

### Supplementary Material

#### **1** Supplementary Text 1.

Land use and land cover change scenario narratives for northern and eastern Serengeti and for southwestern Serengeti from 2019 to 2063.

#### 1) Northern and Eastern Serengeti scenario narratives

#### 1.1) Scenario name: Wasiwasi

# Description - High population growth and infrastructure development with weak political will in supporting climate change adaptation and mitigation strategies.

This scenario was named 'Wasiwasi' which is a Swahili word meaning 'uneasiness' that would be expected under a scenario with high population growth, high infrastructure development and lack of political will in supporting climate change adaptation and mitigation strategies. The political leadership will favor inequalities in acquisition and benefit sharing of natural resources. The political leadership will not include communities in decision making and top-down governance approaches will be in force. Planned and effective climate change management strategies that integrate community knowledge with scientific research to prioritize interventions for future climate change risks will be lacking. Instead, quick solutions that reduce climate change impacts will be used in the event of droughts, floods, or any other climate dis-service.

By 2030, higher exponential population growth rate in north-western Tanzania and lack of proper land use management plans will lead to unregulated settlements mushrooming in communal lands, wildlife dispersal zones and in forests, shrubs and grasslands along boundaries of Serengeti National Park, Ikorongo, Grumeti, and Maswa Game Reserves. Human encroachment into wildlife dispersal zones and protected areas will fragment wildlife habitats, intensify human-livestockwildlife conflicts and reduce wildlife numbers and plant biodiversity. With increasing population and settlements, agriculture will expand in fertile and wet areas in the forests outside protected areas and in the northern and eastern villages bordering the Serengeti National Park. Agriculture expansion will promote growth of agriculture industries that will provide farmers with agriculture input, trainings on optimizing agriculture production and capital for agriculture related start-ups. However, ineffective climate change management strategies will not protect agricultural production and food security from climatic variability and unpredictable rainfall intensity and seasonality. Pastoralist livestock production would be concentrated at the Loliondo Game Controlled Area, Sarakwa in Bunda district and other non-protected areas in Serengeti district. Land available for livestock grazing land in 2030 will, however, not be enough as land use plans done in 2020 by villages surrounding protected areas in north-western Tanzania confirmed none of the villages had enough grazing areas for the livestock numbers in their village. Ineffective climate change management strategies will discourage exclusive pastoralism and lead to livelihood diversification amongst pastoralists. Mining will expand outside key protected areas with mineral deposits and will provide additional income to the miners.

Key opportunity for this scenario in 2030 will be better provision and access of social services, such as health facilities, schools, local markets, roads and water infrastructure to communities in north and eastern Serengeti. Most of the feeder, collector, regional and trunk road

will be improved and paved. Airports inside and outside protected areas will also be improved and paved. The key challenges for this scenario will be lack of participatory approaches in decision making and in developing land use policies, plans and management strategies. Agricultural expansion and unregulated settlements to cater for high population growth will be challenging as the farms and settlements will occupy livestock and wildlife production areas. The policy trade-off in 2030 for this scenario will be in land allocation between mining, livestock grazing, agriculture and wildlife conservation and tourism sectors.

By 2063, this scenario will prioritize energy production, industrialization, and technological advancement in manufacturing industries. There will also be potential for multilateral agreements involving all East African governments to collectively manage the social-ecological connections that support ecosystem services delivery in northwestern Tanzania. The extent of cooperation in managing natural resources amongst the East African countries will determine the likelihood of northern Tanzania to achieve the social, governance and environmental targets of the African Union Agenda 2063 and other national development objectives set up by the Tanzanian government.

In 2063, the pressure from population increase will start to manifest in the environment through heavily deforested areas, shrinking of Mara River, increased invasive species, particularly *Chromoleana odorata*, and sparsely vegetated areas, increased human-wildlife conflicts, and fragmented wildlife and livestock dispersal lands that will be replaced by built-up infrastructure. Fragmented wildlife habitats will reduce tourist experiences and consequently, tourism revenues. Land degradation, and unfavorable climate change management strategies will challenge food security and reliance on livestock herding and agriculture livelihoods. Unpredictable and changing weather patterns will also lead to emergence of new crops, animal and human diseases.

Improved social infrastructure, road network and access to markets will lead to livelihood diversification and will provide opportunities for local and foreign investments in communication, transport and mining industries. Socio-culturally, Musoma town, the administrative capital for Mara region, will be a melting pot metropolis with residents from diverse local ethnicities, and foreign nationalities. The integration of local with foreign communities and non-commitment by District Councils to cultural conservation will discourage conservation of cultural heritage sites and traditions of the Ikoma, Kuria, Suba, Maasai, Sonjo, Kabwa, Ikizu and Ngurimi tribes found northern and eastern Serengeti. Traditional knowledge of environment conservation will be disregarded by the political leadership.

Key opportunities for this scenario in 2063 will be increased and better-developed infrastructure, availability of improved social services, market accessibility for local and foreign products, and technological advancement in industries. High human population will provide industrial labor and will limit importing labor from other neighboring regions and foreign countries. Key challenges for this scenario in 2063 will be unregulated land uses that will impede environmental conservation, mining, and sustainable agriculture and livestock production in northern Tanzania.

#### 1.2) Scenario name: Parks and People

# Description - High population growth and infrastructure development with strong political will in supporting climate change adaptation and mitigation strategies.

