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Spatial scenario modelling to support integrated landscape management in the Kilombero valley landscape in Tanzania

A case study on landscape strategies to achieve the Sustainable Development Goals

Background Report

20 November 2018

Spatial scenario modelling to support integrated landscape management in the Kilombero valley landscape in Tanzania

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Cover photo
J. Meijer (PBL), view from Udzungwa National Park over the Kilombero floodplain.

PBL Netherlands Environmental Assessment Agency is the national institute for strategic policy analysis in the fields of the environment, nature and spatial planning. We contribute to improving the quality of political and administrative decision-making by conducting outlook studies, analyses and evaluations in which an integrated approach is considered paramount. Policy relevance is the prime concern in all of our studies. We conduct solicited and unsolicited research that is both independent and scientifically sound.

EcoAgriculture Partners is a non-profit organisation advancing the practice of integrated agricultural landscape management and the policies and tools to support it. By facilitating shared leadership and collaborative decision-making by all stakeholders in a landscape, EcoAgriculture Partners empowers agricultural communities to manage their lands to enhance livelihoods, conserve biodiversity and ecosystem services, and sustainably produce crops, livestock, fish and fibre. The organisation serves as the secretariat for the global partnership Landscapes for People, Food and Nature Initiative (LPFN).

African Wildlife Foundation
The African Wildlife Foundation (AWF) was legally established in 1961 and immediately from 1962 started to extend its conservation support to Tanzania. The AWF mission is to ensure wildlife and wild lands thrive in modern Africa. AWF work is organized into the following thematic areas: capacity building; species protection; land and habitat conservation; conservation enterprises; and community conservation & policy initiatives. AWF operates in northern and southern Tanzania. In southern Tanzania AWF has an office in Ifakara and Mbeya focused on the Kilombero Landscape and the Mbeya, Njombe, Songwe regions. This program aims to enhance conservation and management of the protected areas, restore traditional wildlife corridors and utilize agriculture as an economic driver. AWF aims to leverage agriculture value chain interventions to incentivize forest, wetland and wildlife conservation. AWF supports smallholder farmers to sustainably intensify and add value to crops while improving water quality and catchment management. An integral part of AWF’s approach involves strengthening the use of business models and innovative financing to generate economic incentives and revenue streams for biodiversity conservation. AWF uses this integrated and holistic approach in two of SAGCOT (Southern Agriculture Growth Corridor) clusters (Ihemi and Kilombero) to facilitate partnerships with the public, private sector, non-governmental organizations, research institutions and communities to deliver inclusive green growth.

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Main findings

Achieving the Sustainable Development Goals at the landscape level
The Sustainable Development Goals (SDGs) provide a comprehensive framework for countries planning to achieve an integrated development vision for 2030. The interventions for realizing this vision will need to be planned and implemented at smaller scales where stakeholders can more clearly understand the impact of the specific actions. The landscape--a socio-ecological system which is organized around a distinct ecological, historical, economic and socio-cultural identity-- is a manageable unit at which these goals can be integrated (Denier et al 2015).
Integrated Landscape Management (ILM) is a process by which managers and stakeholders can plan, implement and monitor actions to support the SDGs at a workable scale. ILM explicitly seeks to minimize tradeoffs between goals and maximize synergies between them. The ILM process can result in a plan for action that includes win-win interventions; opportunities for blended investments; an improved understanding among stakeholders of the conditions and dynamics in the landscape; and collaborative action to improve institutional and policy conditions (Scherr, Shames and Friedman 2013; Heiner et al 2017).

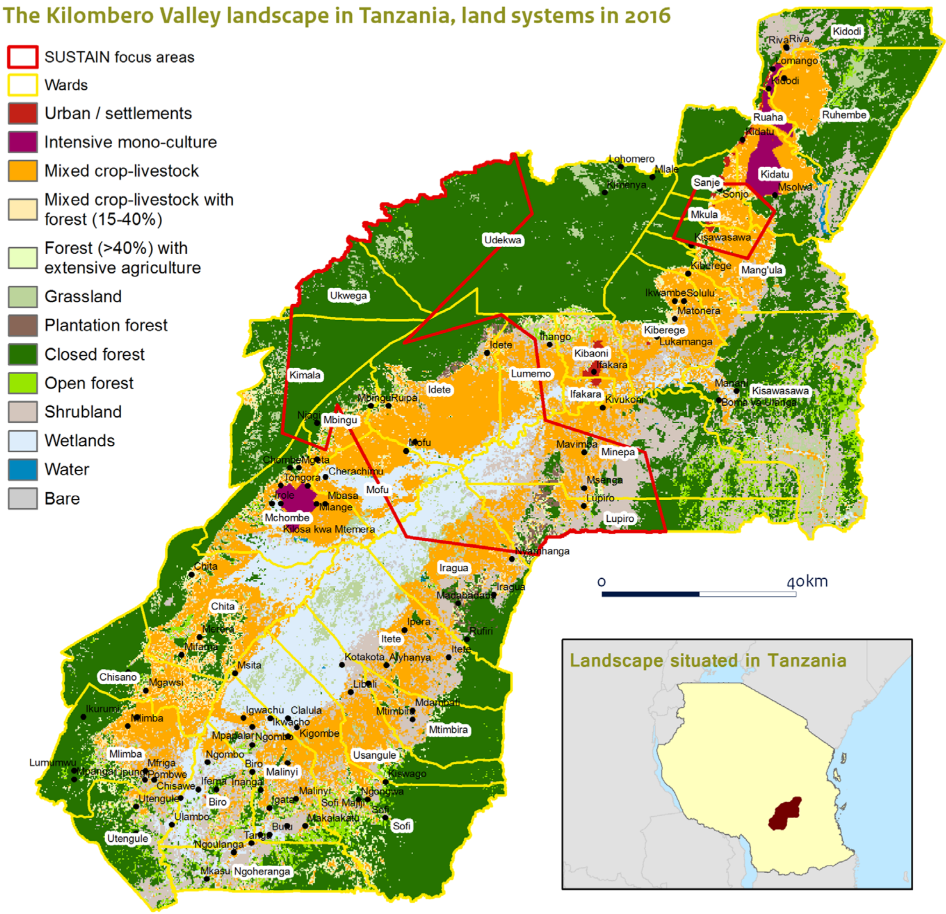
Goals and objectives of the project
PBL Netherlands Environmental Assessment Agency and EcoAgriculture Partners, with funding from the Netherlands Ministry of Foreign Affairs, are collaborating to develop and assess the use of spatially explicit modelling and scenario tools to help stakeholders in integrated landscape initiatives achieve multiple SDGs. This project seeks to understand the potential of scenario modelling to demonstrate the trade-offs, synergies, and spatial impacts of proposed interventions at the landscape scale, and to develop a tool and methodology that will strengthen the capacity of stakeholder groups for long-term collaborative planning and design. The project draws from three case studies, the North Coast landscape of Honduras, the Atewa-Densu landscape in Ghana, and the Kilombero Valley landscape in Tanzania.

The Kilombero Valley landscape, Tanzania
The Kilombero Valley landscape is bounded by the Kilombero River (southeast) and the Udzungwa Mountains (northwest). It is characterized by a combination of highland forest along the Udzungwa escarpment to the west and transitioning into a large lowland wetland system with the Kilombero river at its center. Rice and sugar cane are produced in the lowland areas, transitioning into banana, some cocoa and maize in the boundary area, interspersed with teak plantations. The population is predominantly composed of smallholder farmers who are largely dependent on rivers, springs and streams for their water supply for both domestic and productive uses.

Much of the population is considered to be food insecure as a result of (1) low yields due to climate change, soil degradation, poor inputs, pests and disease, and insufficient water and (2) external factors such as inadequate access to markets and financial services, human-wildlife conflicts, insufficient land, and conflicts over control of natural resources.

Expanding agriculture production, settlement and livestock grazing (pastoralist migrating from the north) in the landscape are rapidly transforming forest and wetland systems thereby threatening both ecological functions those systems provide and the core values to biodiversity, including several rare and endemic species, such as the red colobus monkey, sanje mangebey, and puku antelope, as well as several major wildlife corridors that are crucial to maintaining connectivity between Tanzania's two largest elephant populations anchored by the Selous Game Reserve to the east and Ruaha National Park to the west.

Figure 1



Source: PBL

Landscape ambitions in the Kilombero valley landscape

Limited livelihood opportunities, environmental degradation and effective land use planning are perceived by landscape stakeholders to be the major challenges for development in the Kilombero landscape. Through the multi-stakeholder assessment and planning process, they articulated six major ambitions for their landscape over the next 15-20 years. The selected ambitions were:

- Ambition 1: Conservation of forest cover, wildlife and bio-corridors
- Ambition 2: Improve water conservation, access and security
- Ambition 3: Improve livelihoods (food security; crop and livestock production; commercial development; energy security)
- Ambition 4: Improve social equality (particularly on health and gender)
- Ambition 5: Sustainable management of crop/ livestock areas (soil and water conservation, production efficiency)
- Ambition 6: Improve and strengthen governance (land use plan development and enforcement; policy and planning coordination; reduce conflict)

Once the ambitions were selected, an exercise was organized with workshop participants in which specific actions were identified for each ambition.

Scenarios to 2030

The scenario development started with baseline conditions for the landscape around years 2016. Drawing from information gathered during the 2017 field visit, and information provided by the African Wildlife Foundation. In preparation for the March 2018 workshop a business as usual scenario was developed. During the workshop with diverse stakeholders from throughout the landscape an alternatives 'Living Landscape' scenario was developed.

The **Business as Usual (BAU) scenario was** based on literature, government plans, historical and current data a benchmark scenario for the year 2030 was created. It scenario assumes that current pressures in the landscape will persist and no new policy responses will be implemented. The core assumptions of the BAU by 2030 are:

- Population increases by 3.5% annually
- Agricultural food production will follow the trend in population change, meaning a 60% increase of food production towards 2030.
- Grazing also follows the increase in population, with a continuing and growing inflow of pastoralists bringing their cattle from outside the landscape
- There is a slight increase in monoculture production
- Plantation forestry follows KVTC model growth ambitions on their own teak plantation and for outgrower expansion

An Integrated Landscape scenario

The Kilombero stakeholders' landscape ambitions for inclusive green growth reflect an ILM strategy, explicitly aiming for synergies and reducing trade-offs between economic and agricultural growth, environmental protection and local livelihoods. The ILM scenario used in this modelling study is inspired by those landscape ambitions. Specific landscape interventions were defined that could be incorporated into a land use-driven scenario model to achieve inclusive green growth. Key interventions incorporated in the ILM inspired scenario were:

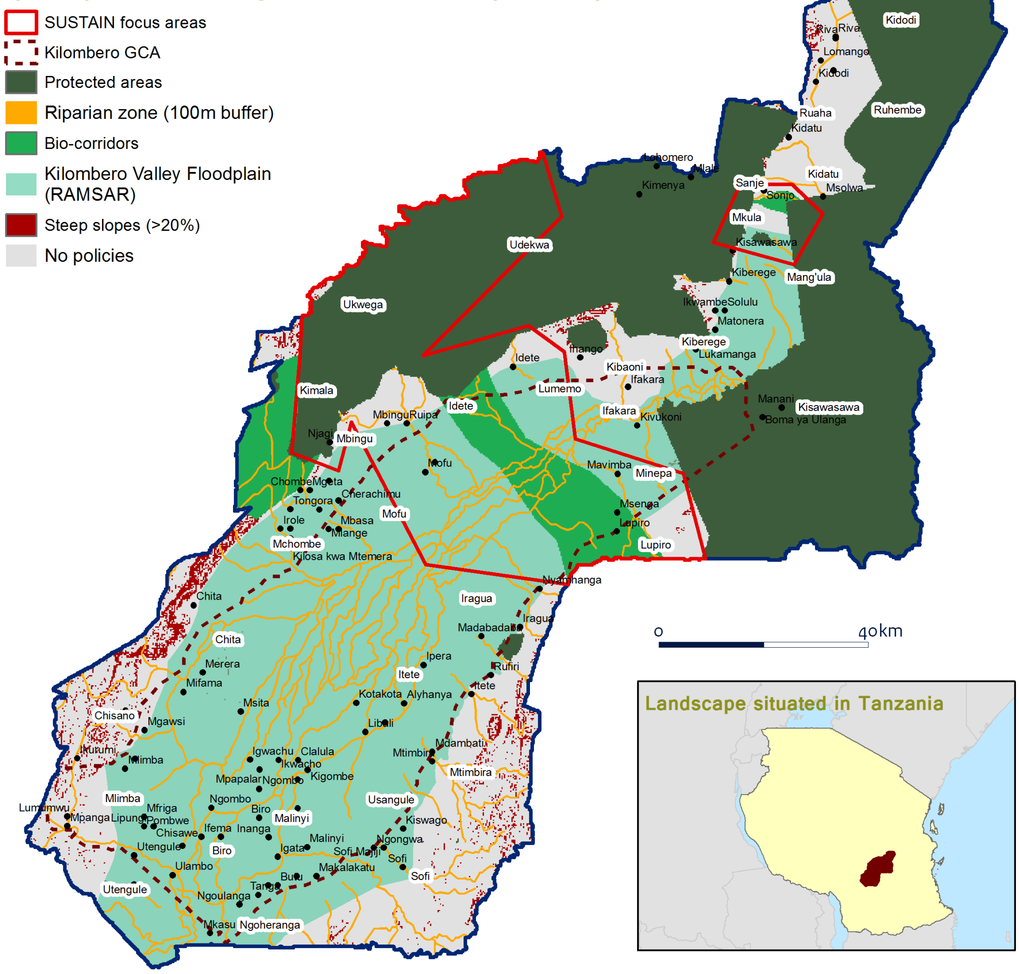
- Improve livelihoods of the population
- Increase local sustainable production of staple foods by shifting from annual crop to mixed
- Promote sustainable watershed management to meet household, economic and
- Expand 'green infrastructure', including forests, protected areas, and biological
- Promote sustainable eco-tourism development around protected areas and bio-corridors, and
- Strengthen land rights and territorial planning.

Key elements of the modelling and scenario development

In order to operationalize the interventions suggested by the stakeholders and to assess the scenario outcomes on progress towards the landscape ambitions a number of spatial policy layers have been created that can guide, promote or restrict certain activities or land uses under specific scenarios.

Figure 2

Spatial policies covering the Kilombero Valley landscape in Tanzania



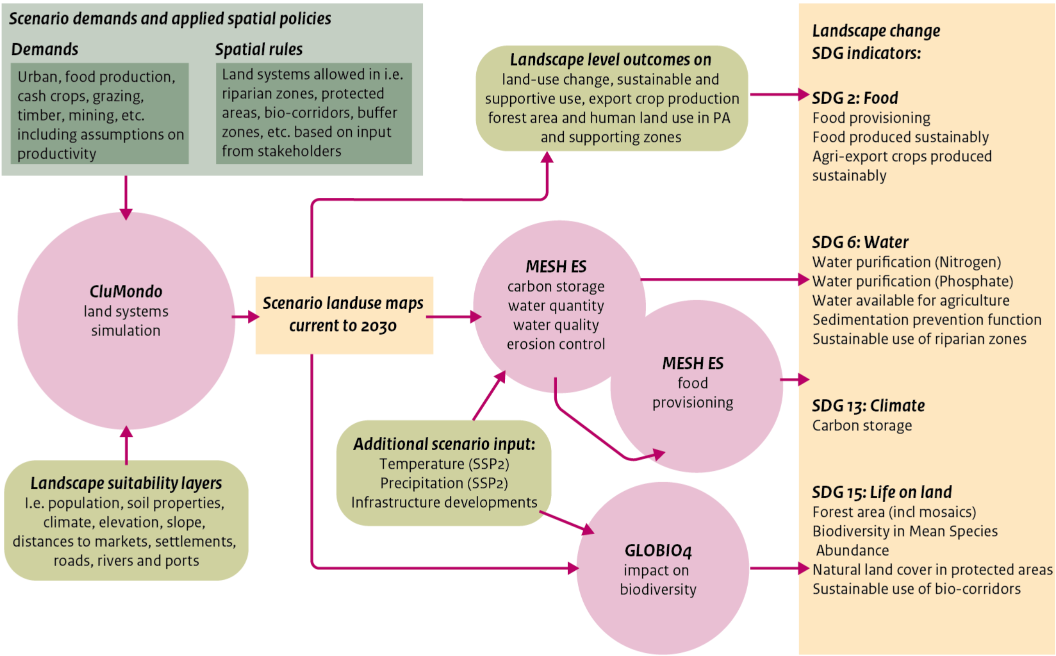
Source: PBL

With the intention to assess various tools, the core modelling tools selected for this project are the CluMondo land systems simulation model for analysing land use change in response to market demand and policy/program interventions, the GLOBIO model that assesses impacts on biodiversity from human-induced pressures and the MESH tool that maps (changes in) ecosystem services to impacts on human well-being.

Figure 3 shows how these tools are connected and how the information flows from input data and assumptions to output indicators. The tools are all open source and freely available.

Figure 3

Overview of the models used and the flow of information



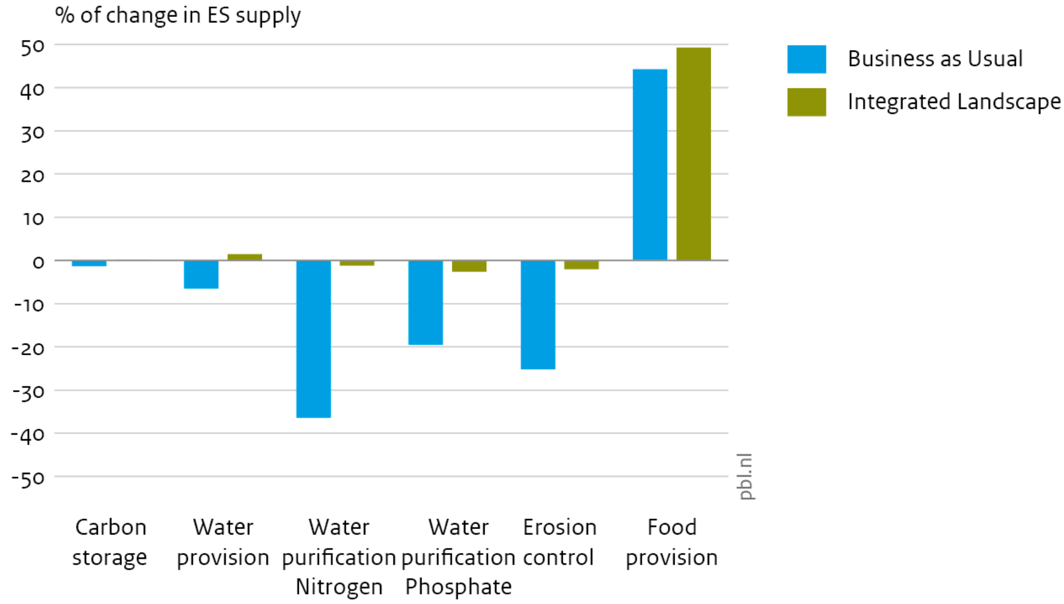
Source: PBL

Main outcomes

The following two figures aim to summarize the scenario outcomes and to visualize the trade-offs occurring within and between the different scenarios that were explored. The First focus will be on the changes in the supply of the ecosystem services that were included in the analysis.

