuilding. There have been fruitful opinions regarding fish stock enhancement to complete the goals for recovering fisheries resources. Fisheries rebuilding operations that run for 10 years have brought positive results on several ecological, economical, and social aspects; however, there are some challenges to be considered to get the best output to continue a comprehensive national stock rebuilding approach in Korea. These are some specific factors to be taken into consideration as follows:

1. The first challenge involves the preservation of the genetic resources. In order to succeed, all programs must ensure a high genetic variation for the offspring of targeted species for stocking in wild environments. In Jeju, Abalone showed a reduction of its genetic diversity, probably due to intensive breeding within the same hatchery brood stock [19]. Thus, Tokobushi Abalone could not establish their population like among other targeted species in FSRP since a genetic drift also observed due to breeding practices among limited brood stocks in the same hatchery without having enough facilities to exchange broods between hatcheries to get verity of genetic characteristics in produced fish seedlings [20].

2. Rebuilding plans focused on maximizing stocks but did not pay attention to the reduction of unwanted by-catch species. Annual catches of Butter Clam, one of the 10 targeted species for FSRP, declined sharply due to mixed catching.

3. There are inherited limitations to assess the efficiency of the enhancement strategies due to the lack of data available and the fact that only few species are examined well enough to drive definite conclusions. For better result, some aspects such as environmental, production, migration, and resources may be taken into account to collect effective data and expand them to evaluate data in an appropriate way [19].

4. Korean coastal fisheries comprise multispecies harvesting for small-scale and commercial fishing industry. Thus, conventional fisheries management could not fulfill sole target for single species through FSRP. Accordingly, related species must be taken into consideration for carrying out ecosystem-based FSRP gradually for achieving goals to enhance stock [21]. Community-based fisheries management tools are aimed for fisheries resources utilization sustainably through FSRP. Fishermen are encouraged to involve actively to both gain knowledge about their concerns and to reduce overexploitation. In order to compensate the loss in fishermen's profitability [12] and ensure a successful rebuilding plan, market stabilization and some form of compensation support may need to be provided to the fishermen community.

5. Operation of FSRP in Korea will not bring fruitful result unless cooperative action can be taken to continue large marine FSRP among adjacent nations, for example, China and Japan [22].

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6. Conclusion

A decade ago, Korea implemented an eco-friendly community-based national stock rebuilding approach in coastal and seashore areas within exclusive economic zone. The aim of this study is to uphold the scenarios of rebuilding fishery stocks which depleted mainly due to an excess in fishing pressure during the last 40 years. Despite the efforts of traditional fisheries management policies against unlawful fishing, unwanted trends were observed with marine fisheries resources. Based on the 10 years experience, FSEP-based FSRP in Korea has proven to be helpful for governing fishery resources for next generations. The fisheries rebuilding plan increased the fishermen's annual income by 95%. From a social perspective, fisheries enhancement has brought a secured livelihood for increasing income in a consistent manner. Despite having many praiseworthy reasons to continue ecosystem-based fisheries management, fisheries enhancement rebuilding plans have been moving with some risks of dwelling unavoidable challenges in main policy to achieve rapid effective results. Therefore, systematic research on the biology of species, mixed catches effects, pollution management, and net income loss recovery by stabilizing market for fishermen will be helpful to carryout Korean permanent fisheries rebuilding in the future. At the bottom line, cooperative fisheries resources management by adjacent nations may be a benchmark for rebuilding marine resources not only within EEZ but also between neighboring states.

Korean fisheries have been struggling to enhance depleted stocks at sustainable level with their conventional management policies for a couple of decades. Usually, input and output control policies, for instance, vessel buyback, total allowable catch, and restriction on breeding season, were applied by government agencies to keep resources at an optimum level. Despite immense endeavor to limit fishing pressure for meeting seafood demand sustainably in the near future, a significant proportion of stocks were dropped below sustainable level. Artificial reefs, marine ranching, fry releasing, and marine gardening programs were selected in an effort to recover environmental degradation and provide a friendly ecosystem to marine communities. Awareness of fishermen was built throughout FSRP programs for a better understanding of the existing stock abundance and evaluation of risk factors.

To sum up, FSRP has brought positive results in most of the targeted species. These rebuilding plans helped fishermen to increase catches noticeably for generating additional income. Sustainable fishery has been achieved due to voluntary participation of fishermen community to restrict unlawful fishing. In addition, they were provided government-supported training to develop core strategies to keep stocks at a sustainable level in the long term. Such self-governance program was a proof to rebuild stocks effectively even though some limiting factors should have been addressed to raise effectiveness of FSRP.

Possible rebuilding of stock may be triggered by correcting bio-ecological shortfalls in comprehensive national Korean FSEP-based FSRP. Moreover, scientific analysis on stock estimation is also an important parameter to determine the exact required period of rebuilding and to select species for improving stock status. Multinational stock rebuilding is recommended to extend targeted species number from sea shore to common boundaries of neighboring

countries. For instance, Japan has been running stock rebuilding programs since 2001 [6]. Likewise, in 2016, China started the 13th 5-year mega plan to restore their exclusive economic zone to get at a higher rate of fish catch [23]. Besides commercial species, other species may be taken into account for enhancing their stocks in developing a friendly marine ecosystem to improve ecosystem status.