This scenario named 'Parks and People' will be characterized by proactive political leadership in pro-environment matters related to sustainable development and climate change management interventions. Use of climate-smart agriculture techniques, drought and disease resistant

seeds and animal breeds, building water reservoirs inside protected areas for wildlife and outside protected areas for people, and using renewable energy sources, such as solar and wind, will be used to mitigate climate change impacts. This scenario will also have high human population, increased settlements in smaller towns surrounding Serengeti National Park and evenly distributed social services (such as education, health, water and transport facilities) in rural areas.

By 2030, higher population will increase demand for water, food, energy and livelihood options. Agriculture production will increase in wet unprotected woodlands and grasslands near existing farms. Settlements will increase in village land and private land. The focus of livestock production will not be on livestock numbers, rather on improved livestock breeds and services. Wildlife will be concentrated in protected areas as unprotected areas will be used to meet agriculture and settlements land demands. Conservationists and community based nongovernmental organizations will demand fencing of protected areas such as Kijereshi and Ikorongo Game Reserves to control human- and livestock-wildlife conflicts and livestock and agriculture encroachment along protected area boundaries. Annexing Serengeti National Park along Grumeti River to the Speke's Gulf in Lake Victoria might be done to sustain the wildlife resources and the Great Wildebeest Migration in the Serengeti-Mara ecosystem in the event of climate change and upstream human activities reducing Mara River flow. Tourism infrastructure will be developed outside protected areas to avoid damaging plants, road kills, expansion of unnecessary roads in the protected areas, and to contribute to the local economy. Local people will be consulted in tourism development initiatives and invited to share tourism benefits. This will help mitigate wildlife losses because people will have economic opportunities in the tourism sector. There will be effective regulations on mining that will ensure it is done sustainably and is beneficial to the miners.

Key priorities for this scenario in 2030 will be 1) securing land for protected areas and wildlife corridors to avoid agriculture, livestock, settlement and private fences encroachment; 2) formal protection of Grumeti River, Mara River, Lake Victoria and other permanent water sources; 3) development and implementation of effective land use plans; and 4) creating environmental awareness to the growing human population to discourage them from land degradation. Opportunities for this scenario in 2030 will be effective social, economic and environmental policies, better access to social facilities, and road networks and availability of adequate human labor from resident communities. Challenges faced by this scenario will be more related to pressure from human population growth and will include concentration of wildlife in protected areas and wildlife corridors as some wildlife dispersal areas will be used for agriculture and settlements, use of fences around protected areas to reduce human-wildlife conflicts, and human-wildlife conflicts created by increasing human population. A policy trade-off for this scenario would be allowing fencing of some parts of the protected area to reduce human-wildlife conflict associated with increasing human population or to avoid fencing the protected area to accord wildlife bigger dispersal areas in community land.

By 2063, this scenario will continue prioritizing the balance between environmental conservation, agriculture production, and industrialization. Provision of tertiary education and job opportunities for all, securing land for protected areas, developing effective land-use plans, and socio-economic development of rural communities will be prioritized in this scenario. The national, district and local government council will purpose to secure the Serengeti-Sale-Natron and the Serengeti-Ngorongoro crater wildlife corridors. Transboundary cooperation between Tanzania and Kenya will ensure the Maasai Mara-Loita Plains wildlife corridor is protected. The tourism industry will be strong because the government will be investing in infrastructure, provision of loans and promoting building of accommodation facilities. Additional museums will be built in the Mara region to preserve the cultural heritage of different ethnicities found in northern Tanzania. Due to concerted

efforts by Tanzania's national government and the district and local governments in northern Tanzania, the boundary of Serengeti National park will remain unchanged by 2063 in this scenario. However, the size of Ikona Wildlife Management Area, Loliondo Game Controlled Area, and Kijereshi Game Reserve will reduce in 2063. In addition, the Loliondo highland forest and other forest cover outside protected areas will be reduced.

Weather forecasts will be more accurate, reliable and useful for monitoring and planning livestock and food production activities. Agriculture will be improved by using disease- and drought-resistant seeds and recycled water for irrigating dry areas. Urban spaces will expand in Musoma and Mugumu, which will be larger cities providing better employment opportunities. Major and feeder roads will expand to attract investors and to connect markets in western Serengeti, Mwanza, Dodoma, Arusha, and Dar es Salaam. Specifically, there will be a highway flyover linking Loliondo and Mugumu and the Naabi-to-Fort Ikoma road that traverses Serengeti National Park will be paved.

#### 1.3) Scenario name: The Dying Giant

# Description - Low population growth and infrastructure development with weak political will in supporting climate change adaptation and mitigation strategies.

This scenario was named 'The Dying Giant' as it will be characterized by weak governance, lack of climate change adaptation and mitigation strategies, and basic infrastructure in an environment that is rich in biodiversity, available minerals, heterogeneous landscapes, and cultural diversity. Due to lack of favorable climate change adaptation and mitigation strategies under this scenario, communities will adapt to climate change by diversifying their livelihoods from (smallholder agriculture and livestock keeping) to ecotourism, small scale entrepreneurship and trade in livestock products in Serengeti and Ngorongoro districts. Lack of commitment by national, district and community councils to environmental and wildlife conservation will lead to habitat fragmentation, wildlife loss, and a reduction in wildlife and cultural tourism in core protected areas and community managed protected areas. There will be human-wildlife conflicts caused by encroachment of people into protected areas, wildlife corridors, buffer zones between wildlife and agricultural areas, and key resources areas such as swamps, rivers, and forests.

By 2025, intensive use of key resource areas will lead to land degradation in Ngorongoro and Serengeti. Lack of support for livestock grazing by district councils and poor climate change adaptation and mitigation plans will reduce per capita livestock units in Ngorongoro, Tarime, Bunda and Serengeti districts.