Figure 4

Change in supply of ecosystem service compared to the current situation



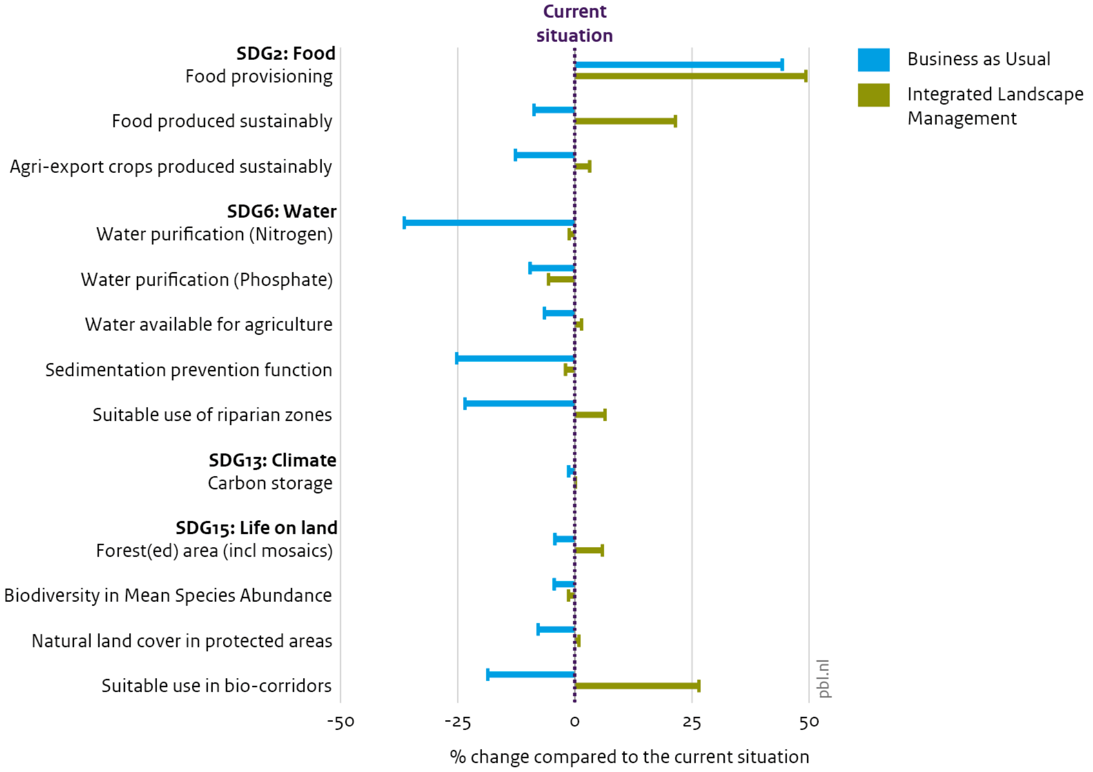
Source: PBL

The synergy that can be derived from Figure 4 is that by aiming for strategies and actions that organize the various activities and regulate access to resources in the landscape according to the Living Landscape scenario, the supply of most ecosystem services is higher than under the Business as Usual. In order to produce sufficient food and create a sustainable livelihood for population growing at 3.5% annually, the improvement of water quality and the protection of soils and forest are essential to maintain the green infrastructure on which the sustainable future of the Kilombero landscape will be built. The ecosystem service components of the landscape models allow a comparison of the provision of ecosystem services under the three scenarios.

With respect to the selected SDGs, Figure 5 provides an overview of the scenario outcomes on the indicators presented in Figure 3.

Figure 5

Impact on selected SDGs under 2030 scenarios compared to the current situation



Source: PBL

For **SDG2** only the Integrated Landscape scenario is showing a positive change on all indicators, compared to the current situation. With the increasing area in use for food production under both scenarios, also under the BAU scenario food provisioning is increasing. However, the share of food production being sustainable and contributing to the landscape ambitions is only improving under the Integrated Landscape scenario. If food provisioning is translated to per capita change (see Figure 6.13), it is clear the growing population is putting a large demand on the landscape, also given the landscape policies (Figure 2) that limits the space available for options. To cope with this challenge and secure SDG2, it might be that the required agricultural productivity increases need to be even higher than those used under the Integrated Landscape scenario (see Table 5.1), which would require larger investments.

For **SDG6** the implementation of the riparian zone policy, protection of forest and the restoration of the bio-corridors clearly have a positive outcome the water quality and sedimentation prevention function, that controls soil erosion, for the Integrated Landscape scenario. The BAU scenarios are not showing any improvement and will not support the landscape in achieving this SDG. Due to increasing agricultural production the nitrogen and phosphate loads are increasing and affecting water quality most under the BAU scenario.

For **SDG13** only carbon storage was included. The BAU scenario shows a decrease of carbon storage in the landscape due to further loss forest, where also remaining patches of forest already surrounded by agricultural activities will be converted. Under the Integrated Landscape scenario the overall halt on deforestation in forest reserves and national parks minimizes the loss of forest. Also the focus on agricultural mosaics, where tree coverage is maintained or increased, and the protection of riparian zones is resulting in a (very small) increase of the carbon storage function in the landscape under this scenario compared to the current situation.

For **SDG15** the results for the Integrated Landscape scenario are obviously the most optimistic. Given the magnitude of the pressures affecting biodiversity in the landscape it is very promising that the Integrated Landscape scenario is able to reduce the loss in MSA occurring under the BAU scenario by 80%. The other indicators illustrate that under the Integrated Landscape scenario specific focus is on halting further loss of wetlands, forest and effectively protect forest and restore the role of the bio-corridors, also in relation to supporting indicators under SDG2, 6 and 13 as was also shown in section 6.2. This a potential synergy that is clearly turning into a trade-off under the BAU scenario.

Value of scenario modelling for ongoing landscape initiatives

Spatial modelling tools can help to increase awareness among stakeholders about the order of magnitude of drivers of landscape change, like a growing population and increasing urbanization, the (unbridled) expansion of agricultural production and how this is affecting natural resources in a landscape.

Spatial modelling of potential alternative future scenarios can be a catalyst for building landscape partnerships. The focus of the modelling tools was on facilitating stakeholder discussions, and less on being the most advanced and complex model in covering every detailed element of i.e. biodiversity or hydrology.

The Sustainable Development Goals, considered as an integrated and inseparable framework for sustainable development, provide a useful framework for focusing discussions on shared ambitions and benefits, and can, in combination with spatial scenario analyses, be used in action planning of integrated landscape initiatives. In our modelling we focused on SDGs that could be more directly related to spatial planning and land use change modelling: food, water, climate and life on land.

The scenario model exercise was implemented along with the Landscape Investment and Finance Tool (LIFT) which is designed to support stakeholders in translating landscape ambitions into investable ideas and then accessing appropriate sources of finance to fund these investments. By joining these two tools in a single workshop the participants could clearly see how their discussions around landscape ambitions in the scenario modelling component to directly lead to a landscape finance strategy which would help them achieve these ambitions. This process also helped to stimulate the creation of a formal multi-stakeholder landscape platform.

Overall, based on the outcomes, we would conclude that a scenario that uses an integrated approach like the Living Landscape scenario, that involves multiple sectors, is organized in (effective) multi-stakeholder platforms, has a larger potential in achieving progress on multiple SDGs simultaneously in this landscape, provided that it is also combined with substantial increases in productivity of current agricultural activities, increased capacity and enforcement of local and landscape level land use planning and (continued) effective management of protected areas and nature reserves. Given the limited SDG coverage in our modelling is it obvious that in order to achieve sustainable development in the landscape also progress on other SDGs like health, education and gender needs to be achieved.

1 Introduction

1.1 Modelling landscape interventions to assess progress on the SDGs

The Sustainable Development Goals (SDGs) provide a comprehensive framework for action. Integrated Landscape Management (ILM) offers a promising means of implementing the Sustainable Development Goals (SDGs) to meet the full range of Goals by minimizing trade-offs and maximizing synergies between them. The anticipated improved outcomes may result from improved understanding among stakeholders of the ongoing socioeconomic and ecological processes in the landscape; from facilitated negotiations among stakeholders to design more win-win interventions and opportunities for blended investments; opportunities to address farm, forest or business problems through solutions at a landscape scale; and/or collaborative action to improve institutional and policy conditions (Denier et al 2015; Heiner et al 2017; Scherr, Shames and Friedman 2013; Thaxton et al, 2015).

Supported by the Netherlands Ministry of Foreign Affairs, PBL Netherlands Environmental Assessment Agency and EcoAgriculture Partners collaborated to develop, apply and assess the use of spatially explicit modelling and scenario tools to help stakeholders in integrated landscape initiatives to explore strategies aimed at achieving multiple SDGs. The objective of this project was to combine a set of modelling tools into a framework that could capture local and spatially explicit landscape characteristics and use these to compare several plausible future scenarios that were developed through a participatory, multi-stakeholder process. This focus of this project, linking scenario models for SDGs to multi-stakeholder landscape planning process, is a substantial innovation. Our research questions were: 1) How could these models most efficiently and effectively be developed?; and 2) How could these models be effectively utilized in the context of multi-stakeholder landscape initiatives?

In 2017-2018, PBL and EcoAgriculture collaborated with the African Wildlife Foundation (AWF) to model a Business as Usual scenario to use this scenario model as a basis for discussion for AWF and the other stakeholders to identify key ambitions and actions that would be necessary to achieve a sustainable landscape by 2030 as well as the actions that would be necessary to achieve those ambitions. Based on feedback during the workshop an additional 'Integrated Landscape Management' scenario was developed that reflected the landscape stakeholders ambitions. The participants subsequently identified and characterized various concrete and spatially explicit actions, reflecting relevant technical, market and institutional interventions that could help the landscape achieve greater progress towards achieving the selected SDGs (e.g. food, health, water, climate and biodiversity) simultaneously by 2030. The main field consultations were in June 2017, and a workshop was held in Ifakara, March 5-8, 2018.

The landscape modelling of scenarios was undertaken with two sets of users in mind: the stakeholders in the Kilombero Landscape of Tanzania who are now - as a result of this process, in part - building a new multi-stakeholder landscape platform to transform their landscape in more sustainable directions. Participatory scenario development was designed to deepen shared stakeholder understanding of the landscape and to motivate sharper analysis of options and impacts. In this case, because of the nature of the March 2018 workshop, which included discussions on how ambitions and actions would be financed, the scenario modelling process also served as the foundation for what could become a landscape investment plan.

The second audience was policymakers seeking to advance sustainable development and spatial planning, including the National Land Use Planning Commission as well as local government officials. This report aims to provide insights for them on useful approaches, tools and methods for integrated landscape-scale modelling that is multi-stakeholder, multi-sector and spatially-explicit.

The authors fully recognize the limitations of models and scenario outcomes, they are meant to illustrate broad changes and highlight potential interactions and implications of different avenues of action. Models provide a simplified view of reality, but can help make explicit the trends over time, distinguish what variables have the largest effects, and identify gaps in policy and action. Our model focuses on areas where close linkages between ecosystem services from natural resources in the landscape are expect to impact achievement of the SDGs.

1.2 Organization of the Report

Section 2 of the report briefly introduces the Kilombero landscape. Section 3 describes the participatory methods and modelling tools used for the scenario development. Section 4 describes the current state of sustainable development in the landscape and stakeholder ambitions for the future. Section 5 describes the scenarios used in the study and Section 6 presents the results of the scenario analysis. Section 7 concludes the report and reflects on how the study has been used by the Kilombero landscape stakeholders, how the methodology could be further improved and how this process could support other coordinated landscape efforts.

2 The landscape

2.1 Overview of the landscape

The Kilombero landscape bounded by the Kilombero River (Southeast) and the Udzungwa Mountains (Northwest) is 16,000km2. It encompasses the Kilombero Valley floodplain, which is a Ramsar designated wetland, one of the largest freshwater floodplains in East Africa, and regulates the flow of the Rufiji river, an important source of water, nutrients and sediment for downstream areas. The landscape is characterized by a combination of highland forest along the Udzungwa escarpment to the west and transitioning into a large lowland wetland system with the Kilombero River at its center.

The landscape is a major center for biodiversity and contains several rare and endemic species such as the red colobus monkey, sanje mangebey and puku antelope including. It is linked to two national parks and a game reserve. Much of the landscape is still covered by forest. The Udzungwa Mountains National Park contains habitats including tropical rain forest, mountain forest, miombo woodland, grassland and steppe; Ruaha National Park, largest park in Tanzania, large elephant population has more than 571 identified species of birds; and the Selous Game Reserve is one of the largest fauna reserves of the world. Several major wildlife corridors crucial to maintaining connectivity between Tanzania's two largest elephant populations anchored by the Ruaha Park to the east and the Selous Game Reserve to the west. Expanding agriculture production, settlement and livestock grazing in the landscape is rapidly transforming forest and wetland systems.

Soils and climate of the Kilombero landscape are suitable for a wide variety of productive agricultural, forestry and livestock uses. Rice and sugar are produced in the lowland areas, transitioning into banana, cocoa and maize, interspersed with teak plantations. Compared to many other parts of the region the landscape is endowed with basic infrastructure of road, railway, electric grid, water supply and communications. Combined with the areas natural resources, this infrastructure is attracting commercial farming, especially sugarcane.
The landscape’s population is predominantly composed of smallholder farmers who are largely dependent on rivers, springs and streams for their water supply for both domestic and productive uses. Approximately half of the population of 600,000 is considered to be food insecure as a result of (1) low yields due to climate change, soil degradation, poor inputs, pests and disease, and insufficient water and (2) external factors such as inadequate access to markets and financial services, human-wildlife conflicts, insufficient land, and conflicts over control of natural resources (Ladislaus et al., 2017; Malopola, 2006; Msinde et al, 2016; Nindi et al., 2014; Rowhania et al., 2011).

Table 2.1
Population growth and projections in the landscape, 2012, 2016, 2036

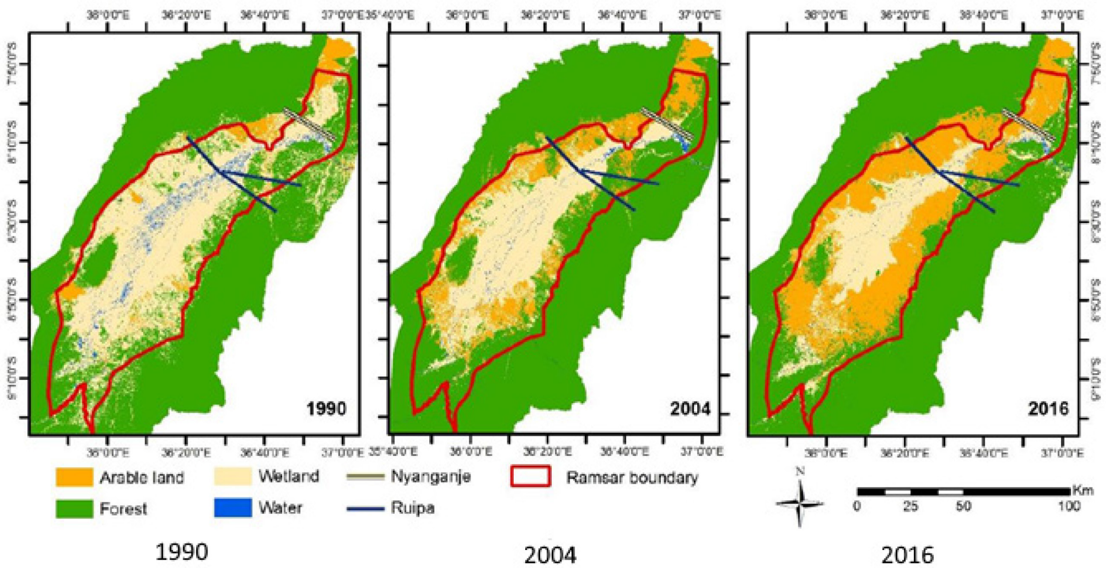
			Population			
District	**Wards**	**Villages**	**2012**	**2016**	**2036**	**Rate of growth**
Kilombero	26	99	407,880	475,329	1,021,657	3.9%
Ulanga	21	59	151,001	169,294	299,757	2.9%
Malinyi	10	33	114,202	128,037	226,801	2.9%
Total	57	191	673,083	772,660	1,548,215	3.5%

Source: RAMSAR assessment, April 2017

Population in the landscape is growing at 3.5% a year (see Table 2.1) which has led to a greater need to produce food. (See Figure 2.1.) Consequently, the land and resources dedicated to agricultural and livestock have been expanding rapidly. This is putting intense pressure on natural resources. Wetlands and forest areas are being converted for agriculture, livestock is encroaching on cropland as well as remaining natural grass areas, and human-wildlife conflicts are becoming more common. Water quality and quantity are degrading due to unplanned settlements, cultivation and grazing near river bank, deforestation, and the use of agro-chemicals near rivers (Kashaigili, 2013; Wilson et al, 2016).

Figures 2.1 and 2.2 illustrate the reduction in forest and wetland cover in the landscape over the past 25 years. The maps in Figure 2.1 are the result of the analysis of remote sensing imagery for the year 1990, 2004 and 2016. They illustrate the encroachment of the agricultural practices within the valley, particularly, the conversion of wetlands. The area of forest changes only slightly in this analysis, because much of the forest is situated on steep mountains and within protected areas and is, therefore, not as attractive for agriculture as the floodplain grass and wetlands.

Figure 2.1
Change in land use and cover in the period 1990 – 2004 - 2016



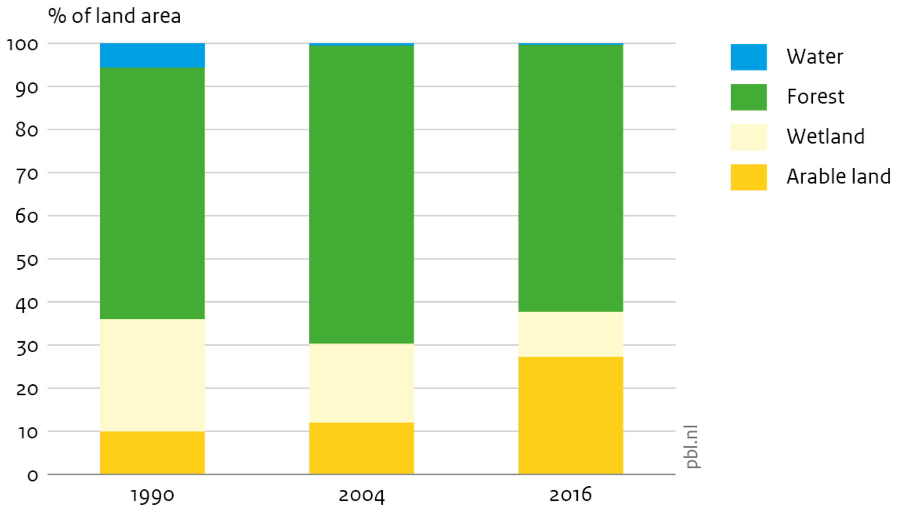
Source: Leemhuis et al, 2017

There is a lack of effective government planning efforts in the landscape, with many village and district land use plans unclear or unimplemented. Tenure clarity and security is a major issue in this landscape and throughout Tanzania. In this context, government continues to sell and lease the land to foreign investors, and migrants put additional pressure on the land governance systems.

The protection of ecosystems, inclusive green growth and investment in climate resilience are hugely important for the future of the landscape and its people. To achieve this, will require slowing or halting of deforestation, more efficient collection of water for agriculture, protection of river water and buffer zones, hydropower systems and the development of wildlife corridors to ensure the movement of wildlife between the protected areas.

Figure 2.2

Kilombero floodplain land cover from 1990 to 2016



Source: Leemhuis et al, 2017.