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Chapter 9

Evaluation of a White Seabass (*Atractoscion nobilis*) Enhancement Program in California

Theresa Sinicrope Talley, Nina Venuti, Richard Starr and Christopher Myrick

Additional information is available at the end of the chapter

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Abstract

The scientific knowledge and technologies needed to attempt marine stock enhancement have grown in recent decades, yet contributions of many enhancement programs to wild stocks generally remain low. Additionally, enhancement programs are often less effective than they could be in contributing to associated social, economic and management objectives due to exclusion of non-science factors in program planning. An independent evaluation of a White Seabass (*Atractoscion nobilis*) enhancement program in California highlighted advances and shortfalls in a 30-year old, publicly funded program. While the program advanced the knowledge of biology and culture of White Seabass, it contributed <1% of fish caught in the state's fisheries. Further, the social and economic impacts of the program remained unassessed despite the potential significance of these impacts. The review highlighted the importance of regular, independent reviews to help stock enhancement programs achieve progress in meeting goals, and for adaptive management. In general, the California White Seabass enhancement program's success in meeting goals was dependent upon the existence of clear, agreed-upon goals and objectives; appropriate levels of funding; internal organizational cooperation; evidence of public benefit and support; improved assessment strategies; and unified, transparent messaging. Lessons learned from this review are applicable to other stock enhancement efforts.

Keywords: finfish aquaculture, fisheries management, hatchery program, integrated management, Sciaenidae, stock enhancement, tag and recapture, White Seabass

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1. Introduction

Marine stock enhancement holds promise for augmenting and strengthening resilience of recruitment-limited wild populations that are of recreational and commercial fishing interest. Enhancement effectiveness is not only dependent on the contributions to enhancement itself, which involves the production, release and survival of juveniles in the wild, but also on the contributions of the program to a variety of other biological, ecological, social, economic and management objectives surrounding the environment and the fishery [1–13]. The aquaculture and fisheries science needed to attempt enhancement, in particular the knowledge and technologies needed to breed, rear, tag, release, recapture and estimate the contributions of hatchery fish to wild populations, all exist to varying degrees for different taxa [5, 10]. However, the contributions of most enhancement programs to wild stocks remain variable and generally low [2, 5, 11, 14], indicating that there is much to be learned about applying the science. Further, enhancement programs' effectiveness in contributing to associated social, economic and management objectives tends to fall short due to the trade-offs involved in meeting varied program goals and a general lack of inclusion of these non-science factors in program planning [5, 8, 11, 12].

Commonly missing is the application of a comprehensive (inter-sector) program framework that guides unbiased and well-informed decisions about the most appropriate tools and approaches to use given the place, time, species and other potentially complicated contexts surrounding enhancement [1, 6, 15]. Use of such an integrative framework could help with decisions about the application of science and technology and how best to integrate associated priorities. In particular, the program framework should include factors such as clear, broadly-agreed upon program goals and objectives; integration of stakeholder input and both fisheries and other management priorities; a plan to oversee, evaluate and adaptively manage the program; appropriate funding levels; coordination among program elements and partners, and; information to optimize biological and economic efficiency [5, 10, 11, 15, 16]. A recent evaluation of a marine finfish enhancement program in California highlighted this need to include periodic, comprehensive (inter-sector) reviews of an enhancement program's goals, objectives, and management plan, and provided recommendations for syncing the science with program-wide management [17].

The Ocean Resources Enhancement and Hatchery Program (OREHP) was established by the California State Legislature in 1983 to conduct a program of basic and applied research on the artificial propagation, rearing and stocking of important marine fish species occurring in ocean waters off southern California [18]. The current legislation focuses on determining "if hatchery-released fish can artificially enhance certain stocks of various desirable species, through increased hatchery production of fish and increased monitoring of fisheries to assess the contribution of hatchery-released fish to that enhancement" [18]. The ultimate goal of the OREHP has been "to enhance populations of marine finfish species important to California for their sport and commercial fishing value" [19].

The legislative intent was used to craft a primary goal for the OREHP, which is "to evaluate the economic and ecological feasibility of releasing hatchery-reared fish to restore depleted, native, marine fish populations to a higher, sustainable level" [19, 20]. The original objectives developed to achieve this OREHP primary goal were to:

1. Develop and implement hatchery operation and growout methods that provide a supply of healthy and vigorous fish.
2. Conduct the replenishment program in a manner that will avoid any significant environmental impacts resulting from operation of either the hatchery or pen rearing facilities.
3. Maintain and assess a broodstock management plan that results in progeny being released that have genotypic diversity very similar to that of the wild population.
4. Quantify contributions to the standing stock in definitive terms by tagging fish prior to release and assessing their survival in the field.
5. Continue to develop, evaluate, and refine hatchery operations to maximize the potential for achieving the goal of the program.
6. Develop quantitative measures of success.