In 2030, there will be food insecurity and to supplement the food shortage, food will be bought from Mbeya, Arusha, Manyara, Morogoro, and other regions that have higher agricultural productivity. Poor health, education, water, communication and road services will cause emigration to neighboring towns, and other East African countries with better governance and access to social facilities, roads and job opportunities. Conversion of forests to open woodlands and shrubs will largely be driven by timber and wood fuel demand, and conversion of grasslands to woodlands or sparsely vegetated areas will be caused by changing climates, overgrazing, and poor farming methods. Availability of gold, limestone, and other minerals in Nyamongo, Nyigoti and Buhemba mines will increase small-scale mining in the area.

Key challenges for this scenario in 2030 will be the disastrous impacts of climate variability on land based livelihoods, mainly agriculture and pastoralism; poor governance of natural resources, land degradation, poor infrastructure and non-attractive investment opportunities, and emigration of people to other developed urban areas in search for decent livelihoods and lifestyles. As habitat fragmentation is currently the biggest threat to wildlife conservation, an opportunity for this scenario in 2030 will be adequate land availability for wildlife in sparsely populated areas that are less developed and unsuitable for agriculture. Policy trade-offs for this scenario would involve; 1) the Land Policy on whether the focus should be on land restoration or land management; 2) the Livestock Policy on whether zero grazing or modern livestock grazing should be encouraged vis-à-vis pastoralism considering northern Tanzania has supported pastoralism for many years; and 3) the agriculture and wildlife policies on whether investments on agriculture technology should be done at the expense of wildlife conservation.

By 2063, climate change impacts will be more severe than 2030 and will include food insecurity, inadequate pasture, land degradation, biodiversity loss, and increase of invasive plant species. Weak governance and ineffective land use plans that are not prepared through participatory approaches will continue to promote land transformation. There will be less dependence on wildlife related livelihoods because of degraded landscapes, and lower wildlife densities and wildlife tourism opportunities. Non-wildlife based tourism, such as geotourism of natural features, sports and international volunteering tourism will be introduced. Agriculture and livestock production will be affected and irrigation schemes made by drilling for ground-water will be introduced to boost food production. Forest loss will continue up to 2063 with forests converted to grasslands, agriculture and mining areas. Mining will provide a strong revenue generating opportunity for families and the local governments.

#### 1.4) Scenario name: Life is Good

# Description - Low population growth and infrastructure development with strong political will in supporting climate change adaptation strategies.

Under the 'Life is Good' scenario, effective land use plans will be developed using participatory approaches. Proper and efficient governance will ensure the land use plans are implemented in all villages and regularly monitored to ensure they are not violated. Good governance will ensure there is sustainable development, climate change management approaches are in place, social services are accessible to all, and poverty alleviation or reduction measures are efficient.

In 2030, effective land use plans and effective climate change adaptation strategies will minimize land use land cover change in the ecosystem. Competition for natural resources between farmers, pastoralists, agropastoralists and wildlife will be reduced. Conservation of natural resources will promote sustainable development in community lands neighboring the protected areas network in the Serengeti ecosystem. Local and foreign investors will be attracted to northern Tanzania and will create jobs in the tourism, agriculture, livestock, education, medical, industrialization and mining sectors. Improving food security using sustainable methods will be prioritized by improving access to agricultural inputs, using climate smart farming methods, setting up processing industries for adding value to agricultural products, and connecting producers (farmers and livestock herders) directly to markets (food processing industries, hospitality industries, supermarkets among others).Other opportunities for the 'Life is Good' scenario' in 2030 will be the protection of wildlife spaces due to low population and good governance, low human-wildlife conflicts, and reduced vulnerability of land-based livelihoods to climate change impacts. The main challenge encountered by this scenario will be basic access to linear infrastructure and social facilities.

By 2063, the political leadership will see the need to review social, economic and environmental policies to accommodate the effects of increased anthropogenic activities and demand for natural

resource areas for settlement, farming, livestock keeping, minerals and gemstone extraction, and infrastructure investment. With population having grown from 2030, the political leadership will seek a new and sustainable development pathway that will meet the land demand for economic development, natural resource conservation, mining and agriculture. Poverty levels in areas surrounding protected areas will be reduced, and the employability skills sets for local communities in these areas improved. The government will diversify and aggressively market other tourism options, besides wildlife and cultural tourism, such as sports, minerals, and geographic features. Manufacturing industries will be more specialized and focused on producing quality products. Proper land use and land management plans will improve the production and distribution of agricultural, extracted and manufactured goods. Production of crops like tobacco, barley, paddy rice and sunflower seeds will be increased, marketed and sold locally and abroad to increase agriculture revenue in the area. The main challenges in 2063 for this scenario will be ensuring wildlife habitats with mineral deposits are protected from artisanal mining and improving the economy of Serengeti under basic infrastructure and low access to local and foreign markets.

### 2) Southwestern Serengeti scenario narratives

#### 2.1) Scenario name: Tutaponaje?

#### Description - High population growth and an unsustainable agriculture economy

The scenario name 'Tutaponaje?' is a Swahili question asking 'how will we recover'? The name was chosen to portray a scenario with high population growth rate, weak governance structures, passive environmental conservation initiatives, and an unsustainable agriculture economy in western Serengeti.