2.2 Multistakeholder planning efforts in the Kilombero landscape

The Kilombero landscape does not have a unified, multi-stakeholder, multi-sectoral landscape platform for actors to coordinate their objectives in the service of the common vision. However, there are a variety of public and civic initiatives that operate on different scales that are working towards sustainability within the landscape.

SAGCOT

In 2010, the Government of Tanzania launched the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) initiative as a public-private partnership dedicated to ensuring food security, reducing poverty and spurring economic development in Tanzania's Southern Corridor. Stretching from the Indian Ocean to the Zambian border, the Southern Corridor encompasses nearly 300,000 km2 stretching along both sides of the infrastructure backbone that extends inland from Dar es Salaam. While the region has considerable agricultural potential, it currently suffers from low productivity, low levels of investment, and high rates of poverty.

The SAGCOT Initiative was created to attract more than US $3 billion of investment to greatly increase food production, increase annual farming revenues by more than US $1.2 billion, benefit small-scale farmers and the rural poor, and establish southern Tanzania as a regional food exporter. Meeting these ambitious goals would require an action plan to deploy resources, engage partners, and coordinate activities and investments throughout the Corridor.

The SAGCOT strategy is centered on the *Cluster approach*. The Cluster approach is based on the idea that greater progress can be made by co-locating different types of investments (e.g. interconnected companies, specialized suppliers, service providers, and associated institutions) in specified priority areas. Theoretically, this clustering would create vertical integration of agricultural production, processing, and marketing, while ensuring a critical mass of demand and supply to sustain full-service agricultural input supply chains, post-harvest value chains, and support functions. One of these clusters in Kilombero.

While SAGCOT stimulated new programs to develop within Kilombero (see section below on SUSTAIN), currently it has only a week influence within the landscape. Most people do not know what it is, and those who do not seem to hold it in very high regard.

African Wildlife Foundation and SUSTAIN-Africa

The African Wildlife Foundation (AWF) is working in partnership with IUCN to coordinate the implementation of the Sustainability and Inclusion Strategy for Growth Corridors in Africa - SUSTAIN-Africa. This program was designed to operate in the Kilombero as well as the Ihemi clusters. SUSTAIN-Africa was created in the context of SAGCOT to deliver green and inclusive growth and provide a model for greening growth corridors across Africa. The program to support the Kilombero cluster was built in partnership with the basin water authority, regional and district authorities, private sector partners research institutions, and local civil society organizations to strengthen management of critical forest and water resources, create opportunities for smallholder farmers to increase production in ways that safeguard ecological systems, and generate economic incentives for compliant producers. The project was designed to increase knowledge, skills and capacities among communities, business and government entities on ways to manage water, land and ecosystem other ecosystem services to build climate-resilient water and food security while generating growth.

As part of this program, in Kilombero AWF had completed a baseline rapid assessment, launched a study to study value chain on cocoa and rice, identified topographic datasets for spatial planning and held multiple planning meetings with beneficiaries such as farmers' groups leaders, agriculture extension officers, private companies and water use association and discussed the details of the programme and their roles in the implementation of project activities. A 2017 workshop in Mngeta addressed the connection of upper and lower stream users and the possible development of a Payments for Ecosystem Services (PES) program. However, at the time that the scenario modelling project began they had not yet worked to convene or facilitate a multi-stakeholder landscape platform that could develop a vision for landscape and coordinate actions to achieve that vision.

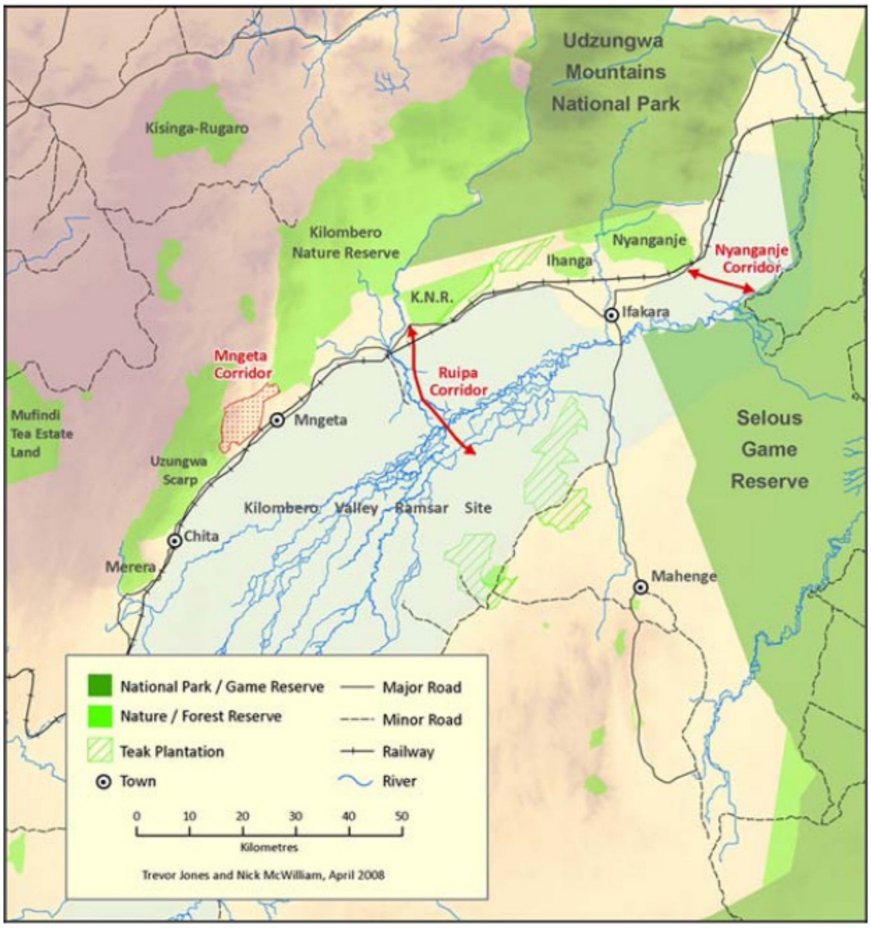
Kilombero Valley Ramsar status

In 2000, Tanzania ratified the RAMSAR convention which requires wise use of wetlands which meet its standards. The Kilombero Valley wetlands gained RAMSAR status due to their importance for national and international wildlife; in particular the presence of 75 per cent of the world's remaining wetland dependent Puku population. The wetland also has several species found only in the Rufiji River basin and provides important breeding grounds which support fish populations throughout the basin (Kolding et al., 2017). Biodiversity corridors for elephants and buffalo also cross the flood plain. A management plan for the wetland was created in 2006, after which funding was provided through the Belgian government to implement it. However, land use in the valley remains complicated by competing demands by agriculture, forestry, water and wildlife sectors (Wilson et al., 2017). Official oversight through RAMSAR is provided by the Ministry of Natural Resources and Tourism. However this ministry can only establish policies on wildlife use and management, not for the other competing uses which, by Tanzania law, are under the jurisdiction of other ministries. Wetland protection is currently supported, in part, through the Kilombero and Lower Rufiji Wetlands Ecosystem Management Project which is a Belgian supported project that supports the implementation of the existing policy framework of decentralized natural resources management in the wetlands ecosystem of the Kilombero Valley and Lower Rufiji. It aims to address key enabling environment issues such as stakeholder's coordination and monitoring of policy implementation.

Biodiversity corridors

There are two biodiversity corridors remaining in the valley for wildlife including elephants, buffalo and puku to cross from Selous Game Reserve to the Udzungwa Mountain National Park (see Figure 2.3). Both of the corridors are critically threatened from pressure by livestock encroachment, deforestation and continuing immigration of human populations. In the Nyanganje Corridor, between Nyangaje Forest Reserve and Selous, more than 80 per cent of residents reported elephants passing through their farms. Since this corridor is the shortest possible route across the valley, the elephants do not always pause to raid crops resulting in slightly lower levels of perceived conflict. However in the Ruipa corridor, near the Ruipa River, there is evidence of the corridor being closed off by hunting pressure, teak plantation and agricultural expansion. Here, where the animals must cross a larger distance to reach the next protected area, nearly half of the residents perceive conflict with large mammals passing through their land.

Figure 2.3
Udzungwa-Selous and Uzungwa Scarp-Kilombero Nature Reserve Corridors



Source: TAWIRI, 2009: Wildlife corridors in Tanzania

The southern part of the valley has been designated as a Game Controlled Area, which, protects against illegal hunting, but has no control over the encroachment of livestock grazing or expansion of agriculture into wildlife corridors. Several new management approaches have been proposed, however there is a lack of capacity and education among local residents on the importance of wildlife corridors and sustainable forestry management.

Village and district land use planning processes

In the landscape, there is a lack of collaborative governmental spatial land use plans. Consequently, each land used often want to maximize their own natural resource use, but these resources are limited. Within this context, rice or sugar production are also poorly coordinated.

Different areas and stakeholder groups within the landscape have their own plans, and with a strong coordination entity, these plans can be brought together. Priorities for this platform, as discussed in the workshop, would be a shared understanding of the landscape boundaries, trends in social development, trends in land use change, land use conflicts, and a process to identify areas of misunderstanding or disagreement among landscape stakeholders. The foundation of understanding could lead to a robust and well-coordinated landscape planning process.

Textbox: Overview of land use planning developments in Tanzania

Land use planning and implementation is a responsibility of planning Authorities i.e. the National Land use Planning Commission (NLUPC), which is a planning authority at national and zonal level. Others include: city councils, municipal/village councils and township authorities. Sustainable development, growth and control of rural and urban areas are guided by general and detailed planning schemes. General planning schemes, which include National, Zonal and District land use planning frameworks, are considered to be expensive to prepare and implement, and hence have not been prepared for quite a long time. Overtime, preparation of village land use plans has been slow compared to the large number of villages (12,545) in Tanzania. There are few villages with land use plans (1,745) and few districts have district land use framework plans which are not adequately implemented. To the year 2016, only 13.1% of the villages out of 12545 have land use plans and 26% of districts have land use framework plans. As a result, there are growing social conflicts and environmental concerns among various land uses as such as farming, livestock keeping, forest, woodland, wildlife and other uses as both human and animal population increase.

Several key issues relating to land use and spatial planning these days are:

- The common means of **accessing land in Tanzania** is through inheritance, allocation by village or planning authorities or purchase from existing owners. A foreigner can access land for investment purposes only under Tanzania investment Act, 1997. Although land is supposed to be accessible to all, the costly allocation fee needed to be paid on formal allocation, limits accessibility of majority of citizen to easily access land, especially the poor.

- **Lack of clear spatial organisation of settlements.** The pattern of settlements in Tanzania lack clear spatial organisation and definition of major settlements to serve as centres for stimulating socio-economic development. Human settlements development has been therefore taking place largely unguided and with limited articulation in the type of investments that are pre-requisite for stimulating economic growth. There has been significant change in the spatial growth of settlements especially those located along the major roads. Spectacular growth is notable in larger cities of Dar es Salaam, Mbeya, Dodoma, Mwanza and Arusha. Dar es Salaam has been growing spatially more than 200% in the intervals of the past 10 to 15 years.

- **Agricultural land use and related conflicts**. Much of the productive land is already densely settled and, as population pressure continues to rise, more and more people are settling and cultivating in the marginal areas and encroaching into forest reserves and/or wildlife and livestock grazing areas. In most cases agriculture is inter-mixed with settlements.

- **Land degradation** is caused by clear cutting of vegetation and deforestation, nutrient depletion though poor farming practices, uncontrolled grazing/overgrazing. Land degradation effects include soil erosion by wind and water, soil acidification or alkalization, salinization, destruction of soil structure including loss of organic matter, and derelict soils.

- **Smallholder agricultural production** of cereals and food crops has traditionally relied on long fallow (five to seven years) to regenerate cultivated areas. In many parts of Tanzania, as the rural population densities increases, the farming systems become more intensive and extensive, additional pressures are expected on the productive capacities of land.

- **Unplanned expansion** of large scale farms, traditional farming systems and rapid rural population growth has caused cultivation expansion into marginal lands with inadequate rainfall and poor soil quality

- **Livestock Migration**. Currently most of the pastoral and semi-pastoral areas of Mwanza, Shinyanga, Arusha, Manyara, Singida and Dodoma have been overgrazed. Livestock migrations to the South of the country in the hope to alleviate this situation (i.e. the overgrazing syndrome) are doing more harm than good. Already Usangu Plains, Kamsamba and Chunya areas in Mbeya region have been overgrazed by the incoming Masai and Sukuma pastoralists.

- Lack of **legal framework to safeguard agricultural land**. Agricultural land lacks legal a framework which makes possible its identification and protection together with guidelines on the use and management. This implies that land under agriculture will often be under a threat of reclassification in its use. It also means that farmers using land are not legally compelled to manage their land according to some laid down norms to prevent it from becoming degraded. Agricultural land users are not by law obliged to protect their land or put in place measures that prevent land degradation and apply appropriate management practices that foster improved or sustainably high productivity levels.

- **Environmental issues**. Agriculture depends on the natural resources of land, water, forest, air. However, the use of these resources can affect directly or indirectly, other natural resources, through dynamic and complex interrelationships existing in the natural systems. This implies that wrong use of land, water and forest in the production of crops and livestock can have far-reaching effects on the integrity of the environment including adverse climatic changes. To avoid such consequences, the agricultural sector policies must fit in the overall environmental policy, which is critical in providing guidance for the proper and balanced use of natural resources and in defining sectoral responsibilities for the environmental management.

Source: Dr. Stephen Nindi, Director General of the National Land Use Planning Commission

3 Modelling and participatory scenarios

A key element in this project was to combine and try out a set of suitable tools to capture local and spatially explicit landscape characteristics and use these to compare several plausible future scenarios that were developed in a participatory way, based on information and discussions with the stakeholders involved in the initiatives described in the previous chapter.

The research was setup in 4 phases: (1) gather and share landscape information and required datasets to support building the modelling framework and create a 2030 trend scenario; (2) organize a landscape stakeholder workshop to present the first outcomes and collectively design alternative scenarios and identify integrated landscape interventions with stakeholders; (3) produce preliminary results of the scenario analysis and report on the impacts of these interventions for feedback; (4) generate feedback on the outcomes from landscape stakeholders for revision and final reporting of the results.

This section describes the role of the stakeholders and the key elements of the modelling exercise: the modelling framework concept, landscape delineation, models used, data sources and land systems classification.

3.1 Role of stakeholders in scenario development

The first visit (June 2017) was used to familiarize the PBL team with the landscape, collect existing landscape analyses and data, consult separately with various stakeholders to understand and articulate their landscape ambitions for the future and already identify a number of potential interventions that stakeholders suggest in order to achieve their ambitions. Based on this information a draft of the BAU scenario was developed and applied to the modelling framework to produce some first outcomes.

During the second visit (March 5-8 2018), the team facilitated a workshop with about 35 landscape stakeholders. Following the workshop sessions with stakeholders about current state, trends, and priorities for interventions in the landscape, the team presented the draft Trend scenario analyses for group discussion and recommendations for refining input datasets, model assumptions and the scenario storyline.

Based on the feedback, the team updated the Business as Usual scenario assumptions and developed the storyline and required actions for an Integrated Landscape scenario that reflected the identified landscape ambitions that are likely to support selected SDGs.

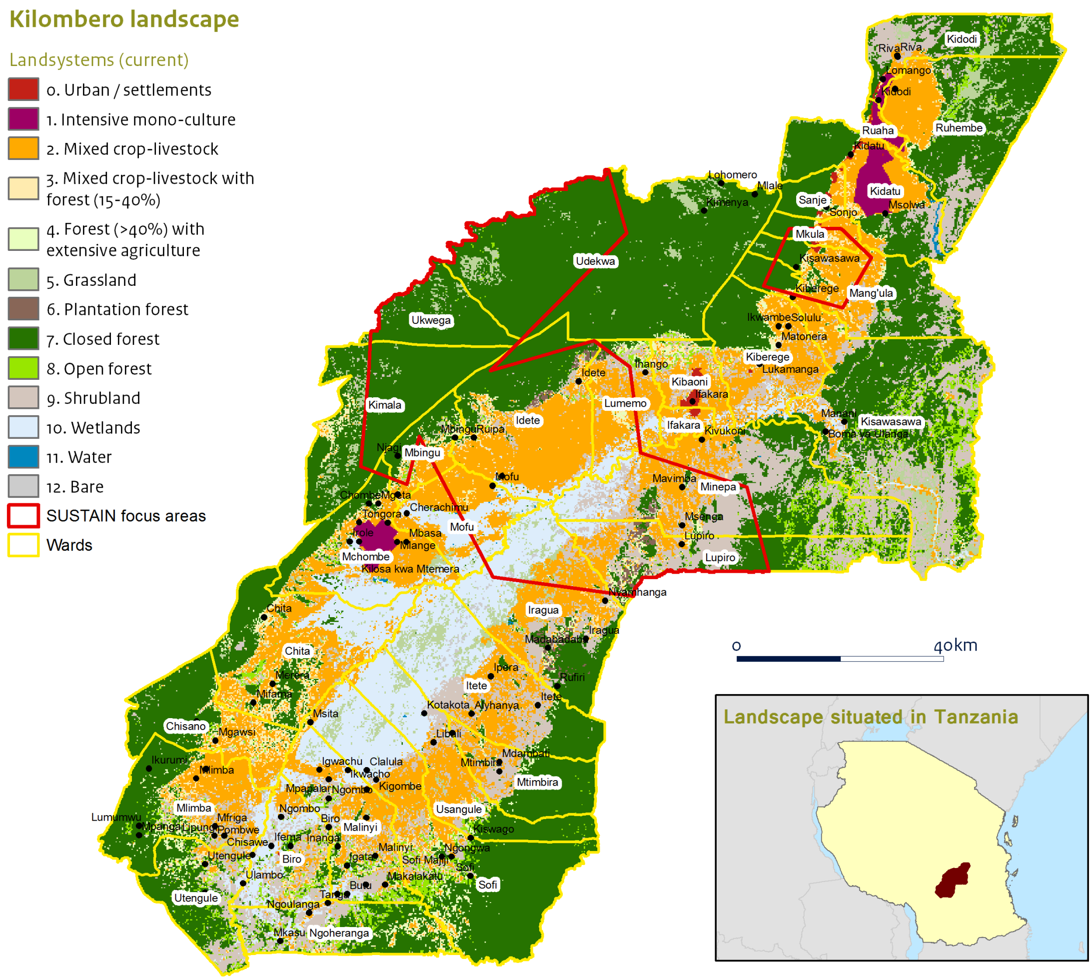
3.2 Landscape delineation

The Kilombero landscape boundary chosen for this case study is based on the Wards of the Kilombero and Ulanga districts, and linked to watershed boundaries. This is a different boundary than the ‘Kilombero cluster’ as defined as part of the Southern Agricultural Growth Corridor of Tanzania (SAGCOT). The landscape area covers about 16,000 square kilometers and is home to about half a million people. We use this revised boundary so that we include the interests of most of the involved stakeholders. This was also done with the intention to link to the existing spatial planning process. It is a landscape seeking to balance substantial ecological and agricultural production objectives. On the one hand, its unique nature and high percentage of endemic species in the region result in internationally well-esteemed conservation efforts. On the other, agricultural production dominates the vast Kilombero floodplain. About 100,000 small-scale farmers rely on rice, maize and cassava, while at a larger scale teak and sugarcane are planted.

3.3 Land systems classification

Land systems represent typical combinations of land cover, livestock, and land-use intensity that describe human-environment interactions. Based on the characteristics of the landscape (area, land cover, land use) and available datasets we decided to create a land systems map at a 250 x 250 meter resolution. The land system map contains 12 classes and is shown in figure 3.1.

