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TANZANIA'S TOURISM FUTURES

Harnessing Natural Assets

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Harnessing Natural Assets

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ABBREVIATIONS AND ACRONYMS

CBNRM	Community-based natural resource management
CBV	Community Business Ventures
CEC	Cation Exchange Capacity
CGE	Computable General Equilibrium
GDP	Gross domestic product
GTAP	Global Trade Analysis Program
GoT	Government of Tanzania
HAT	Hotel Association of Tanzania
HVLD	High-value low-density
MET	Ministry of Environment and Tourism
MNRT	Ministry of Natural Resources and Tourism
NP	National park
PES	Payment for Environmental Services
RNP	Ruaha National Park
SAM	Social Accounting Matrix
SNP	Serengeti National Park
TANAPA	Tanzanian National Parks Authority
USAID	U.S. Agency for International Development
WMA	Wildlife management areas
WTO	World Trade Organization
WTTC	World Travel and Tourism Council

EXECUTIVE SUMMARY

Tanzania is endowed with a rich storehouse of nature-based tourist attractions. Tourism is focused primarily around its renowned attractions in the "Northern Circuit"[1]—the great plains of the Serengeti, the wildlife spectacle of the Ngorongoro Crater, Mount Kilimanjaro the highest mountain in Africa, as well as the island of Zanzibar with its lush tropical beaches.

The tourism industry has emerged as a robust source of growth and an economic stabilizer in times of crisis. In just over a decade, annual tourist numbers have soared from about 500,000 in 2000 to over 1 million visitors in 2012. The sector generates the bulk of export revenues for the country, typically surpassing minerals and gold, is a reliable source of revenue to the government, and provides well-remunerated direct employment to over 400,000 people.

Official statistics from Tanzania's recently updated gross domestic product (GDP) series[2] suggest that in 2013 tourism accounted for about 9.9 percent of GDP (equivalent to an amount of US$4 billion in direct and indirect contributions).[3] Economic simulations reported in this study indicate that the sector has significant cross-sectoral spillover effects and linkages that dominate those of other traditional sectors of the economy. A decline in tourism revenue would have an impact on the exchange rate and consequences that reverberate throughout the economy. Apart from these obvious economic benefits, tourism can stimulate broader benefits to the economy—upgrades to infrastructure, conservation of natural habitats, and gender equity.

[1] Including the Serengeti ecosystem (comprising Serengeti National Park [SNP] and Ngorongoro Conservation Area) as well as Tarangire, Arusha, Lake Manyara, and Mount Kilimanjaro National Parks.

[2] The new series for the period between 2005 and 2013, using 2007 as a base year, was produced by the National Bureau of Statistics, with technical assistance from Statistics Denmark and with the support of other development partners.

[3] Other linkages include wider effects from investment, the supply chain, and induced income impacts. (*Source:* World Travel & Tourism Council, Economic Impact 2014).

Tanzania operates within a globally competitive tourism industry, including with competitors for wildlife tourism. Yet, Tanzania has reached an enviable position as a high-value low-density (HVLD) tourist destination by restricting supply and targeting the high-end segment of the market that is largely unaffected by economic fluctuations. The industry attracts some of the world's most illustrious tour operators, many of whom market only Tanzania. The HVLD approach has served the country remarkably well:

- It provides a buoyant flow of revenues. In contrast, Kenya attracts *twice* the number of visitors as Tanzania but raises *half* as much revenue. Attracting a large number of tourists implies that Kenya draws visitors from the more price-competitive (elastic) segment of the market.
- High-value visitors are typically unaffected by turbulence in the global economy. During the 2008–09 recession, tourist numbers plummeted across the globe, yet tourist numbers in Tanzania were largely unaffected (Lunogelo et al. 2010).
- Low visitor numbers can minimize congestion at popular sites and preserve the economic value of the product by providing visitors with an authentic wilderness experience. This can also avoid overcrowding, which has adverse ecological consequences that diminish the value of the product.

It is important to note that the HVLD approach will not succeed at every destination in Tanzania. Though HVLD tourism is much sought after, it is an exceptional occurrence. For HVLD tourism to succeed, a host of conditions must prevail:

- The product on offer must be *rare* or even unique. The Serengeti clearly falls into this category. The wildebeest migration is obviously unique and the authentic wilderness experience on offer is exceptional and atypical. By contrast, the experience (congestion and location) and product (wildlife observable) on offer at National Parks (NPs) (such as Arusha NP) is unexceptional, so it is not able to attract the HVLD market segment.
- As a corollary, since such HVLD tourism assets are rare, by implication there is *less competition*, allowing for higher prices to be charged for the experience.
- Finally, HVLD tourism attracts people who care *more about experience (*for example, *wilderness) and less about price* (that is, more inelastic demand). This group might include the so-called high-net-worth individuals and also includes interest groups (hobbyists, birdwatchers, and climbers).

Hence, not every destination in Tanzania will fit into the HVLD category and there is a need for a *differentiated strategy* that plays to the economic strengths of each attraction and asset.

CHALLENGES AND OPTIONS

Tanzania has neither fully leveraged its immense endowment of potential tourist attractions nor the opportunities for poverty reduction that the tourism sector offers. Despite an abundance of assets, tourism remains heavily concentrated along the Northern Circuit, and there is a need to diversify the tourism product without diminishing its revenue potential. There are concerns that the major tourist spots in the Northern Circuit are reaching the limits of their carrying capacity. Carrying capacity limits will be reached once the product and experience on offer has been diminished and degraded, either as a consequence of overcrowding, which diminishes the experience, or ecological damage, both of which reduce the earning potential of the asset. This together with a suite of pressures from intrusive activities and developments are adding to existing pressures on the region. Additionally, population densities and poverty incidence are disproportionately higher around the protected areas, suggesting that the benefits from tourism seldom trickle down to the local population. Finally, there are immense infrastructure needs in the economy across all sectors, including to improve access to and within the many underused tourist assets. Building infrastructure "right" is critical because infrastructure choices have long-lived and difficult-to-reverse impacts on land, tourism prospects, water use, and future patterns of development. Development of strategic infrastructure to promote development and connectivity can be fully consistent with efforts to conserve the natural assets that are the basis of Tanzania's tourism and growth. Developments around key tourism assets must be carefully planned and executed to ensure that they do not erode economic value and the sustainability of the underlying ecosystem.

These developments will require close coordination between the private and public sector. Today, the business climate in Tanzania is neither conducive toward tourism operations nor investment. In particular, the levies and taxes within the tourism sector are unpredictable, uncertain, and often duplicative. This reduces Tanzania's ability to compete with the tourism industry in neighboring countries, many of which have already established a better environment for their tourism industry, including more robust regulatory systems for protection of their natural resources. Because public resources are and will remain limited, the government must consider how to best attract private investment, and take measures toward establishing an environment of trust and predictability for the private sector so that current players can operate effectively and partnerships can be fostered for the strategic development of the tourism industry.[4]

Tanzania is now at a crossroads and must make far-reaching strategic decisions. This report explores the implications of two contrasting development strategies, based on guidance from the government of Tanzania (GoT). The first strategy assesses increasing development in the Northern Circuit with a focus on the iconic Serengeti ecosystem. The second scenario promotes tourism development in "new" areas of Tanzania with a focus on the Southern Circuit and Ruaha National Park (RNP). The report identifies opportunities, challenges, and constraints of building a more diversified tourism product.

TOURISM AND DEVELOPMENT IN THE NORTHERN CIRCUIT

There can be little doubt that the allure of the Serengeti has been pivotal in building Tanzania's tourism industry. It is the last intact, fully functioning savanna wilderness ecosystem in Africa. It is among Africa's premier tourist destinations and most people have it on their "bucket list"—a place to see at least once in their lifetime. The principle threats to the Serengeti are those driven by demands for grazing land, poaching, aggressive expansion of tourism, and plans for potentially intrusive infrastructure development. To assess the economic implications of these trends, this study has developed linked models to simulate the consequences of alternative futures. The analysis captures connections between renewable resource (wildlife) stocks and flows, the effects on tourism, and livelihoods in the Serengeti and the resulting micro and macroeconomic impacts (through a Computable General Equilibrium [CGE] model).[5] The conclusions are instructive for policy purposes.

The distributional and macroeconomic consequences are striking. The effects from a plausible scenario where pressures combine to reduce the carrying capacity of the ecosystem by 20 percent and hence a decline in the tourism experience are diffused through the economy and especially large among poor rural households. When tourism revenues fall, the exchange rate is affected so that the impact is transmitted to all other sectors of the economy. The loss of bushmeat as a result of a reduction of carrying capacity is another large loss that affects the rural sector disproportionately. In the scenario considered, overall GDP declines by 7 percent. The qualitative results are robust and hold across a variety of other scenarios.

Could the fortunes of the economy and the Serengeti be reversed by boosting the number of tourists who visit? This is a counterproductive strategy. With a diminished tourism product on offer it is only possible to increase tourism numbers by reducing prices significantly so that total revenue from tourism declines further.[6] Other important results are worth noting.

Impacts on carrying capacity are found to have synergistic effects. In other words, small unconnected pressures, when combined, deliver disproportionately larger and unwelcome impacts. For instance, a small drop in carrying capacity of the ecosystem or a small reduction in the size of the ecosystem has a minor impact on resource stocks (that is, wildlife numbers). However, when

[4] World Bank, Tanzania Sixth Economic Update. "The Elephant in the Room—Unlocking the Potential of the Tourism Industry for Tanzanians." January 2015.

[5] The model was created before the release of the recently updated GDP numbers by the Tanzania National Bureau of Statistics and, as such, reflects GDP numbers that were available before the rebasing exercise.

[6] Since demand is inelastic.

they are combined, one factor tends to exacerbate the effects of the other so that the joint effects exceed the sum of the individual impacts. This has significant policy conclusions that calls for considering the impacts of disparate pressures simultaneously. Debates on the volume and impact of tourism and tourist infrastructure seldom consider effects emanating from the agriculture and land use or connectivity and vice versa.

Finally, if carrying capacity declines, the economically prudent (optimal) strategy is to expand the wilderness areas to restore the payoffs from tourism, trophy hunting, and livelihood resources. This is often the reverse of what is observed when complementary pressures lead to a reduction in habitats together with a decline in ecosystem productivity.

DIVERSIFY TOURISM TO THE SOUTHERN CIRCUIT

Tanzania has the opportunity to avoid these adverse outcomes by diversifying its tourism product. Recognizing that crowding diminishes the economic value of tourism in the Serengeti there would need to be investments in building tourism at new destinations. Coupled with its immense natural endowment, there is the potential for Tanzania to solidify and consolidate its emerging position as Africa's premier wildlife tourism destination, similar to the status achieved by Costa Rica in Latin America.

Diversification has two relevant elements: spatial and market segments. There is scope to expand the available tourist destinations, but there is also scope to diversify the tourism product by attracting different market niches and experiences. Examples include the ability to package wildlife and cultural travel as well as different income ranges and special interest groups who could be attracted to the many available destinations.

A Southern Circuit exists and its development is a government priority, but the route is poorly known and infrequently traveled. The Ruaha National Park has long been recognized as an ecological jewel with the potential to become a major tourist destination in the Southern Circuit. It is the biggest national park in Tanzania, and serves as a vital watershed in its landscape. Spectacular landscapes around the Ruaha River combined with an abundance of charismatic species make the park an obvious tourist attraction. Among its many accolades, the Ruaha landscape can boast of the following: 10 percent of all lions left in the world, the third largest population of wild dogs, and the second largest elephant population after Botswana, as well as prominent endemics such as the newly discovered Kipunji monkey. Despite these attractions, in a typical year Ruaha receives about 20,000 visitors while the Serengeti sees over 250,000 tourists.

To be competitive, it needs to offer a visitor experience that is no worse and preferably better than rivals in a similar category. The tourist experience is not measured in terms of the product on offer alone but the whole continuum of interactions that include travel time and costs. A comparison suggests that travel costs and quality of experience may not match the prices that the tourists have to pay in competing markets, even the high-end attractions such as Chobe NP in Botswana. Additionally, to attract investment in Ruaha or elsewhere, the country needs a more enabling business environment. This is a wider problem but is likely to especially deter global investors.

Ruaha receives little official publicity and more generally it is widely overlooked in travel media. The Tanzania Tourist Board publicizes the Southern Circuit but does not highlight Ruaha. An Internet search with key words such as "Tanzania, wildlife tourism, and lions" fails most often to bring up any links to Ruaha, and the branding of Tanzania as "The land of Kilimanjaro, Zanzibar, and the Serengeti" simply reinforces the bias in favor of the Northern Circuit. It is no surprise that an attraction that remains hidden from potential visitors attracts few tourists.

The most far-reaching and challenging problem for Ruaha lies with the management of water flows from the Great Ruaha River. The river originates in the Usangu highlands and flows through Ruaha and then into the Mtera and Kidatu hydropower plants. On average, the river provides 56 percent of runoff to the Mtera and Kidatu hydropower stations which in turn generate more than half of the country's hydropower-derived

electricity. The river is also an important livelihood resource for many thousands of residents who rely on it for domestic, livestock, and irrigation purposes.

The Great Ruaha River was once a perennial river but has now become seasonal with extended dry periods due largely to upstream irrigation. The major irrigated areas have expanded dramatically from 3,000 ha to over 115,000 ha[7] and this has coincided with an increase in the frequency and duration of zero-flow periods. Increased competition for water has resulted in loss of livelihood income for downstream users and has adversely impacted tourism potential of the RNP.[8]

A study of the value of water in alternative uses suggests that it would be economically prudent to reallocate water in the dry season that would enable flows through the NP.[9] However, this will be especially challenging and will call for greater investment in administrative and institutional capacity to build measurement and monitoring systems with adequate enforcement capabilities.

THE WAY FORWARD

Tanzania's natural assets have catalyzed a buoyant and robust tourism industry and also play a pivotal role in sustaining the livelihoods of the rural poor. To build upon this success Tanzania needs to play to the comparative advantage of each region and attraction. This calls for a strategy that **maximizes tourism revenue and not tourist numbers.** The latter, as demonstrated in this report, could prove to be counterproductive.

Going forward, the approach would build and differentiate tourism by *location* (for example, Serengeti versus the South); *product* (wildlife, beach, culture, and adventure); and *market segment* (domestic, international, and conference). Specifically:

- **Preserve and Strengthen the Status of the Jewel in the Crown of Tourism.** The allure and iconic status of the Serengeti has been pivotal in allowing the country to maintain its status as an exclusive HVLD tourist destination.
- **Address the Litany of Pressures on the Northern Circuit.** There are risks that current trends could undermine the earning potential of the Serengeti with adverse consequences that would be transmitted widely through the economy. Congestion of tourists is not conducive to a high-value tourism experience. Intrusive infrastructure developments and over-building, a feature common in other tourist areas, is also certain to undermine the value of the product as would policies within and outside the ecosystem that damage the carrying capacity and hence the wilderness value of the ecosystem.

The focus of tourism on the Northern Circuit has meant that Tanzania's vast endowment of other tourist assets remain underused. Building tourism in the Southern Circuit has not been easy in a market that grows more competitive and better informed each day as a consequence of improved connectivity and globalization. To grow tourism in the Southern Circuit will call for the following measures:

- **Branding and publicity.** The Southern Circuit needs to define and develop a brand to distinguish itself from rivals.
- **Addressing the challenges of accessibility.** Transport costs are high and the area is hard to reach by road. Without adequate access there is limited scope for commercializing the potential of the RNP.
- **Developing a marketable product.** The product on offer must be competitive both in price and

[7] Tanzania Hydropower Sustainability Assessment: Case Study of Great Ruaha River (Vol 2). November 2014. World Bank.

[8] Few tourists would be attracted by the sight of a distressed ecosystem resulting in increased inter- and intra-species competition, higher mortality rates, and reduced diversity.

[9] However, there are three prominent dissenting views. It is argued that the absence of dry season flows is a consequence of climate change and alterations in vegetation and thus, unconnected to irrigation. Another view holds that under idealized management systems, Mtera Dam's water can be supplied entirely by wet season flows, so there is no need for dry season supplies. Finally, it is arguable that cheap supplies of oil or gas resulting from recent exploration efforts may diminish, or even eliminate, the need for hydropower. World Bank (November 2014) found that (1) irrigation expansion is responsible for the absence of dry season flows in the Great Ruaha River, (2) dam operational procedures could significantly improve current hydropower generation at Mtera and Kidatu, and (3) climate change has not had any effect to date on the power generation at Mtera or Kidatu. Rather, climate change is likely to result in increased hydropower potential at these sites as well as other current and planned sites.

experience. If Ruaha is to play a part in the Southern Circuit it would be essential to address the water constraint and restore flows to the NP.

» **Developing a strategy that recognizes the Southern Circuit's strengths and weaknesses.** Though Ruaha, for example, presents spectacular options for wildlife tourism, it is not likely, for many reasons, to gain the type of popularity witnessed in the Northern Circuit. The strategy for the Southern Circuit can look to diversify toward different types of tourism, especially niche markets, such as cultural or adventure tourism as well as beach tourism.

Poverty is high around tourist attractions, suggesting that few of the benefits trickle down to the rural poor. There is a need to strengthen linkages with the local economy and develop policies and incentives to share benefits with the poorest who often live close to tourist attractions. The challenge for policy is to create a set of commercial incentives for tourism operators to strengthen local linkages while remaining commercially profitable. Two schemes merit consideration:

» **Community conservancies.** These are an extension of the more familiar Community Business Ventures (CBV) between communities and private tour operators, where pieces of community-reserved land are subleased to private tourism investors.

» **Building local capacity.** Another promising model entails building supply chains into local communities to strengthen economic linkages. Agriculture is an obvious entry point because of the availability of land. To address these issues would require intensive programs of capacity building to develop partnerships and a mutual understanding of priorities between the industry and local communities.

CHAPTER ONE
INTRODUCTION

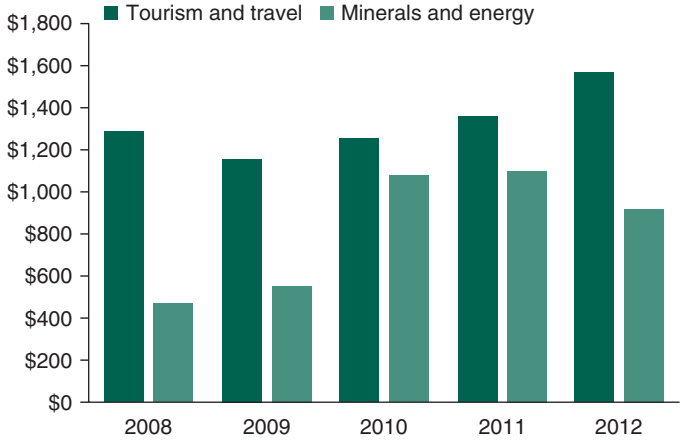
It is no exaggeration that tourism has shaped the development fortunes of Tanzania. The country is endowed with an enviable range of natural attractions that bring tourists from around the globe. The most renowned attractions include the great plains of the Serengeti, which support the world's last remaining large animal migration; the wildlife spectacle of the Ngorongoro Conservation Area which also hosts the earliest hominid remains; Mount Kilimanjaro, the highest mountain in the African continent; and Zanzibar with its tropical beaches and home to Stone Town, a cultural World Heritage Site (see figure 1.1).