In 2030, this scenario will be characterized by high rates of deforestation; shifting cultivation near existing farms, riverine areas, swamp edges, and forests; and, livestock herding inside protected areas. Lack of effective climate change management interventions will increase shrubland, mainly *Vachelia drepanolobium* (whistling thorn acacia), in Maswa; reduce pasture availability and force pastoralists to diversify their livelihoods to agropastoralism, smallholder agriculture and trade in livestock related business; reduce production of subsistence and cash crops; and cause overgrazing. Rapid population growth will increase the demand for settlements near existing settlements and farms in Ngitiri, along the Simiyu River basin, and in protected areas that permit settlements. Energy production and road and water infrastructure will expand to meet the demand from the growing population. However, provision of health and education services, decent housing, and water infrastructure will be overstretched by the growing population. Lack of effective conservation policies and initiatives will lower wildlife densities and wildlife tourism revenues in Maswa Game Reserve and Makao Wildlife Management Area. There will be cultural loss as sites for ritual practices for various ethnic communities will be fragmented. Overgrazing, deforestation, and unsustainable agriculture practices will hasten land degradation in the area.

Key opportunities in 2030 for this scenario will be related to the growing population. More livelihood options and business opportunities would arise from competition between the existing opportunities. Urbanization will grow near densely populated towns. Challenges of human-wildlife conflicts, agriculture-pastoralism-conservation land competition, environmental degradation, deforestation, reduced food production, animal disease outbreaks, and cultural destruction will prompt the political leadership to prioritize development and implementation of proper land use plans, policy reformation, and sensitization to modern and environmental friendly agricultural practices. Policy reformation prioritized by this scenario would be to improve the conservation policy to secure natural resources and ensure environmental benefits are shared more equitably, to develop effective policies on poverty alleviation and continued sustainable development, and to improve existing agriculture policies to incorporate modern and sustainable farming and livestock keeping methods.

By 2063, growing population will create a demand for labor, improved social services, additional settlements, additional agriculture production, and higher economic growth. Traditional livestock grazing land will be significantly reduced; pastoralism will be coupled with zero grazing to meet the beef and dairy demands for Serengeti and the neighboring markets. Protected areas will have shrunk, there will be more competition for provisioning ecosystem services and land under agricultural production will be higher than in 2030. Production of subsistence and commercial crops including cotton and tobacco will involve irrigation and higher agricultural inputs to boost production. Expansion of mines will occur in Gasuma, Dutwa, and Nyaranja. To lower environmental impacts of high population growth, the political leadership will prioritize opening up of remote villages, such as Nyaumata, to encourage people from Bariadi town to relocate there. Other priorities include efforts to restore degraded lands, building of water reservoirs, and afforestation of Nyawa.

#### 2.2) Scenario name: Hamasika

#### Description - High population growth and a sustainable agriculture economy

The 'Hamasika' scenario is described by a Swahili word meaning 'add diligence' and will be characterized by high population growth, sustainable agriculture production approaches, environmental awareness and established climate change management interventions.

In 2030, due to high population and demand for fuelwood, charcoal and timber, there will be minimal change of forests in Meatu, Bariadi, Itilima and Maswa districts to open woodlands. Management of wildlife conservation at Maswa Game Reserve, Makao Wildlife Management Area, Serengeti National Park and Mwiba Wildlife Ranch will be improved to promote sharing of wildlife benefits, sustainable use of wildlife resources, better approaches of rangeland management, and biodiversity conservation. Local government policy will encourage using smart agriculture techniques such as agroforestry, mixed crop farming, contour farming, zero grazing, intercropping, and use of organic farming. Cotton expansion will occur in Kisesa, Meatu, and Itilima districts. Cotton expansion in Busega district will irrigation through a smart agriculture approach such as water capturing and storing.

Livestock production will be managed to sit available pasture. Dietary preference in Maswa district will be influenced by food available from food processing factories such as the maize milling and potatoes industries. Other districts like Bariadi, Meatu and Itilima, will, however, prefer organic food. Culturally, increased interactions between diverse resident communities, higher education levels, and increased media influence will change traditional lifestyles to more homogenized lifestyle modes.

In 2030, key opportunities for the 'Hamasika' scenario will be availability of labor due to high population; industrialization driven by proper governance, available raw materials and labor; expansion of communication and road infrastructure; investment in social services such as schools and hospitals; growth in agribusiness through higher agricultural production, value added agricultural products, and better access to local and foreign agriculture markets. The scenario will be challenged

by shortage of land due to high land demand for settlements, agriculture, and infrastructure development. Other challenges will be: inadequate financial capital for setting up largescale and long-term sustainable agriculture infrastructure.

Priorities for this scenario in 2030 will be to set up proper climate change adaptation and mitigation approaches to ensure unpredictable climate events do not compromise sustainable agricultural production; improving agriculture production technology to strengthen food security; secure wildlife spaces, forests, and water bodies; improving access to and quality of social services; improving skilled expertise; and providing reliable and clean energy.

By 2063, there will be heightened use of technology, such as drones, robotics, and remote sensing, to make decisions on natural resource use and management. The political leadership will develop policies that accommodate population growth with sustainable energy, infrastructure, mining, agriculture, and livestock development. There will be effective land use plans developed and updated through participatory approaches. Reforestation of degraded landscapes will occur across the entire Simiyu region. Non-consumptive wildlife uses will be promoted in Maswa Game Reserve, Makao Wildlife Management Area, and Mwiba Wildlife Ranch. Tourism will not be entirely wildlife-based but will be diversified to cultural and bee-keeping tourism. Smart agriculture techniques will be characterized by sustainable methods such as aquaponics farming, artificial propagation and green houses. Domestic and industrial water demand from Lake Victoria and other sources will increase. Consequently, the emphasis of water use will be on recycling of wastewater, increasing harvesting of rainwater, and conservation of water sources.