Figure 3.1



Source: PBL

Besides several discrete land systems (e.g. urban, intensive mono-culture, grasslands, wetlands) we tried to describe several mosaic classes for combinations of mixed crop/livestock systems with varying degrees of forest cover. The land system classification procedure is further illustrated in the Annex 9.2 to this report.

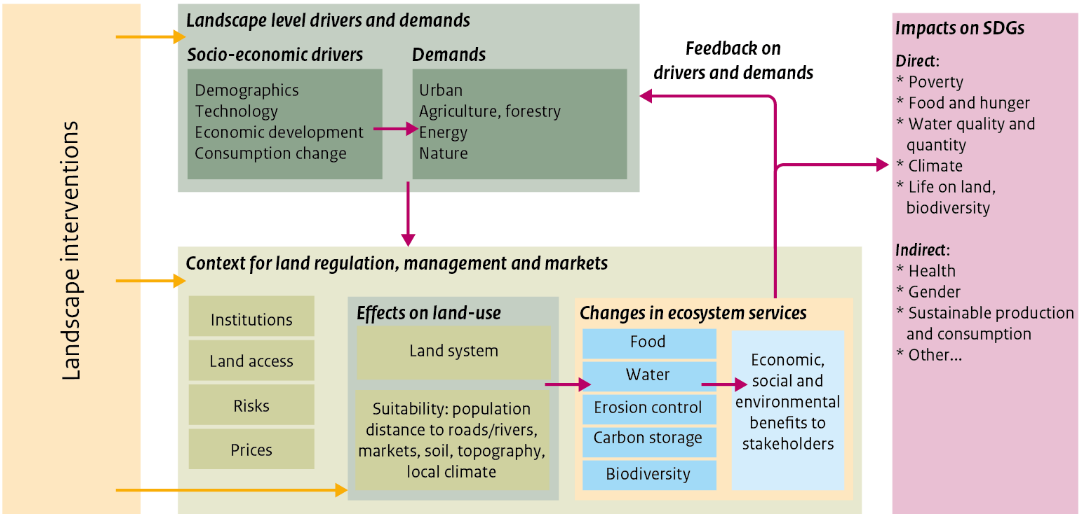
These land systems are associated with different social and economic conditions of the people living and working there. Additional socioeconomic analysis would permit extending the Scenarios to reflect implications for income, wealth and social equality.

3.4 Overview of the modelling framework

The ambition of the modelling is to connect the different spatial scales (global, national, landscape, local) and the sectors and stakeholders that are affecting spatial developments in the landscape. The conceptual framework covering this is shown in Figure 3.2. ILM inspired interventions are expected to influence regional and landscape level socio-economic drivers, enabling conditions at the landscape level and land use practices at the very local level.

Figure 3.2

Conceptual modelling framework for the scenario analysis



Source: PBL

The modelling framework in this project centers around spatial planning, configuration of activities in the landscape and impacts on natural resources. The model does not (presently) include an economic or employment sub-model, but defines economic drivers of change at the landscape level. The indirect impacts are assumed to be reflected in the parameters used. It is assumed that no significant changes in the price trends for inputs and commodities will occur during the 2017-2030 period that would modify incentives for investment or changing practices/utilization beyond the storylines of the scenarios analyzed.

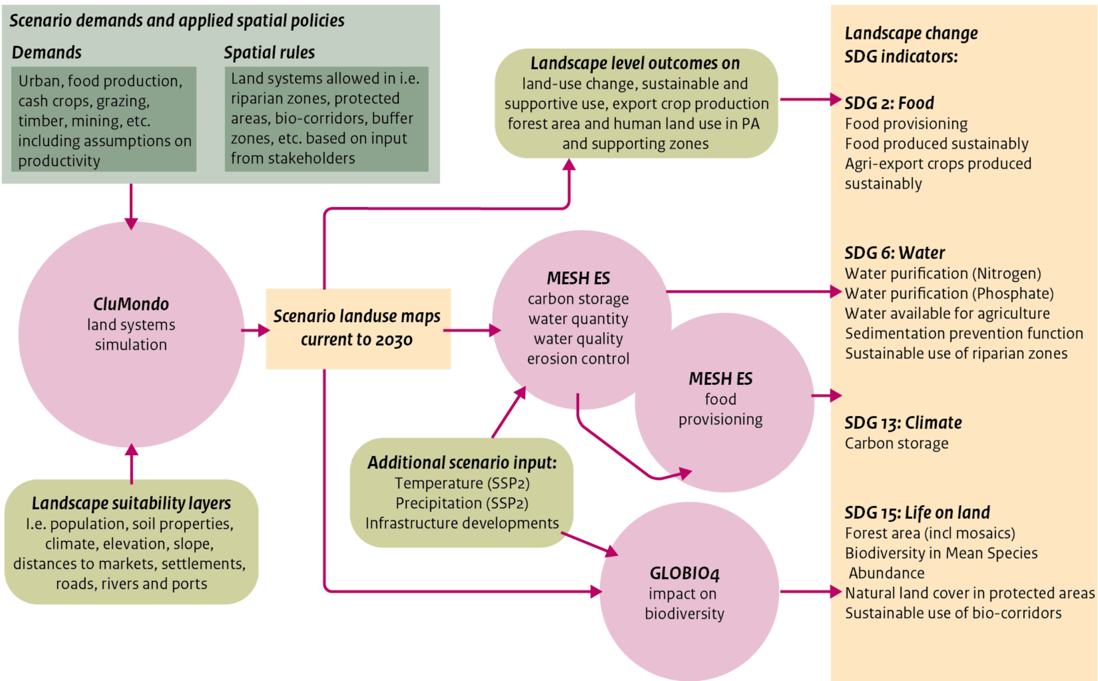
The model emphasizes impacts on the landscape ambitions and selected SDGs resulting from changes in land cover/use, agricultural production and ecosystem services resulting from natural resources in the landscape. We realize that beyond these elements there are also other important factors that affect the achievement of the ambitions and SDGs, such as institutional services and effectiveness, and complementary investments in built infrastructure. Therefore the project focuses more on comparing outcomes between various scenarios and the change from the current situation and to a lesser extent on the actual achievement of official SDG targets, since for many of these the current score and the distance from the target is unknown, uncertain or the required data is not available at the moment.

3.5 Models used in the analysis

With the intention to assess various tools, the core modelling tools selected for this project are the CluMondo land systems simulation model (for analysing land use change in response to market demand and policy/program interventions, Van Asselen and Verburg, 2013), the GLOBIO model that assesses impacts on biodiversity from human-induced pressures (Schipper et al, 2016) and the MESH tool that maps (changes in) ecosystem services to impacts on human well-being (Johnson et al, in prep).

Figure 3.3

Overview of the models used and the flow of information



Source: PBL

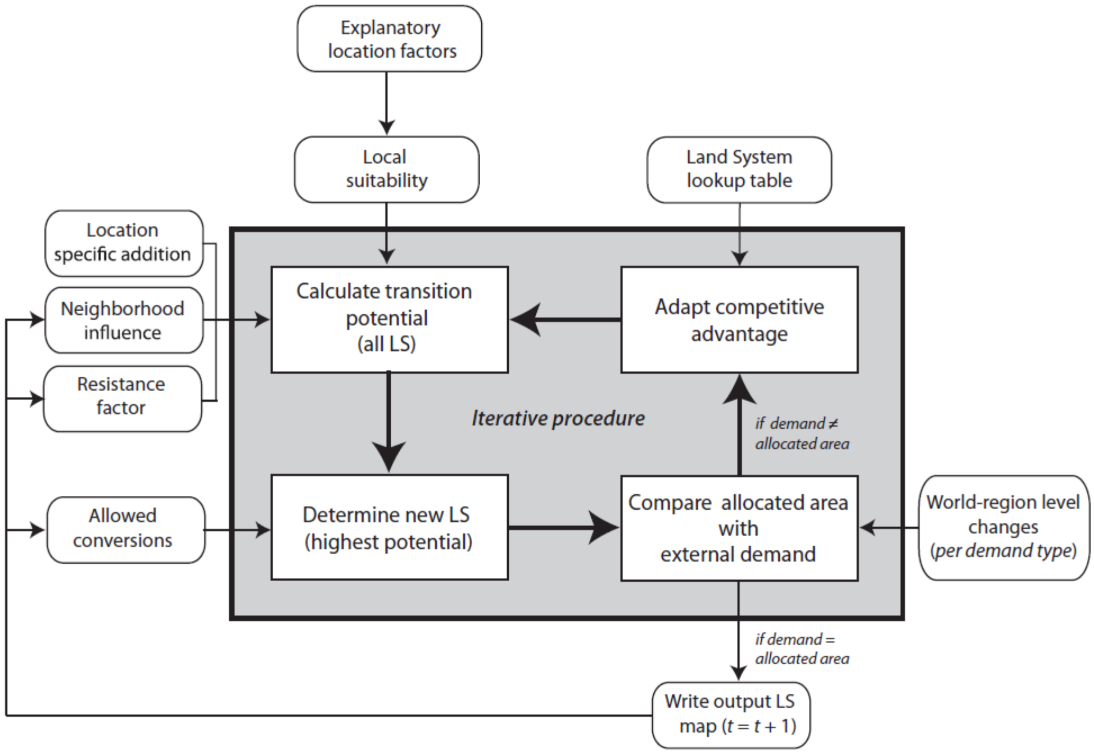
Figure 3.3 shows how these tools are connected and how the information represented in the conceptual model in Figure 3.2 flows from input data and assumptions to output indicators. The tools are all open source and freely available. They are explained in short below.

CluMondo

The CLUMondo model is the most recent version from the CLUE model family that has been used in many local, national and continental level land use change studies (Van Asselen and Verburg, 2013). CluMondo provides a flexible and innovative approach for land-use change modelling to support integrated assessments. Demands for goods and services are, in the model, supplied by a variety of land systems that are characterized by the land cover mosaic, the agricultural management intensity, and livestock production systems. Together these are called land systems. Changes in land systems are simulated by the model and driven by regional market demand for goods and influenced by local factors that either constrain or promote land system conversion.

Figure 3.4 provides an overview of the model. The model allocates at every time step (t) for each grid cell the land system (LS) with the highest transition potential. The transition potential is the sum of the local suitability, the conversion resistance and the competitive advantage of a land system. The local suitability of a land system is determined based on an econometric model that is parameterized by logistic regression. In the model a set of biophysical and socioeconomic explanatory variables is used to predict the probability of occurrence of each land system in each pixel.

Figure 3.4
Overview of the CluMondo land systems (LS) modelling structure



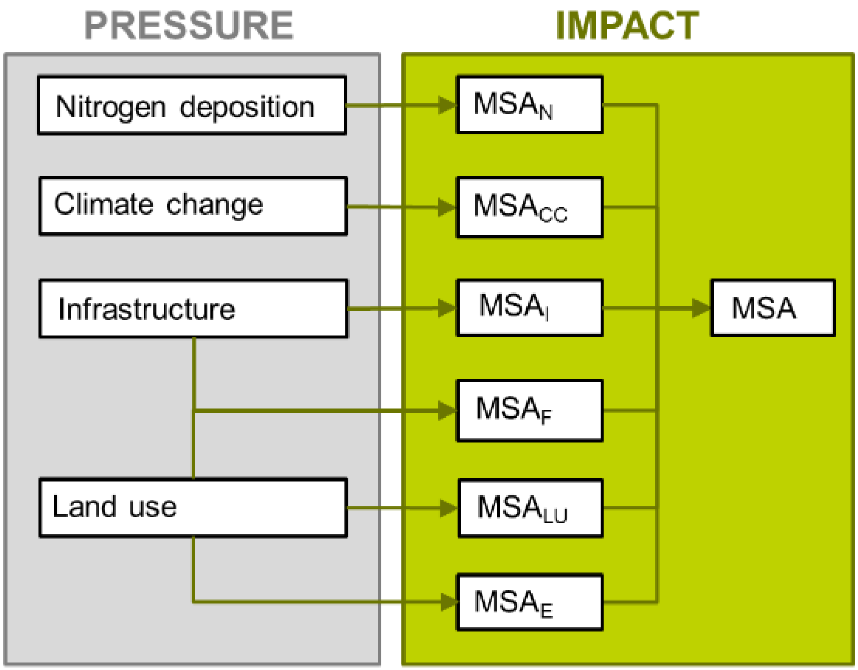
Source: Van Asselen and Verburg, 2013

The CluMondo model can be influenced by promoting or even enforcing interventions, as defined by stakeholders, that only allow, restrict or stimulate certain land use and land cover types that contribute to positive effects on the various landscape ambitions. For example in riparian zones land clearing for intensive agricultural development can be restricted, existing forests can be conserved and/or development of agroforestry activities can be promoted. If combined with investments leading to increased productivity of existing agricultural production systems synergies between income and food production, erosion control, flood prevention, water quality, carbon storage, biodiversity and even tourism can be achieved.

For each scenario time step (14 years) the CluMondo model produces a new land systems map that for this project has a 250 x 250 meter resolution. A number of indicators related to the selected SDGs are directly derived from the CluMondo outputs. More info on CluMondo can be found on https://www.environmentalgeography.nl/site/data-models/models/clumondo-model/.

GLOBIO
GLOBIO is a modelling framework to calculate the impact of environmental drivers on biodiversity. GLOBIO is based on cause-effect relationships, derived from the literature and the model uses spatial information on environmental drivers as input. The GLOBIO model quantifies biodiversity as the mean species abundance (MSA), which is calculated by dividing the abundance (density, numbers or coverage) of each species in disturbed conditions by its abundance in an undisturbed reference situation (Alkemade et al., 2009). Pressures included in the GLOBIO model are climate change, atmospheric nitrogen deposition, human land use, infrastructure and human encroachment by hunting.

Figure 3.5
Schematic representation of the cause-effect relationships included in the GLOBIO model

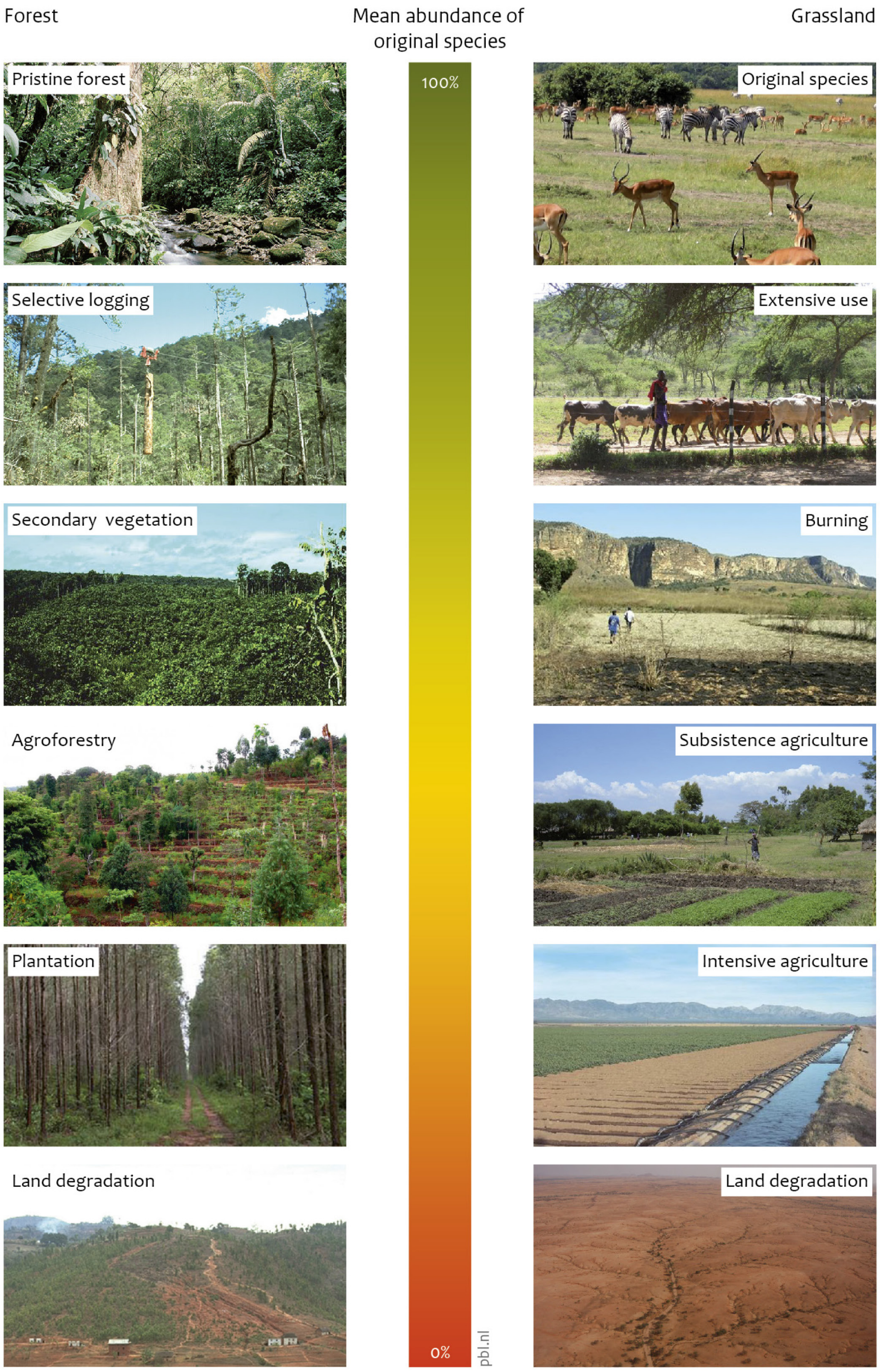


Source: PBL

Figure 3.5 shows the key pressures included in the GLOBIO model. These are the effects from human land use (MSA_{LU}, incl urban settlements, cropland, pastures, mining, plantations of oil palms and forestry), direct disturbance from infrastructure (MSA_{I}, roads and railroads), fragmentation of natural areas by roads and intensive agriculture (MSA_{F}), disturbing encroachment effects from hunting activities on the abundance of birds and mammals (MSA_{E}), effects from nitrogen deposition (MSA_{N}) and the effects from climate change on ecosystems (MSA_{CC}) (Schipper et al, 2016; Benítez-López et al, 2017). For this case study nitrogen deposition data was unavailable, so this pressure was not included in the analysis. The individual pressures are combined in an overall MSA value. For each scenario the GLOBIO model produces a spatially explicit map of the MSA values and landscape level aggregates with MSA impacts per pressure. In general GLOBIO model and MSA indicator do not cover all aspects of biodiversity, but provide an idea of the naturalness of the landscape, see Figure 3.6 for a photographic impression of various levels of MSA. More info on GLOBIO can be found on http://www.globio.info.

Figure 3.6

Photographic impression of mean species abundance indicator at landscape level



Source: PBL

MESH

The Mapping Ecosystem Services to Human well-being (MESH) tool is an integrative modelling platform that calculates and maps ecosystem service supply under different landscape management scenarios. MESH runs on a backbone of InVEST toolkit models (Sharp et al, 2018), that can be tuned to local situations. For the this landscape the following ecosystem services models were included:

- watershed water provisioning, representing water available for agriculture;

- erosion control by avoided sedimentation;
- nutrient exports (nitrogen and phosphate) as an indication of water purification;
- carbon storage;
- food provisioning.