Tourism provides a robust stream of revenues for the country, with benefits that reverberate widely through the economy. The sector generates the bulk of exports for the country. World Trade Organization data (WTO 2013)[10] indicate that since 2008, the combined export revenues from travel and tourism have exceeded those from the mining and energy sector (see figure 1.2). Unlike the low-value-added exports of minerals or agricultural commodities where revenues are vulnerable to global price volatility, demand in the tourism sector has been growing at a stable rate. As a relatively labor-intensive sector, tourism serves as a robust source of good quality jobs in the country, with the potential to alleviate poverty. Resilience in demand and an ability to generate employment make the sector an ideal vehicle for propelling development and growth, especially in lagging regions of the country. The macroeconomic simulations reported in this study suggest that the economic impact of the sector is often underestimated. The economic benefits are stronger than might appear, with cross-sectoral spillover effects and linkages dominating those of other traditional sectors of the economy. Apart from these obvious economic benefits, tourism can stimulate broader benefits to the economy: upgrades to infrastructure, conservation of natural habitats, gender equity by providing decent jobs for women, and greater integration into global economies. However, Tanzania

[10] WTO (World Trade Organization). 2013. WTO Trade Statistics: http://stat.wto.org/StatisticalProgram/WSDBStatProgramHome.aspx.

FIGURE 1.1. MAP OF TANZANIA

FIGURE 1.2. EXPORT REVENUES (IN $MILLION) FROM TOURISM AND TRAVEL VERSUS MINERALS AND ENERGY



Source: World Trade Organization Statistics 2013.

has not fully leveraged the opportunities for job creation and poverty reduction that the tourism sector offers.

This report explores the contribution, the potential, and the challenges that confront the sector. It briefly describes the structure of the sector in Tanzania and compares it to some of its closest competitors in Sub-Saharan Africa. It identifies the limits and opportunities of current policy priorities through a series of integrated economic-biological models and suggests alternative strategies for growth and development of the industry. It begins with a brief overview of the sector and then explores alternative development paths for the sector—one which focuses on the established Northern Circuit and the other which explores the opportunities and constraints of diversifying tourism into the Southern Circuit, especially in the Ruaha landscape.

CHAPTER TWO
ANATOMY OF THE TOURISM SECTOR

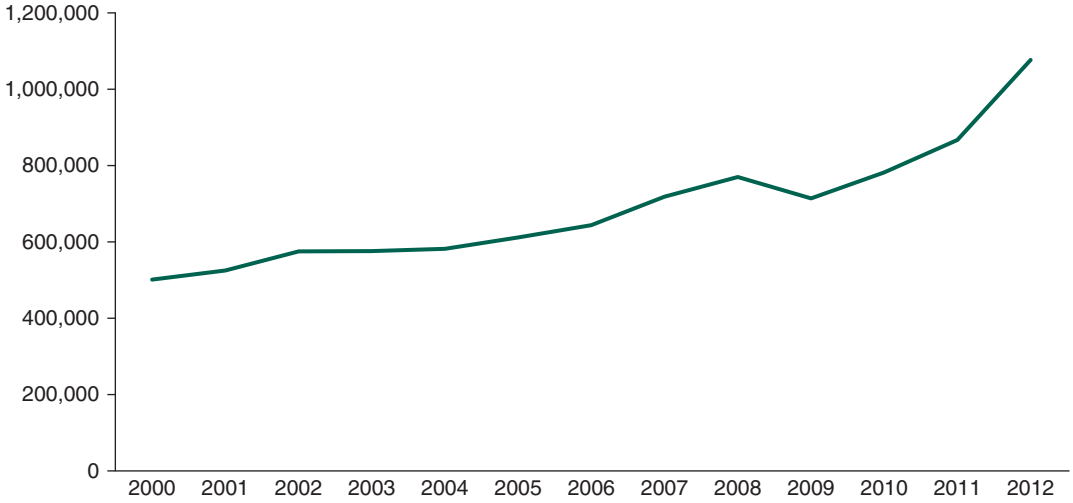
Largely unaffected by turbulence in the global economy, tourism growth has been rapid and robust. Within a decade the number of foreign visitors has doubled from about 500,000 tourists per year in 2000 to just above 1,000,000 per year by 2012 (see figure 2.1).[11] The world share of international tourist arrivals to Tanzania has also increased from 0.05 percent in 1995 to 2 percent by 2012 with approximately 5 percent of international tourist receipts accruing to the country (WTTC 2013). The majority of international tourists (close to 80 percent) arrive from either Europe or America, with Asian tourists exhibiting a rapid increase over recent years as a result of focused promotional efforts (GoT 2012). About 64 percent of visitors in 2010 arrived on packaged tours organized through travel agencies that dominate the market. The average length of stay has remained stable over a decade at about 11 days, the highest in East Africa. Around 55 percent of visitors were aged between 25 and 44 years and 27 percent were aged between 45 and 64 years.

Tanzania's tourism is predominantly nature-based and largely focused on three assets: the Serengeti, Mount Kilimanjaro, and Zanzibar. Tourism is focused on the exceptional natural assets—abundant wildlife, spectacular iconic landscapes, and tropical coral-fringed beaches—which these areas provide. Wildlife tourism, especially along the Northern Circuit, remains the country's primary attraction, followed by beach tourism in Zanzibar. Most tourists combine a wildlife experience with a beach excursion. The annual park revenues from Serengeti and Mount Kilimanjaro represent 85 percent of the total park system revenue and provides an income stream sufficient to manage the entire Tanzanian National Parks Authority (TANAPA) system.[12] Yet these represent just a small fraction of the country's potential

[11] The total number of visitors to Tanzania is not available because the Mainland and Zanzibar entry statistics are not coordinated, and hence some double counting occurs. The figures reported here are for both Mainland Tanzania and Zanzibar.

[12] TANAPA manages the country's 16 national parks, providing conservation, anti-poaching, education, and community services. Of these 16 parks, only four produce a revenue surplus, with two—Kilimanjaro and Serengeti—responsible for 85 percent of TANAPA income; the remaining 12 are subsidized by these revenues.

FIGURE 2.1. FOREIGN VISITORS TO TANZANIA (2000–12)



Source: Tanzania Tourism Statistical Bulletin 2012, Tourism Division, MNRT.

tourism assets. Despite plans to develop the Southern Circuit (anchored around the Selous Game Reserve and RNP, two high-density animal habitats together totaling 70,300 km^2, about the size of Georgia or Sierra Leone), fewer tourists visit these areas. Between 2006 and 2012, the RNP had on average just above 20,000 annual visitors while the key national parks within the Northern Circuit had significantly higher average annual visitations rates: Serengeti NP—322, 000; Kilimanjaro NP—48,000; Arusha NP—60,000; Lake Manyara NP—157,000; and Tarangire NP—116,000 (see appendix A). With the majority of tourism concentrated in a few areas in the north, there are significant opportunities for diversification of tourism products, which could allow for continued sector growth.

Table 2.1 provides a snapshot of some of the economic impacts of the industry, based on data from the World Travel and Tourism Council (WTTC). The industry invested TZS 1,634.2 billion or US$882.9 million in 2013—an increase of 1.3 percent from the previous year. The travel and tourism sectors combined accounted for nearly 9.9 percent of GDP in 2013 and contributed to almost 3 percent of the country's growth. About 30 percent of the industry's revenue is paid to the government in taxes and fees. Tourism has stimulated about 1.2 million jobs (11 percent of total employment) of which 402,500 jobs were created directly in the industry. It is widely presumed that employment in the tourism industry builds skills and human capital and provides higher-paying employment prospects that can pull families out of poverty. The bulk of workers (96 percent) are Tanzanians and the managerial cadre is split equally between nationals and foreigners, with 22 percent Tanzanian females.

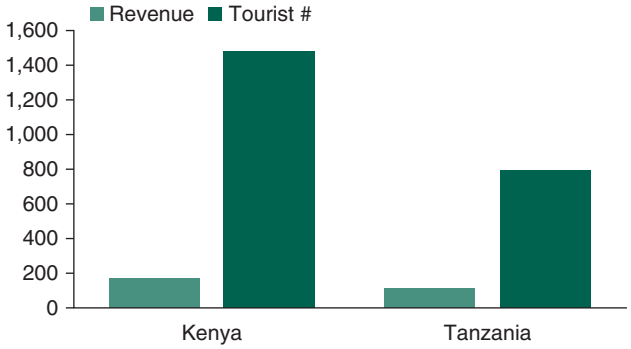
TABLE 2.1. KEY TRAVEL AND TOURISM PERFORMANCE INDICATORS, 2013

Key Indicator	2013 Value
Average length of stay (days)	11
Tourism contribution to GDP (%)	9.9
Tourism contribution to GDP growth (%)	2.8
Number of people directly employed	402,500
Direct and indirect (induced) employment	1,196,000
Capital investment (TZS, billions)	1,634.2.1

Source: WTTC (2014), Tanzania National Bureau of Statistics.

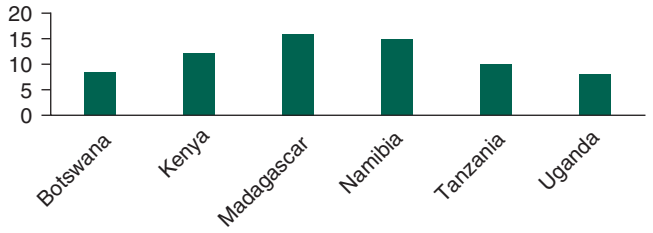
Tanzania attracts some of the world's most illustrious tour operators. Tanzania's natural assets are exceptional, as evidenced by the number and caliber of active tour operators. Many operators market only Tanzania, and some headquartered in Kenya bring their more exclusive customers to Tanzania and Kenya's private reserves. Official statistics suggest that Tanzania has about 32,000 hotel rooms of all types, with 58,000 beds and room occupancies of around

FIGURE 2.2. TOURIST NUMBERS (THOUSANDS) AND RECEIPTS (US$, MILLIONS)



Source: WTTC (2014).

FIGURE 2.3. TOTAL CONTRIBUTION OF TRAVEL AND TOURISM TO GDP



Source: WTTC (2014).

60 percent, which far exceeds the global average of about 30–50 percent. In the period of 2001 to 2011, hotels and restaurants alone contributed between 2.3 percent and 2.8 percent to the GDP of Mainland Tanzania (Bank of Tanzania 2013). Until recently the country's reputation as an elite destination was built primarily by small- to medium-sized privately owned hotels, except in Dar es Salaam, where familiar international groups operate. There is some evidence that the travel industry has been gradually diversifying its products and services through creative packaging, including visits to local communities.

Tanzania reached an enviable position as a high-expenditure low-density destination, by restricting supply and targeting the high-end segment of the market. The impressive performance reflects the government's commendable HVLD approach. Figure 2.2 shows that while Tanzania received fewer visitors in 2011 compared to Kenya, the country generated the most absolute revenue as each visitor to Tanzania spends significantly more per trip. Thus, despite lower tourist numbers than most of the important regional competitors, Tanzania's total tourism revenue is the highest, something made possible by the limited supply. Figure 2.3 shows the relative economic importance of the sector for the same regional neighbors. The HVLD strategy is also a good one for maximizing revenues without exceeding the carrying capacity of natural attractions on which Tanzania's tourism depends. Kenya which has developed mass-market beach products linked to wildlife tourism provides a useful contrast; lower-end tourist arrivals have grown more rapidly than in Tanzania,[13] and as a result, Kenya receives **50 percent more tourists but generates about 50 percent less revenue from tourism in total** than Tanzania. Higher visitation rates in Kenya's national parks have also led to important negative impacts on the wildlife that is the very draw for tourists (World Bank 2010).

The HVLD approach brings clear advantages to Tanzania—particularly for high wildlife areas—and the policy needs to be strengthened, formalized, and complemented where this approach is suitable. There is also scope to develop a diverse set of products catering to different market niches. The HVLD is a sound strategy which ensures that Tanzania competes in a market with more inelastic demand, where visitors are willing to pay more for an exclusive experience. This is the more stable segment of the market with *fewer* competitors—differentiating Tanzania's tourism products from other regional competitors—and hence generates more predictable and resilient flows of tourism revenue. Although niche markets attract fewer numbers, they have high rates of growth, with customers who are prepared to pay a significant premium for a crowd-free wilderness experience. The HVLD segment is also the more resilient part of the market. During the 2008–09 economic crisis, tourist numbers were largely unaffected in Tanzania even when tour operators, on average, raised prices (UN WTO and ILO 2011), while other tourism destinations saw visitor numbers from traditional markets plummet. The HVLD segment is less vulnerable to economic shocks and involves demanding

[13] The growth in Kenya's tourism industry has also been far more volatile in recent years as a result of internal and external political shocks (that is, election violence and spillover from chronic instability in Somalia).

customers who are difficult to attract but easy to lose. Forgoing this much-sought-after market niche is likely a counterproductive strategy if the intention is to maximize revenues from tourism.

An additional long-term benefit is that lower volumes allow for the sustainability of the distinctive natural environments upon which tourism depends. This contrasts significantly with mass tourism that has eroded the value of the wildlife tourism market elsewhere. High tourist numbers in wildlife areas are not only a possible threat to sustainability but repel the higher-value tourists, precipitating a downward spiral along the value chain. This suggests the need for a diversified set of tourism products that preserve the high-value niches while competing with lower-margin segments at other locations.

Institutional structures in the sector have stabilized with responsibility for tourism dispersed across agencies. Primary responsibility for tourism policy lies with the Ministry of Natural Resources and Tourism through five entities: MNRT's Tourism Division; the TANAPA; the newly created Tanzanian Wildlife Authority (TAWA), responsible for management of most protected areas outside the National Parks System; the Ngorongoro Conservation Area Authority (NCAA), which manages the high-value Ngorongoro Crater; and the Tanzania Tourist Board (TTB), which is responsible for marketing the industry. The Tanzania Investment Center (TIC) handles investment promotion. As tourism is a non-union issue, Zanzibar has a distinct set of agencies: the Ministry of Information, Culture, Tourism and Sports; the Tourism Commission; the Zanzibar Investment Promotion Agency (ZIPA); and the Commission for Land and Environment. The Tourism Confederation of Tanzania, the umbrella private sector institution, has 14 industry and trade member associations. A Tourism Master Plan was created in 2002 for Mainland Tanzania, which emphasized the need for diversifying the tourism product away from the relatively crowded Northern Circuit, especially through the creation of the Southern Circuit. Despite these plans and a wealth of potential attractions, tourism remains dependent on a small range of locations around Arusha (the Northern Circuit) and Zanzibar.

CHAPTER THREE
CHALLENGES AND OPPORTUNITIES

Despite the recent growth of the tourism industry, important challenges remain and need to be tackled if the sector is to boost its contribution to growth and poverty reduction goals. Three key issues threaten the value and sustainability of the industry: the need to strengthen linkages with the rural economy, the impacts of visitor numbers on industry value and carrying capacity, and the need for balancing infrastructure growth while maintaining revenue flows from tourism.

A. LINKAGES BETWEEN TOURISM AND THE RURAL ECONOMIES NEED TO BE STRENGTHENED

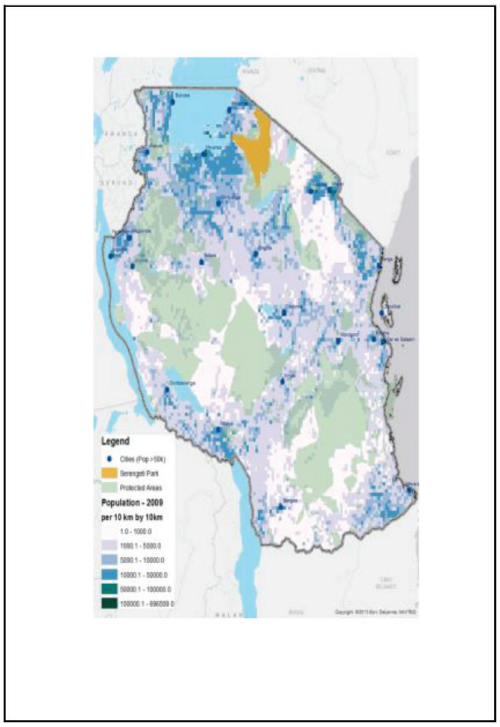
A major challenge that has not been adequately addressed is that the proceeds from tourism rarely trickle down to local communities. Greater integration between the tourism industry and local communities is important for inclusive growth and sustainability of the sector. Paradoxically, poverty incidence is highest in areas that attract the greatest numbers of tourists, suggesting an urgent need for developing economic linkages and sharing benefits in a more equitable manner.

The extent of the problem is illustrated in figures 3.1 and 3.2. Figure 3.1 maps population densities at a 10 km x 10 km spatial resolution using data from Landscan (2009).[14] It shows that population densities in areas around many protected areas (such as west of the SNP) are often as high or greater than in Dar es Salaam. Figure 3.2, which maps the corresponding levels of poverty as defined by the official poverty line of TZS 23,000 (approximately US$14.25; from Baird et al. 2013), suggests a higher incidence of poverty around protected areas. The problem seems more intense in the mainly agricultural region west of the Serengeti (Baird et al. 2013 and figure 3.2).

Caution must be exercised in inferring causality between the presence of a protected area and a high concentration of poverty. Causality may run

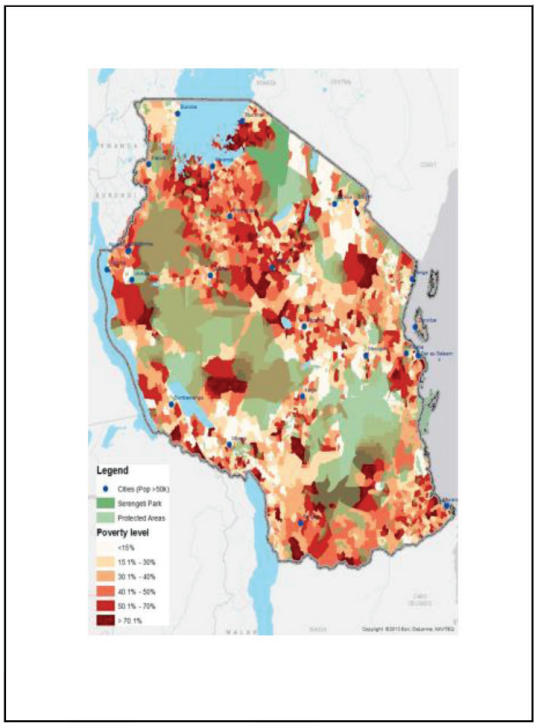
[14] http://web.ornl.gov/sci/landscan/.