The California Department of Fish and Wildlife (CDFW) administers the OREHP with the assistance of the 10-member Ocean Resources Enhancement Advisory Panel (OREAP). The program is primarily funded by revenue from the federal Sport Fish Restoration Act and sales of California Sport Fishing Ocean Enhancement Stamps. The primary hatchery facility where OREHP activities take place is the Leon Raymond Hubbard, Jr. Marine Fish Hatchery in Carlsbad, California run by the Hubbs-SeaWorld Research Institute (HSWRI), the OREHP's primary contractor. As part of their OREHP contractual obligations, the primary contractor has developed the culture protocols required to raise White Seabass (*Atractoscion nobilis*) [17, 20] and has conducted research on culture protocols for other species, including California Halibut (*Paralichthys californicus*), California Yellowtail (*Seriola lalandi*), Giant Seabass (*Stereolepis gigas*) and California Sheephead (*Semicossyphus pulcher*) (see [21, 22]).

The OREHP is the longest-running experimental marine fish stock enhancement program in the United States, created in 1983. There were no formal assessments of the program until early 2015 when California Sea Grant (CASG), at the request of CDFW, began to coordinate a comprehensive review of the OREHP, including its progress in achieving its goals and objectives. With guidance from CDFW, CASG created a nine-member Science Advisory Committee (SAC), comprised of scientists from around the country, and tasked them with evaluating the program. The SAC, appointed by the CDFW Director, included members with demonstrated expertise in a wide variety of disciplines, including aquaculture, fish pathology, population dynamics, genetics, and water quality. Comprehensive and rigorous evaluations of marine enhancement programs are, in general, lacking, making this thorough and detailed evaluation one of the first of its kind.

2. Evaluation of the program

The SAC spent 2 years (2015–2017) conducting a review of the OREHP hatchery and enhancement operations. The purpose of the review was to assess the program's functionality and efficiency, environmental impacts, scientific accomplishments, economic costs and benefits,

and contribution to the wild White Seabass stocks [17]. The SAC reviewers also considered alternative hatchery uses.

2.1. Fulfillment of the ultimate program goal: enhancement of marine fish stocks

The review concluded that the OREHP met the intent of the program laid out by the California State Legislature to conduct basic and applied research on the propagation, rearing, stocking, and distribution of an important marine fish, White Seabass [18]. In 1983, little was known about the techniques needed to successfully spawn, rear, and release saltwater fishes [9]. Since then, the OREHP has significantly contributed to the world's knowledge about marine enhancement science and techniques (see Chapter 6.3 in [17]). However, the review also found that White Seabass enhancement had not been effective to date, and thereby the program had not fulfilled its ultimate goal.

An analysis conducted for the review [17] using tag-recapture data generated by the OREHP between 2000 and 2011 [23] indicated that the program made a less than 1% contribution to the California White Seabass fishery due to high levels of mortality suffered by hatchery-reared White Seabass following release into the wild. According to the analysis, if mortality rates of released hatchery fish were reduced to equal those of wild White Seabass, then current stocking rates could result in a hatchery contribution of 18% instead of <1% of the total fishery catch [17]. Therefore, in order to achieve fisheries enhancement, the approaches and technologies developed for White Seabass would require further development aimed at reducing post-release mortality, including the related recommendations made throughout the evaluation report.

It should also be noted that, whereas the White Seabass stock was considered to be depleted when the OREHP was initiated and White Seabass was chosen as the program's focal species, the stock has since increased, likely due to a combination of high recruitment related to favorable environmental conditions and fisheries management measures (e.g., closure of the coastal gill net fishery) [24], and then decreased again, likely due in part to unfavorable environmental conditions [25].

2.2. Fulfillment of the six OREHP objectives

The review [17] concluded that several of the six OREHP objectives had been partially or fully met. The biggest achievements of the OREHP have been its contributions to research discoveries surrounding the biology and culture of all life stages of White Seabass (Objective 6) and the transferability of those discoveries to other marine finfish species. Other notable successes include the development of appropriate hatchery (Objective 1) and tagging methods (Objective 4) for White Seabass, and the constant improvements in hatchery practices that have been made over the years (Objectives 1 and 5). Through its program of releases of tagged fish, and fisheries-independent and dependent monitoring of released fish, the OREHP had successfully collected enough data to evaluate the post-release survival of hatchery fish and the contribution of hatchery fish to the White Seabass fishery (Objective 4), both of which were determined to be low. Substantial engagement and outreach regarding White Seabass life history and culture has been conducted to the sportfishing community, K-12 students, and members of the

interested public (Objectives 1 and 6). Further, there has been no evidence that the program has caused any adverse environmental impacts at the production levels to date (Objective 2).