As shown in Figure 3.3, per scenario the models take the specific land systems outcomes map and produce spatial and landscape level outputs on the same resolution of the supply of the selected ecosystem services. These outcomes are used to calculate the relative change in supply between the current situation and the future scenarios and between the scenarios. More info on MESH can be found on https://www.naturalcapitalproject.org/mesh/.

As indicated with the arrow in Figure 3.3, the food provisioning outcomes are adjusted for changes in scenario explicit assumptions on productivity in agricultural production and the relative changes in supply of the water related ecosystems services (provisioning and water purification) are used to derive a tentative indication of crop failure impacting agricultural production in riparian zones. This indication is still very much under development and mainly based on some literature covering the landscape and local expert judgement. The availability of monitoring time series data on both crop harvests and water quality indicators could also improve this.

3.6 Coverage of Sustainable Development Goals

The models emphasize impacts on the landscape ambitions and selected SDGs (focusing on SDG 2, 6, 13 and 15, see Table 3.1) resulting from changes in land cover/use, agricultural production and impacts on ecosystem services depending on the natural resources in the landscape.

We realize that there are also more factors that may affect the achievement of the ambitions and SDGs, such as institutional strength and effectiveness, and complementary investments in built infrastructure. Therefore the project focuses more on comparing outcomes between various scenarios and the change from the current situation. It focuses to a lesser extent on the actual achievement of official SDG targets, since for many of these the current definition, score and/or distance to the target is uncertain or the required data is not currently available. When we mention *sustainable, supportive* or *suitable use*, this means the human land use activities are, as proposed by the stakeholders and based on available literature, promoting related ecosystem services and supporting positive change towards achieving the landscape ambitions.

Whenever additional model outcomes and SDG indicators were considered relevant by the stakeholders, and these had a spatial impact in the landscape, they were explored and analysed depending on the availability of suitable input datasets.

Table 3.1
Selected SDGs and used model outcome indicators

SDG	Related target	Theme	Model outcome indicators
2	2.1-2.3	Food provisioning	Change in food provisioning function (%)
2	2.4	Land used sustainably	Change in share of food production complying to spatial polices on sustainable land use supporting the landscape ambitions (%)
2	2.4	Land used sustainably	Change in share of agro-export production complying to spatial polices on sustainable land use supporting the landscape ambitions (%)
6	6.3	Water quality	Change in water purification function (Nitrogen) (%)
6	6.3	Water quality	Change in water purification function (Phosphate) (%)
6	6.3	Water quantity	Change in water availability for agriculture (%)
6	6.6	Water quality and soil conservation	Change in sedimentation prevention function (%)
6	6.6	Ecosystems	Change in supportive use of riparian zones (%)
13	13.2	Climate	Change in carbon storage (%)
15	15.1	Land system	Change in forest(ed) area (%)
15	15.5	Biodiversity	Change in Mean Species Abundance in the landscape (%)
15	15.2	Supporting bio-corridors	Change in supportive use in bio-corridors (%)

3.7 Data sources

With the tools and models determined and the landscape boundary for this study defined, the list of data requirements was created. PBL provided a list of potential sources, with the challenge for AWF and their local partners to help gather data and contribute additional data. During Phase 1 of this project many relevant documents and statistical and spatial datasets were gathered. Specifically from the ABCG consortium basic datasets covering land use and cover and various topographic datasets (roads, settlements, rivers) were shared.

During the exploratory visit by PBL in June 2017 various regional and district level statistics on agricultural production and demographics were retrieved. During a meeting at the Udzungwa Ecological Monitoring Center (UEMC) we met with several local researchers, various people from the Kilombero District Council and researchers from the Pennsylvania State University in the United States, who briefed us on their work and also pointed us to potential relevant data sources.

Overall, the spatial characterization of the landscape and the foundation of the modelling were drawn from a variety of data sources including:

Landscape and national level:

- UEMC – local climate monitoring data
- ABCG/AWF and CIAT – geo-information
- National Statistics Service – census and survey data, reports

- MOFA – livelihood profiles, agricultural statistics and geo-information
- TZ Meteorological Office – climate info
- Various government reports on future plans (Vision 2025, SAGCOT projections)

Continental and global datasets with varying resolutions

- FAO – soil data (type and characteristics)
- WorldClim – long term precipitation and temperature
- ESA – African Sentinel land use/cover data
- NASA – SERVIR land use, elevation and tree height data
- WRI – global forest watch (tree cover gain and loss)

For a complete overview of data sources used see the Annex 9.1.

4 Landscape ambitions for the future

An important condition for the implementation of an integrated landscape management plan is a shared agreement on the various ambitions to be pursued by the stakeholders in a landscape. This section first provides an overview of the six landscape ambitions expressed by the stakeholders during the March 2018 workshop and how these relate to the SDG goals and targets. Then the importance of ecosystem services on landscape ambitions and the SDGs is discussed.

4.1 Stakeholder ambitions in the landscape and links to the SDGs

Limited livelihood opportunities, environmental degradation and effective land use planning are perceived by landscape stakeholders to be the major challenges for development in the Kilombero landscape. Through the multi-stakeholder assessment and planning process, they articulated six major ambitions for their landscape over the next 15-20 years. The selected ambitions were:

- Ambition 1: Conservation of forest cover, wildlife and bio-corridors
- Ambition 2: Improve water conservation, access and security
- Ambition 3: Improve livelihoods (food security; crop and livestock production; commercial development; energy security)
- Ambition 4: Improve social equality (particularly on health and gender)
- Ambition 5: Sustainable management of crop/ livestock areas (soil and water conservation, production efficiency)
- Ambition 6: Improve and strengthen governance (land use plan development and enforcement; policy and planning coordination; reduce conflict)

Once the ambitions were selected, an exercise was organized with workshop participants in which specific actions were identified for each ambition. The results of this exercise are presented in Table 4.1. This was just a first step, and eventually these actions will need to be filled out with additional details and geographic areas and responsibilities must be clarified.

Table 4.1
Ambitions and actions suggested by the stakeholders linked to relevant SDGs

Ambitions	Actions	Relevant SDGs	Indicators	Value
Conservation of forest cover, wildlife and bio-corridors	-Forestry restoration -Protection of KNR -Secure wildlife corridors -Upgrade the Magombera forest status to Nature reserve -Investment on sustainable management of wildlife and protected areas -Establishment of new protected areas	13-Climate 15-Life on Land	Land use management and plans	Land use plans conducted in all 81 villages (source: Kilombero district)
Improve water conservation, access and	- Water source conservation and restoration	6: Water	Population access to clean and safe water	63% (=2013, goal 2013: 70%)

Ambitions	Actions	Relevant SDGs	Indicators	Value
security	- Mapping and monitoring of water resources -Implement best agricultural practices - Establish and strengthen water management institutions -Develop Management plan for Kilombero Catchment - Form and strengthen water users associations - Kihansi catchment conservation			(source: Kilombero district
Improve livelihoods (food security; crop and livestock production; commercial development; energy security)	-Create alternative income generating activities - Improve market linkage - Value addition practices - Build farmers' business skills - Improve markets for smallholder farmers - Agricultural technology transfer - Identification and mapping of potential areas for economic and livelihood improvement	1: Poverty		
Improve social equality (particularly on health and gender)	Improve water sanitation and hygiene - Improve health services facilities - Improve social services (health facilities, school infrastructure, water supply) - Job creation - Gender mainstreaming in land use development, water resource management	3: Health 4: Education 5: Gender 9: Infrastructure	Infant mortality Under 5 child mortality Enrollment and literacy Number of women groups Improvement and maintenance of roads	123 per 1000 225 per 1000(source: Kilombero district) Almost all households send their children through secondary school (source: MOFA, profile LZ42) 40 (source: Kilombero district) Road upgrade planned and in progress (source: Kilombero district)
Sustainable management of crop/ livestock areas (soil and water conservation, production efficiency)	- Improve efficiency agriculture, livestock and energy production practices	See Water, climate and Life on Land		
Improve and strengthen governance (land	- Better understand responsible institutions, - policies, and regulations	Cross-cutting		

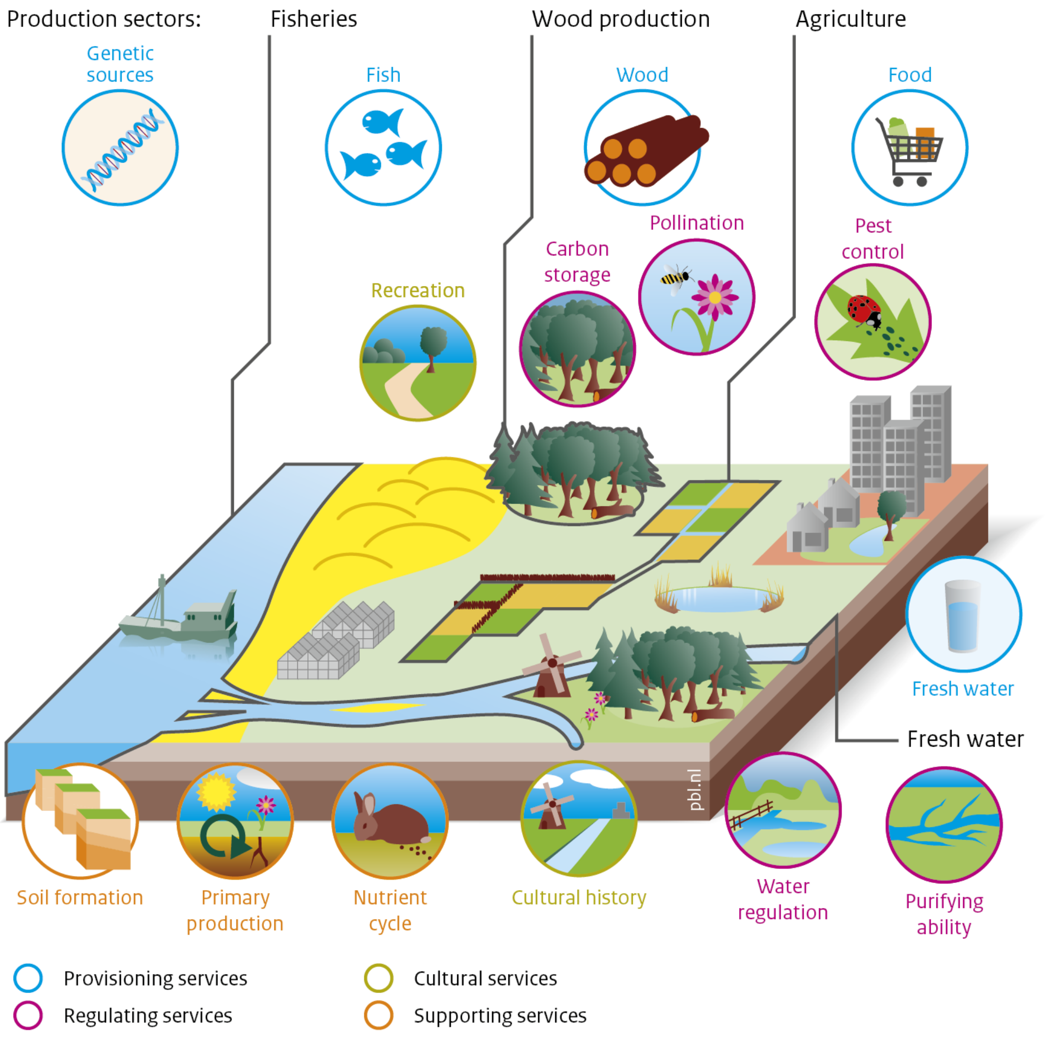
Ambitions	Actions	Relevant SDGs	Indicators	Value
use plan development and enforcement; policy and planning coordination; reduce conflict)	for Protected Area law enforcement - Build capacity in responsible institutions - Improve village land use plans - Develop an integrated water management plan			

4.2 Changes in ecosystem services

Achieving the ambitions formulated by the stakeholders in the Kilombero landscape relies on many factors, but in this case study we focus on the role of spatial planning by doing the right thing in the right place and how this can support, conserve or restore various ecosystem services that are generated by land, vegetation and water resources.

Figure 4.1

Examples of ecosystem services for production sectors



Source: PBL

There are four categories of ecosystem services:

- provisioning services (e.g. food production)
- regulating services (e.g., carbon storage)
- cultural services (e.g., biodiversity values in local culture)
- supporting services (e.g., nutrient cycling)

Figure 4.1 illustrates the some of the key relationships between these ecosystem services within a landscape, such as those between wetlands and food sources. These interactions are a strong rationale for integrated landscape planning, action and monitoring. Reflecting these relationships is a key feature of the scenario modelling approach, by showing how interventions in one part of the landscape will impact ecosystem services, and how those changes in turn affect outcomes in other sectors.

In our analysis we are using the changes in the supply of ecosystem services to analyse the potential synergies or trade-offs occurring under the scenarios and to identify strategies to achieve progress on the selected SDGs simultaneously.

Table 4.2
SDGs addressed through the Kilombero landscape ambitions. Highlighted SDGs (2, 6, 13, 15) are covered in the spatial scenario analysis. (More info on the SDGs can be found at https://sustainabledevelopment.un.org/sdgs)

	Sustainable Development Goals																
Ambitions	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
Conservation of forest cover, wildlife and bio-corridors																	
Improve water conservation, access and security																	
Improve livelihoods																	
Improve social equality																	
Sustainable management of crop/ livestock areas																	
Improve and strengthen governance																	

Table 4.2 illustrates how the landscape ambitions map onto achievement of the SDGs. The SDG framework is seen as an integrated and inseparable framework for sustainable development. For example, there are powerful interactions between **agriculture, food security, water, terrestrial biodiversity and human settlements (SDGs 2, 6, 15, and 11)**. Farming is strongly dependent on and affects the quality and availability of water, because boosting agricultural production can increase water withdrawals and worsen land and water degradation. Achieving nutrition targets requires access to clean water and sanitation, and in many places, to wild plants and animals for micronutrients or supplemental food and livestock feed. Sustainable agricultural systems and practices contribute to ecosystem health, while unsustainable systems may result in deforestation and land and water degradation, jeopardizing long-term food security. Water and watershed management have important impacts on habitat conditions for native biodiversity and on water quality and quantity in urban areas.

There are also important interactions and interdependencies between **agriculture, food security and climate (SDGs 2 and 13).** Agriculture is an important source of greenhouse gas emissions, through soil disturbance, land clearing, fossil fuel use for agricultural machinery and irrigation, and use of nitrogen fertilizers. Conversely, climate change has wide-ranging impacts on agriculture and food security through extreme weather events as well as long-term changes in temperature and precipitation. Sustainable agricultural and land use practices play an important role in climate adaptation and mitigation.

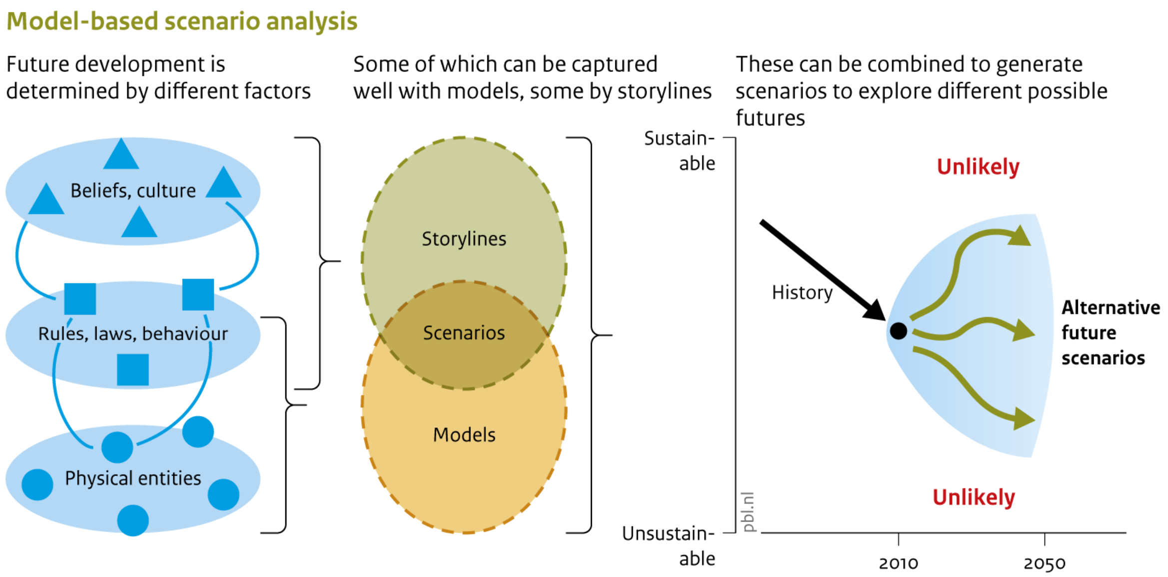
These interactions are a strong rationale for integrated landscape planning, action and monitoring. Reflecting these relationships is a key feature of the scenario modelling approach, by showing how interventions in one part of the landscape will impact ecosystem services, and how those changes in turn affect outcomes in other sectors.

5 Exploring scenarios to 2030

The ambitions of the Kilombero landscape initiative stakeholders are highly aligned with the Sustainable Development Goals. But will the intervention strategies they are planning actually achieve the desired impacts by 2030? Do interventions in different sectors and sub-sectors conflict with one another? In order to refine these action strategies, they need to be made more concrete and spatially specific. The strategy can be improved if constraints and limitations are identified early on. The aim of this study was to provide insights into potential strategies whose synergies enable simultaneous progress on multiple Sustainable Development Goals.

The project explored different plausible futures by combining stakeholder storylines with models to generate 'scenarios' (Figure 5.1). The process builds on the classic 'driver-pressure-state-impact-response' (DPSIR) approach to change. That is, certain external factors provide pressures on the current state of the landscape which produces an impact (changing state), which in turn provokes a response from the resource or from human actors.

Figure 5.1



Bron: PBL

Each of these elements was defined for the Kilombero landscape of Tanzania. The study compared the results of scenarios reflecting 'business-as-usual', i.e., a continuation of current trends in the landscape, with a scenario inspired by strategies of integrated landscape management reflected in the Landscape Ambitions (section 3). Given the focus on achieving the SDGs, the time frame for the analysis was to 2030.

Sub-sections 5.1 and 5.2 describe, respectively, the Business as Usual and ILM scenarios, and also the visualizations developed to assist in scenario development. Sub-sections 5.3 and 5.4 summarize the main scenario assumptions that generate the outcome maps. Subsection 5.5 describes the visualizations that were developed to help stakeholders envision how the landscape would look and behave under different scenarios.

5.1 A Business as Usual scenario to 2030

Based on literature, government plans, historical and current data a benchmark scenario for the year 2030 was created. This Business as Usual (BAU) scenario assumes that current pressures in the landscape will persist and no new policy responses will be implemented.

The core features of the Business as Usual scenario are:

- **Population increases** by 3.5% annually (workshop input, NBS and RAMSAR report). This will result in a 60% increase of the total population by 2030, growing from 0.7 in 2016 to 1.2 million people in 2030. This increase will also have an effect on the extent of urban areas, settlements and villages, which will expand by 36%, based on trends derived from the growth of the urban population in the landscape from 2002 to 2012.
- **Agricultural food production** will follow the trend in population change, meaning a 60% increase of food production towards 2030. Under the BAU scenario there will be a focus on more intensive mixed crop livestock systems to fulfill the increasing demand for food. No dietary changes are included in this scenario.
- There is a **slight increase in monoculture production,** with sugarcane processing already at full capacity and intensive rice production concentrated at the KPL farm.
- **Grazing** also follows the increase in population, with a continuing and growing inflow of pastoralists bringing their cattle from outside the landscape.
- **Plantation forestry** follows KVTC model growth ambitions on their own teak plantation and for outgrower expansion, which is 8,000 Ha on the plantation and 3,000 Ha for outgrowers.