FIGURE 3.1. POPULATION AND PROTECTED AREAS



Source: Landscan (2009) and authors' calculations.

FIGURE 3.2. POVERTY AND PROTECTED AREAS



Source: Landscan (2009) and authors' calculations.

both ways or may not exist. It is possible that poverty may be induced because of a lack of access to the bountiful resources in protected areas—land, water, and the supply of wildlife that could be harvested for consumption or sale. In this case, the presence of a protected area might induce poverty. Conversely, it is also conceivable that the abundance of wildlife and other resources attract poor people to the area, resulting in high levels of both population density and poverty incidence.

There is some evidence to support the latter hypothesis. Harvesting wildlife for meat is widespread around the Serengeti and other national parks (Arcese and Campbell 1995). There is ample statistical evidence that the rural poor around protected areas depend disproportionately on bushmeat that often comprises over 60 percent of protein consumption in their diets (Barett and Arcese 2000; Knapp 2007, 2012; Rentsch and Damon 2013). The large herds of resident and migratory game that inhabit most of Tanzania's protected areas are a significant source of readily accessible protein. In the Serengeti and other protected areas, there are numerous reports of local teams setting traplines of snares that catch wildebeest, zebra, giraffes, impala, and eland; these are butchered and dried at temporary camps and transported to markets. Annual offtake of wildebeest in the Serengeti alone may be higher than 100,000 animals per year (Mduma et al. 1996), though simulations conducted for this study indicate that a higher harvest is likely in equilibrium.

All of this suggests that the availability of resources around protected areas attracts individuals with few other employment opportunities. Sinclair et al. (2008) report that population growth rates have exceeded 10 percent around the SNP as a consequence of migration from other parts of the country. Hence, there is a need to formalize resource use and create better incentives for communities to benefit from activities that are sustainable.

Linkages between tourism and the rest of the economy, especially with the rural poor, could be strengthened. Table 3.1 illustrates how an average hypothetical dollar is spent by a tourist in Tanzania. Not surprisingly, the bulk of spending (over 60 percent) is on

TABLE 3.1. AVERAGE TOURIST EXPENDITURE CATEGORIES

Category of Expenditure	Proportion of US$1 Spent
Accommodation	0.28
Food and drinks	0.23
Transport	0.105
Shopping	0.14
Sightseeing	0.105
Other	0.14

Source: Global Trade Analysis Program (GTAP) database.

accommodation, food, and transport, with little spent on other items that might fall in the shopping category. The consequence of this pattern of spending on the local economy will depend on how this money is spent by the suppliers in these sectors.

Table 3.2 illustrates the consequences of this spending pattern across the economy, with the impacts depending on the many interlinkages that exist between sectors. The results are from estimates of the Social Accounting Matrix (SAM) developed for this work (see appendix B). The table shows how a dollar spent according to the pattern in table 3.1 circulates through the different sectors of the economy. The consequence of spending on food, for example, will depend on whether items purchased have been imported or not. For instance, a crop grown locally will stimulate the agriculture sector, whereas an imported item would register as a "leakage" accruing to the rest of the world. The effects will be determined by the stages of production and processes undertaken within the country.

Table 3.2 tracks the consequences of such linkages for the hypothetical dollar spent in the tourism sector according to the distribution in table 3.3. Three features are notable. First, the largest share of spending (28 percent) leaks to the rest of the world. Second, there are positive impacts on agriculture (14 percent) and financial and other services (11 percent), suggesting that tourism is indeed providing important benefits to the Tanzanian economy. Third, the resources accruing to financial services reflect the flow of funds and the dependence on agencies to garner tourists and transfer funds across borders. This suggests that though tourism is providing important benefits to the Tanzanian economy, there are important opportunities to better capture tourism benefits through investments that promote local capacity for providing services and goods to the industry and more broadly to strengthen linkages with other sectors of the economy. Such changes would need to be fostered through targeted policies and economic incentives to build stronger links with the rest of the economy, especially the more labor-intensive agricultural sector.

TABLE 3.2. CONSEQUENCE OF US$1 SPENT IN THE TOURISM SECTOR

Receiving Sector	Proportion
Capital	0.030719
Agriculture	0.144816
Mining and extraction	0.001646
Processed food	0.103675
Labor-intensive manufactures	0.035107
Capital-intensive manufactures	0.002743
Utilities and construction	0.017553
Transportation and communication	0.070762
Financial and other services	0.110258
Tourism	0.161821
Dwelling	0.017553
Taxes and government	0.005485
Rest of the world (leakage)	0.281404

Source: Authors' calculations, based on SAM.

B. ECONOMIC CONSEQUENCES OF CONCENTRATED TOURISM

Despite an abundance of assets, tourism remains heavily concentrated along the Northern Circuit and there is a need to diversify the tourism product without diminishing its revenue potential. There are concerns that the major tourist spots in Northern Tanzania, commonly referred to as the "Northern Circuit"[15] are reaching the limits of their carrying

[15] Including the Serengeti ecosystem (comprising the SNP and Ngorongoro Conservation Area) as well as Tarangire, Arusha, Lake Manyara, and Mount Kilimanjaro.

capacity. This together with a suite of pressures from further development, infrastructure that neglects adverse spillover effects, poaching, and other activities are adding to existing pressures on the carrying capacity of the region. Tourism development must be carefully planned and executed to ensure it does not erode the value of the tourist product and the sustainability of the underlying ecosystem in areas where carrying capacity limits are reached. The problem is most severe along the popular wildebeest migration corridor Kenya's Maasai Mara Reserve, which adjoins the SNP and provides a salutary lesson: Maasai Mara Reserve has nearly twice as many tourist visitors as Serengeti though it is less than a tenth of the size, and as a consequence of congestion, Kenya raises but a fraction of the revenue. Most of the visitors arrive in July and August when the wildebeest migrate across the Kenyan border. The litany of documented problems is large (Ikiara and Okech 2002):

- Lodges built near watering holes compete for prime habitat. In these areas, excessive construction of tourist lodges combined with withdrawal of water from the Mara River for upstream irrigation has reduced wildebeest densities, with concomitant impacts on predator abundance and tourist satisfaction.
- Congestion of vehicles around traditional wildebeest breeding grounds is thought to have an impact on the timing of the annual wildebeest migration. There is also evidence of impacts on hunting success of large predators because of the sheer volume of vehicles.
- Tourists often spend more time viewing each other, rather than the object of attraction—typically a pride of lions surrounded by increasing numbers of vehicles.
- A vast profusion of lodges and "private" safari camps mean that no camp is isolated and the experience is far removed from a wilderness one.

The consequence is a diminished tourist experience, with adverse impacts on the economic productivity, biological carrying capacity, and revenue earning potential of the ecosystem.

If Tanzania were to pursue a policy of significantly increasing wildlife tourist numbers it would need to enter a more competitive segment of the market with likely adverse revenue consequences. There is evidence that demand is inelastic in the high-end market, implying that current visitors are prepared to pay a high price since they value the experience (exclusivity) on offer.[16] With an inelastic demand, boosting visitor numbers by 5 percent, for example, would necessitate a price reduction of more than 5 percent, resulting in a decline in revenues accruing to the country. Put simply if the quality of the tourist experience and its reputation is diminished, high-end tourists would eschew Tanzania for other more desirable destinations. Hence caution is warranted before embarking on a simple strategy of increasing tourist numbers to compete with Kenya or other more price-sensitive market niches.

A high-value strategy is not suitable for every market niche. Given the variety of assets and the diversity of customers, products can be designed in multiple, interesting, and creative ways. There is scope to diversify the tourism product while maintaining the earning potential of the Serengeti and the greater Northern Circuit, particularly through efforts to develop the Southern Circuit. On the other hand competition in the sun-and-sand market has reached a point where beach tourists are largely indifferent about location and highly sensitive to price and travel times, providing an opportunity for developing beach tourism more intensively along Tanzania's long coastline. Every market segment will call for trade-offs, and given the customer base, one destination may be better positioned than others to compete for a given market (customer) segment. The choices would depend on building an appropriate brand for the alternative products without eroding the value of current tourism assets.

Several alternatives have been proposed to improve the contribution of the tourism industry to the national economy and generate more efficient patterns of resource use. One option suggests developing two pri-

[16] Time series data is sparse but regression of log of tourism numbers using standard procedures in the literature (Lim 2010) suggests an elasticity of about −0.88 for a levels regression and lower elasticity for a regression in first differences though the price term is not significant, no doubt because of a lack of degrees of freedom.

ority tourism zones: a southern "safari" circuit and a southern coastal zone. The establishment of these two new zones, or other similar expansions of the industry, could attract mid-market tourists who may not be willing to pay the premiums required to vacation in the traditional Northern Circuit areas but nevertheless want to experience the ecotourism that is unique to Tanzania. It can also go a long way toward establishing Tanzania as the ecotourism capital of Africa, much like Costa Rica has branded itself the ecotourism capital of Latin America.

C. INFRASTRUCTURE DEVELOPMENT

Tanzania has significant infrastructure needs across all of its sectors. Improved roads and irrigation are needed to improve agricultural yields and promote greater commercialization of agriculture, while mineral, oil, and gas rents, if judiciously employed, can provide the resources needed to invest in human capital (a key engine of growth) and fund social infrastructure. Infrastructure is important too for the tourism industry. Efficient travel hubs, robust road networks, and reliable electricity can improve a tourist's experience and reduce the cost, both in terms of time and money. However, for Tanzania, where ecotourism is the main attraction, it is important that infrastructure investments are done with consideration of their long-term impacts on local development and the tourism assets that should provide an important engine of growth. Therefore, there is a need to weigh the full array of economic benefits and costs of different options.

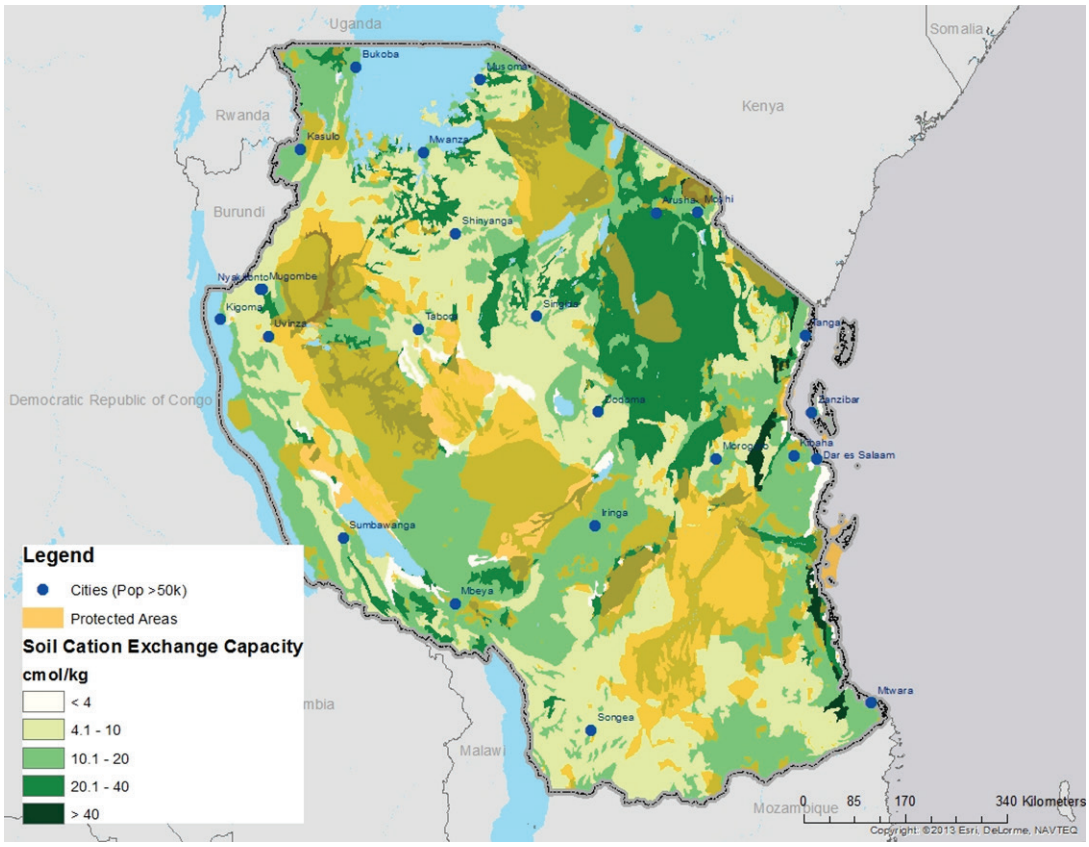
The fact that much remains to be built in Tanzania creates an opportunity to build "right." Getting infrastructure "right" is critical because infrastructure choices have long-lived and difficult-to-reverse impacts on land, wildlife, water use, and future patterns of development. Infrastructure decisions influence the type and location of development and, as such, create substantial inertia in economic systems, with irreversible consequences that need to be weighed against alternatives. The right infrastructure also offers substantial co-benefits that could enhance the productivity and earning capacity of the country's natural capital. This is especially important for Tanzania given its high dependence on natural endowments. The issues are complex and there are often trade-offs between "building right" and "building more." Building right typically brings benefits that accrue over the longer term while consequences of building more are immediate and visible gains.

Much of Tanzania's global comparative advantage lies in its immense endowment of renewable and non-renewable natural resources. The fact that infrastructure needs are so large implies that there are wide opportunities to build right—garnering benefits while minimizing or avoiding possible negative impacts on the country's comparative advantage. There are opportunities to improve connectivity while enhancing the revenue potential of tourism. One of Tanzania's greatest assets is the wilderness experience that it offers its high-paying clientele. As human population densities increase through Tanzania and the rest of Africa, there will be a growing premium on places that offer such experiences. Likewise, in a water-constrained economy such as Tanzania there is scope to enhance land productivity without compromising the revenue potential of ecosystems that sustain water flows. In fact, Tanzania's protected areas play an important role in regulating downstream water flows and, if well-managed, can continue to provide these important hydrologic services. Interestingly, Tanzania's most productive agricultural lands are largely outside of protected areas, as shown in figure 3.3, which maps total nutrient fixing capacity of soil as measured by its Cation Exchange Capacity (CEC) (soils with low CEC have little resilience and cannot easily build up stores of nutrients). These data suggest that the largest portion of resilient agricultural lands lie outside of protected areas and that there is ample scope for agricultural extensification without necessitating large trade-offs between conversion of protected areas and agriculture.[17] Rather, with proper planning to target agricultural development in high productivity lands, while conserving adjacent protected areas for other environmental services, there are large opportunities for win-wins.

[17] Another variable that needs to be considered is precipitation levels and variability.

Development of large strategic infrastructure to promote growth and connectivity can be consistent with efforts to conserve the natural assets that are the basis of Tanzania's tourism. Strategic planning of infrastructure—through establishing and enforcing transportation and development corridors that maximize development of targeted zones but protect Tanzania's most valuable natural habitats—is needed to ensure long-term resilience of natural habitats.

FIGURE 3.3. SOIL CATION EXCHANGE CAPACITY



Source: FAO[18].

[18] http://data.fao.org/map?entryId=065ec570-b1db-11db-8beb-000d939bc5d8.

CHAPTER FOUR
TOURISM FUTURES

Tourism in Tanzania is at a crossroad. The country has done exceptionally well in building a resilient and high-revenue-generating tourism industry that brings significant national economic benefits. However, as noted in the previous section, the path going forward is not without challenges. There are far-reaching strategic decisions to be made. Should the country seek ever greater tourist numbers and thus compete more intensively and directly with its rivals in the "mass" market? Or should it retain its exclusivity? Or might there be options to segment the market with a variety of differentiated products that combine exclusivity in some locations with more intensive development in others? And how should tensions between ever-rising land, water, and infrastructure needs and those of the wildlife tourism industry be resolved?

To shed light on these questions, the GoT, through TANAPA, has requested the World Bank to explore the issues through rigorous economic modeling approaches. Two contrasting scenarios were selected to provide insights into possible future scenarios:

- **Spatially concentrated tourism development in the Northern Circuit.** The first scenario assesses increasing development in the Northern Circuit with a focus on the iconic Serengeti ecosystem. This scenario describes a spatially concentrated development strategy aimed at enhancing economic activities within and in the immediate neighborhood of the SNP. The policies to be considered include an expansion of agricultural output to stimulate the local economic activity, combined with pressures in the carrying capacity of the ecosystem emerging from a variety of factors, including intensified development and concentrated tourism. This is analogous to a business-as-usual trajectory that represents the current situation with growing pressures on the ecosystem.
- **Geographic diversification and inclusive tourism development by building the Southern Circuit.** The second scenario promotes tourism development in "new" areas of Tanzania (with a focus on the RNP) while emphasizing measures to better promote local economic linkages. This recognizes that economic potential varies with geographic endowments and maximizing

returns calls for investing in the geographic comparative advantage of each region. In this scenario, investments would recognize and build upon the economic potential of each location. The focus would be on exploring the constraints and opportunities of the RNP as a complement and possibly an alternative to the Northern Circuit.

A. TOURISM IN THE SERENGETI ECOSYSTEM

There can be little doubt that the allure and iconic status of the Serengeti has been pivotal in building Tanzania's tourism industry. The Serengeti is the last intact, fully functioning savanna wilderness ecosystem in Africa. It is arguably Africa's premier tourist destination and most people have it on their "bucket list"—a place to see at least once in their lifetime. Few tourists to Tanzania depart without a visit to the Serengeti. Its central attraction is its wildlife, namely the vast herds of wildebeests and zebras that migrate northward from their calving grounds in the southern part of the ecosystem in February to arrive at Kenya's Maasai Mara Reserve for the dry season months of July and August. Following the migration of the wildebeest are significant numbers of predators: lions, hyenas, cheetahs, and leopards. The open grasslands of the Serengeti provide world-class opportunities to get photographs of these species interacting in the wild and hunting in the surrounding reserves is another significant draw. The ecosystem[19] also contains a further 40 easily visible mammal species, over 500 bird species, and numerous plants and animals (Morell 1997). The Olduvai gorge runs through the southern part of the ecosystem. Over 70 years of archaeological study here have produced a vast trove of sub-fossils that clearly outline the world where humans first appeared as a species (Leakey and Hay 1979). In fact, the Serengeti provides the only remaining opportunity to consider, and understand the world as humans first saw it (see box 4.1).