In terms of lifestyle, dietary preference will change to accommodate a balanced diet and people will have more options of choosing either plant-based or meat-based diets. There will be integration of foreign communities into western Serengeti and cultural exchanges among the communities.

Key opportunities for the 'Hamasika scenario' in 2063 will be in the agriculture sector where more food processing industries will grow to provide food to the growing population. There will be better incorporation of biotechnology in food production, use of mobile technology for monitoring agriculture production, training on better farming methods and provision of capital to agribusiness start-ups. Expansion of transport and communication infrastructure will bring more investors into western Serengeti. Use of renewable energy sources will enhance environmental functioning. The main challenge the scenario will face will be in balancing land allocation between the agricultural production, settlement, and urbanization needs of a growing population with environmental conservation. Thus, there will be a focus on developing effective technology and industrial policies that will reinforce food security, sustainable use of natural resources, and industrialization while limiting pollution, environmental degradation, biodiversity loss, and poverty.

#### 2.3) Scenario name: Tujikomboe

#### Description - Low population growth and an unsustainable agriculture economy

The scenario name 'Tujikomboe', a Swahili word meaning 'let us redeem ourselves' was selected to represent a future scenario with low population growth and an unsustainable agriculture economy. The name was selected to describe this scenario because it needs to have strategies that will promote good governance, sustainable agriculture, and climate change management strategies in place but it will not. In 2030, deforestation and loss of indigenous woody species will be caused by demand for fuelwood, timber and land for smallholder agriculture. Environmental conservation will not be a priority for this scenario leading to lower wildlife numbers, encroachment along boundaries of protected areas, loss of biodiversity, poaching, human-wildlife conflicts, encroachment on water bodies, illegal mining, soil erosion, and emergence of new diseases. Shortage of resources (pasture and water) and poor livestock husbandry methods will reduce per capita livestock numbers and may promote tsetse invasion and livestock diseases such as Rift Valley Fever. Low population and minimal interactions between different ethnicities will preserve cultures of different communities. Contribution from the agriculture sector into the western Serengeti economy will decline because of reduced livestock herding, food production, and employment opportunities. Provision of infrastructure and social services will be basic.

Key opportunities for the 'Tujikomboe' scenario in 2030 will be land availability for potential investment in agriculture, wildlife spaces, livestock herding and built-up areas. There will also be small-scale and large-scale opportunities for mining nickel and copper in Ngasamwa, Maswa Game Reserve and Makao Wildlife Management Area. The scenario will be challenged by ineffective land use plans, lack of climate change management approaches, environmental degradation, low agriculture production, and basic provision of social services, transport and water infrastructure. Following the challenges, the scenario will prioritize increasing agricultural production, attracting investors and skilled labor to boost economic growth, and improving provision of social services.

In 2063, agricultural land-use will expand in remote and wet areas with sparse population. With no strategies for sustainable use of natural resources, deforestation and land degradation will continue and woodlands will increase in Maswa district, water and pasture demand for wildlife and livestock will be challenging to meet, invasive species will appear, and the frequency of disease outbreaks will increase. Livestock herding will be continue being practiced. There will be conflict between farmers and livestock herders over use of resources in key resource areas such as water bodies. Illegal and unsustainable mining will be done to provide additional income to households. Wildlife related tourism will be minimal.

Lack of proper land-use plans, reliance on rain-fed agriculture, and climate change impacts will challenge land-use options for this scenario. Mining and land availability will provide opportunities for residents. However, food production would be affected by bad governance, use of low-level agriculture technology, poor access to infrastructure, climate change impacts and unsustainable farming methods. A priority for this scenario in 2063 would be to improve food security by expanding agriculture in wet areas to boost agriculture yields. The scenario will also prioritize improving market accessibility, and increasing investment opportunities for investors from other communities. Policy formulation will need to address issues related to balancing agricultural production and environmental conservation, and ensuring buffer zones between wildlife conservation areas and agricultural areas are protected.

#### 2.4) Scenario name: Yajayo Yanatufurahisha

### Description - Low population growth and a sustainable agriculture economy

Yajajo Yanatufurahisha, meaning 'the future makes us happy' is a Swahili phrase selected to describe a scenario that will be characterized by low population growth and a sustainable agriculture economy.

In 2030, the scenario will focus on sustainable development. Strong governance of natural resources under this scenario will ensure proper land use plans are in place, and social and

environmental policies related to economic opportunities, mining, wildlife conservation, climate change management approaches, and food production are developed by multiple stakeholders, regularly updated and implemented. There will be harmonious interaction between people and nature with a small fraction of forests lost by 2030 to supply fuelwood and timber demands, and agriculture and settlements will expand near existing farms, roads and towns. Water bodies, protected areas and wildlife dispersal areas will be protected from human encroachment to discourage habitat fragmentation and biodiversity loss. The wildlife conservation policy will alter community use of buffer zones around Makao Wildlife Area, Maswa Game Reserve and Mwiba Ranch to wildlife use. Cultural heritage sites with traditional medicinal plants, religious and burial sites will be protected and antiquity programs will be monitored and updated to ensure they stay relevant. The food production policy will ensure sustainable methods are used for agriculture and livestock production. Mining will occur where mineral deposits are found in Serengeti, Butiama and Tarime districts. Access to infrastructure, health, water, education services will be improved.