This scenario assumes no land new land regulation or spatial planning policies are introduced or implemented.

5.2 An Integrated Landscape scenario to 2030

Integrated Landscape Management (ILM), regardless of the ‘entry point’ for action in a particular landscape or the community of practice, has five key features (Scherr, Shames and Friedman 2013):

1. Shared or agreed management objectives that encompass the economic, social and environmental outputs and outcomes desired from the landscape (commonly human well-being, poverty reduction, economic development, food and fiber production, climate change mitigation, and conservation of biodiversity and ecosystem services)
2. Field, farm and forest practices are designed to contribute to those multiple objectives
3. Ecological, social, and economic interactions among different parts of the landscape are managed to realize positive synergies among interests and actors or to mitigate negative trade-offs
4. Collaborative, community-engaged processes are in place for dialogue, planning, negotiating and monitoring decisions
5. Markets and public policies are shaped to achieve the diverse set of landscape objectives.

The Kilombero stakeholders' landscape ambitions for inclusive green growth reflect an ILM strategy, explicitly aiming for synergies and reducing trade-offs between economic and agricultural growth, environmental protection and local livelihoods.

The ILM scenario used in this modelling study is inspired by those landscape ambitions. Specific landscape interventions were defined that could be incorporated into a land use-driven scenario model to achieve inclusive green growth. During the workshop there was particular attention to identify interventions that would meet multiple ambitions and SDGs.

The scenario interventions exercise was particularly useful for stakeholder discussions, as it required clarifying interventions, including the scale of action and explicit spatial focus.

Key interventions incorporated in the Integrated Landscape scenario were:

1) **Improve livelihoods** of the population
    a. Impacts of agricultural interventions (area expansion, productivity growth, sustainability, new products and product markets) are assumed to improve livelihoods based on vision of the stakeholders, but are not explicitly modelled.
    b. *Not included in the model: proposed market innovations; expanded education, health, sustainable urban developments, expand sustainable energy*
2) **Increase local sustainable production of staple foods** by shifting from annual crop to mixed crop-livestock-agroforestry systems, to improve rural food security, and mitigate environmental degradation:
    a. Promote a shift of food production systems from annual crop-livestock systems to crop-livestock-agroforestry systems
    b. Increased productivity in mixed crop-livestock systems in mosaics by increased use of soil conservation practices in cropping systems (modelled by switching to more mixed systems)
    c. *Improve infrastructure for local food storage and market access (not included in the modelling)*
3) **Promote sustainable watershed management** to meet household, economic and environmental water needs, and minimize environmental risks for flooding, sedimentation and agrochemical pollution.
    a. Strengthen and enforce municipal regulations requiring year-round natural vegetative cover or agroforestry systems in riparian zones—reflected in assumptions on effective enforcement
    b. Strengthen and enforce municipal regulations requiring year-round natural vegetative cover or agroforestry systems on slopes greater than 20 degrees
    c. Increase soil conservation and erosion control in agricultural production (modelled by switching to mixed classes and reforestation)
    d. *Improved water governance and monitoring to ensure adequate flow of water for household, economic and environmental needs (not explicitly included in the modelling)*
4) **Expand 'green infrastructure'**, including forests, protected areas, and biological corridors/habitat networks (coordinated with agroforestry and other above)
    a. Strengthen protection of core parts of terrestrial protected areas.
    b. Promote only sustainable land uses in the buffer zones of protected areas.
    c. Expand protected areas
    d. Increase terrestrial carbon sequestration and storage across the landscape.
5) **Promote sustainable eco-tourism development** around protected areas and bio-corridors, and link to sustainable agriculture and local culture, to increase income and employment
    a. *Ecotourism innovations, infrastructure, training, marketing not explicitly in the model*
6) **Strengthen land rights and territorial planning.**
    a. Territorial land use planning is embedded in the assumptions above.
    b. *Land rights not included in the model.*

Each of these interventions was translated in the landscape model into specific, spatially-explicit activities, rules and conditions, in a trajectory over time between 2016 and 2030.

The model enabled assessment of the outcomes that include the interaction effects among land and resource users and uses.

The modelling did not take into account the costs or gross income changes or multiplier effects from the various interventions. The business models currently being generated by the involved stakeholders for major landscape interventions, will provide more rigorous estimates of economic costs and benefits that could be used in subsequent studies.

5.3 Overview of scenario assumptions

Table 5.1 provides the main assumptions related to agricultural production area and productivity that were used in the spatial modelling exercise to characterize each scenario.

Table 5.1
Scenario assumptions for key variables under BAU and ILM scenarios

Scenario matrix	Business as usual	Integrated landscape
Landscape zone		
Protected areas	No expansion of existing conservation areas and reserves. Further encroachment of reserves, RAMSAR wetland and GCA continues by grazing and small scale food production	Magombera Forest status upgraded to protected area, also to support bio-corrodor restoration and buffer to agricultural areas. All areas are effectively managed and protected, current unsupportive and disturbing activities are converted and restored as much as possible
Bio-corridors	Further expansion of population settlements, agriculture and grazing undermines the functioning (if any) of the original bio-corridors in the landscape (Mngeta, Nyangange and Ruipa).	Special attention is being paid to restore the function of the Mngeta, Nyangange and Ruipa bio-corridors by focusing on restoring natural areas in combination with the development of suitable agroforestry activities (i.e. mixing cocoa, fruits, timber) and to develop tourism activities around these zones, as described for the Magombera area by Jones et al (2012) and visualized by Bleeker et al (2013)
Agricultural areas	Increase of the area under agricultural production. Continuing trends of the last 15 years, also from Leemhuis et al (2017), with a focus on unrestricted expansion of agricultural and grazing activities, all at the expense of remaining tree coverage and wetland and shrubland areas	Increasing agricultural production, but strong emphasis on spatial planning and enforcement of regulations on agricultural and grazing activities. Much attention to improving productivity of current practices.
Assumptions		
Population	A 3.5% annual growth of the population, based on NBS regional statistics, the RAMSAR assessment and workshop. Based on 2002-2012 census trends most people live in rural areas. Based on this, urban expansion will accommodate 10% of the additional poplation growth.	Same as BAU, but ambition to prevent urban expansion in riperian zones, wetland and conservation areas.
Food production	Following the large increase in population a 60% growth of area used for foodproduction is projected. Priority for more crop-livestock production systems, with only sparse tree coverage. No improvement in productivity are assumed. Due to erosion, pollution and sedimentation a cropfailure rate is applied in riparian zones in the landscape	Investments and improved practices significantly increases productivity by 2.5% annually, therefore only a 15% expansion of the area under cultivation is needed, in order to feed the growing population. Priority is given to multi-functional mosaic crop-livestock production systems with >15% and >40% treecover
Grazing	Based on trend information and driven by the growing population and the unrestricted inflow of pastoralists the area used for grazing increases by 50%. No improvements in productivity are assumed	Strong spatial regulation of grazing activities and limitation on the number of cattle limit the BAU exansion by 50%. Combined with the improvement of productivity (1.5% annually) the areal expanion for needed for grazing is only of 7% compared to the current situation
Forestry	Area expansion based on information from KVTC on ambition of own plantation and outgrower plantations. Total area planted increases by 15%	Same as BAU, with additional timber harvested from increase in agroforestry and restoration activities

These reflect estimates from data and stakeholder definition of landscape ambitions.
The model takes these assumptions, and then shows the resulting land use and ecosystem impacts, given the basic rules of land system allocation described in section 4 (related to suitability, distance to markets, etc.) and interactions among variables.

The costs associated with achieving changes in area and productivity are not included in the model, however examining these assumptions helped stakeholders to consider what kinds of interventions would be required to make them happen. The model did not include different use levels for agrochemical fertilizers and pesticides or the nitrogen and phosphorus levels associated with the different land use systems.

By building the BAU and ILM scenarios, it was possible to compare results from both to the goals laid out in the SDGs. The results are summarized in section 6.

5.4 Operationalization of the interventions

Similarly, to operationalize the interventions suggested by the stakeholders and to assess the scenario outcomes on progress towards the landscape ambitions, a number of spatial policies and restriction layers have been created as a guide, to promote or restrict certain activities or land uses under the specific scenarios. These are the following:

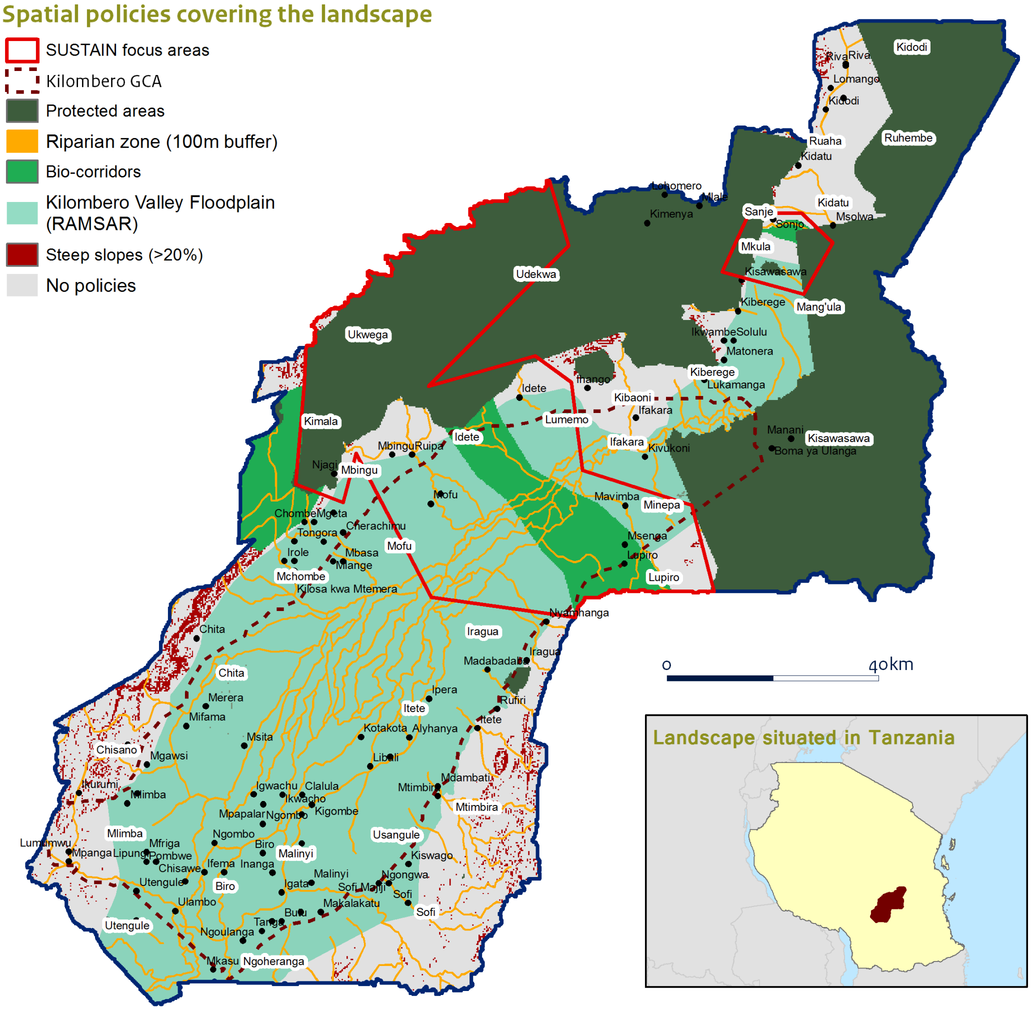
- A spatial layer containing the riparian zones, defined as the area covered by a 100 meter buffer of rivers, which were derived from the rivers dataset from the RCMRD Geoportal (http://geoportal.rcmrd.org/)
- A spatial layer containing information on the latest version of the protected areas in the landscape, including conservation areas, forest reserves, RAMSAR and game controlled area, derived from the World Database of Protected Areas (WDPA)
- A spatial layer containing the bio-corridors in the landscape, as derived from the maps from the 2009 TAWIRI report and indications by participants by the workshop
- A spatial layer containing the areas with more than 20 degrees of slope, as derived from the global SRTM digital elevation model.

Figure 5.2 displays an overlay of the spatial policies and restrictions layer. In total the area covered by one or more of the policies is 12,885 km2, equal to almost 80% of the landscape area.

The spatial policies were specifically used in the CluMondo landsystems simulation which is described in Chapter 3. For the BAU scenario no policies or restrictions were applied, so the 2030 land allocation for that scenario is based on the land use suitability regression models developed by CluMondo. For the Integrated Landscape scenario however all the identified spatial policies were applied in order to support as many of the landscape ambitions as possible.

Figure 5.2

Spatial policies covering the landscape



Source: PBL

In Table 5.2 information is provided on how the different land systems and the policies were combined under the ILM inspired scenario, in order to support progress on the landscape ambitions.

Table 5.2
Policies on selected land system under the ILM scenario

	Riparian zone	Protected area	Wetland/ GCA	Steep slopes	Bio-corridor & SUSTAIN
Urban / settlements	0	0	0	0	0
Monoculture	0	0	0	0	0
Mixed crop-livestock	0	0	0	0	0
Mixed crop-livestock with some forest	0	0	1	0	1
Forest with extensive agriculture/agroforestry	1	0	1	1	1
Plantation forest	2	0	2	2	2

Info: value 0 means the land system is not allowed to expand in this zone, value 1 means the land system is allowed to expand in this zone, value 2 means the land system is allowed to expand in this zone, but cannot replace existing natural land systems like forests or wetlands.

Both the current situation and the scenario outcomes are assessed on their support to the landscape ambitions based on the settings from this table (i.e. urban or monoculture in a protected area or riparian zone is considered undesired and therefore not supporting progress towards achieving the ambitions).

These policies and restrictions have also helped to assess the current activities in these areas. Under the Integrated Landscape scenario the ambition was to convert existing restricted and undesired land systems to supporting land systems allowed in the respective zones. To simulate the halting of further loss of wetland and forest, the current remaining wetland area within the RAMSAR site and forest in protected areas and bio-corridors are maintained and unable to change to (other) human land use systems.

5.5 Visualizing landscape scenarios

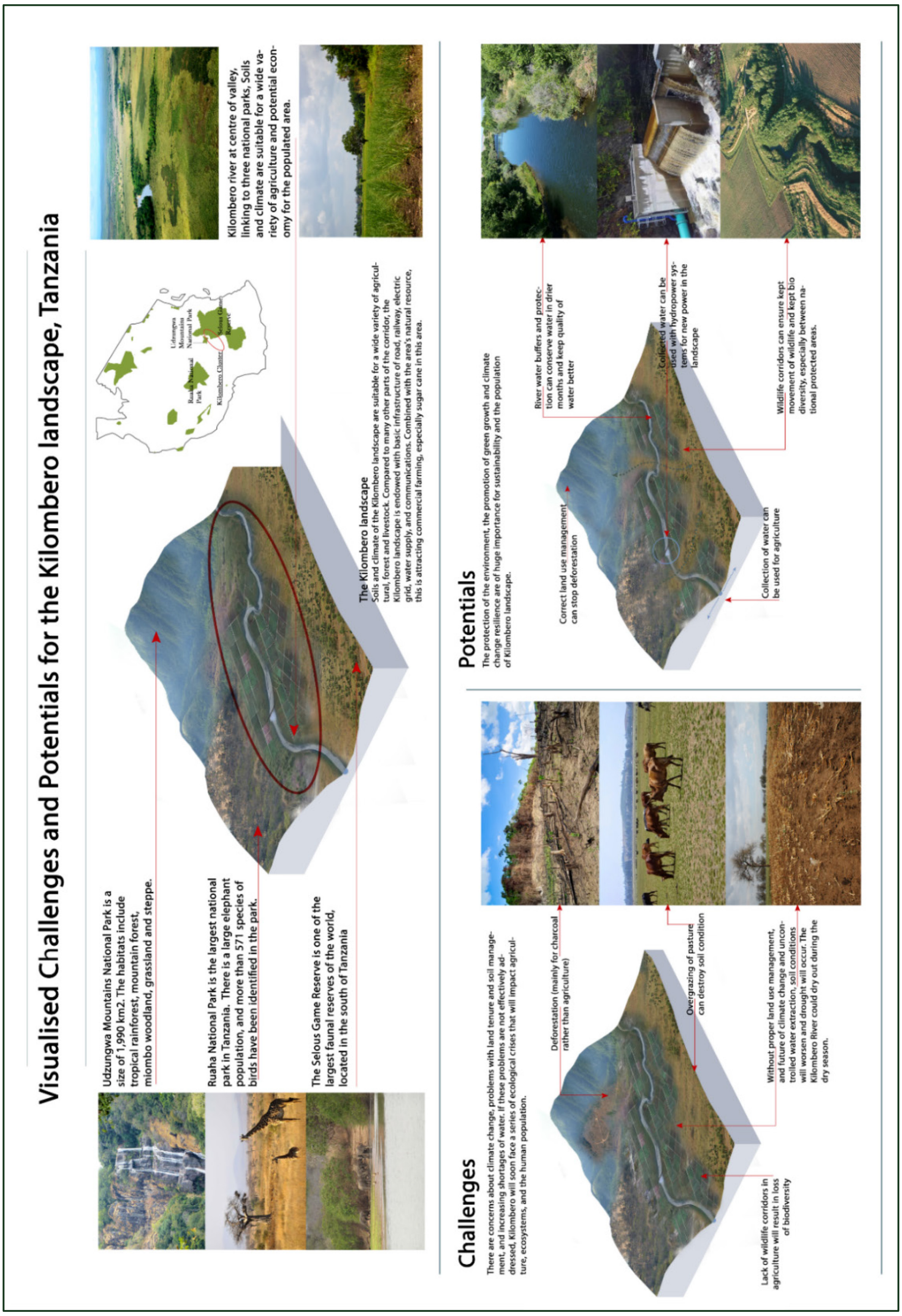
To support the development of the scenario storylines by the stakeholders and their understanding of the various scenarios in the landscape, PBL created visualizations. These helped stakeholders be aware of the consequences of their choices, showed different solutions for the landscape, and helped to integrate the agendas of the different stakeholders. These visualizations were developed through a PBL internship on landscape architecture with the TU Delft University in the Netherlands.

Figure 5.3
Photo of groups of workshop participants discussing ambitions and actions

Source: PBL (J. Meijer)

Figure 5.4 illustrates the key themes of the visualizations. The visualizations were posted on the walls of the workshop meeting room for easy discussion and direct marking by the participants. They were particularly valuable in enabling stakeholders to understand and compare the ambitions and impacts of the various scenarios, to discuss to potential effects, to check the accuracy of protected area boundaries, and to mark where additional protected areas are needed.