The vast herds of wildebeest that attract both the tourists and the predators are the central drivers of the ecosystem; they are keystone species, and their abundance determines key ecosystem processes such as fire frequency and intensity as well as the abundance of the major predators, including lions and hyenas. Their migration and daily movement patterns transfer nutrients from the highly productive soils of the southern part of the ecosystem and concentrate them in northern "grazing lawns" that can be used by smaller herbivores that focus on shorter grasses during the dry season (McNaughton 1984). Suppression of fires by wildebeest grazing has allowed the woodlands to recover in the central and northern parts of the ecosystem, creating a large carbon sink.

The principle threats to the Serengeti are those driven by demands for grazing land, poaching, an aggressive expansion of tourism, and plans for potentially intrusive development. Climate change may eventually be a threat, but it is more likely that this will initially manifest itself as increased frequency of extreme droughts (both longer and drier) followed by unusually excessive rains that lead to significant erosion. The impact of climate change may not be felt for another

BOX 4.1. THE HIDDEN ECOLOGY OF THE SERENGETI

Biologists have been studying the ecological structure and dynamics of the Serengeti since the 1950s; it is one of the best studied ecosystems on the planet having produced over 500 widely cited scientific papers, the key results of which are collated in the three edited Serengeti volumes (Sinclair and Arcese 1995; Sinclair and Norton-Griffiths 1979; Sinclair et al. 2008); the fourth volume will appear in 2015. The mammal species living in the Serengeti illustrate almost every known social system: from the unusual monogamy of the jackals and nocturnal cats (Moehlman 1986) to the more sociable groups of lions and hyenas whose fiercest enemies are both each other and members of their own species (Grinnell et al. 1995; McComb et al. 1994). The antelope similarly illustrate a social system that ranges from the monogamous family groups of dik-diks, through the extended family groups of the giraffe, to matriarchal societies of elephants and the harems of impala and wildebeest (Jarman and Jarman 1979). All of these social systems lead to selection for the different morphologies that make each species in turn dependent upon the way that resources are distributed and defended.

[19] Throughout this paper, the Serengeti ecosystem is consistently defined to imply the ecological biome rather than the administrative zones that encompass three types of protected areas or conservation zones.

BOX 4.2. A DESCRIPTION OF THE ANALYTICAL MODELING FRAMEWORK USED

The three main users of the Serengeti are included in the model: (i) tourists who are attracted by the abundance of wildlife, (ii) trophy hunting ventures that are allocated a hunting quota by the government, and (iii) local residents who engage in two types of activities; they hunt wildlife (bushmeat) for consumption and farm within the ecosystem under consideration.

In keeping with existing literature, the focus is on a single representative species, the wildebeest. This simplification is reasonable in the context of the Serengeti and has been adopted in the biological literature (for example, Holdo et al. 2011). Wildebeest are widely regarded as the keystone species in the Serengeti. They fulfill important ecological functions as ecosystem regulators and also have significant impacts on the local economy. Data on tourism also indicate that tourist numbers closely correlate with wildebeest populations, suggesting that they remain an important draw card for visitors, especially because of the migration. As noted earlier, for the locals, the wildebeest are a primary source of protein.

It is hard to overstate the challenges of regulating an area as large as the Serengeti—an expanse extending over 25,000 km^2 and spanning an international border. Poaching by the local population is a concern. Simultaneously, land conversion and encroachment, especially in the buffer zones is an issue that grows more pervasive with rising population densities. The model allows for imperfect regulation with breaches of regulatory quotas and possible legal sanctions for poaching and encroachment onto areas reserved for wildlife.

The bioeconomic model is then linked to a CGE model. At the core of the CGE is the SAM, whose architecture reflects the main components of the Tanzanian economy. The information for the SAM is drawn from the GTAP database which is augmented with other data to extend the natural resource component of the model. A CGE approach seems warranted in this context, given the size of the tourism and wildlife sector and the importance of the Serengeti to the national economy of Tanzania. Tourism in Tanzania is among the largest sources of foreign exchange, estimated at over US$1.28 billion and the overwhelming majority of benefits derive from tourist visits to the Serengeti. Additionally, the government earns significant revenue from fees and licenses for tourism and trophy hunting. A CGE approach is also useful in that it provides a consistent framework to assess the overall and distributional impacts of trade-offs between segments of the economy, such as ecosystem and environmental losses in the Serengeti that occur as a consequence of gains in other parts of the economy (for example, agriculture, mining, and so on).

25 to 30 years (Holdo et al. 2011). In contrast, human population growth around the Serengeti is already high and increasing. Understanding the economic role and linkages of the Serengeti ecosystem with sectors of the economy is not without significance for an economy so dependent upon natural-resource-based revenues. Accordingly, this study has developed linked models to capture connections between renewable resource (wildlife) stocks and flows and the resulting micro and macroeconomic impacts. A summary of the models used is in box 4.2, with full technical details relegated to appendices B and C.

Reflecting current policy deliberations, the simulations explore three key issues: policies to boost agricultural productivity, a declining carrying capacity from the interconnected suite of pressures, and the effects of boosting tourist numbers. Policies to intensify agricultural productivity are a clear and necessary priority given the high poverty incidence in rural areas. There are also a host of other proposals involving intensifying tourism and intrusive activities or infrastructure that could either collectively or individually lower the carrying capacity of the ecosystem, especially if they impede the wildebeest migration which helps sustain the high density of ungulates.[20] Finally, if increased tourism is to remain concentrated in the Northern Circuit, this will have repercussions for the current high-value niche market. These effects are explored first in the context of a bioeconomic (renewable resource) model and followed by an assessment of the economy-wide impacts. Technical details are in appendix B.

[20] A decline in numbers could be a result of restrictions on the ability of wildebeest to track temporal shifts in high-quality forage resources across the landscape. In the most rigorous quantitative assessment available, Holdo et al. (2011) find that habitat fragmentation resulting from such structures (even without habitat loss) would lead to a projected median decline of 38 percent of the population.

TABLE 4.1. EFFECTS OF POLICY CHANGES

	Baseline	20% Reduction in Carrying Capacity	20% Increase in Agricultural Profits	Combined 20% Increase in Agricultural Profits and 20% Reduction in Carrying Capacity	Combined + Doubling of Fines
Wildebeest (#)	1,120,000	855,000	810,000	600,000	740,000
Harvest (#)	300,000	210,000	200,000	140,000	180,000
Tourists (#)	289,000	260,000	240,000	200,000	210,000
Land to wildlife (km^2)	17,300	17,600	16,900	17,200	18,100

The results suggest that small and unconnected pressures to the ecosystem combine to deliver disproportionately larger and unwelcome impacts. In other words, combined pressures have synergistic effects, with one factor exacerbating the effects of the other, so that the joint effects exceed the sum of the individual impacts. The outcomes are in table 4.1. The first column summarizes the baseline case which describes the current situation. The baseline simulation tracks observed outcomes with reasonable accuracy, projecting about 1.12 million wildebeest in the steady state, which corresponds closely to an actual population of between 1.2 and 1.3 million animals. The projected (legal and illegal) hunting off-take at 300,000 is somewhat larger than the estimated harvest, perhaps reflecting the clandestine nature of much hunting, while projected tourist numbers at 282,000 are within the current range of between 200,000 and 330,000 visitors a year.

Consider first the effects of a decline in the carrying capacity, which could occur for a number of reasons (examples include the numerous intrusive structures that would impede the migration, high intensity tourism, mining, or other pressures). Suppose that carrying capacity declines by (a modest) 20 percent, which is lower than median predictions in the scientific literature (see, for example, Holdo et al. 2011).[21] In such a case, wildlife numbers fall by about 22 percent to 850,000 and tourist numbers also decrease. The next column explores the effects of a 20 percent increase in agricultural revenues. As the payoffs from agriculture rise, the amount of land devoted to agriculture increases. Once again, wildlife numbers decline by about 25 percent to 810,000, with a corresponding fall in tourist numbers and the wildebeest harvest (for example, hunting off-take).

The next column—termed the combined scenario—considers the combined effects of 20 percent higher agricultural profits together with a 20 percent decline in the carrying capacity. This time there is a much more dramatic decline in wildebeest numbers (by about 50 percent) to 600,000 together with an equally significant reduction in the hunting off-take and tourist numbers by almost 30 percent. The implication is clear. The combined pressures have synergistic effects, with one factor intensifying the effects of the other, so that the joint effects exceed the sum of the individual impacts.

Could these negative consequences be reversed through improved enforcement? The final column considers the optimistic, though unlikely, case where all penalties are doubled. While there is some improvement in wildebeest numbers, the decline in the population is still significant at 32 percent. Evidently, though increasing penalties may lead to improved compliance, this does little to address the root cause of the decline in wildlife numbers—a lower carrying capacity resulting from a degraded ecosystem.

These results have striking implications for policy and suggest the need to avoid damage in the first instance if the economic gains outweigh the foregone benefits. They suggest the need to be alert to potential synergisms, which may lead to unwelcome surprises when multiple impacts interact. Of greater

[21] The detailed simulations by Holdo et al. (2011) based on a spatially explicit model suggest a median population decline of 38 percent. To guard against exaggerating possible impacts, we consider a more modest reduction in carrying capacity.

TABLE 4.2. BOOSTING TOURIST NUMBERS

	Combined 20% Increase in Agricultural Profits and 20% Reduction in Carrying Capacity	Combined Scenario with Boosting Tourist Numbers
Wildebeest (#)	600,000	600,000
Harvest (#)	140,000	150,000
Tourists (#)	200,000	218,600
Price change (%)	0	21%

concern is that the standard policy instruments—fines and enforcement of quotas—may do little to reverse the population decline when the carrying capacity and hence productivity of the ecosystem is diminished. This result has implications for the way intrusions into protected areas are managed. Often as an offset or compensation for environmental damage, funds are provided for improved environmental management. These results indicate that this approach may not be highly effective once the engine of sustainability has been damaged.

Increasing tourist numbers under the pressures identified would be challenging, with possibly adverse impacts on net tourist revenues. It is instructive to consider the consequences of boosting tourist numbers in the combined scenario. Table 4.2 summarizes what might occur with attempts to increase tourist arrivals with a diminished Serengeti ecosystem. The first column outlines the baseline situation and the second the outcome of the combined scenario. **With a diminished tourism product on offer it would only be possible to increase tourism numbers by reducing prices.** Column 4 records the outcome. To achieve a target close to even a 10 percent increase in tourism numbers, price would need to decline dramatically (by close to 20 percent), suggesting that net revenues accruing from tourism would drop significantly. The reason is obvious: with a less desirable product on offer, an increase in visitor numbers could only be achieved by lowering prices sufficiently.

The results provide other instructive guidance for policy. Contrary to popular policy wisdom it suggests that policies that diminish ecological carrying capacity need to be accompanied by a reduction in farmed area (intensification) rather than the reverse. Agricultural expansion is often the stated rationale for reducing land in and around protected areas, which is the opposite of the optimal response implied by this model. Conversely, if the carrying capacity of the Serengeti ecosystem can be preserved or increased, the optimal response would suggest an expansion of agricultural land.

Could the economic benefits of these changes outweigh the potential costs? To address these issues, the results and model of the ecosystem are imbedded into a (macroeconomic) CGE model to assess the economy-wide consequences of the changes. A CGE approach is also useful in this context since it provides a consistent framework to assess the overall and distributional impacts of trade-offs between segments of the economy, such as ecosystem losses in the Serengeti that occur as a consequence of gains in other parts of the economy. The introduction of wildlife in a CGE model is a novel feature of this work that has not been attempted previously.

The framework is useful to investigate trade-offs between sectors. To explore a set of reasonable trade-offs, it is assumed that agricultural profits (economy-wide) rise by 20 percent or about US$100 million and connectivity costs decline through the economy by 15 percent, or about US$50 million, while there is a reduction in carrying capacity of 20 percent. To guard against exaggeration of impacts, the assumed benefits from the proposed changes in the Serengeti are considerably higher than suggested gains while assumed impacts on carrying capacity are lower than suggested by recent demographic models.[22] These changes would result in a reduction in proceeds from international tourists of US$552 million per year.[23] To avoid overstatement of benefits, tourist expenditures are significantly underestimated. Data reported in the WTTC suggest expenditures of about US$300 per day in Tanzania while we assume a more modest US$200 a day.

[22] The assumed changes are far above what is suggested might eventuate (see GoT 2011; Holdo et al. 2011).

[23] Tourist numbers go from 750,000 to 550,000; expenditure per day is US$200 with 10 days average stay.

TABLE 4.3. CGE SIMULATIONS (IN US$, MILLIONS)

	Baseline	20% Reduction in Carrying Capacity and 15% Fall in Travel Costs	20% Increase in Agricultural Profits and 15% Fall in Travel Costs	Combined 20% Reduction in Carrying Capacity, 20% Increase in Agricultural Profits, 15% Fall in Travel Costs	Double Fines with 20% Reduction in Carrying Capacity, 20% Increase in Agricultural Profits, 15% Fall in Travel Costs
Harvest (Value)	750	409.31	265.31	141.48	292
Tourism (Value)	578	458.28	427.21	285.56	341.52
Value added	26,461	25,233	25,451.23	24,429.4	24,946.44
Change in value added	–	−1,227.37 (−4.6%)	−1,009.77 (−3.8%)	−2,031.60 (−7.7%)	−1,514.56 (−5.7%)
Urban households (Change)	–	−434	−375.9	−730.5	−546.4

The effects are diffused through the economy and especially large among poor rural households. The economy-wide effects emerge from the adverse exchange rate impacts associated with a decline in tourism. When tourism revenues fall, the exchange rate is affected so that the effects are transmitted to most other sectors of the economy. The simulations in table 4.3 show that even in a case when there is a very large positive shock on agriculture, to compensate for a loss of bushmeat, there is a net loss registered in the rural sector as a result of economic contraction. Value added (a proxy for GDP) also changes by more than the flow of tourist revenue as a result of changes in the exchange rate effects. The simulation which considers the case of a combined increase in agricultural profits (of 20 percent), a decline in transport costs (of 15 percent), and a decline in carrying capacity (of 20 percent) indicates that value added (GDP) declines by about 7 percent.

In summary, the results suggest that the Serengeti is a valuable economic asset and that policies which alter revenue flows will have wide-ranging impacts that spill over to other sectors of the economy. Understanding the direction and magnitude of these spillovers is crucial to policy analysis. The exercise indicates that it would be difficult to compensate for the economic losses from the ecosystem with other policy interventions. In managing this asset it is also crucial to consider complementary impacts of disparate pressures as a result of possible synergistic effects. This suggests practical and conceptual challenges for policymaking which typically considers impacts and issues separately and by sector. For instance, debates on the volume and impact of tourism and tourist infrastructure seldom consider effects emanating from the agriculture and land use or connectivity and vice versa. Managing this complex natural asset calls for holistic and comprehensive planning approaches.

B. DIVERSIFYING THE TOURISM PRODUCT—THE CASE OF RUAHA NATIONAL PARK

Tanzania possesses a rich storehouse of tourist attractions and has the opportunity and potential to diversify its tourism product by investing in the geographic comparative advantage of each part of the country. Recognizing that crowding diminishes the economic value of tourism in the Serengeti, there would need to be investments in building tourism at new destinations—a distinctive tourist experience, with a differentiation strategy. Coupled with its immense natural endowment, there is the potential for Tanzania to solidify and consolidate its emerging position as Africa's premier wildlife tourism destination, similar to the status achieved by Costa Rica.

A Southern Circuit exists, but the route is poorly known and infrequently traveled. The RNP has long been recognized as an ecological jewel with the potential

to become a major tourist destination in the Southern Circuit (Fox 2005). Established in 1910 as the Saba Game Reserve, the RNP now covers an area of about 20,000 km^2. It is the largest national park in Tanzania, the second largest in Africa and serves as a vital watershed in its landscape. The RNP remains a central pillar in plans to diversify tourism in Tanzania through a Southern Circuit, aimed at relieving ever-increasing pressures in the Northern Circuit and the Serengeti. Yet, visitation rates are low, in part because of high travel costs.

Spectacular landscapes around the Ruaha River combined with an abundance of charismatic species make Ruaha an obvious tourist attraction. The diversity and density of charismatic species is exceptionally high in the RNP, reflecting variations in flora and vegetation.[24] Among its many accolades the Ruaha landscape can boast the following:

- 10 percent of all the lions left in the world, in a period where they have vanished from over 80 percent of their range
- The third largest population of wild dogs
- The second largest elephant population after Botswana
- Prominent endemics such as the newly discovered Kipunji monkey

The protected area also encompasses two "important bird areas" and two potential Ramsar sites (WCS 2006). The RNP is deemed to be one of the most significant areas in the world for large carnivores and their ungulate prey.

If the Southern Circuit (including Ruaha) succeeds in boosting tourism revenues by even 10 percent, this would bring significant benefits to the economy as a whole. Table 4.4 summarizes the macroeconomic consequences of a 10 percent increase in tourist revenues. Overall value added (a proxy for GDP) would rise by about 1 percent and government revenue by about 1.25 percent. Most notably, benefits are equally distributed between the primary factors of production—land, labor, and capital—suggesting that the sector may be a force for reducing aggregate inequalities in the economy. However, the spatial distribution of benefits is far from equitable, with the bulk of benefits accruing to urban households (as a result of the nature of linkages of the sector and the exchange rate effects) and a smaller fraction of benefits in the rural sector. This once again highlights the importance of enhancing rural sector linkages with tourist spending.[25]

TABLE 4.4. A 10 PERCENT INCREASE IN TOURISM VALUES

	Baseline (in 2010 US$, millions)	Absolute Impact (change in 2010 US$, millions)	Percentage Impact
Value added	26,001.97	239.35	0.92
Land	1,966.00	18.86	0.96
Labor	12,725.00	114.19	0.90
Capital	11,311.00	106.30	0.94
Urban	13,437.00	124.64	0.93
Rural	509,961.00	130.27	0.03
Tax and government revenue	1,241.00	15.54	1.25

Commercializing Ruaha's tourism potential has not been without challenges. Its many attractions are largely unknown in the world of nature-based tourism and few visitors to Tanzania arrive at this spectacular location. Table 4.5 compares tourism in Ruaha to that in the Serengeti. In a typical year the Serengeti receives between 250,000 to 330,000 visitors, while Ruaha receives about 20,000. The constraints appear to lie not in the availability of accommodation; there are an adequate number of lodges in Ruaha (for the given visitation rates). Likewise the RNP entry fees are clearly insignificant compared with total travel costs incurred by international tourists. The obstacles to Ruaha's growth must lie elsewhere. Visitor profiles, though sparse, suggest that the typical Ruaha tourist seeks a more discerning and

[24] This is where *Commiphora-Acacia* vegetation communities merge with southern *Zambezian Brachystegia-Isoberlinia (miombo)* communities.