Key opportunities for the scenario will be investment in cotton production as land will not be scarce. Cotton production will expand and cotton will be exported to regional and international markets. Growth of subsistence crops will also expand to improve food insecurity in southwestern Serengeti. Minimal human-wildlife conflicts will facilitate wildlife conservation and tourism. The political leadership will plan to develop wildlife conservation initiatives in southwestern Serengeti compared to present levels. Sharing of wildlife benefits with the entire community will be encouraged and policies will be put in place to ensure it happens. The scenario will be challenged by low infrastructure development, industrialization, and access to markets. Thus it will prioritize attracting Tanzanian and foreign investors to western Serengeti to invest in agriculture and livestock production, wildlife tourism, and other viable activities. Land use plans will prioritize delineating livestock grazing zones from agricultural zones.

By 2063, the scenario will improve policies on sustainable agriculture, forest resources, mining, wildlife conservation, and land-use among others to improve the coexistence between people and nature. Wildlife spaces will be separated from agriculture and settlement areas. Use of traditional medicinal plants will be regulated to avoid overexploitation. Felling of trees for wood fuel consumption will be reduced as green energy generating options will be encouraged. Durable alternatives of timber will be used for home and furniture constructions. Agriculture will expand in wet unprotected areas near existing farms and cotton processing and maize milling industries will be built in the area. Other agriculture value-addition industries will be built to improve agriculture revenues in southwestern Serengeti. Livestock production will utilize drought and disease resistant livestock breeds. Settlements and built-up areas will expand near existing settlements, roads and built-up zones. Technology for rainwater harvesting will be improved to maximize water conservation. Sustainable use of protected areas will discourage encroachment, human-wildlife conflicts, wildlife decline, and dwindling wildlife tourism revenues. In the event of high anthropogenic pressures on the Makao Wildlife Management Area and Mwiba Ranch, the political leadership might consider upgrading their status to higher priority protection. The number of museums and heritage centers will be increased in southwestern Serengeti and the 'Mbina' annual festival will be maintained over the years to preserve and educate people about the cultures of different ethnicities in southwestern Serengeti. High environmental awareness will constantly initiate environment management and revenue generating programs such as agroforestry, bee keeping, and green energy production. Provision of water, health, education, infrastructure and market access will be advanced to meet the demands of most people in southwestern Serengeti.

Balancing wildlife conservation, socio-economic development, and agriculture production will be challenging to this scenario because of moderate access to infrastructure, markets, and investment opportunities and reliance of the population on natural resources. There will be political and societal will to attract more sustainable investments that will benefit southwestern Serengeti residents and the investors.



#### 2 Supplementary Text S2.

# Calculation of future land demand estimates used for modelling future land cover change scenarios

Future loss of forests through deforestation was determined by the annual rate of change of area for forests and woodlands in Tanzania. From the National Forestry Resources Monitoring and Assessment (NAFORMA) report (MNRT, 2015), wood loss in Tanzania is driven by per capita household wood demand  $(m^3/ha)$ , per capita industrial wood demand  $(m^3/ha)$ , per capita wood loss from land use and land cover change (m<sup>3</sup>/ha) and per capita illegal felling for charcoal, lumber or trade  $(m^{3}/ha)$ . The annual wood demand in each of these categories as of 2010 was determined by MNRT (2015). Using the latest census data for Tanzania (URT, 2012), the population for this study's area of interest in 2012 was calculated and, together with Tanzania's average population growth rate of 2.7% per annum, was used to estimate the population for the study area in 2010, when the NAFORMA wood demand estimates were done (MNRT, 2015), and for 2030 and 2063, the time horizons for the land use and land cover change scenarios developed by this study. The expected wood demand in 2030 and 2063 under the scenarios with strong environmental practices (i.e. the 'Parks and People' and 'Life is Good' scenarios for northern and eastern Serengeti and the "Hamasika' and 'Yajayo Yanatufurahisha' scenarios for southern and western Serengeti) was calculated as a sum of the projected per capita household wood demand, projected per capita industrial wood demand, and projected per capita wood loss from land use and land cover change. On the other hand, wood demand in 2030 and 2063 for the scenarios with weak environmental practices and weak political will in managing natural resources, was calculated from the sum of projected per capita household wood demand, projected per capita industrial wood demand, projected per capita wood loss from land use and land cover change, and projected per capita illegal felling for charcoal, lumber or trade. The unit for the calculated land demand was changed from hectares (ha) to square kilometer (km<sup>2</sup>). Estimation of the number of grids that would lose their forest land cover in 2030 and 2063 under each scenario was then calculated using the percent likelihood of deforestation determined by the stakeholders for each scenario.

Future land demand estimates for agricultural production and livestock grazing were determined from the Food and Agriculture Organization scenarios (FAO, 2018) for future land demand for growing crops and keeping livestock in Tanzania. The FAO data projects crop production and livestock keeping land demands under three scenarios namely: Business as Usual, Stratified Societies, and Towards Sustainability between years 2030 and 2050. FAO land demand estimates from the 'Business as Usual' and 'Towards sustainability' scenarios were used to calculate land demand for the sustainable scenarios in Serengeti with low and high population growth respectively. Future land demand estimates from the 'Stratified Societies' FAO scenario was used to calculate the land demand for Serengeti scenarios with unsustainable environmental practices and weak political will in supporting climate change intervention measures.