Figure 5.4
Scenarios and themes of the landscape design analysis focusing on ILM



Source: PBL

6 Results from the scenario analysis

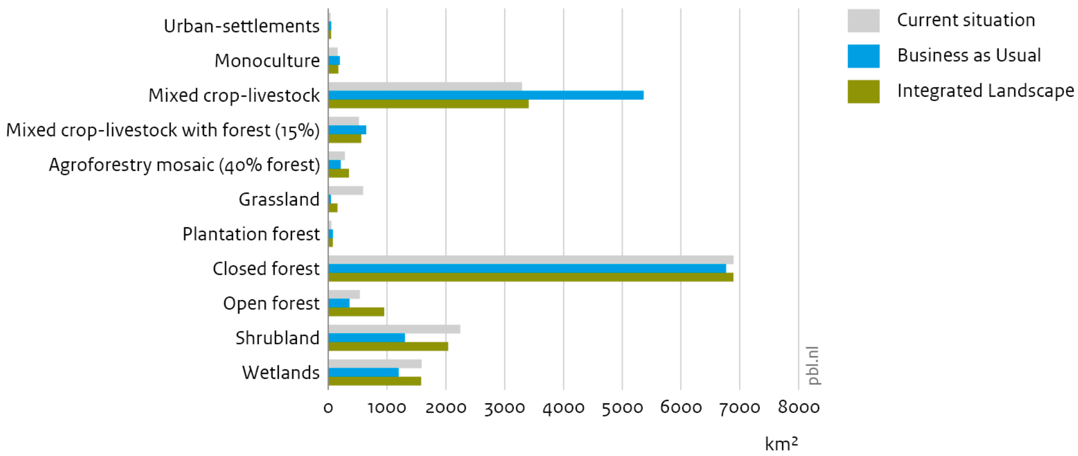
This section presents the results of the spatial scenario modelling exercise. The outcomes of the Business as Usual Trend (BAU), and Integrated Landscape (ILM) scenarios to 2030 are compared with to the current situation and also with each other. First a number of key projected changes in the landscape are presented, followed by an overall assessment of the impacts on the identified landscape ambitions and related SDGs.

6.1 Changes in the landscape

Changes in land use and cover are the most prominent outcome of change in the landscape and provide a first insight into how the scenario storylines and assumptions are translated into spatially explicit outcomes for the year 2030.

Figure 6.1

Landsystems in 2016 and under 2030 scenarios



Source: PBL

Compared to the current situation both 2030 scenarios show considerable changes (Figure 6.1 and 6.2) at the landscape level, with the increase of the areas used by mixed crop-livestock production under the BAU scenario and the limited loss of natural land systems under the ILM scenario as the most striking.

To compare the change in land systems in more detail, table 6.1 provides a more detailed overview of the area covered by the various land systems

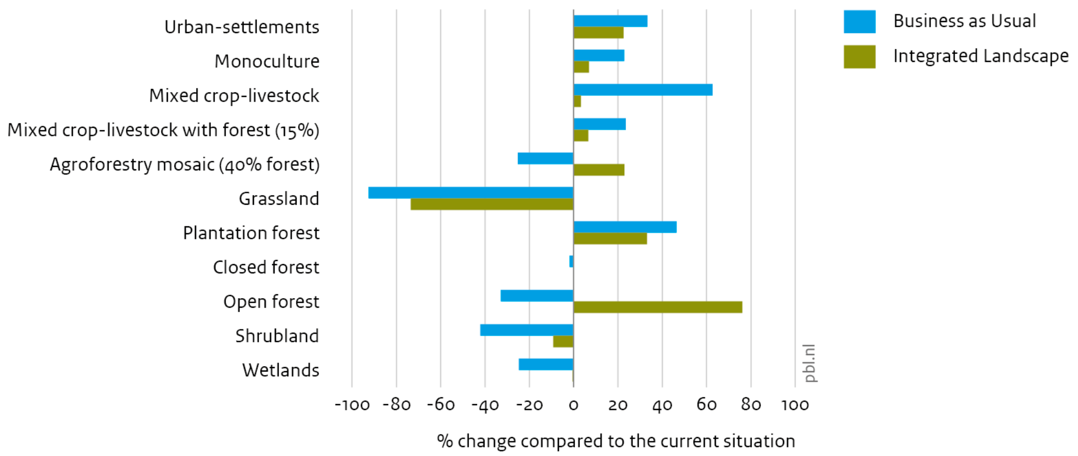
Table 6.1
Landscape level area by land use for current situation and 2030 scenarios

Land system (area in km2)	Current situation	Business as Usual	Integrated Landscape
Urban-settlements	38	51	46
Monoculture	160	196	171
Mixed crop-livestock	3,297	5,362	3,404
Mixed crop-livestock with forest (15%)	522	645	557
Agroforestry mosaic (40% forest)	283	212	348
Grassland	593	44	157
Plantation forest	53	78	71
Closed forest	6,892	6,766	6,890
Open forest	538	361	947
Shrubland	2,246	1,301	2,039
Wetlands	1,588	1,196	1,581
Water	15	15	15
Bare	28	28	28

Figure 6.2 illustrates the proportional change relative to the current situation. Under the BAU scenario most increases in agricultural land use systems are causing losses of natural land use systems, especially in open and closed forests, grass- and shrubland areas and parts of the RAMSAR wetland area. Under the ILM scenario the increases in agricultural productivity and the strong regulation of grazing activities enable the limiting the loss of natural land systems. Due to reforestation and restoration within conservation areas, grassland even gradually develop back into open forests.

Figure 6.2

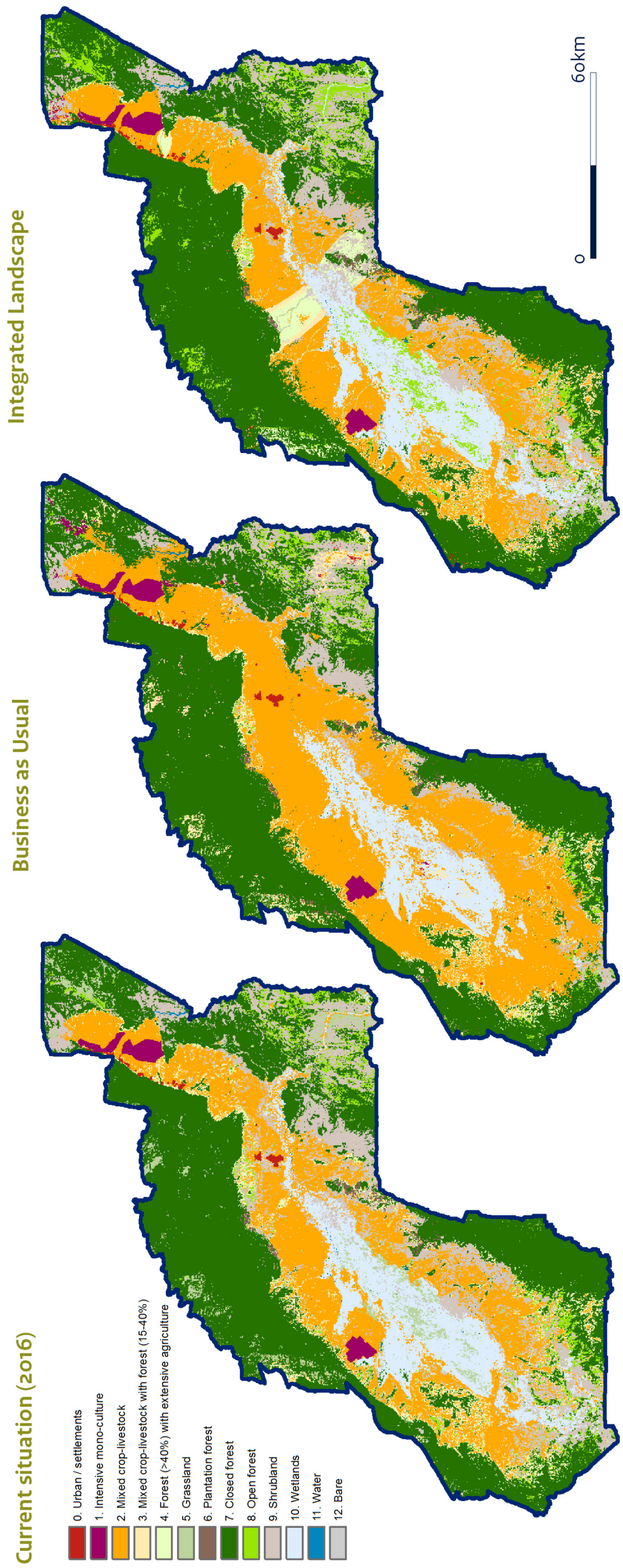
Land use change compared to the current situation



Source: PBL

The maps in Figure 6.3 show the scenario outcomes for land use spatially, on which also many other results are based. Each element is described below.

Figure 6.3
Land system maps for the 2030 scenarios

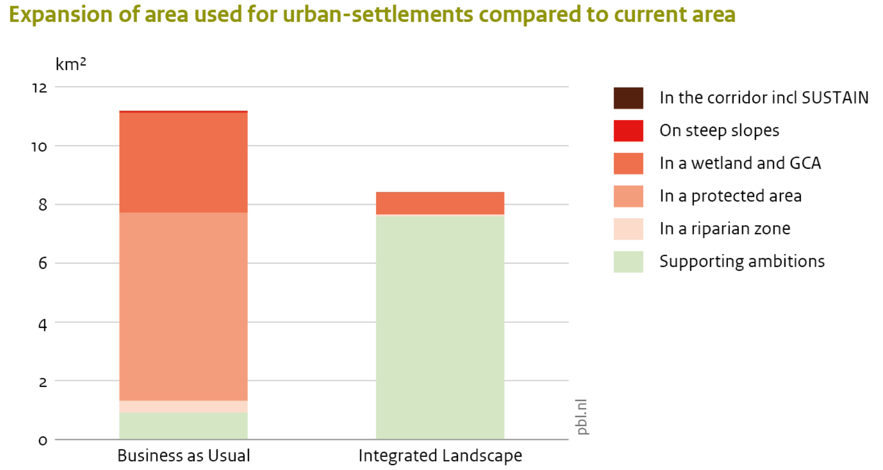


Source: PBL

Urban settlement expansion

Currently about 20% of the population in the landscape is living in urban settlements, mainly in Ifakara and the Kidatu region. Within the landscape, the area classified as urban settlement (based on remote sensing data) is relatively small. However, figure 6.4 shows that under the BAU scenario a large share of the future urban expansion is projected to take place in areas that are affecting progress towards the landscape ambitions. This concerns especially expansion projected to take place in protected areas, bio-corridors and the RAMSAR wetland, which will have impacts on water quality and biodiversity.

Figure 6.4

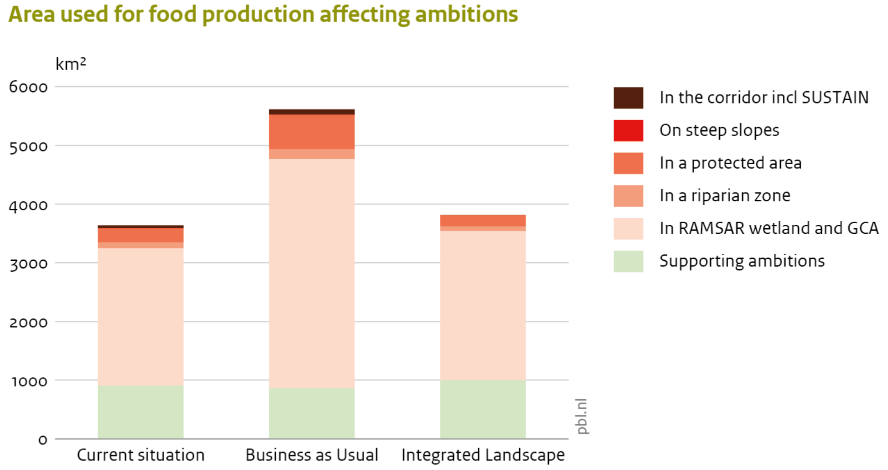


Source: PBL

Food production

As can be derived from Table 6.1, in the period 2016-2030 the total area used for food production is expected to increase by more than 50%, from 4,262 km2 to 6,416 km2 under the BAU scenario, in response to the increasing demand from a growing population. Fulfilling this demand happens mainly by converting wetlands, shrubland, grassland and forest areas to mixed crop and livestock systems, where none or only sparse tree coverage (15%) remains. Due to these practices 85% of the area used for food production under this scenario is used in such a way that it affects the landscape ambitions.

Figure 6.5



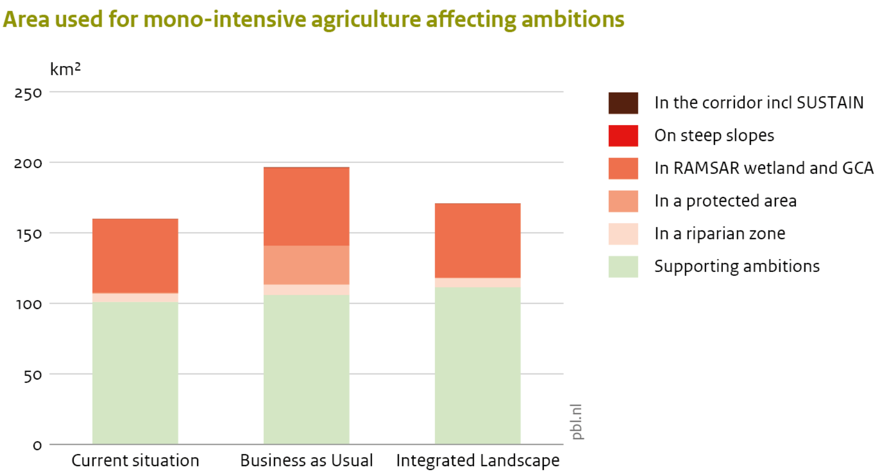
Source: PBL

Under the Integrated Landscape scenario the main challenges were to limit further conversion of RAMSAR wetland area for agricultural production by strong regulation of land use planning including grazing activities, and to improve productivity of existing mixed crop and livestock practices (increases of 2.5% and 1% annually respectively), in order to contribute to producing more on the same amount of land, and therefore only requiring a 5% expansion of the area under cultivation.

Monoculture production

Most mono-intensive agricultural activities consist of the sugar cane fields near Kidatu, around the processing plants of the Kilombero Sugar Company (KSC) and bordering the Magombera Forest, and on the area covered by the Kilombero Limited Plantations (KPL) croplands and neighbouring farmers near Mngeta. The changes under the BAU scenario are not reflecting the original SAGCOT plans for expansion. With current sugar cane processing facilities operating near full capacity expansion mainly depends on the decision to build a new processing plant and how outgrowers can be controlled. With the southern KPL farms more or less locked in between upstream forested areas and downstream remaining wetland there is not much room for area expansion, without compromising progress towards the landscape ambitions. Under the BAU scenario some expansion is projected to take place around Kidatu, causing encroachment of protected areas and the RAMSAR wetland.

Figure 6.6



Source: PBL

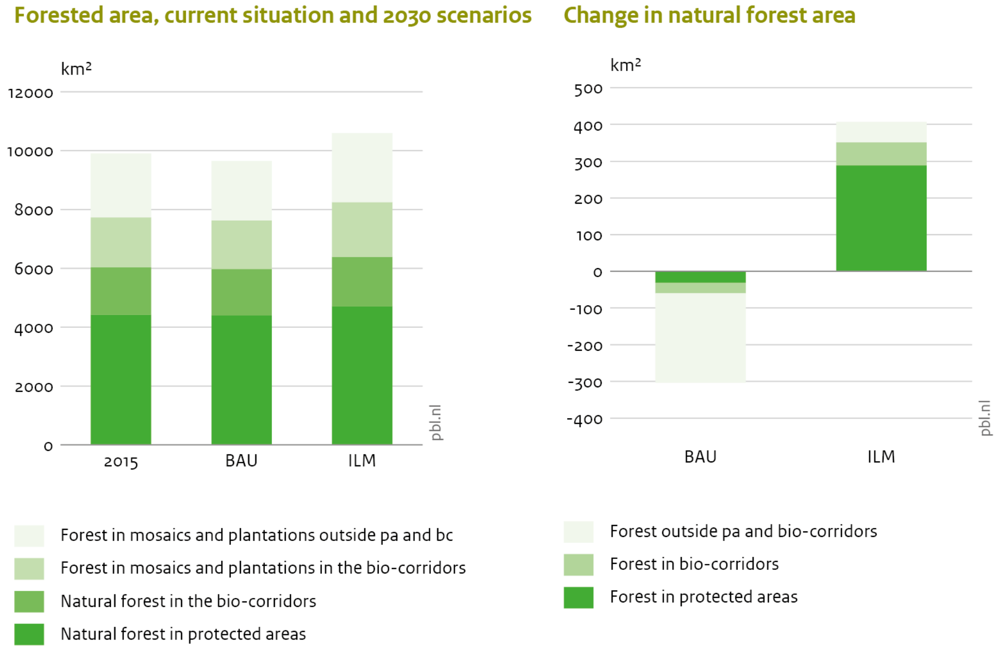
Area under forest cover

The forested area in the landscape is defined as the area covered by natural forest (undisturbed closed and open forest) plus the tree cover contained the mosaic land system classes with mixed crop-livestock and agroforestry systems, like for instance cocoa, and in plantation forest such as managed by Kilombero Valley Teak Company (KVTC). In the analysis we distinguished between forest in protected areas, bio-corridors and forest outside these areas. Here we focus mainly on area covered, while in other sections the difference in terms of biodiversity and naturalness between these different land systems is analysed.

Most deforestation is expected to take place under the BAU scenario (Figure 6.7), mainly due to large expansion of agricultural activities in the valley consuming the remaining isolated pockets of open and closed forest outside of protected areas and bio-corridors. Also in these areas deforestation is taking place, but since most closed forest is located on mountainous regions (like Udzungwa National Park), these forests are less suitable and attractive for conversion to agricultural land, when sufficient shub- and grassland or wetland is still available close by.

Under the Integrated Landscape scenario protected areas and bio-corridors are assumed to be effectively managed and restored and agroforestry is promoted in riparian zones and bio-corridors, all contributing to an increase of forested area within the whole landscape.

Figure 6.7

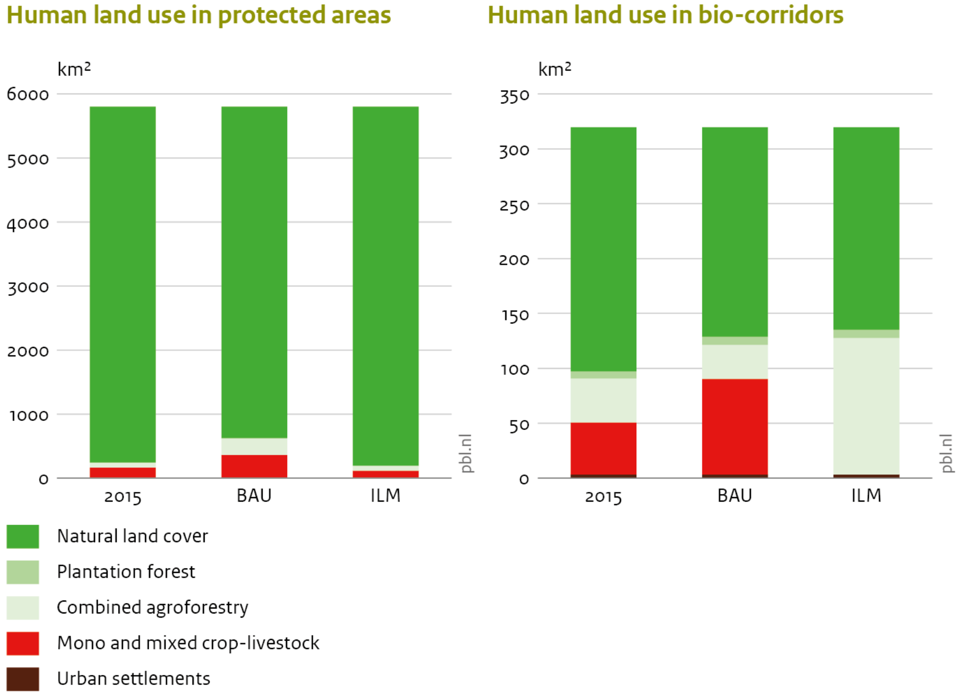


Source: PBL

Protected Areas and bio-corridors

Besides considering Magombera Forest as a protected area, there were no additional areas added to the most recent delineated protected areas dataset for the scenario analysis. From the stakeholder workshop there were mainly suggestions on restoring and improving the supporting role of the Mngeta, Nyangange and Ruipa bio-corridors by focusing on restoring natural areas in combination with the development of suitable agroforestry activities (i.e. mixing cocoa, fruits, timber) and to develop tourism activities around these zones, as described for the Magombera area by Jones et al (2012) and visualized by Bleeker et al (2013).