[25] In comparing results, it is important to note that unlike the simulations in the previous section there is no assumed change in either trophy hunting or bushmeat hunting. As noted earlier, according to the simulations the latter has extremely wide impacts on rural welfare because of the importance of bushmeat as the primary source of protein.

TABLE 4.5. COMPARING RUAHA TO THE SERENGETI

Description	Ruaha NP	Serengeti NP
Size	20,226 km^2 (largest NP in Tanzania)	14,763 km^2 (second largest NP in Tanzania)
Annual visitors 2011/12 (approx.)	2,100	330,000
Conservation fee for 24 hours—visitors above the age of 16 years (US$)		
– Citizens	3 (TZS 5,000)	6 (TZS 10,000)
– Residents (expatriates)	15	30
– Foreign	30	60
Bed capacity inside the NP (number)		
– Excluding TANAPA camps	222	1,633
– Including TANAPA camps	302	1,863

authentic wildlife experience and is either on a second trip to Tanzania (having done the obligatory Serengeti visit) or arrives at Ruaha from the Serengeti.[26] Attracting a larger proportion of the Serengeti tourists to Ruaha would do much to boost the park's economic fortunes. However, despite efforts to promote Ruaha as part of the Southern Circuit, success has been elusive thus far, with an insignificant increase in annual visitors from 19,721 in 2006/07 to 21,600 in 2011/12.

There are three major challenges that constrain the development of tourism in Ruaha: competition over water use, challenges of access, and the park's obscurity in the public eye.

WATER CONSTRAINTS

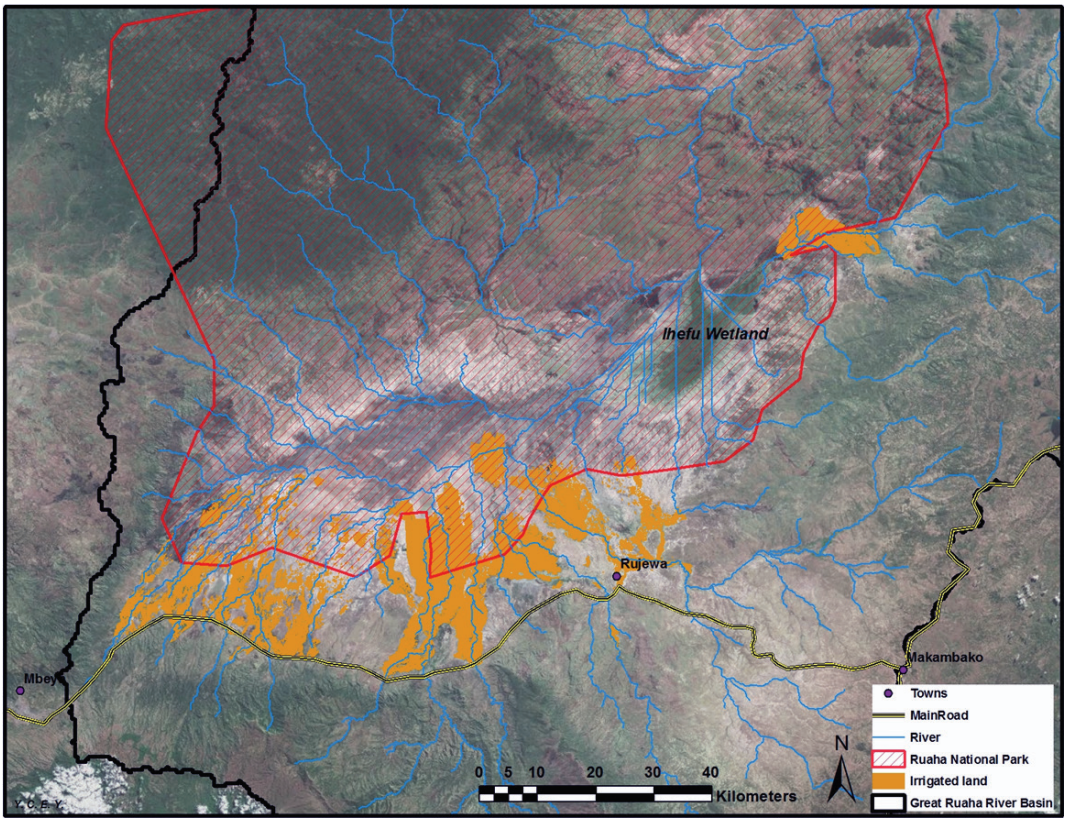
Water is the most-contested resource in the area. The landscape and the economy of the region are dominated by the Great Ruaha River, part of the Rufiji Basin, the country's largest. The river originates from the Usangu highlands and flows through the Usangu plains and Ihefu wetland to the RNP. Downstream of the park, the Great Ruaha River joins the Little Ruaha to supply water to the Mtera and Kidatu hydropower plants. On average, the Great Ruaha provides 56 percent of run-off to the Mtera and Kidatu hydropower stations, which in turn generate more than 50 percent of the country's electricity from hydropower. Significantly, the river is an important livelihood resource and is used for domestic, livestock, and irrigation across the south and southwest of the country.

Until the early 1990s, the Great Ruaha was a perennial river which flowed through the RNP and into the Mtera Dam but has since become seasonal. River flows indicate an increasing frequency and extension of zero-flow periods in excess of 50 days between 1990 and 2004 (Kashaigili et al. 2007). Competition over water resources between upstream irrigation and other users continues to escalate. The major irrigated areas are located upstream and have expanded dramatically in recent years (from 3,000 ha to over 115,000 ha (World Bank 2014). During the dry season, from July to November, the river is the only source of water for downstream users who include subsistence agriculture, livestock, the RNP, and hydropower in the Mtera Dam which has in the past relied upon dry season flows to augment supplies (though the need for such supplies remains contested; Kadigi et al. 2008; Machiba et al. 2003).

This has far-reaching consequences for the immediate and long-term ecology of the park and its tourism potential. Lack of dry season flows has had direct and observable effects as well as more subtle indirect impacts on the downstream economy, water quality, and ecology (see figure 4.1). Most immediately, lack of flows in the dry season lead to a decrease of buffalo and other water-dependent species that have economic implications for the RNP. Buffalo are a high-profile species for photographic and hunting tourism. Currently, Ruaha's tourism is confined to a small area along the river. As visitor numbers have increased, so has crowding along the Ruaha "River Drive," leading to a decline in tourist satisfaction (Fox, 2005). Therefore, to maintain the "wilderness character" for which Ruaha is known, tourism must expand beyond its current area. However, drying of the Ruaha River prevents expansion of tourism to the

[26] TANAPA officials, pers. comm.

FIGURE 4.1. MAP SHOWING FORMAL IRRIGATION SCHEMES IN USANGU WETLAND



Source: World Bank, Draft Hydropower Sustainability Assessment Report, 2015.

downstream areas. Likewise, a lack of dry season water adversely affects the subsistence farmers in the Wildlife Management Areas (WMAs) (Coppolillo et al. 2003) and reportedly leads to increased human-wildlife conflict as park predators prey on the livestock of nearby communities.[27] None of this is conducive to attracting tourists in the dry season when game-viewing is at its peak because of the concentration of wildlife around water sources.

The more subtle impacts include changes in the predator-prey balance and negative impacts on the livelihoods of downstream users. While much attention has been given to the consequences on the energy sector, there has been limited analysis of the effects on downstream users and the impacts on poverty levels in these areas.

Box 4.3 presents results from an illustrative assessment of the consequences of seasonal water deprivation in the Ruaha ecosystem. In the absence of data on the economic dimensions of the problem, the exercise can only be viewed as demonstrative and hypothetical. For policy use there would be a need to calibrate the model with actual data on livelihood attributes from the landscape, which will require a minimalist, rapid data collection exercise.

There is a general consensus that upstream abstraction of water, especially in the dry season, induces water shortages among downstream users.[28] The irrigation schemes (for rice) are located upstream of the hydropower plants. Water that is not diverted upstream for irrigation or other purposes in the Usangu flows naturally to downstream users, including the Mtera and Kidatu hydropower stations. There is

[27] A. Dickman, pers. comm.

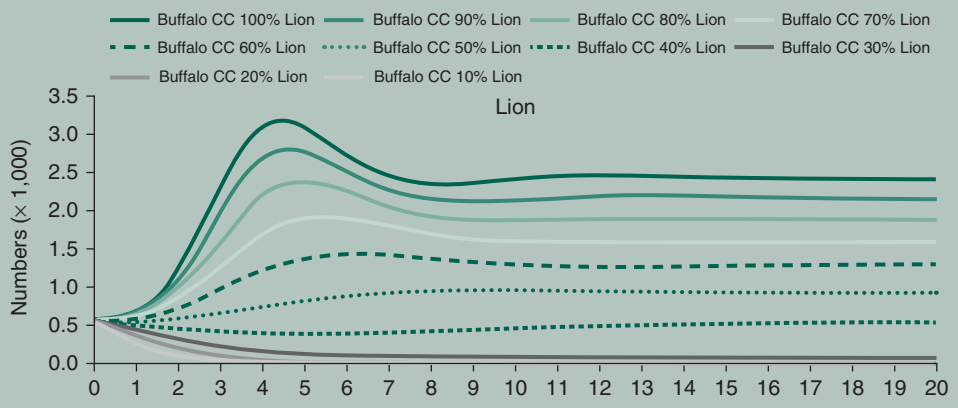
[28] However, there are dissenting views that the problem is independent of abstraction levels and is a consequence of alterations in land use and/or climate change.

BOX 4.3. WATER SCARCITY IN THE RUAHA LANDSCAPE

To better understand the linkages between water, the ecosystem, and the economy, an analytical model was developed for this report with the aim of identifying linkages that are often ambiguous and exploring trade-offs. Because of a lack of data on livelihoods in nearby communities, the results presented are based on assumed rather than actual parameters rendering the analysis limited for policy guidance; however, results are illustrative. The formal model is in appendix B.

The model incorporates the key economic decisions of the extremely poor residents who inhabit the lands downstream and adjacent to the park (which are largely WMAs providing joint management opportunities between state and communities) and survive through a combination of subsistence activities: farming for domestic consumption; livestock rearing for reasons that are well documented in the literature (cash, store of value and tradition, food); bushmeat hunting which is a primary source of protein; and finally, the occasional lion hunt prompted by revenge killings as well as for ceremonial purposes, usually as part of an initiation ceremony for adolescent males. Not unrealistically, farm output in the dry season is assumed to depend upon the availability of water. The biology of the ecosystem is described by an extension of the predator-prey model outlined by Fryxell et al. (2007). Carrying capacity depends essentially upon the availability of dry-season water flows.

The model illustrates how changes in water flow impact wildlife interactions and the incentives of subsistence farmers. As the following figure shows, there are several key issues emanating from reduced water availability. With less water for farming, there is an increase in bushmeat hunting, assumedly to replace missing calories. There is higher livestock mortality. In the short run, predator-prey imbalances favor predator numbers as hunting becomes easier. However, this advantage quickly vanishes, not just because of reduced prey numbers but also because of a diminished capacity to form prides. If water shortages are significant and sustained, there is rapid population decline as illustrated in the example below. There is also an increase in predation on livestock, inducing greater human-wildlife conflict in these equilibria. The figure shows how water constraints lead to proportionately lower lion numbers in different equilibria.



an assumption that when optimally managed, average wet season flows are adequate for the needs of the Mtera reservoir (Lankford et al. 2007). However, when this assumption does not hold, there remains a need to augment wet season flows with dry season supplies (Kadigi et al. 2008). If so, this implies that there is a direct trade-off between water used for irrigation and energy, suggesting that in the dry season water ought (in the optimum) to be allocated to its highest valued use.

Kadigi et al. (2008) explore water allocation trade-offs in greater detail and find that water used for hydropower generates substantially higher economic benefits than that used for agriculture. Their results are summarized in table 4.6. In all scenarios examined, the economic value of water for hydropower far exceeds that for agriculture. The result seems unsurprising as rice yields in the basin are low and below the global average. Generally, water productivity of rice in Sub-Saharan Africa ranges from

TABLE 4.6. PAYOFFS FROM IRRIGATION VERSUS HYDROPOWER

Description	Rice Alternative Scenarios	Hydropower Alternative Scenarios
Water used (mm^3)	542–979	1,000–4,096
Net value of water (US$/$m^3$)	0.01–0.04	0.06–0.21

Source: Kadigi et al. 2008.

0.10 to 0.25 kg/m^3, with an average yield of 1.4 tons/ha. China and some Southeast Asian countries have higher water productivities for rice, ranging from 0.4 to 0.6 kg/m^3 (Rosegrant et al. 2002). In contrast, in this basin, the equivalent figure is 0.11–0.19 kg/m^3, with a corresponding value of US$0.01–0.04 per m^3, reflecting lower yields and higher levels of water consumption (Kadigi et al. 2008). In contrast, the equivalent value for hydropower varies from US$0.08 to US$0.21 per m^3.

However, a number of caveats are in order. First, the results likely underestimate the benefits of transfers from irrigation as impacts on other downstream users (see box 4.3) are not considered. Downstream water is needed by other users, including for livelihoods in WMAs and building tourism in the RNP. Second, alternative scenarios that reverse these results are conceivable. For instance, it could be assumed that there is an unexpected surge in the availability of cheap supplies of oil and gas (perhaps from recent exploration efforts or a further collapse of oil prices in global markets) that dramatically drive down the marginal cost of thermal generation. This in turn would call for a switch on the margin from hydropower to thermal generation. Further, it is at times suggested that water constraints derive entirely from climate change. Finally, it is arguable that in an idealized management system, the dams can be filled entirely with wet season flows and the water stored for appropriate generation and use in the dry season.

THE CHALLENGES OF ACCESS

To make Ruaha attractive to tourists, it must be both accessible and affordable to its targeted market. Tanzania's natural tourism products are in many ways unparalleled globally, offering a range of experiences. However, to be competitive it needs to offer a visitor experience that is no worse and preferably better than rivals in a similar category. A comparison of Ruaha with Botswana and, in particular, the Chobe NP as a possible rival destination is instructive. The products on offer are similar in many respects. Tourism (and the attractions, scenery, and wildlife) in both locations are highly dependent upon a river-based ecosystem. In the Chobe NP, as in Ruaha, the river in the dry season becomes the only source of water and survival for wildlife. Both parks are renowned for their lions and large elephant herds. However, unlike Ruaha, Chobe is located close to the Victoria Falls and benefits from tourists who combine a visit to both attractions.

TABLE 4.7. APPROXIMATE ACCOMMODATION AND TRAVEL COST AND TRANSPORTATION TIME

Description	Ruaha NP	Chobe NP
Average accommodation costs per person per night full board—high season (US$)	390	580
Travel time by road from nearest international airport	11 hours (625 km)—from Dar es Salaam	Chobe NP is located just next to Kasane Airport.
Average price of one-way air ticket from nearest international airport (US$)	345	Chobe NP is located just next to Kasane Airport.

Table 4.7 compares accommodation and travel costs as well as transportation times for both locations. The average cost of accommodation during the high season is US$580 in the Chobe NP and US$390 in the RNP. The next tables show that arriving at Ruaha from various destinations in Tanzania is more time-consuming and expensive compared to the Chobe NP, which is located just next to an international airport. Thus, a more likely constraint for tourism development in the RNP is the very high cost of traveling to the park, which on average is US$345 for a one-way ticket (see table 4.9) or the fact that it takes about 11 hours by road (see table 4.8)

TABLE 4.8. APPROXIMATE DISTANCES BY ROAD

From/To	SNP (Seronera)	Ruaha*	Selous
Dar es Salaam	965 km (14 hours)	625 km (11 hours)	230 km (6 hours)
Arusha	335 km (5 hours)	700 km (14 hours)	1,000 km (14 hours)
Selous	–	855 km (17 hours)	–
SNP (Seronera)	–	800 km (16 hours)	2,000 km (28 hours)

Note: * Estimated transportation time during dry season.

TABLE 4.9. AVERAGE AVIATION PRICES (ONE WAY, US$)

From/To	SNP (Seronera)	Ruaha	Selous
Dar es Salaam	450	330	175
Arusha	200	330	420
Zanzibar	335	420	210
Selous	–	320	–
SNP (Seronera)	–	520	575

from the closest international airport (Dar es Salaam). Moreover, despite the fact that the road network in the RNP has been prioritized for improvement by TANAPA, almost all the lodges inside the park are closed during the rainy season (April–May) as the roads are impassable during that period. The tourist experience is not measured by the product on offer alone but by the whole continuum of interactions that include travel time and costs. Consumers are becoming better informed. Price, quality of accommodation, and the product on offer are critical determinants when selecting a destination. They increasingly seek destinations that offer "value for money." Given that Ruaha offers a less attractive experience, especially during dry periods when river flows have ceased, and is the more expensive destination to reach, competing with the Chobe NP in Botswana may be difficult.

In summary, the transport infrastructure and quality of experience may not match the prices that the tourists have to pay in competing markets.

RUAHA—AN UNKNOWN DESTINATION?

Despite its many attractions, Ruaha receives little publicity in the official media and, more generally, it is widely overlooked in travel media. The Tanzania Tourist Board publicizes the Southern Circuit, but does not mention Ruaha, and on the official home page Ruaha is ranked eighth among the top ten destinations and below several with less to offer in terms of attractions.[29] An Internet search can be uninformative also. A search with key words such as "Tanzania, wildlife tourism, and lions" fails most often to bring up any links to Ruaha, and when Ruaha is mentioned, it is typically in academic work from the Carnivore Project. With such limited global recognition, it is no surprise that Ruaha's tourist numbers lie far below potential. There needs to be a concerted effort to increase awareness and information about Ruaha's many attractions. The branding of Tanzania as "The land of Kilimanjaro, Zanzibar, and the Serengeti" clearly warrants reconsideration to be made more inclusive to reflect the diversity of unspoiled destinations and what each has to offer.