Other OREHP objectives, or aspects of objectives, were deemed to be unmet. The analysis of tag-recapture data revealed that hatchery fish suffer high mortality rates within the first few months following release (Objective 1) that likely limit contributions to fishery stock. Low post-release survival and fishery contribution rates likely stem from some combination of fish health and fitness challenges (e.g., effects of unresolved gas supersaturation issues, inconsistency in diagnosis and response to health findings, domestication effects; Objectives 1 and 4), and uncertainty about optimal release strategies (Objectives 1 and 4). While the maintenance of genotypic diversity (Objective 3) has not been sufficiently addressed throughout the program, the lack of significant hatchery contribution to the wild population has prevented any adverse genetic effects to the wild population (e.g., the Ryman-Laikre effect) [26, 27].

2.3. Budget conclusions

The review revealed that the operating budget needed to achieve all aspects of the OREHP objectives exceeded the base funding level of approximately $1.6 million per year that had been available for the program. With inadequate funding, the OREHP objectives suffered. Restricted funding reduced or limited several OREHP capabilities, including the ability to exchange broodstock at rates needed to ensure adequate genetic diversity in released fish (Objectives 1 and 3), provide stricter oversight of volunteer-run growout facilities (Objective 1), address reoccurring gas supersaturation issues (Objective 1), consistently and extensively perform and address challenges related to recapture surveys (Objective 4), and perform fisheries enhancement modeling (Objective 4). Limited resources also likely prevented the initiation of a genetic monitoring program (Objective 3) and (socio-) economic assessments (Objective 5 and 6). The primary OREHP contractor contributed in excess of $400,000 annually to meet operational expenses that were at least in part related to the OREHP, and sought grants and both monetary and in-kind contributions from a mix of private and government sources to make infrastructure repairs and improvements to the hatchery facility, to get assistance with White Seabass collections, and to operate the volunteer-run growout facilities [28]; the contractor also brought in external funds to cover research and outreach efforts that were related to, but not part of, the OREHP.

2.4. Lessons from the program evaluation

While the scientific and aquaculture advancements of the enhancement program have had worldwide impacts, the negligible (<1%) contributions of hatchery fish to fishery stocks revealed that there is still much to learn about applying the science, given the conditions and uncertainties under which the program operates (e.g., inadequate funding, uncertainty about the causes of post-release mortality and the drivers of White Seabass population change). Insufficient funds to support the dual objectives of research and actual enhancement, as well as a lack of consensus about which of the two objectives was the higher priority, likely contributed to the shortfalls in meeting program objectives. Decisions about research priorities, integration of aspects of the program with other social and fisheries

management priorities, and funding requirements and levels need to be made in a comprehensive, program-wide, coordinated fashion.

3. Program level recommendations

Although the review [17] did not include a comprehensive review of OREHP management processes, it recommended that the organizational structure of those groups overseeing the OREHP be updated to better achieve program goals and objectives. The review also highlighted several program-level weaknesses and made recommendations for strengthening the OREHP.

3.1. Need to strengthen and update the program organizational structure

The ultimate authority for many programmatic decisions within the OREHP was unclear. It was deemed necessary to clarify, for example, who had the authority to make decisions relating to research priorities and issues that influence hatchery operations and scientific research, or issues that put these two things into conflict with one another. Part of this uncertainty was caused by the OREHP's dual focus on production and research, two activities which can be very different and for which there were limited resources. Additional uncertainty may have been due to "mission creep"— the change in the internal interpretation and communication of OREHP intent, goals and objectives through time, and in the absence of periodic program reviews.

The review [17] noted that the program's advisory panel (OREAP) had not been as effective or valuable as it could have been, and that CDFW should reconsider how to best utilize an advisory panel. The current OREAP does not include representatives from all of the groups detailed in the original legislation, as some of these groups no longer exist or have changed focus. It was recommended that CDFW restructure and reconstitute the OREAP, and, in addition, create an independent science and technical advisory group with expertise in hatchery science (and associated issues, such as fish health), population dynamics, release and recapture strategy optimization, and genetics to help develop and evaluate quantitative criteria, benchmarks, and timelines to be used in future, regular evaluations of the program.

3.2. Need for external, independent guidance

3.2.1. Fish health guidance

The OREHP voluntarily has one of the most rigorous fish malformation, or deformity, assessment protocols of any of the stocking and supplementation programs in the U.S. (see Chapter 1.9.1 in [17]). The deformity level of hatchery-raised White Seabass, as with many other cultured fish, is generally of little concern because the deformities are typically thought to be linked to environmental factors, such as nutrition, water temperature and water quality, and therefore pose little risk to wild fish [17, 29–31]. Deformities in yet other cultured fish have, however, been shown to have low to sometimes moderate heritability [32–35]; because the OREHP is charged with research, the monitoring of physical anomalies informs the program's scientific research (see Chapter 1.9.1 in [17]) and provides a better general understanding of the underlying causes and effects of deformities.