The indicator from the FAO data used for estimating future land demand for agricultural production was the arable land (ha) that could be used for rain-fed or irrigated production of crops that are grown in the study area. Using an annual population growth rate of 2.7%, the population of Tanzania was projected to 2030 and 2063 in annual time steps and the annual per capita agricultural land demand under alternate FAO scenarios calculated. The projected per capita agricultural land demand for Tanzania was used to estimate the agricultural land demand for Serengeti based on the projected population for the study area in Serengeti. From the stakeholders' estimate of the percent

likelihood of meeting the projected agricultural land demand under each of the Serengeti scenarios, the number of grids anticipated to change to agriculture in 2030 and 2063 were calculated and used in the simulation. The indicator from the FAO data used for estimating future livestock grazing land demand was the livestock units. Under each FAO scenario, the annual rate of increase of demand in livestock units in Tanzania was calculated and used to estimate the livestock units needed in Tanzania up to 2063. The projected livestock units in Tanzania under each scenario in 2030 and 2063 was then used to estimate the livestock units that would be supported in northern and eastern Serengeti (36589.88 km2) and southwestern Serengeti (33138.27 km<sup>2</sup>). The stakeholders associated livestock grazing pressure with conversion of grassland to shrubland and sparse vegetation. Consequently, calculation of the number of grids to be converted to shrubland and sparse vegetation was done based on the percent likelihood of change to shrubland and sparse vegetation as identified by stakeholders under each scenario and the land demand required for the estimated livestock units for each scenario in 2030 and 2063. Calculation of future land demand for the built-up area in 2030 and 2063 was based on a 5.2% average annual increase of the built-up area in Tanzania (MNRT, 2015).

### 2 References from Supplementary Text 2

Food Agriculture Organization (FAO). (2018). The future of food and agriculture–Alternative pathways to 2050. Rome: FAO.

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United Republic of Tanzania (URT). (2012) Population and housing census. Population Distribution by Administrative Areas.

### **3** Supplementary Tables

Supplementary Table 1. Composition of stakeholders who attended the Serengeti land use and land cover change scenarios development workshops in Mugumu, Bariadi, and Bunda on 5-7 August 2019, 28-30 August 2019, and 10-11 December 2020 respectively.

Stakeholder group	Interest and expertise	Percent representation
Community	Pastoralist, farmer and hunter-gatherer	9%
Local government and parastatals	Geologists, land use planners, road engineers, foresters, environmentalists, and community, water, wildlife, livestock and agriculture officers	58%
Non-governmental organizations	Wildlife, livestock, community , and cultural officers, entrepreneur, land use planner	20%
Research and academic institutions	Ecologists, archaeologist, social- economist	13%
Number of participants involved	54 (seven females and forty seven males)	100%



Supplementary Table 2. Area (km2) of different land cover classes in 2019, 2030 and 2063 under the Wasiwasi (Uneasiness), Parks and People, The Dying Giant, and Life is Good scenarios for northern and eastern Serengeti and the Tutaponaje? (How will we recover? Hamasika (Add diligence), Tujikomboe (Let us redeem ourselves), and Yajayo Yanatufurahisha (The future makes us happy) scenarios for southern and western Serengeti.