A marketing strategy is needed that fits the range of attractions on offer with market preferences. It is unclear without further research whether Ruaha is better suited to the generic traveler or more specialized segments such as experiential travelers and the growing adventure travel market. The length of stay of the average visitor in Tanzania is 11 days. The most cost-effective way to increase tourist revenue is to increase the length of stay, such as through offering additional attractions. The private sector has a clear role to play in leading this process, with the state providing regulatory support to ensure that developments do not erode the economic or ecological value of the park. Finally, the form of marketing will also be critical. Internet-based marketing offers the most cost-effective opportunity, but other vehicles need to be considered

[29] http://www.tanzaniatouristboard.com/places-to-go/southern-circuit/ viewed on August 3, 2014, 6 A.M. EST.

depending upon targeted market and strategy. Consumers have always taken advice from other travelers when selecting a destination, and the Internet has increased possibilities and the range of opinions available. Websites such as Trip Advisor (where travelers post their own reviews and experiences of destinations and products) are extremely popular. The two most significant sources of information when selecting a long-haul holiday are previous experience (that is, the traveler has been there before) and recommendations (Frias et al. 2012).

CHAPTER FIVE
WAY FORWARD

Tanzania's natural assets have catalyzed a buoyant and robust tourism industry that has served the country well, especially in times of economic volatility and recession. Its natural assets also play a pivotal role in sustaining the livelihoods of the rural poor, who are highly dependent upon ecosystem services such as bushmeat, hydrological flows from water-sheds, and fuelwood. The CGE analysis has demonstrated that the effects of natural resource depletion in the Serengeti have a disproportionate impact on the rural poor through the impact on tourism flows and the availability of livelihood resources. This suggests that degradation of the natural asset base could precipitate a downward spiral of poverty when alternative sources of employment are limited.

The macroeconomic simulations reported in this study also suggest that the economic impact of the sector is often underestimated. The benefits are stronger than might appear, with cross-sectoral spillover effects and linkages that dominate those of other traditional sectors of the economy. Tourism as a labor-intensive industry has become an important source of employment in Tanzania and provides good quality jobs, especially to women[30] who often have few other opportunities for well-paid employment. All of this has emerged as a consequence of the HVLD approach that has built a resilient sector. To build upon this success, Tanzania needs to play to the comparative advantage of each region and attraction. This calls for a strategy that **maximizes tourism revenue and not tourist numbers.** The latter, as demonstrated in this report, could prove to be counterproductive. However, with a high incidence of rural poverty there are opportunities to further build the industry and strengthen linkages with the rural poor.

BENEFIT SHARING AND BUILDING LINKAGES WITH THE LOCAL ECONOMY

There is a need to strengthen linkages with the local economy and develop policies and incentives to share benefits with the poorest who often live close to tourist attractions. Current benefit-sharing policies (summarized in box 5.1) have had limited impact in

[30] Respectively 22 percent and 24 percent of permanent Tanzanian employees in managerial and non-managerial positions in hotels are female (Survey prepared for the HAT, 2014).

BOX 5.1. THE WILDLIFE MANAGEMENT AREAS AND OTHER BENEFIT SHARING IN TANZANIA

As a result of past failures, traditionally centralized wildlife management policies and the crisis facing wildlife population the community-based natural resource management (CBNRM) approaches and Wildlife Management Areas (WMAs) emerged during the reform process in the 1990s. Through direct involvement of local communities in managing wildlife for tangible local benefits WMAs was recognized as the best option for conserving wildlife outside. Protected Areas (PAs). Passage of the 1998 Wildlife Policy (revised 2007) laid out the legal underpinnings of Tanzania's approach to CBNRM through the establishment of WMAs. This policy promoted wildlife management at the village level by allowing "rural communities and private land holders to manage wildlife on their land for their own benefit" and "devolving management responsibility of the settled and areas outside unsettled protected areas to rural people and the private sector." New WMA Regulations under the 2009 Act were issued in 2012, which contain a number of key changes, including strengthening the communities' involvement and influence over trophy hunting concession allocations in WMAs, as well as providing greater clarity around benefit-sharing.

WMAs began to be formally implemented in 2003 and the first WMAs were gazetted in 2006. Currently 17 WMAs, covering an area of 28,389 km^2 or about 3 percent of Tanzania, have successfully completed the required 12-step participatory process leading to WMA gazettement and 22 others are in various stages of development. Considerable progress has been made during the past decade in terms of creating a basic legal and institutional framework for WMAs; supporting communities to establish the basic management structures and land use patterns required to form and oversee WMAs; and building broad support for WMAs as a key component of both conservation and natural resource-related development policies and approaches in Tanzania.

However, despite this significant progress, major challenges remain, particularly in the economic and governance realms. A U.S. Agency for International Development (USAID) evaluation report of WMAs performance (USAID 2013) found many critical issues threatening the success and sustainability of WMA namely: (i) lack of transparency and accountability among WMA stakeholders; (ii) incomplete devolution of responsibilities to WMAs; (iii) costs of establishing and running WMAs are too high and payments from government too unpredictable; (iv) lack of diversified (and sustainable) revenue streams; and (v) benefits to communities are low and are not perceived to be adequate at the household level.

inducing a greater integration of the industry into the local economy. This arguably reflects the large gap that prevails between the industry's needs and the available supply capacity in the surrounding rural areas. Economic participation by the poor would be difficult when they are unable to provide the goods and services that are of value to the industry. The challenge for policy is to create a set of commercial incentives for tourism operators to strengthen local linkages while remaining commercially profitable. A number of schemes merit consideration.

Community conservancies. Box 5.2 describes the Namibian experience of Community Conservancies. These are an extension of the more familiar CBV between communities and private tour operators, where pieces of community reserved land are subleased to private tourism investors for direct, annual set sub-lease base fee; bed-night fees; and in some cases, extra activity fees per day that are paid directly to the village governments. Evidence suggests (Platteau 2004, Wong 2010) that problems often arise with the distribution of benefits within communities, especially when revenues are captured by community leaders and the elite.

Building local capacity. Another promising model entails building supply chains into local communities to strengthen economic linkages. Agriculture is an obvious entry point because of the availability of land. However, constraints would likely arise as a result of a lack of local knowledge, capacity, and work culture, all of which combine to limit the ability to generate reliable supplies to the industry. To address these issues would require intensive programs of capacity building to develop partnerships and a mutual understanding of priorities between the industry and local communities.

A. MAINTAIN AND STRENGTHEN THE HVLD SEGMENT

The HVLD approach has been the default strategy that has served as a robust source of employment and growth.

BOX 5.2. NAMIBIA COMMUNAL CONSERVANCIES AND TOURISM

Communal conservancies in Namibia grew out of the recognition that wildlife and other natural resources had disappeared in many parts of the country and that the livelihoods of rural communities could be improved if these losses were reversed. The Namibian CBNRM approach is based on devolving user rights over natural resources and management authority to community institutions established in terms of national legislation. The policy and legislation provide an incentive-based approach to conservation—enabling communities to earn income and other benefits from their sustainable management of natural resources. Moreover, by linking conservation to poverty alleviation, conservancies provide livelihood and employment opportunities while at the same time unlocking great tourism development potential.

Conservancies are self-selecting social units or communities of people that choose to work together and become registered with Namibia's Ministry of Environment and Tourism (MET) and are in turn provided with technical advice and support by the Namibian government and nongovernmental organizations (NGOs). To meet the conditions for registration, a conservancy must have a legal constitution and clearly defined boundaries that are not in dispute with neighboring communities. It must also have a defined membership and a committee representative of community members. Conservancies are also required to draw up a clear plan for the equitable distribution of conservancy benefits to members. Once registered by the MET, the conservancies gain user rights to sustainably use wildlife and tourism and retain 100 percent of the revenues generating from hunting and tourism.

The CBNRM program has become one of Namibia's most effective forms of rural development and is considered the most successful in the region. There are currently 79 registered conservancies in Namibia, which occupy 15.4 million ha equivalent to 19 percent of the country. The total programmatic investment of N$1.2 billion from 1990 to 2011 has produced an estimated net national income of N$2.8 billion, while the Namibia CBNRM program has attained a net present value of N$451 million, or the equivalent of an economic internal rate of return of 21 percent (NACSO 2012). However, despite the success achieved to date, several challenges confront the CBNRM program, namely, the financial dependency of conservancies on donors and government; weak institutional capacity of conservancies; increasing threats from commercial poaching; and lack of long-term cost-effective and efficient support systems.

The HVLD is an inelastic segment of market demand that has exhibited resilience and steady growth over economic cycles. It attracts customers who are willing to pay high prices for the experiences they desire. Nonetheless, this is a market segment that is difficult to attract and one that can easily be lost if the product fails to meet expectations. Forgoing this much-sought-after market niche would likely be economically imprudent if the intention is to maximize revenues from tourism.

Preserve the Jewel in the Crown of Tourism. The allure and iconic status of the Serengeti has been pivotal in allowing the country to maintain its status as an exclusive HVLD tourist destination. The Serengeti is the last intact, fully functioning savanna wilderness ecosystem in Africa and its central attraction is the vast herds of wildebeest that migrate north from their calving grounds in the southern part of the ecosystem. There are risks that current trends could undermine the earning potential of the Serengeti with adverse consequences that would be transmitted widely through the economy.

Address the Litany of Pressures on the Northern Circuit. Congestion, as it occurs in the Massai Mara Reserve or the Ngorongoro Crater, is not conducive to a high-value tourism experience. Intrusive developments and over-building—a feature common in other tourist areas—is also certain to undermine the value of the product. Likewise, policies within and outside the ecosystem that damage the carrying capacity and hence the wilderness value of the ecosystem would also have counterproductive economic consequences that erode the earning potential of this natural asset. The implication is that there is a need to preserve and strengthen the status of the Serengeti as an HVLD destination that caters to a different market segment to that of the Massai Mara Reserve. This will allow the country to maximize revenues from this market without entering into direct competition with a more volatile (and elastic) segment of the market.

For HVLD tourism to succeed, the product on offer must be rare, exclusive, or unique. The Serengeti clearly falls

into this category. The wildebeest migration is obviously unique and the authentic and uncrowded wilderness experience on offer is exceptional and atypical. By contrast, the experience (congestion and location) and product (wildlife observable) on offer at NPs would not be able to attract the HVLD market segment. Second, since such HVLD assets are rare, by implication, there is less competition, which allows for higher prices to be charged for the experience. Third, HVLD tourism attracts people who care more about experience (wilderness) and less about price (that is, more inelastic demand). This group might include the so-called high-net-worth individuals but also includes interest groups (hobbyists, birdwatchers, climbers, and so on). Hence, not every destination in Tanzania will fit into the HVLD category.

B. DIVERSIFY THE PRODUCT

There is a need for a differentiated strategy that plays to the economic **strengths of each attraction** and asset. Going forward, the approach would need to build and differentiate tourism by **location** (for example, Serengeti versus Arusha NP versus the South); **product** (wildlife, beach, culture, adventure); and **market segment** (domestic, international, conference).

The focus of tourism on the Northern Circuit has meant that Tanzania's vast endowment of other tourist assets remains underused. The country has failed to adequately leverage the opportunities for employment, growth, and poverty reduction that these assets offer. Building tourism in the Southern Circuit has not been easy in a market that grows more competitive and better informed each day as a consequence of improved connectivity and globalization. There are four preconditions that will need to be met to make the Southern Circuit a competitive offering for tourists who can choose between an array of similar products.

Address the challenge of water constraint. If the RNP is to become one of the central attractions there is a need to address the problem of dry-season water flows in the basin and restore flows to the NP. The problem is especially challenging because water use in this basin is treated as an open access, common property resource, where the number of users is difficult to control. Put simply, in the absence of enforceable regulations, if water is made available to upstream farmers, it will be used so long as there are benefits from additional use (irrigation) that exceed the opportunity costs of the users.[31] Addressing this problem will be especially challenging given the number and diversity of users and the regulatory constraints.

There are three ways in which water use can be controlled: through quotas (quantity controls); water pricing schemes; and payments to reduce water use (payment for environmental services). The first approach involves regulating water use through physical quotas. However, in the absence of water monitoring and measurement systems and a transparent, credible system of sanctions for breaches, quotas will inevitably be unenforceable. Cultural and rights-based beliefs are other common reasons why registering for "water rights" is not seen as legitimate in many communities. The second and more complex alternative is to impose a price (fee) for water use. This is often difficult to implement and resisted by users accustomed to free water supplies. Finally, there is the possibility to pay current users to reduce the amount of water extracted from the system, a Payment for Environmental Service (PES) scheme. This is more likely to gain community acceptance so long as the payments cover opportunity costs.

PES schemes are typically complex and call for considerable investment in monitoring and enforcement, and where institutional capacity is weak, it would be necessary to outsource implementation of the program. A problem with such schemes is determining the right price. If payments are too small, users will have little incentive to participate in the scheme (also part of the "additionality problem") and a payment too large will be both wasteful and risk attracting new entrants, thus worsening the problem. In essence, the problem is that of asymmetric information—information on the opportunity costs of participation is private. A typical solution in such situations is to use auction schemes to extract private infor-

[31] More formally, it is well known that each user will extract water to maximize his or her payoffs, but overall entry will ensure that all rents from resource use are depleted. In short, there is economic overuse of the resource, which is inefficient.

mation and generate more efficient outcomes.[32] Without adequate investment in water management and control, none of this will be feasible.

Common to all of these schemes is the need for greater investment in administrative and institutional capacity to build measurement and monitoring systems with adequate enforcement capabilities. A system of property rights is needed that identifies users, defines their legal rights, and limits new entrants. Monitoring systems are needed to identify violations while effective penalties and rewards provide the incentives for compliance with the rules.

Access and costs. Inadequate infrastructure results in higher transportation times and costs to reach the RNP from international airports compared to NPs in the Northern Circuit as well as the Chobe NP in Botswana. Moreover, lodges inside the RNP are forced to close down during the long rainy season during the months of April and May as roads are impassable during that period. To allow the RNP to become an alternative wildlife destination throughout the year and be attractive in terms of price, the road network both inside the park and the road to the park from the closest larger city, Iringa, need to be upgraded.

Branding and publicity. The Southern Circuit needs to define and develop a brand to distinguish itself from rivals. There is much that is unique to offer prospective tourists. Ruaha alone can boast 10 percent of all the lions left in the world, the third largest population of wild dogs, the second largest elephant population after Botswana, and prominent endemics. The Selous Game Reserve is a World Heritage Site with an impressively large array of wildlife that includes the endangered black rhinoceros. There are considerable opportunities for resourceful marketing and packaging of these products. However, they receive little publicity. Tanzania's marketing slogan as "The land of Kilimanjaro, Zanzibar, and the Serengeti" simply reinforces the current bias in favor of the much-visited Northern Circuit. A coherent and well-funded marketing plan would need to be an essential part of the diversification process.

Develop a marketable product. The product on offer must be competitive in both price and experience. Beach tourism is perhaps the most-competitive and well-informed segment of the market, with models that cover the entire range of prices. The price-conscious tourists are largely indifferent about location but sensitive to price, travel cost, and travel times. With a long coastline, there are opportunities to compete in many of the segments of the sun-sea-sand holiday destinations.

In summary, the tourism industry is central to the economy of Tanzania with significant contributions to government revenues, employment, and the external balance. Expanding the sector will require building on the country's distinctive strengths and the comparative advantage of its many tourism assets. HVLD tourism is both necessary and has done well in the past to build a niche and robust industry in the iconic Serengeti. Dramatically expanding tourist numbers in the Serengeti will inevitably call for more competition in the less lucrative spectrum of the market.

There are also considerable opportunities elsewhere to build a more diversified tourism product. This will call for combined efforts across sectoral boundaries, to address the challenges of infrastructure, contests over water resources, policies to strengthen linkages with the rural poor, and finally, the need for a sound marketing strategy.

[32] This established result from the Theory of Contracts is being increasingly used in determining land-use decisions in environments with limited enforcement capacity (Laffont and Tirole 1999). Competition is the driving force behind this so-called "revelation mechanism." In formulating a bid, participants face a trade-off between a higher net gain from raising the asking price and a reduced chance of winning (being selected). Competition thus reduces overcompensation and increases cost-effectiveness. Auctions have the added advantage of acting as a price discovery mechanism for environmental services for which there are no well-established markets and thus no prices.

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APPENDIX A
TREND OF VISITORS ARRIVALS AT NPS FOR FY2006/07–2011/12

TREND OF VISITORS ARRIVALS AT NPS FOR FY2006/07–2011/12

		Financial Year					
Sl. No.	**National Park**	**2006/07**	**2007/08**	**2008/09**	**2009/10**	**2010/11**	**2011/12**
1	Arusha	55,098	56,076	56,393	52,907	65,645	78,636
2	Gombe	888	1,012	1,393	2,261	1,708	2,792
3	Katavi	1,746	2,041	2,359	2,137	3,128	3,003
4	Kilimanjaro	40,599	42,715	41,967	46,856	52,641	64,467
5	Kitulo	98	175	340	503	229	328
6	Lake Manyara	143,916	158,019	143,504	146,573	171,606	181,621
7	Mahale	1,235	1,293	1,048	710	1,239	3,688
8	Mikumi	29,462	33,574	34,912	35,539	42,292	45,535
9	Mkomazi	n.a.	n.a.	887	833	1,175	1,230
10	Ruaha	19,721	20,958	19,786	17,374	22,703	21,600
11	Rubondo	377	432	593	643	1,156	754
12	Saadani	2,224	3,711	4,159	4,564	7,490	13,533
13	Saa Nane	n.a.	n.a.	n.a.	4,131	4,600	5,416
14	Serengeti	272,035	288,185	262,122	271,901	507,432	330,412
15	Tarangire	102,693	122,631	104,864	80,927	130,041	158,687
16	Udzungwa	3,003	3,602	4,648	4,027	5,942	8,870
	Total	**673,095**	**734,424**	**678,975**	**671,886**	**1,019,027**	**920,572**

Source: Tanzania Tourism Statistical Bulletin 2012, Tourism Division, Ministry of Natural Resources and Tourism.

APPENDIX B
SERENGETI BIOECONOMIC MODEL

1. THE BENCHMARK MODEL WITH A SOCIAL PLANNER

This appendix begins by presenting a simplified benchmark model of the social planner's problem and obtains closed form solutions that are compared to second-best outcomes under imperfect regulation. There are three main users of the Serengeti who are the agents in the model: tourists who are attracted by the abundance of wildlife, trophy hunting ventures that are allocated a hunting quota by the government, and locals who engage in two types of activities—they hunt wildlife (bushmeat) for consumption and farm within the ecosystem under consideration.