The main concern about deformity that emerged during the review was the difference in opinions between the pathologists working for CDFW and those working for the primary contractor regarding the definition of deformed fish, and the implications of the range of morphological variability found in hatchery fish for vigor and fitness. These differences in opinion catalyzed a large public relations problem and inhibited smooth operations at the Carlsbad hatchery, thereby resulting in reduced juvenile production due to diversion of resources and delays in decisions about health diagnoses and appropriate responses. Further, differences in opinion, and therefore the outcome of diagnoses and actions taken, may have ultimately affected release numbers and post-release survival. Although risk of introduction of disease or unwanted genetic characteristics to the wild fish population via deformed fish is low due to the low likelihood that deformities are linked with disease or genetics, it is critical to have consistent decision-making criteria and to set appropriate policy for dealing with malformed fish so the OREHP can meet its objective of producing healthy and vigorous fish. The review strongly recommended that CDFW and the primary contactor engage an independent panel of experts that would be charged with the following:

1. Compare the morphological diversity of wild fish with that of hatchery fish.
2. Determine which unique hatchery morphologies pose a genetic or other biological threat to wild populations.
3. Determine which morphologies cause a measurable loss in post-release fitness.
4. Develop a set of criteria and protocols for identifying and responding to fish that have unacceptable phenotypes and/or levels of deformity that both CDFW and the primary contractor's staff agree upon.
5. Develop approaches that minimize frequencies and levels of deformities.

3.2.2. Science and technical advice

The review [17] strongly recommended that CDFW periodically enlist an independent external group of science and technical experts to work with CDFW and stakeholders to develop, and later to help evaluate, a set of quantitative criteria, benchmarks, and timelines for each of the established OREHP objectives. The review presented assessment topics within each OREHP objective that guided determinations about the extent to which each objective had successfully been met. However, needed is the further development of a set of more focused, clear, feasible, and occasionally updated metrics (e.g., see Chapter 6 in [17]) that would allow for more efficient, and more frequent, assessments of the program, and that would provide clearer guidance to OREHP staff and researchers.

3.3. Need to strengthen public communication and transparency

Throughout the program's life, the primary contractor has taken the lead on public outreach, stakeholder engagement, and public relations for the OREHP without provision of communications and development professionals, or adequate resources to support this task. This responsibility taxed the contractor's already limited resources for the OREHP and added the stress of

public scrutiny. The reviewers occasionally had to dig deeply to find information needed to assess the status of various aspects of the OREHP and noticed the presence of potentially confusing statistics about various aspects of the program in reports and non-peer reviewed publications (e.g., newsletters). The review recommended that the primary contractor and CDFW make greater efforts to keep information about the OREHP openly available to each other and to the public, and to improve consistency and transparency of outcomes and incidences, particularly for issues of public interest (e.g., contribution of the program to wild stocks, recapture rates of tagged fish in gill nets, incidences of disease and deformity, occasional accidents or die-offs, costs and benefits of the program, etc.). Improved transparency may include the development of a process that allows communication with a broad range of stakeholders, including those not already associated with the program, to collect input regarding priorities and development of the program. Further, the review recommended that CDFW assist more with this duty, or find and support knowledgeable public communications professionals to help.

4. The future of the program: review and reform

The evaluation of the OREHP objectives, goals, intent and budget indicated that 30 years was too long for the relevant authorities and stakeholders to wait to review and reevaluate the overall focus and strategy of the program. The evaluation showed that, while the research and technology development objectives of the program have largely been met, the program is not currently in a position to substantially enhance the White Seabass fishery due to a variety of factors, including high post-release mortality of juvenile White Seabass. Further, the California White Seabass stock, which is estimated to have been very low when the OREHP was established and White Seabass was chosen as its focal species, has cycled through a higher level of abundance and is again in decline [25]. Additionally, White Seabass proved to be a difficult species to use in enhancement, in part due to its lack of site fidelity and long, oceanic dispersal distances and distributions outside of U.S. waters. These factors, together with changes in the status and management of other California stocks, and increased understanding of the potentials and limitations of stock enhancement to contribute to fisheries management outcomes (e.g., see [11, 15]), suggested that it is timely to reassess the program's utility, and to review and reform the program's priorities and the approaches used to fulfill each of the program's objectives.

The review [17] outlined the following five steps (4.1–4.5) for assessing the future of the OREHP (**Figure 1**), noting that these recommendations were made without consideration of cost and thus would need to be evaluated with respect to program priorities and levels of available funding.

4.1. Step 1: conduct a science-based and participatory public process

The OREHP review indicated that the future of the program should be determined through a process that is both science-based and participatory with respect to the program's stakeholders (**Figure 1**) (e.g., see [4]). Overall guidance for such a process can be found in the Updated