Present and future land cover area (square kilometres)										
		Ν	orthern and ea	astern Serengeti	land cover change sce	enarios				
	2019	2030			2063					
Land cover class		Wasiwasi	Parks and People	The Dying Giant	Life is Good	Wasiwasi	Parks and People	The Dying Giant	Life is Good	
Shrubland	5198.47	6506.59	6144.16	6771.36	5734.13	6500.89	6400.12	7364.85	6052.34	
Grassland	12715.43	11280.30	11771.80	11045.30	12496.38	9802.11	11443.01	9993.59	11967.23	
Agriculture	10607.44	12010.51	11582.30	11968.56	11170.13	15219.85	13312.08	13575.65	12721.85	
Built-up	22.23	94.51	69.33	43.56	42.11	408.87	274.72	200.77	115.86	
Sparse vegetation/Bare ground	13.49	40.15	31.04	34.37	23.76	127.70	77.48	110.56	51.64	
Forest	7425.24	6054.36	6386.14	6122.60	6518.04	3933.10	4480.89	4745.68	5077.77	
Forest area as a percentage of total land area	20.29	16.55	17.45	16.73	17.81	10.75	12.24	12.97	13.88	
Agricultural area outside protected area, forests and river edges	753.57	2154.96	1767.41	2122.76	1330.70	5258.69	3553.08	3403.43	2908.82	
Southern and western Serengeti land cover change scenarios										
		S	outhern and w	estern Serengeti	land cover change sce	enarios				
Land cover class	2019	Se	outhern and w	estern Serengeti 2030	land cover change sce	enarios		2063		
Land cover class	2019	So Tutaponaje?	outhern and w	estern Serengeti 2030 Tujikomboe	land cover change sco Yajayo Yanatufurahisha	enarios Tutaponaje?	Hamasika	2063 Tujikomboe	Yajayo Yanatufurahisha	
Land cover class Shrubland	<b>2019</b> 2766.64	Se Tutaponaje? 2691.47	United States St	estern Serengeti 2030 Tujikomboe 2535.02	land cover change sce Yajayo Yanatufurahisha 2577.81	Tutaponaje? 1709.38	<b>Hamasika</b> 2086.12	<b>2063</b> <b>Tujikomboe</b> 1677.64	Yajayo Yanatufurahisha 2425.39	
Land cover class Shrubland Grassland	<b>2019</b> 2766.64 6342.51	So Tutaponaje? 2691.47 5828.60	Hamasika           2693.10           5811.22	estern Serengeti 2030 Tujikomboe 2535.02 5878.59	land cover change sco Yajayo Yanatufurahisha 2577.81 6079.58	Tutaponaje?           1709.38           4159.56	Hamasika 2086.12 4357.95	<b>2063</b> <b>Tujikomboe</b> 1677.64 4161.33	Yajayo           Yanatufurahisha           2425.39           4876.54	
Land cover class          Shrubland         Grassland         Agriculture	<b>2019</b> 2766.64 6342.51 21466.17	Se Tutaponaje? 2691.47 5828.60 22142.76	Hamasika           2693.10           5811.22           22052.33	estern Serengeti 2030 Tujikomboe 2535.02 5878.59 22205.92	land cover change sco Yajayo Yanatufurahisha 2577.81 6079.58 21936.91	Tutaponaje?           1709.38           4159.56           24958.56	Hamasika 2086.12 4357.95 23977.04	<b>2063 Tujikomboe</b> 1677.64 4161.33 25180.39	Yajayo           Yanatufurahisha           2425.39           4876.54           23325.34	
Land cover class          Shrubland         Grassland         Agriculture         Built-up	<b>2019</b> 2766.64 6342.51 21466.17 38.69	Se Tutaponaje? 2691.47 5828.60 22142.76 100.26	Hamasika           2693.10           5811.22           22052.33           100.26	estern Serengeti 2030 Tujikomboe 2535.02 5878.59 22205.92 80.48	land cover change sco Yajayo Yanatufurahisha 2577.81 6079.58 21936.91 69.96	Tutaponaje?           1709.38           4159.56           24958.56           394.16	Hamasika 2086.12 4357.95 23977.04 345.11	<b>2063 Tujikomboe</b> 1677.64 4161.33 25180.39 145.86	Yajayo           Yanatufurahisha           2425.39           4876.54           23325.34           122.71	
Land cover class Land cover class Shrubland Grassland Agriculture Built-up Sparse vegetation/Bare ground	<b>2019</b> 2766.64 6342.51 21466.17 38.69 15.77	Se Tutaponaje? 2691.47 5828.60 22142.76 100.26 33.31	Hamasika           2693.10           5811.22           22052.33           100.26           25.48	estern Serengeti 2030 Tujikomboe 2535.02 5878.59 22205.92 80.48 26.19	Vajayo           Yajayo           Yanatufurahisha           2577.81           6079.58           21936.91           69.96           18.56	Tutaponaje?           1709.38           4159.56           24958.56           394.16           92.92	Hamasika 2086.12 4357.95 23977.04 345.11 57.06	<b>2063 Tujikomboe</b> 1677.64 4161.33 25180.39 145.86 83.62	Yajayo           Yanatufurahisha           2425.39           4876.54           23325.34           122.71           39.12	
Land cover class Land cover class Shrubland Grassland Agriculture Built-up Sparse vegetation/Bare ground Forest	<b>2019</b> 2766.64 6342.51 21466.17 38.69 15.77 2339.66	Se Tutaponaje? 2691.47 5828.60 22142.76 100.26 33.31 2173.49	Hamasika           2693.10           5811.22           22052.33           100.26           25.48           2298.79	Estern Serengeti           2030           Tujikomboe           2535.02           5878.59           22205.92           80.48           26.19           2243.33	Vajayo           Yajayo           Yanatufurahisha           2577.81           6079.58           21936.91           69.96           18.56           2287.00	Tutaponaje?           1709.38           4159.56           24958.56           394.16           92.92           1696.93	Hamasika 2086.12 4357.95 23977.04 345.11 57.06 2188.91	2063 Tujikomboe 1677.64 4161.33 25180.39 145.86 83.62 1757.27	Yajayo           Yanatufurahisha           2425.39           4876.54           23325.34           122.71           39.12           2208.43	
Land cover class Land cover class Shrubland Grassland Agriculture Built-up Sparse vegetation/Bare ground Forest Forest area as a percentage of total land area	<b>2019</b> 2766.64 6342.51 21466.17 38.69 15.77 2339.66 7.06	Solution           Tutaponaje?           2691.47           5828.60           22142.76           100.26           33.31           2173.49           6.56	Hamasika           2693.10           5811.22           22052.33           100.26           25.48           2298.79           6.94	estern Serengeti 2030 Tujikomboe 2535.02 5878.59 22205.92 80.48 26.19 2243.33 6.77	Vajayo           Yajayo           Yanatufurahisha           2577.81           6079.58           21936.91           69.96           18.56           2287.00           6.90	Tutaponaje?       1709.38       4159.56       24958.56       394.16       92.92       1696.93       5.12	Hamasika 2086.12 4357.95 23977.04 345.11 57.06 2188.91 6.61	2063 Tujikomboe 1677.64 4161.33 25180.39 145.86 83.62 1757.27 5.30	Yajayo           Yanatufurahisha           2425.39           4876.54           23325.34           122.71           39.12           2208.43           6.66	



Supplementary Table 2. List of desirable and undesirable futures for northern and eastern Serengeti in 2030 and 2063.

Supplementary Table 3. List of desirable and undesirable futures for southwestern Serengeti in 2030 and 2063.



**Supplementary Figure 1.** Scenario matrices and summaries for northern and eastern Serengeti (Wasiwasi, Parks and People, The Dying Giant, Life is Good) in 2030 (**A**) and 2063 (**B**) and southern and western Serengeti (Tutaponaje?, Hamasika, Tujikomboe, Yajayo Yanatufurahisha) in 2030 (**C**) and 2063 (**D**). S1, S2, S3, and S4 represent scenario one, scenario two, scenario three, and scenario four respectively for northern and eastern Serengeti and for southern and western Serengeti.