In keeping with the existing literature, the focus is on a single representative species, the wildebeest. It is important to emphasize that this simplification is reasonable in the context of the Seregenti and has been widely adopted in the biological literature (for example, Holdo et al. 2011). Wildebeest are widely regarded as the keystone species in the Serengeti. They fulfill important ecological functions as ecosystem regulators and also have significant impacts on the local economy. As the keystone species wildebeest numbers regulate biomass growth, tree dynamics, predator populations, and ungulate competitors (Sinclair et al. 2008). Reducing their numbers from habitat patches results in marked changes in biodiversity and community structure. All of this suggests that as a first approximation a focus on the dominant species is reasonable in a modeling context. Data on tourism also indicate that tourist numbers closely correlate with wildebeest populations, suggesting that they remain an important draw card for visitors, especially because of the migration.[33] For the locals, the wildebeest are a primary source of protein, and the migration periodically brings large numbers into proximity of humans and increases their vulnerability to hunting outside protected areas (Rentsch and Damon 2013).[34]

Because of the paucity of quantitative information, in what follows, functional forms are used that economize on data requirements. Accordingly, tourists are assumed to visit the area to view wildlife and their numbers T_τ, depend on the stock of wildlife. As noted above, wildlife stocks are proxied by wildebeest population W (Sinclair et al. 2008). The number of tourists is then given by:[35]

$$T_\tau = AW^\beta;\ 0<\beta<1. \tag{1a}$$

The other main agents in the model are the trophy hunting concessionaires who are granted an allocation Ω by the government.[36] The harvest of wildebeest allocated to trophy hunting is:

$$T_h = \Omega W. \tag{1b}$$

Finally, locals in the model engage in farming and hunting for bushmeat.[37] Numerous empirical studies confirm that bushmeat remains an important source of protein for the (mainly) poor households that live in the Serengeti ecosystem. In some parts of the ecosystem, bushmeat hunting

[33] A regression yields the following log tourist numbers = 0.5 log (wildebeest) + 0.211 time trend, with an R^2 = 0.879 though the correlation need not imply causality. (2.45) (0.81)

[34] As noted earlier, this species is disproportionately affected by hunting, leading to concerns that this could result in wider trophic changes with impacts across the food chain (Holdo et al. 2011).

[35] Note that it is possible to interpret this formulation as the outcome of a utility maximizing problem such that tourist utility $U(T)=\frac{1}{b}(WT)^b - PT$ where P is price per tourist day, which upon maximization yields $T_\tau=\left\{\frac{W^b}{P}\right\}^{\frac{1}{1-b}}$; In equation (1) this implies that $A=\left(\frac{1}{P}\right)^{\frac{1}{1-b}}$ and $\beta = b/1-b$, or equivalently $b = \beta/(1+\beta)$. Hence, $\frac{\partial T}{\partial P}=-\frac{1}{1-b}(W/P)^{(b/1-b)}$ and finally for completeness, we note that the price elasticity of T is $-P/(1-b)$.

[36] Trophy hunting in Tanzania is largely outsourced to commercial organizations who market the hunting experience as an elite and high-end activity often with "guaranteed" kills (Kideghsesho et al. 2006). The aim here is not to examine the bioeconomics of trophy hunting but to explore the interactions of multiple uses, so we abstract from more detailed industrial organization concerns in what follows.

[37] In an extension, we explicitly model labor supply decisions. This adds realism but does not alter the qualitative conclusions, so is ignored in what follows.

is legal though subject to controls. If $\mathcal{N}$ is the legal allocation of bushmeat, the model subsumes the case where all hunting is illegal ($\mathcal{N} = 0$) and allows for poaching and noncompliance in subsequent sections. Farming in this context could represent either livestock rearing (the traditional Maasai activity) or crop production (dominant among other groups). An important feature of the model is that there is competition for land used either for farming or wildlife. Let $L = L_w + L_g$ be the total amount of land allocated to wildlife and agriculture respectively and further assume that $L_w = L_p + L_{wnp}$, where, L_p denotes land in the protected national park and L_{wnp} is land outside the national park used by wildlife. Finally let $L_{np} = L_{wnp} + L_g$ be land outside the protected areas. Utility to locals from hunting and farming is given by:

$$V(\Pi) = [(\rho - c)(W\mathcal{N}) + (P - k)((L - L_w)]^{\vartheta} = [\pi_{\mathcal{N}} W\mathcal{N} + \pi_L (L - L_{np} - L_p)]^{\vartheta}; \vartheta < 1, \quad (1c)$$

where ρ and c define the benefits and costs respectively from the harvest of wildebeest[38] and $\pi_{\mathcal{N}} = (p - c)$, while $\pi_L = (P - k)$ are unit profits from land used in agriculture, $L_g = L - L_w$.

Social welfare which is maximized by the planner is simply the aggregate utility of the three agents and takes a Cobb-Douglas specification, defined as:

$$U = T_c^{\alpha} T_h^{\gamma} \Pi_l = (AW^{\beta})^{\alpha} (B(\Omega W)^{\gamma})^{\theta} [\pi_{\mathcal{N}} W\mathcal{N} + \pi_L L_g]^{\vartheta} = FW^{\sigma} \Omega^{\eta} [\pi_{\mathcal{N}} W\mathcal{N} + \pi_L W(L - L_w)]^{\vartheta}, \quad (2a)$$

where $\beta\alpha + \gamma\theta + \vartheta = \phi < 1$, $\sigma = \beta\alpha + \gamma\theta = \phi - \vartheta$ and $F = A^{\alpha} B^{\theta}$.

The stock of wildebeest evolves according to the usual logistical differential equation. This functional form has been parameterized for the Serengeti wildebeest (Stratton 2012) and is used to proxy the evolution of this keystone species:

$$\frac{dW}{dt} = rW(1 - \frac{W}{qL_w}) - \Omega W - \mathcal{N}W, \quad (2b)$$

where r is the intrinsic growth rate, q is a parameter that measures the carrying capacity per unit of land available for wildlife and Ω and $\mathcal{N}$ are the harvest of trophy hunters and locals respectively. We begin by deriving the social planner's optimal allocations in an idealized situation of full compliance, with control variables Ω, $\mathcal{N}$, L_w, subject to the dynamics of W in (5). The Hamiltonian can be defined as:

$$H = FW^{\sigma} \Omega^{\eta} [\pi_{\mathcal{N}} \mathcal{N} W + \pi_L L_g]^{\vartheta} + \mu[rW(1 - \frac{W}{q(L - L_g)}) - \Omega W - \mathcal{N}W], \quad (3a)$$

where μ is the co-state variable.

The first-order conditions for a maximum are:

$$\frac{\partial H}{\partial \Omega} = \eta \frac{U}{\Omega} - \mu W = 0, \quad (3b)$$

$$\frac{\partial H}{\partial \mathcal{N}} = \vartheta \frac{U}{\Pi} \pi_{\mathcal{N}} - \mu = 0, \quad (3c)$$

$$\frac{\partial H}{\partial L_g} = \vartheta \frac{U}{\Pi} \pi_L - \mu r \frac{W^2}{q(L - L_g)^2} = 0, \quad (3d)$$

$$\dot{\mu} - \delta\mu = -\frac{\partial H}{\partial W} = -\sigma \frac{U}{W} - \vartheta U \frac{\pi_{\mathcal{N}}}{\Pi} \mathcal{N} - \mu r - 2\mu r \frac{W}{q(L - L_g)} + \mu\Omega + \mu\mathcal{N}, \quad (3e)$$

where δ is the discount rate.

Using equations (3d) and (3e) and recalling that $L_g \leq L_{np}$, the optimal allocation of land to wildlife is:

$$L_w = L - L_g = W\sqrt{\frac{r\pi_{\mathcal{N}}}{q\pi_L}}, \quad \text{if } L_g \leq L_{np} \text{ and } L_w = L_p \text{ otherwise.} \quad (4)$$

Thus the ratio between the land allocated to wildlife and the stock of wildebeest at the optimum is independent of wildlife non-consumptive use and directly proportional to the relative payoffs to hunting, relative to farming ($\pi_{\mathcal{N}}/\pi_L$) with an adjustment for the carrying capacity of land (q) and the intrinsic growth rate (r). Observe that L_w is declining in q since a higher carrying capacity implies that less

[38] Note that ρ and c can be derived from the primitives of a Cobb-Douglas utility function. We avoid this step to economize on space.

land needs to be allocated to wildlife to achieve any given payoff.[39] Combining equations (3b)–(3e) yields the optimal change in the stock of wildlife:

$$\frac{\dot{W}}{W} = r(1-\sqrt{\frac{\pi_L}{qr\pi_{\mathcal{N}}}}) - \Omega - \mathcal{N}. \quad (5)$$

By equation (5) it is clear that non-negative growth requires that the relative profitability of farming is sufficiently low for an equilibrium to be sustained (that is, $\frac{\dot{W}}{W} > 0 \rightarrow \frac{\pi_L}{\pi_{\mathcal{N}}} < \frac{q}{r}[r-(\Omega-\mathcal{N})]^2$).

The optimal growth paths of the control variables are given by:

$$\frac{\dot{\Omega}}{\Omega} = \frac{1}{\alpha\beta}[r(1-2\sqrt{\frac{\pi_L}{rq\pi_{\mathcal{N}}}}) - \delta] + \frac{\Omega}{\eta} \text{ and} \quad (6a)$$

$$\frac{\dot{\mathcal{N}}}{\mathcal{N}} = \frac{1}{\omega_{\mathcal{N}}(\alpha\beta)}[r(1-2\sqrt{\frac{\pi_L}{rq\pi_{\mathcal{N}}}}) - \delta] + \frac{[1-(2\omega_{\mathcal{N}}-1)\eta}{\eta\omega_{\mathcal{N}}}\Omega - (\frac{2\omega_{\mathcal{N}}-1}{\omega_{\mathcal{N}}})[r(1-\sqrt{\frac{\pi_L}{rq\pi_{\mathcal{N}}}}) - \mathcal{N}]. \quad (6b)$$

The results under perfect regulation are intuitive. A higher value of tourism ($\alpha\beta$) or a lower regenerative capacity (r) diminishes growth of both types of hunting, whereas a higher carrying capacity (q) unambiguously leads to higher harvest rates in both sectors.[40] The intuition is straightforward: greater tourism benefits and a lower regenerative capacity of wildlife favor non-consumptive tourism. While in (6b), the rate of increase in bushmeat hunting rises with the level of trophy hunting (Ω), suggesting complementarity, when η is sufficiently small.

Finally, for later use, we note that solving for the steady-state values yields:

$$\Omega_{ss} = \frac{\eta}{\alpha\beta}[r(2\sqrt{\frac{\pi_L}{qr\pi_{\mathcal{N}}}} - 1) + \delta] \quad (7a)$$

$$\mathcal{N}_{ss} = \frac{\vartheta}{\alpha\beta}[r(2\sqrt{\frac{\pi_L}{qr\pi_{\mathcal{N}}}} - 1) + \delta] - \frac{\pi_L L}{\pi_{\mathcal{N}} W} + \sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}}). \quad (7b)$$

In the steady state, hunting levels decline with the benefits derived from tourism ($\alpha\beta$) but increase with the profitability of agriculture and with the rate of discount, suggesting a higher preference for current consumption (or a longer path of accumulation of natural capital). From expression (5) in the steady state, the combined value of the harvest must equal $r(1-\sqrt{\frac{\pi_L}{rq\pi_{\mathcal{N}}}})$. Using expressions (7a) and (7b) with the equilibrium condition, $\frac{\dot{W}}{W} = 0$, yields the steady-state stock of W:

$$W_{ss} = \frac{\frac{\alpha\beta}{\phi}\frac{\pi_L}{\pi_{\mathcal{N}}}L}{[2\sqrt{\frac{r\pi_L}{qr\pi_{\mathcal{N}}}} - r + \frac{(\phi-\alpha\beta)}{\phi}\delta)\frac{\pi_{\mathcal{N}}}{\pi_L}]}, \quad (8a)$$

where $\phi = \alpha\beta + \eta + \vartheta < 1$ is a measure of the scale parameter of the welfare function.

Expression (8a) reveals that in the steady state, the stock of wildlife will be larger the smaller the relative profitability of hunting compared to farming. Conversely, the steady state values of land in the benchmark model are given by:

$$L_w^{ss} = \frac{\frac{\alpha\beta}{\phi}\frac{\pi_L}{\pi_{\mathcal{N}}}L}{2-\sqrt{\frac{q\pi_{\mathcal{N}}}{r\pi_L}}[r-\frac{(\phi-\alpha\beta)}{\phi}\delta]}. \quad (8b)$$

In the steady state, the optimal level of land allocated to wildlife is positively related to factors that increase their relative payoffs, such as the value of non-consumptive uses of wildlife and the relative profit of trophy hunting. These results are largely predictable and provide a benchmark for comparison with outcomes under regulatory imperfections.

[39] Since agriculture occurs only on non-park land L_{np}, this can be stated as: $L_w = L_p + (L_{np} - L_g) = (L - L_{np}) + W\sqrt{\frac{r\pi_{\mathcal{N}}}{q\pi_L}}$.

[40] By inspection, $\frac{d\left(\frac{\dot{\Omega}}{\Omega}\right)}{d(\alpha\beta)} < 0$ and $\frac{d\left(\frac{\dot{\mathcal{N}}}{\mathcal{N}}\right)}{d(\alpha\beta)} < 0, \frac{d\left(\frac{\dot{\Omega}}{\Omega}\right)}{dr} < 0$ and $\frac{d\left(\frac{\dot{\mathcal{N}}}{\mathcal{N}}\right)}{dr} < 0, \frac{d\left(\frac{\dot{\Omega}}{\Omega}\right)}{d(pq)} > 0$ and $\frac{d\left(\frac{\dot{\mathcal{N}}}{\mathcal{N}}\right)}{d(pq)} > 0$ and $\frac{d\left(\frac{\dot{\mathcal{N}}}{\mathcal{N}}\right)}{d\Omega} > 0$ if $\eta < \frac{L_g}{\omega_L}$.

2. IMPERFECT REGULATION

In this section, we take a step toward realism by extending the benchmark model to include imperfect enforcement of hunting quotas and land allocated to farming. It is hard to overstate the challenges of regulating an area as large as the Serengeti, an expanse extending over 25,000 km^2 and spanning an international border. Poaching by the local population is a widespread problem, estimated at over 10 percent of the wildebeest population in certain years (Rentsch and Damon 2013*)*. Simultaneously, land conversion and encroachment, especially in the buffer zones is a problem that grows more pervasive with rising population densities. This section extends the core model by allowing for breaches of regulatory quotas and possible legal sanctions for poaching and encroachment onto areas reserved for wildlife. There is limited evidence of trophy operators violating their quotas; perhaps a reflection of the large hunting blocks that are leased to operators over significant periods together with generous hunting allocations, which are likely more incentive compatible. Allowing violations by trophy hunters in the model would be straightforward but is ignored in what follows as it is not considered to be a problem.

With regulatory imperfections, the timing of events becomes significant. It is assumed that the government is the first mover and defines the policy parameters, taking account of the downstream responses (the reaction functions) of other agents where relevant. Observing these policies, the local population responds by setting the level of hunting (N) and the land allocated to farming (L_g). Lacking property rights, the local population ignores resource dynamics and they myopically maximize short-term expected utility, given the observed policy parameters. In contrast, the government maximizes long-term welfare taking account of resource dynamics. Thus, the local population maximizes:

$$\text{Max } u = \left\{\pi_N WN - \tau\pi_N W(N - N_a)^2 + \pi_L L_g - v\pi_L (L_g - L_a)^2\right\}^{\vartheta}, \qquad (9a)$$

where N_a and L_a are the legally permissible allocations of hunting and agricultural land determined by the government and $\tau\pi_N W$ and $v\pi_L$ represent the expected fines which are levied, respectively, on hunting and farming in excess of these allowable limits.[41] Further, $\tau > 0$ if $N > N_a$ and $\tau = 0$ if $N \leq N_a$ and $v > 0$ if $L_g > L_a$ and $v = 0$ if $L_g \leq L_a$. Note that the expected penalty is assumed to be increasing in the misdemeanor, reflecting the common judicial convention that the punishment should fit (rise with) the crime.

Maximizing equation (9a) yields the first-order conditions which define the reaction functions of the local population:

$$N = N_a + \frac{1}{2\tau} \text{ and } L_g = L_a + \frac{1}{2v} \qquad (9b)$$

Observe that $\forall \infty > \tau > 0$, $N > N_a$; thus, harvest levels will always exceed the allowable quota by an amount that is inversely proportional to the fine for noncompliance (unless the fine is infinite). This is arguably a realistic feature of the model. If the allowable quota (N_a) is zero, the fine coincides with a tax levied on the whole amount of hunting. A similar result applies to the land allocation decision. Note too that since $0 \leq N \leq 1$, and $0 \leq L_g \leq L_{np}$, fines must meet the conditions:

$$\tau \geq \frac{1}{2(1 - N_a)},\ v \geq \frac{L_{np}}{2(1 - L_a)}.$$ [42]

Substitute (9b) in (9a) to define the indirect utility function:

$$\begin{aligned} V(\Pi) = [&\pi_N W(N_a + 1/2\tau) - \tau\pi_N W \\ &\times (N_a + 1/2\tau - N_a)^2 + \pi_L (L_a + 1/2v) \\ &- v\pi_L (L_a + 1/2v - L_a)^2]^{\vartheta} = \Pi^{\vartheta} = \\ &= [\pi_N W(N_a + \frac{1}{4\tau}) + \pi_L (L_a + \frac{1}{4v})]^{\vartheta}. \end{aligned} \qquad (9c)$$

[41] The expected penalty can be interpreted as the product of the probability of detection (say *z)*; the probability of conviction conditional upon being detected (say *c*); and the penalty once convicted (say *e*). Thus $\tau = zce$. Introducing corruption and bribe giving drives a wedge between the probability and cost of detection and conviction but does not alter the analysis.

[42] For example, if the quota on hunting is 5 percent of the stock of wildebeest, the minimum tax that would yield a value of the actual hunting share not exceeding 100 percent would be 52 percent of unit profits. Another interpretation is also possible. Consider, however that the tax is levied such that τ_v is obtained by equating: $\tau_v \pi_N WN = \tau\pi_N W(N - N_a)^2 \rightarrow \tau_v = \tau\frac{(N - N_a)^2}{N}$. Thus, for example, for $\tau = 50$, $N_a = 0.05$, the optimum value of N would be 0.06 and the marginal ad valorem tax rate $\tau_v = 0.01$.