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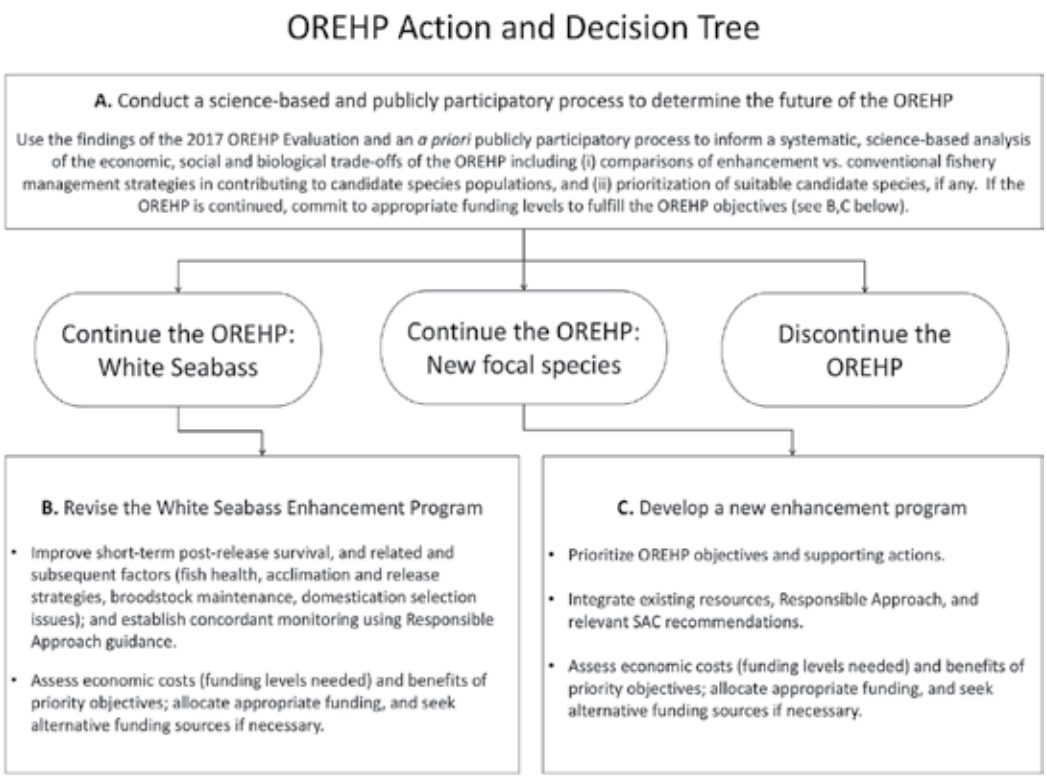

Figure 1. Flow chart of decisions and actions resulting from the Ocean Resources Enhancement and Hatchery Program (OREHP) evaluation.

Responsible Approach to Marine Fisheries Enhancement [6] and in the Hatchery Reform processes implemented for several salmon hatchery programs in the Pacific Northwest [36]. Scientific methods, such as fisheries models used to assess the potential effectiveness of stock enhancement and other fisheries management measures in achieving desired fisheries management outcomes, enable a systematic approach to the planning of enhancement programs. Stakeholders, principally recreational and commercial fishermen, have played a major role in the operation and funding (through license fees) of the OREHP. The program review suggested that it is therefore imperative to involve stakeholders systematically and constructively, and to use current scientific information in making the following decisions about the program's future direction [17].

4.2. Step 2: assess the potential role of enhancement in California fisheries management

The OREHP review indicated that the list of candidate species, including White Seabass, that was identified by CDFW and the primary contractor for use during the review should be honed using analysis of the biological, economic and social costs and benefits of utilizing an

enhancement program as compared to relying solely on (non-OREHP) fishery management strategies (e.g., updating catch quotas and/or size limits) to conserve and manage each of the species (**Figure 1A**). If the analysis indicates that conventional fishery management strategies alone may be sufficient for the conservation and management of most candidate species, then discontinuation of the program should be considered as one option, if legislatively feasible. If some stocks are deemed to be extremely low (i.e., severely depleted), and/or if responses to conventional fishery management actions alone are predicted to be ineffective, then further development or modification of the enhancement program should be considered, and funding adjusted to enable the program to meet its objectives. The candidate species list put forward by CDFW and the primary contractor was generally supported by the review committee, with California Halibut of particular interest for inclusion in this initial assessment given the available information on its biology, ecology, and culture practices, its depressed populations [37], and the high recreational and commercial fishing demand.

4.3. Step 3: prioritize candidate focal species by enhancement potential

The OREHP review recommended that if the initial assessment of the value of enhancement in relation to other fishery management strategies indicates that the program could likely contribute to some of the candidate species' stocks, then those species remaining on the candidate list should be prioritized. Specifically, an *a priori* systematic and quantitative assessment of each candidate species (**Figure 1A**) (e.g., see [13, 38]) should be conducted in cooperation with an independent advisory committee and should include input from a broad range of stakeholders, consideration of economic and social costs and benefits, and more consideration of fit with fisheries management strategies (e.g., see [11]). Criteria should include depressed stock numbers (e.g., consistently low enough to offset genetic risks associated with enhancement), ease of culture, life history that is amendable to rearing, tracking and enhancement (e.g., relatively high growth rates, not highly dispersive), geographic range that can be feasibly sampled (e.g., most common in U.S. waters), availability of existing biological information, and high demand and value within commercial and recreational fishing industries and throughout the food supply chain (see Chapter 6.5.3 in [17]). Clearly, the findings of the economic, social and ecological (e.g., environmental, genetic and population-level) trade-offs analyses used to narrow the candidate species list may be used to inform this process.