As the first mover, the government will take account of the downstream responses of agents as defined in the reaction functions in equation (9b). Thus, the modified Hamiltonian is given by:

$$H = FW^{\sigma}\Omega^{\eta}V(\Pi) + \mu(rW \times (1 - \frac{W}{q\left(L - \frac{1}{2v} - L_a\right)} - \Omega W - \left(\mathcal{N}_a + \frac{1}{2\tau}\right)W. \quad (10a)$$

Since there are two instruments (the fine and the quota) and one objective (the optimal allocation), one of the instruments can be set arbitrarily while the other is defined through the optimization of equation (10a). In what follows, we focus on defining optimal quotas ($\mathcal{N}_a$ and L_a) taking the expected penalties (τ and v) as given. This is perhaps a realistic description of institutional realities. Typically, the conservation authorities have limited jurisdiction over criminal sanctions and their authority is restricted to determining issues directly related to wildlife management such as quotas and allocations. The ultimate penalties for violating regulations are usually determined by other layers of government involving the judiciary, over which conservation authorities have little direct control. For policy purposes, these parameters are given. The first-order conditions are defined by:

$$\frac{dH}{d\mathcal{N}_a} = \frac{\vartheta U \pi_{\mathcal{N}}}{\Pi} - \mu = 0 \quad (10b)$$

$$\frac{dH}{d\Omega} = \frac{\eta U}{\Omega} - \mu W = 0 \quad (10c)$$

$$\frac{dH}{dL_a} = \frac{\vartheta U \pi_L}{\Pi} - \frac{\mu r W^2}{q\left(L - \frac{1}{2v} - L_a\right)^2} = 0 \quad (10d)$$

$$\frac{\dot{\mu}}{\mu} = \delta + (1 - \frac{\sigma}{\eta})\Omega - (\mathcal{N}_a + \frac{1}{4\tau}) + (\mathcal{N}_a + \frac{1}{2\tau}) - r[1 - \frac{2W}{q(L - \frac{1}{2v} - L_a)}. \quad (10e)$$

Using (9b), (10b), and (10d), the allocation of land is given by:

$$L_a = L - \frac{1}{2v} - W\sqrt{\frac{r\pi_{\mathcal{N}}}{q\pi_L}} \rightarrow L_g = L - W\sqrt{\frac{r\pi_{\mathcal{N}}}{q\pi_L}} \quad (11)$$

The amount of land allocated to farming increases with the profitability of farming, declines with the stock of wildlife, and increases with the carrying capacity $q = \frac{W^M}{(L - L_g)}$ of wildlife since the payoffs from wildlife-related activities increase with resource abundance.[43] Further note that as v declines, the amount of land allocated to farming also declines.

Using (10c) and (10d) the steady-state allocation of trophy hunting is given by:

$$\Omega_{ss} = \frac{\eta}{a\beta}[(2\sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}} - r) + \frac{1}{4\tau} + \delta] \quad (12a)$$

Equation (12a) is analogous to the familiar fundamental equation of renewable resources, with an adjustment reflecting imperfect compliance. As compliance declines, so does the stringency of regulations, in recognition of the limits of governance. Hence, the allocation to trophy hunting rises. This simply reflects the fact that the optimal stringency of regulations depend upon levels of enforcement.

Turning next to bushmeat hunting, the steady-state allocation is defined by:

$$\mathcal{N}_a^{ss} = \frac{\vartheta}{a\beta}[(2\sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}} - r) + \frac{1}{4\tau} + \delta] + \mathcal{J}_1, \quad (12b)$$

where $\mathcal{J}_1 = \sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}} - \frac{1}{4\tau} - \frac{\pi_L}{\pi_{\mathcal{N}}}\frac{L}{W}(1 - \frac{1}{4v})$.

The share of bushmeat hunting is:

$$\mathcal{N}^{ss} = \mathcal{N}_a^{ss} + \frac{1}{2\tau} = \frac{\vartheta}{a\beta}[(2\sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}} - r) + \frac{1}{4\tau} + \delta] + \mathcal{J}_2, \quad (12c)$$

where $\mathcal{J}_2 = \sqrt{\frac{r\pi_L}{q\pi_{\mathcal{N}}}} + \frac{1}{4\tau} - \frac{\pi_L L}{\pi_{\mathcal{N}} W}(1 - \frac{1}{4v})$.

[43] Note that a greater carrying capacity allows for higher levels of agriculture. Contrary to popular policy wisdom, this result suggests that policies that diminish ecological carrying capacity need to be accompanied by a reduction in farmed area (intensification) rather than the reverse. Agricultural expansion is often the stated rationale for these policies (for example, water abstraction and intrusive infrastructure) in and around protected areas, which is the opposite of the optimal response implied by this model.

The equilibrium level of bushmeat hunting includes a non-compliance factor $\mathcal{J}_2$, which rises as the penalties τ and v decline. Intuitively, in regimes with weak penalties, there is less compliance, and knowing this the government allows for a higher legal amount of bushmeat hunting, *ceteris paribus*.

Wildlife stocks in the steady state are defined by:

$$W_{ss} = \frac{\frac{\alpha\beta}{\phi}[\frac{\pi_L}{\pi_N}(1-\frac{1}{4v})]L}{\{2\sqrt{\frac{r\pi_L}{q\pi_N}} - r + \frac{(\phi-\alpha\beta)}{\phi}\delta + \frac{\phi}{4\tau}\}}, \qquad (12d)$$

where $\phi = \alpha\beta + \eta + \vartheta < 1$ is a measure of overall convexity of the social welfare function.

Note that a steady state with positive values requires that both the numerator and denominator are positive.[44]

Land allocated to wildlife in the steady state is

$$L^w_{ss} = \frac{\frac{\alpha\beta}{\phi}[\frac{\pi_L}{\pi_N}(1-\frac{1}{4v})]L}{2 + (\frac{q\pi_N}{r\pi_L})^{1/2}\{-r + \frac{(\phi-\alpha\beta)}{\phi}\delta + \frac{\phi}{4\tau}\}} \qquad (12e)$$

The following Lemmas summarize and compare the two equilibria. They suggest that the proportion of stock harvested under imperfect regulation is always higher than under perfect regulation (for finite fines) and as a result, wildlife stocks are always lower under imperfect regulation. This reflects the inability to fully control harvesting and land use in an environment where compliance cannot be assured. In contrast, Lemma 2 asserts that as regulatory compliance improves, the amount of land devoted to agriculture declines since in a better-regulated economy, it is easier to ensure compliance with regulations. Finally, Lemma 3 demonstrates how land allocations need to vary with changes in carrying capacity and relative payoffs.

Let $\Omega^P_{ss}, \Omega^I_{ss}, N^p_{ss}, N^I_{ss}$ be the proportion of wildlife harvested by trophy hunters and bushmeat hunters, respectively, under perfect (p) and imperfect compliance (I) in the steady state and let W^p_{ss}, W^I_{ss} be the respective steady stocks of wildlife. Then:

Lemma 1a. With finite penalties, the proportion of wildlife harvested under imperfect compliance by trophy hunters and bushmeat hunters always exceeds the proportion harvested under perfect compliance. That is, $\Omega^P_{ss} < \Omega^I_{ss}$, *and* $N^p_{ss} < N^I_{ss}$.

Proof: From (7a) $\Omega^p_{ss} = \frac{\eta}{\alpha\beta}[r(2\sqrt{\frac{\pi_L}{qr\pi_N}} - 1) + \delta]$

and from (12a) $\Omega^I_{ss} = \frac{\eta}{\alpha\beta}[(2\sqrt{\frac{r\pi_L}{q\pi_N}} - r) + \frac{1}{4\tau} + \delta]$.

Thus $\Omega^P_{ss} - \Omega^I_{ss} = -\frac{1}{4\tau} < 0 \,\forall\, 0 < \tau < \infty$. From (7b)

$N^p_{ss} = \frac{\vartheta}{\alpha\beta}[r(2\sqrt{\frac{\pi_L}{qr\pi_N}} - 1) + \delta] - \frac{\pi_L L}{\pi_N W} + \sqrt{\frac{r\pi_L}{q\pi_N}})$

and by (12c) $N^I_{ss} = \frac{\vartheta}{\alpha\beta}[(2\sqrt{\frac{r\pi_L}{q\pi_N}} - r) + \frac{1}{4\tau} + \delta] + \mathcal{J}_2$.

Thus $N^p_{ss} - N^I_{ss} = -\frac{1}{4\tau}\frac{\vartheta}{(\alpha\beta+1)} - \frac{\pi_L L}{\pi_N W}\left(\frac{1}{4\nu}\right)$

$< 0 \,\forall\, 0 < \tau < \infty$ *and* $0 < v < \infty$. ■

Lemma 1b. In a steady state, wildlife stocks under imperfect compliance are always lower than under perfect compliance. That is $W^p_{ss} > W^I_{ss}$.

Proof: From (8a) $W^p_{ss} = \frac{\frac{\alpha\beta}{\phi}\frac{\pi_L}{\pi_N}L}{[2\sqrt{\frac{r\pi_L}{qr\pi_N}} - r + \frac{(\phi-\alpha\beta)}{\phi}\delta)\frac{\pi_N}{\pi_L}]}$

and (12d) $W^I_{ss} = \frac{\frac{\alpha\beta}{\phi}[\frac{\pi_L}{\pi_N}(1-\frac{1}{4v})]L}{\{2\sqrt{\frac{r\pi_L}{q\pi_N}} - r + \frac{(\phi-\alpha\beta)}{\phi}\delta + \frac{\phi}{4\tau}\}}$.

Consider first the numerators of these expressions.

Clearly: $\frac{\alpha\beta}{\phi}[\frac{\pi_L}{\pi_N}(1-\frac{1}{4v})]L - \frac{\alpha\beta}{\phi}\frac{\pi_L}{\pi_N}L = -\frac{1}{4v}$

$< 0 \,\forall\, 0 < v < \infty$.

[44] To see why, note that the numerator needs to be positive to ensure that shares of hunting are non-negative but less than unity and therefore the denominator needs to be positive.

Consider next the denominators:

$$2\sqrt{\frac{r\pi_L}{qr\pi_N}} - r + \frac{(\phi - \alpha\beta)}{\phi}\delta)\frac{\pi_N}{\pi_L} - \left\{2\sqrt{\frac{r\pi_L}{q\pi_N}} - r + \frac{(\phi - \alpha\beta)}{\phi}\delta + \frac{\phi}{4\tau}\right\} = -\frac{\phi}{4\tau} < 0, \forall\, 0 < \tau < \infty.$$

Thus, the numerator of (33) is smaller and its denominator larger so that $W_{ss}^{p} > W_{ss}^{I}$. ■

Note also that the difference in wildlife stocks vanishes only if penalties are infinite. For future discussion of policy issues we note the following properties of the equilibria:

Lemma 2. As regulatory compliance improves, the amount of land devoted to agriculture declines. That is $\frac{dL_g}{d\tau} > 0$ *and* $\frac{dL_g}{dv} > 0$.

Note that using (11) we have $\frac{\partial L_g}{\partial W} = -\left(\frac{r\pi_N}{q\pi_L}\right) < 0$ and from (12d) we have $\frac{\partial W}{\partial \tau} = \frac{\chi}{4\tau^2\left(\varsigma + \frac{1}{4\tau}\right)^2} > 0$, *where*

$$\varsigma = \sqrt{\frac{r\pi_L}{q\pi_N}} - r + \frac{(\phi - \alpha\beta)}{\phi}\delta\Bigg\} \quad \text{and} \quad \mathrm{X} = \frac{\alpha\beta}{\phi}[\frac{\pi_L}{\pi_N}(1 - \frac{1}{4v})]L$$

and $\frac{\partial W}{\partial v} = \frac{\chi}{4v^2\left(\varsigma + \frac{1}{4\tau}\right)} > 0$. Hence, $\frac{dL_g}{d\tau} = \frac{\partial L_g}{\partial W}\frac{\partial W}{\partial \tau} > 0$

and $\frac{dL_g}{dv} = \frac{\partial L_g}{\partial W}\frac{\partial W}{\partial v} > 0$. ■

Thus, the optimal allocation of land for conservation is larger in situations with greater compliance. Intuitively, in situations of weak governance, stricter regulations (limits on agricultural expansion) cannot be enforced. Recognizing this, where compliance is weak, a greater amount of land is devoted to agriculture. It is interesting to note that this result emerges even without incorporating monitoring costs in the model.

Lemma 3. As carrying capacity declines, the optimum steady-state allocation of land to wildlife increases and as the relative payoffs to hunting increase, the optimum steady-state allocation of land to wildlife declines. That is, $\frac{\partial L_{ss}^{w}}{\partial q} < 0$ *and* $\frac{\partial L_{ss}^{w}}{\partial \pi_N} < 0$.

Proof: From (12e)

$$\frac{\partial L_{ss}^{w}}{\partial q} = -\frac{\left(\frac{\alpha\beta}{\phi}\right)BL^2}{2r\left(\frac{q\pi_N}{r\pi_L}\right)^{\frac{1}{2}}\left(B\left(\frac{q\pi_N}{r\pi_L}\right)^{\frac{1}{2}} + 2\right)^2} < 0; \text{ where}$$

$B = \left\{\frac{\phi}{4\tau} - r + \frac{(\phi - \alpha\beta)}{\phi}\delta\right\}$ and upon simplifying

$$\frac{\partial L_{ss}^{w}}{\partial \pi_N} = -\left(\frac{\pi_L}{\pi_N} + \frac{Bq}{2r\pi_N\left(\frac{q\pi_N}{r\pi_L}\right)^{\frac{1}{2}}\left(B\left(\frac{q\pi_N}{r\pi_L}\right)^{\frac{1}{2}} + 2\right)^2}\right) < 0. \blacksquare$$

In policy terms, Lemma 3 seems especially instructive. Activities that lower carrying capacity (q) call for an increase in land allocated to wildlife, often the reverse of what is observed. Intuitively, as q increases (decreases), wildlands become more (less) productive, so any given payoff from W can be obtained with less (more) land devoted to wildlife.

APPENDIX C
RUAHA MODEL

The following is a brief description of the models used in the simulation. Let L be the total annual endowment of labor available in a representative household. Let L_f denote labor devoted to farming, L_c labor devoted to cattle herding, L_b bushmeat hunting and L_g lion hunting. Then:

Farm output is given by:

$$Q = L_f^a W, \tag{1}$$

where W is the amount of arable land and could be made dependent on water availability in the dry season.

Lion hunting is:

$$H = L_g^\gamma G, \tag{2}$$

where G is the given stock of lions taken from the predator prey model.

Bushmeat hunting is linear in effort:

$$B = qXL_b. \tag{3}$$

Cattle are set to graze on open pastures with no inputs. Labor is expended protecting the herd. Cattle growth is given by a logistical function:

$$C = rC\left(1-\frac{C}{\overline{C}}\right)-\left(1-\delta L_c\right)GDC, \tag{4}$$

where C is the herd size and $\overline{C}$ is the carrying capacity. G is the number of lions and GDC the number consumed without protection. L_c is protection time which reduces the deaths by a factor δ.

The household maximizes:

$$U = P_f L_f^a W + P_c C + P_g L_g^\gamma G + qX\left(L - L_f - L_c - L_g\right), \tag{5}$$

subject to equation 4.

The terms P_i $(i = f, g, c)$ are prices or weights given by households to each of the outputs

The Hamiltonian of the problem is thus:

$$H = U + \lambda\left(rC\left(1-\frac{C}{\overline{C}}\right)-\left(1-\delta L_c\right)GDC\right), \tag{6}$$

where λ is the costate variable.

The solution to be used for the simulations includes the labor supply variables, which when substituted into the production functions give the hunting levels and farm output (not of critical interest at this stage).

The solutions are as follows:

$$L_f = \left(\frac{\alpha P_f W}{qX}\right)^{\frac{1}{1-\alpha}} \tag{7}$$

$$L_g = \left(\frac{\gamma P_g G}{qX}\right)^{\frac{1}{1-\gamma}} \tag{8}$$

$$C = \frac{\overline{C}qX\rho}{Xqr - DGP_c\delta\overline{C}} \tag{9}$$

$$L_c = \frac{r(qX\left(\rho+r\right)-DG(qXr+\delta rP_c\overline{C}-DG\delta P_c\overline{C}}{\delta DG\left(DGP_c\overline{C}\delta - qXr\right)}, \tag{10}$$

where ρ *(rho) is the interest rate* $= 0.05$ *approximately.*

Modified Predator-Prey Model:

$X = Y + Z$, where Y is African buffalo numbers and Z is Giraffe numbers. (11)

$$\frac{dY}{dt} = S_y Y\left(1-\frac{Y}{KY}\right) - a_y YG - 0.5qYL_b, \tag{12}$$

where S_y = average calf survival rate for buffalo, KY = carrying capacity for buffalo, and a_y = probability that encounter between lions and buffalo will result in removal of buffalo individual. Labor for bushmeat hunting is assumed to be equal for both prey species (that is, 0.5).

$$\frac{dZ}{dt} = S_z Z\left(1-\frac{Z}{KZ}\right) - a_z ZG - 0.5qZL_b, \tag{13}$$

where S_z = average calf survival rate for giraffe, KZ = carrying capacity for giraffe, and a_z = probability that encounter between lions and giraffe will result in removal of giraffe individual.

$$\frac{dG}{dt} = RG + \frac{\varepsilon\left(YG + ZG + CG\right)}{1 + 0.5G} - L_g^y G, \qquad (14)$$

where R = intrinsic growth rate of lions or cubs per year per adult female. This value is negative because cubs die in the absence of prey animals. ε = lion efficiency of converting food into fertility. This value is the ratio of number of cubs (1.5) to number of kills per adult lion (4.5) times the ratio of adult females to the pride (0.375).

Parameter values:

S_y = 0.73 (from Jolles et al 2005 and Jolles 2007)
KY = 36,407.

This value uses density estimates of 1.8 per km^2 for the RNP during the dry period from Barnes and Hamilton 1982 and current estimate of park area of 20,226 km^2 (including recent annexation of Usangu Game Reserve).

α_y = 0.115 (from Hayward et al. 2011)
S_z = 0.41 (from Sinclair et al. 1995)
KZ = 6,877.

This value uses density estimates of 0.34 per km^2 for the RNP during the dry period from Barnes and Hamilton 1982 and current estimate of park area of 20,226 km^2 (including recent annexation of Usangu Game Reserve).

a_z = 0.18 (from Stander 1991)

Initial numbers used in model:

Buffalo = 19,843

This value is the sum of estimates from RNP and Usangu Game Reserve from the 2006 Tanzania wildlife aerial survey.

Giraffe = 1,556

This value is the sum of estimates from RNP and Usangu Game Reserve from the 2006 Tanzania wildlife aerial survey.

Lion = 580 (from Mesochina et al. 2010)

This value refers to RNP with area of 14,507 km^2 but is a best estimate.

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