The challenges associated with each candidate species should be assessed and applicable recommendations from the OREHP evaluation report [17] should be used. For example, a fish with a range that extends into Mexico will require collaborative efforts for population/fishery assessments, and relatively slow growth rates will still require decisions surrounding size at release trade-offs. New challenges should also be assessed; for example, the demersal California Halibut would require different tank designs than those established for the pelagic White Seabass, and as such would require a significant capital contribution to reconfigure hatchery systems.

If a change of focal species is decided, White Seabass should be phased out by ceasing breeding efforts while completing the rearing and release of existing early life stages. The rate of phasing, however, may depend upon space, resources (including availability of new species

broodstock), and other logistical considerations. An independent advisory panel should be used for guidance on planning of the phasing and the development and initiation of a new enhancement program (**Figure 1C**).

4.4. Step 4: focus future White Seabass enhancement on reducing post-release mortality

The results of the program evaluation stress the importance of minimizing post-release mortality of hatchery White Seabass to increase the potential of the enhancement program. The same need would likely exist for new focal species that might be chosen for enhancement. Greater emphasis should therefore be placed within the program on research of factors that affect post-release mortality, and on husbandry and release strategies that minimize this mortality (**Figure 1B**) (e.g., see [39–42]). This focus may require increased funding to the program in order to fulfill a commitment to understanding, and subsequently reducing short-term (e.g., 6 month) post-release mortality rates. Increasing production to compensate for high mortality rates is not recommended because of the increased expenses, increased infrastructural and resource needs (e.g., staff time, supplies), and increased risk of fish health issues that would be associated with higher production rates.

In particular, to improve survival and stock contribution rates, greater attention should be given to:

1. Domestication issues (Objective 1).
2. Resolution of fish health challenges (e.g., resolving gas supersaturation and its health effects, understanding effects of deformity types and severity on fitness, consistency in diagnosis and response to health findings; Objective 1).
3. Continued improvements to placement and oversight of growout facilities (Objective 1).
4. More research focused on optimizing release strategies such as timing, size, location and magnitude of releases (Objectives 1 and 4).
5. More effort on post-release monitoring needed to optimize release strategies and estimate recapture rates (Objective 4).
6. Greater integration with fishery management to understand relationships between enhancement efforts and wild populations/fisheries (Objective 4).

If White Seabass production is increased or if there is a change in focal species, however, potential environmental impacts associated with these changes should be reassessed (Objective 2), and monitoring efforts should be modified appropriately to account for higher production levels and/or different impacts depending upon system changes (all Objectives).

If survival rates increase, improved genetic practices and monitoring should also be implemented in order to address the potential genetic effects associated with enhancement (e.g., the Ryman-Laikre effect [26, 27]), which to date have not been an issue because of the extremely

small possibility that a hatchery fish will survive to spawn with wild fish. If higher survival rates become the focus, then the broodstock management plan should be reassessed and reworked to include more frequent rotation of wild-caught broodstock, more emphasis should be placed on reducing domestication selection and increasing the proportion of spawns that go on to be reared, and monitoring of family contributions throughout the rearing process should take place to maintain the desired levels of genetic diversity and limit domestication selection (Objectives 1 and 3).

Further, a framework for conducting, evaluating and refining the enhancement program (Objectives 5 and 6) should be developed and used, regardless of the focal species selected. For example, the Updated Responsible Approach to Marine Stock Enhancement proposed by Lorenzen et al. [6] provides guidance on goal setting and evaluation, research and technology development, and adaptive management strategies (Objectives 5 and 6). In particular, an economic analysis should be performed for whichever program approaches are selected in order to ensure that the financial benefits of the program outweigh potential costs, and to inform future assessments (Objectives 5 and 6). More attention should also be given to adaptive management [1, 6]. The OREHP has many hatchery and growout protocols and plans in place, but data collection, record keeping, and reporting are not currently structured to allow formal assessment of whether protocols are being followed, and how findings and operational changes are contributing to protocol updates. For example, release strategies need to be optimized, and more formal data collections, record keeping and reporting of results (i.e., adaptive management experiments) can inform the evaluation of model assumptions about survival and the effects of fish size at release, release (micro)habitat, season, acclimation and acclimatization, and release magnitude. An adaptive management approach would also be useful for addressing many of the other challenges identified through the review.

4.5. Step 5: address the economics of the enhancement program

4.5.1. Assess the economic benefit of the program

The OREHP review indicated that, given that funds for the program are largely public and much of the benefit of the program may be social, a socio-economic analysis would make program expenditures more defensible, help to indicate social and economic strengths and weaknesses of the program, and may provide insights into stakeholder priorities (e.g., see [12]). Improved economic awareness and efficiency is important because the accomplishment of priority objectives, and the breadth and depth of actions needed to fulfill those objectives, will be dependent upon available funds (**Figure 1B**, **C**). The extent that review recommendations can be implemented will also be dependent upon funding levels. For example, if the program's funding remains static, it may be necessary to narrow the focus of the program to solving the challenges of enhancement that were identified to be the highest priority in the review (e.g., reducing post-release mortality). But, if funding is increased, then there may be opportunity to also test and address the challenges of a program that contributes more significantly to wild populations (e.g., developing and initiating genetic monitoring). However, resolution of all identified challenges exceeds the scope of a relatively small increase in funding and may require alternative funding sources, such as private organizations or foundations.

4.5.2. Need to expand public-private partnerships

There is a need to expand public-private partnerships such as those established already within the program. The primary contractor for the program has forged partnerships with private groups, such as recreational fishing groups and private foundations, which have provided a substantial supplement of non-program funds and in-kind resources (e.g., volunteer time, boat time, supplies) to operate the hatchery and growout facilities. Because of the infusion of supplemental funding from the primary contractor, the review considered the potential for conflict of interest, and concluded that the State has benefited from the private funding, and that all information has been publically shared so that there is no conflict of interest among partners associated with the program. If the program continues, CDFW should consider expanding the public-private partnership concept to bring in additional partners (and funds), such as other foundations and commercial fishing communities, to expand the capabilities of the program, which may allow for the implementation of recommendations made in the review for fulfilling each program objective.

5. Roadmap to enhancement based on lessons learned

Enhancement programs, such as the OREHP, often contribute to knowledge about the biology and culture of marine species [5, 10]. Actual stock enhancement, however, tends to be low, as does effectiveness in contributing to associated social, economic and management objectives [2, 5, 8, 11, 12, 14]. The shortfalls of enhancement programs are often due to the dynamic nature of marine environments and also to the need to meet the varied, sometimes conflicting, objectives of a program that include social, economic and management goals [5, 8, 11, 12]. This is especially true for programs lacking sufficient funding to accomplish multiple objectives or regular program assessments.

New enhancement ventures or those that have been underperforming in one or more ways would do well to perform a systematic analysis of the economic, social and biological tradeoffs of their programs. Involvement of public input in this process is recommended to ensure stakeholder needs and values are addressed because fisheries are characterized by complicated biological, social and economic interactions [5, 6, 8, 11, 12]. First, a list of candidate species should be identified based on need (e.g., depressed population sizes), availability of scientific information for the species, conduciveness to enhancement (e.g., ease of culture and monitoring, drivers of initial decline addressed, if possible), low risk of harm to wild populations if post-release survival is high (e.g., low risk of inbreeding depression and density dependent mortality), and stakeholder desirability [13, 38]. To hone and prioritize this species list, biological, economic and social costs and benefits of enhancement should be assessed, to the extent possible, for each species. These assessments should include comparisons of predicted outcomes of enhancement with those of conventional fishery management strategies alone (i.e., no enhancement); if there is high expected benefit from enhancement relative to other fishery management actions, or if benefits are predicted to outweigh costs, species should be made a higher priority.

Planning for the enhancement of a chosen focal species should start by defining clear, broadly supported goals that consider the whole fisheries management system, and a prioritized set of objectives with supporting actions to achieve the goals [6, 17]. Use of pilot studies, especially when focusing on species not previously used in enhancement efforts, is highly recommended for improving understanding of the information, technology and approaches needed for developing practices and plans, as well as for testing the feasibility of culture, release and recapture [6]. Establishment and use of an independent, cross-sector advisory panel with expertise in relevant scientific fields, fisheries management, economics and stakeholder engagement, as well as an accountable decision-making process are advised [17]. Adaptive management and regular program-wide reviews should form the scaffolding of both short-term (day to day-within year) and longer-term (inter-annual-5-year periods) decision-making processes. As challenges arise, such as fish health problems or high post-release mortality rates (causing low recapture rates, for example, see [17]), resources may be re-allocated in real time to address challenges, or research and production objectives refocused on more feasible priorities given levels of funding or conditions. Assessments of economic costs and benefits of priority objectives should guide allocation of appropriate funding levels along the way, with effort dedicated to alternative funding sources, if necessary [17].

Once implemented, the breadth and depth of enhancement efforts, and, ultimately, the progress in meeting program goals, will be dependent upon the existence of clear, broadly agreed-upon goals; appropriate and sustained levels of funding; internal organizational cooperation and support; evidence of broader public benefit and support; rigorous and accountable assessment strategies, including strong adaptive management and frequent assessments using well-defined ecological and economic metrics; and unified, transparent public communications in order to clearly demonstrate the values of the program to commercial and recreational fisheries and society.

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The decline of wildlife populations is increasingly posing a challenge to wildlife management agencies. In the face of increasing challenges such as wildlife diseases, human–wildlife conflicts, climate change, illegal hunting, and habitat loss, among others, new management models and strategies are being adopted to address these challenges. These models and strategies have, however, produced some mixed outcomes—both failures and successes.

Wildlife Management - Failures, Successes and Prospects provides an understanding of some of the realities shaping wildlife management policies in different parts of the world. Drawing from case studies, the book presents some challenges facing wildlife management and the emerging management models, strategies, options for action, and success stories. This book offers a real field experience to conservation practitioners, planners, researchers, academicians, and students.

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