Figure 6.8



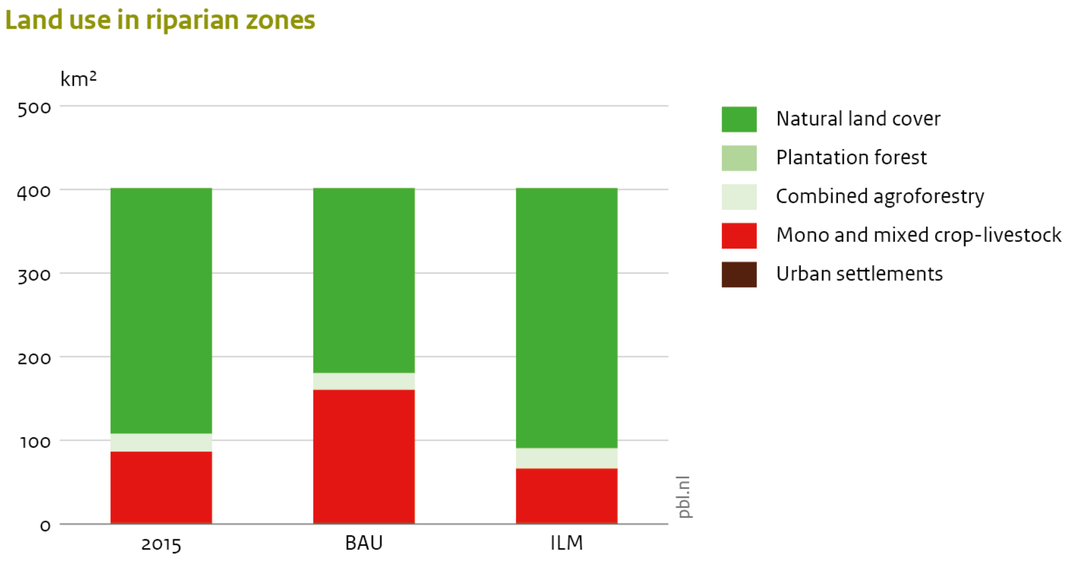
Source: PBL

As shown in Figure 6.8, the applied spatial policies under the Integrated Landscape scenario are clearly able to limit the expansion of more intensive human land use activities and promote the mixed income generating agroforestry activities with a high level of tree cover that support restoring the function of the bio-corridors in the landscape. The policies also prevent further degradation and encroachment of the protected areas, as compared to the increase of intensive agricultural activities, like projected to take place under the BAU scenario.

Land use in riparian zones

In 2015, more than 25% of the area classified as riparian zones was used for more intensive human land use activities that are assumed to have a negative effect on water quality and soil protection. Without any spatial policies or restrictions this is expected to increase under the BAU scenario to 43%, mainly due to the expansion of agricultural activities. The Integrated Landscape scenario is challenged to halt further deterioration by intensive use of riparian zones and to change as many of these undesired practices as possible and promote restoration of natural land cover and/or a shift towards agroforestry practices in this zone, potentially requiring investments in various types of commercially interesting and ecologically sound tree crops.

Figure 6.9



Source: PBL

6.2 Progress towards the Kilombero landscape ambitions

The scenarios of 'Business as Usual' (continuing 2000-2017 trends) and 'Integrated Landscape' have significantly different impacts on the landscape ambitions as defined by the Kilombero stakeholders. Each is summarized in turn below, also recapturing some of the outcomes presented in section 6.1.

Ambition 1: Conservation of forest cover, wildlife and bio-corridors

As shown in section 6.1 the scenarios have different outcomes with respect to changes in natural forest, forested areas in mosaics and the encroachment of human activities in protected areas and bio-corridors in the landscape. Figure 6.10 shows the resulting impacts on biodiversity, expressed as the loss in mean species abundance (MSA), providing an indication of the naturalness of the landscape.

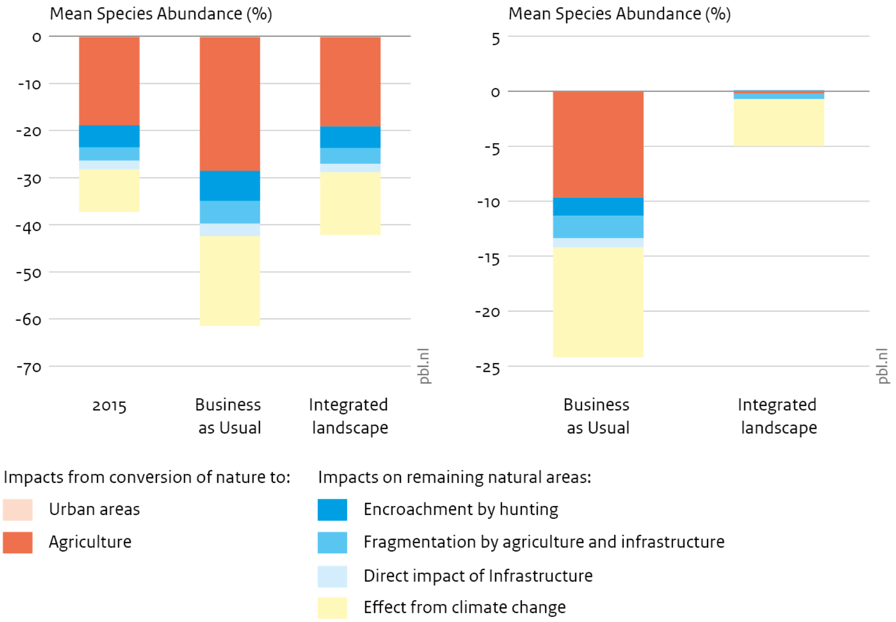
When looking at the whole landscape the current MSA value was 63%, meaning 37% of the original biodiversity in MSA terms has been lost compared an undisturbed pristine situation. For the year 2030, neither none of the scenarios is able to completely halt the loss of biodiversity, which is given the challenges of increasing population, agricultural land use and impacts from climate change a serious challenge. Under the BAU scenario the MSA value strongly declines to 38% while the Integrated Landscape scenario is able to maintain the MSA value at 58%.

Much biodiversity loss is caused by the conversion of natural areas now used for agricultural production and encroachment by hunting in remaining natural areas. Also the impact from climate change, that affects MSA by causing shifts in the distribution ranges of species, is increasing in both 2030 scenarios.

Figure 6.10

Pressures driving biodiversity loss

Change in biodiversity loss compared to current situation



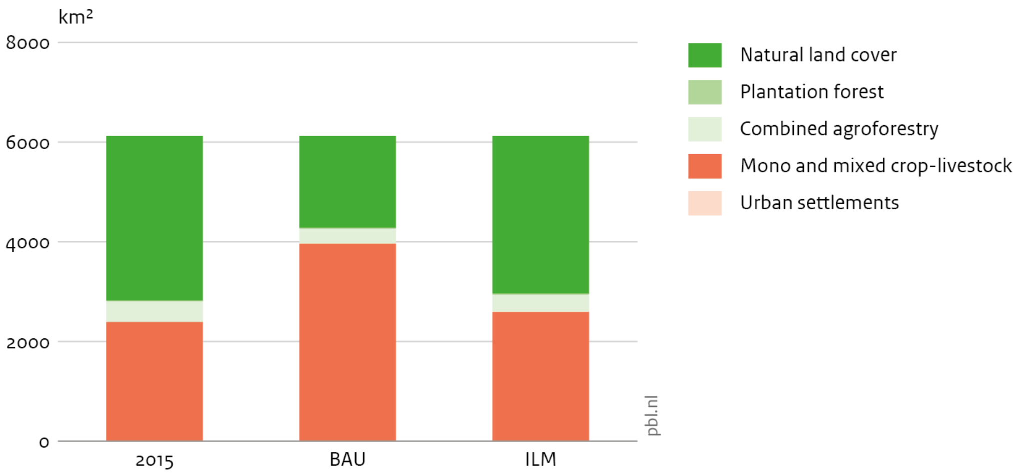
Source: PBL

Nevertheless, the Integrated Landscape scenario is able decrease the rate of loss and even able to prevent 80% of the loss in biodiversity when compared to the BAU scenario. To illustrate the order of magnitude of change, a 1% loss of MSA for the whole landscape, would be equal to converting a 160 km2 pristine and undisturbed closed forest to an urban settlement.

When looking at the combined extent of the RAMSAR wetland and the Game Controlled Area (GCA) the expansion of agricultural practices under the BAU scenario is strongly affecting the natural land cover in this area (Figure 6.11). Under the Integrated Landscape scenario this expansion is halted and agroforestry mosaics are maintained.

Figure 6.11

Human land use in the RAMSAR wetland and GCA zones



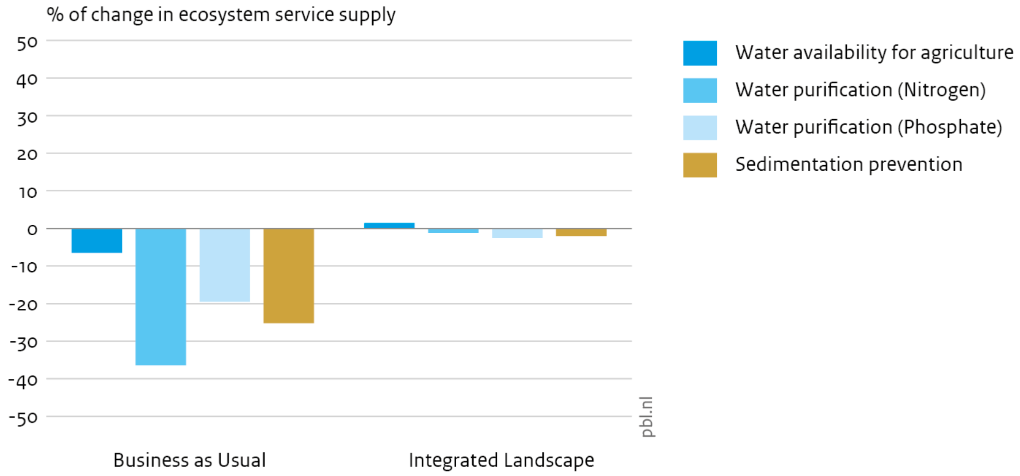
Source: PBL

Ambition 2: Improve water conservation, access and security

Doing the right thing in the right place is especially important when trying to prevent deterioration of water quality (Figure 6.12).

Figure 6.12

Change in water related indicators



Source: PBL

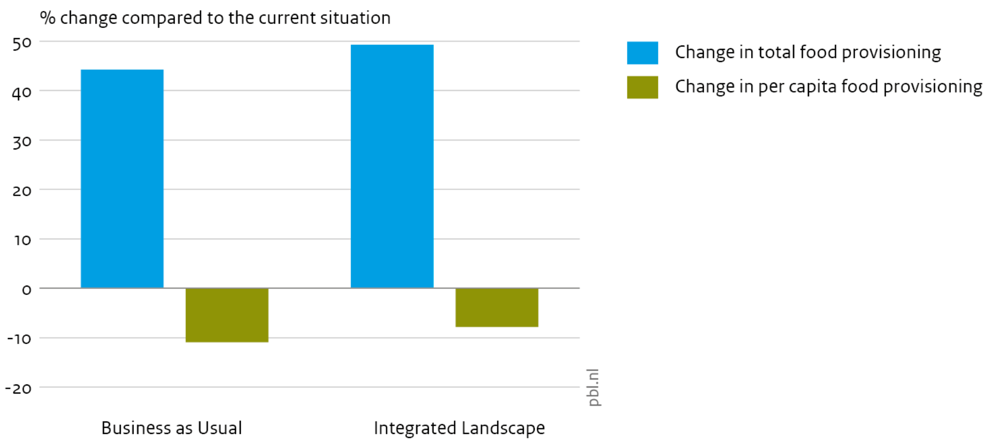
By improving land use in riparian zones, limiting expansion of agriculture on steep slopes and halting further deforestation in upstream areas, like the PES program in the Mngeta region, the Integrated Landscape scenario is the only pathway that is able to prevent large negative changes in water quality, which seriously affect food production in the riparian zones under the BAU scenario. Due to continuing deforestation under the BAU scenario the erosion control function is deteriorating, causing increased sedimentation which could affect the quantity and timing of the flow of water in relation to rain-fed agricultural production.

Ambition 3: Improve livelihoods

Compared to the current situation more food is expected to be produced in the landscape by 2030 (Figure 6.13).

Figure 6.13

Change in food provisioning in the landscape



Source: PBL

Depending on the scenario this will either be achieved by expanding the area under cultivation, often at the expense of natural areas, or by increasing productivity of the current production areas. However, when taking into account the growing population, per capita availability of locally produced food appears to be decreasing under both scenarios, with the Integrated Landscape scenario being able to absorb most of the population increase.

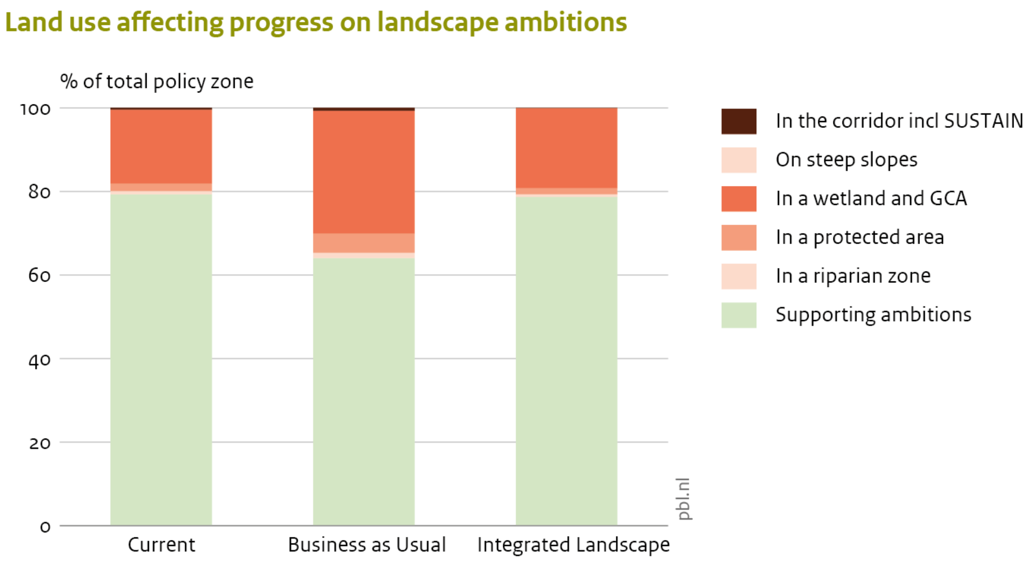
Ambition 4: Improve development on equality, health and gender

Changes in equality, health and gender were not directly outcomes of the modelling tools used, so this remains somewhat difficult to assess. However, some assumptions we implicitly part of the scenario storylines. Improving land use planning and clarity on land ownership could have implications on aspects of equality and gender. Also improvements of water quality (or preventing further deterioration) could also have positive effects on health, for both rural and urban populations.

Ambition 5: Sustainable management of crop/livestock areas

The Integrated Landscape scenario assumes strong territorial planning and collaboration among various organisations (government, NGOs and private sector) in order to successfully implement the various spatial policies.

Figure 6.14



Source: PBL

Together with substantial improvements in agricultural productivity and careful management and regulation of livestock grazing, the Integrated Landscape scenario is able to maintain the current share of 79% of the area being used in a manner that supports the stakeholder ambitions, in contrary to the decline to 64% under the BAU scenario (Figure 6.14). Even under the ambitious Integrated Landscape scenario there is room for improvement, though one should keep in mind both future scenarios are dealing with a 62% increase in population.

Ambition 6: Improve and strengthen governance

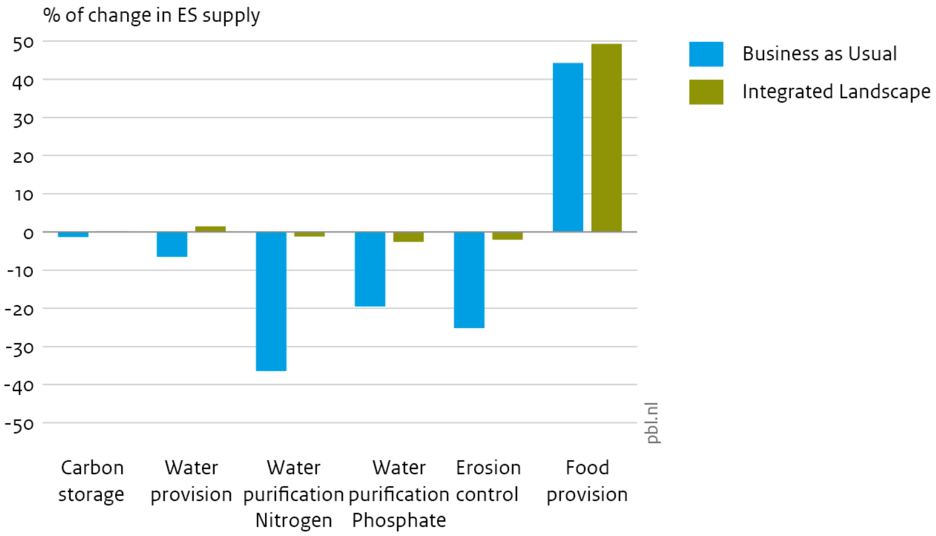
The Integrated Landscape scenario assumes strong territorial planning and collaboration between various organizations (government, NGOs and private sector) in order to successfully implement the various spatial policies. The costs and organization to do so are not explicitly included in the model. This is also so for details on land access and ownership. The National Land Use Planning Commission (NLUPC) attended the workshop and is coordinating the land use planning process, in order to develop spatial land use plans for all villages in Tanzania. We think the policies underlying the Integrated Landscape scenario and its outcomes could potentially be helpful for this process.

6.3 Summary of synergies and trade offs

The ecosystem service components of the landscape models allow a comparison of the provision of ecosystem services under the three scenarios, as shown in Figure 6.15.

Figure 6.15

Change in supply of ecosystem service compared to the current situation



Source: PBL

With respect to the selected SDGs, Figure 6.16 provides an overview of the scenario outcomes on the indicators presented in Table 3.1.

For **SDG2** only the Integrated Landscape scenario is showing a positive change on all indicators, compared to the current situation. With the increasing area in use for food production under both scenarios, also under the BAU scenario food provisioning is increasing. However, the share of food production being sustainable and contributing to the landscape ambitions is only improving under the Integrated Landscape scenario. If food provisioning is translated to per capita change (see Figure 6.13), it is clear the growing population is putting a large demand on the landscape, also given the landscape policies (Figure 2) that limits the space available for options. To cope with this challenge and secure SDG2, it might be that the required agricultural productivity increases need to be even higher than those used under the Integrated Landscape scenario (see Table 5.1), which would require larger investments.

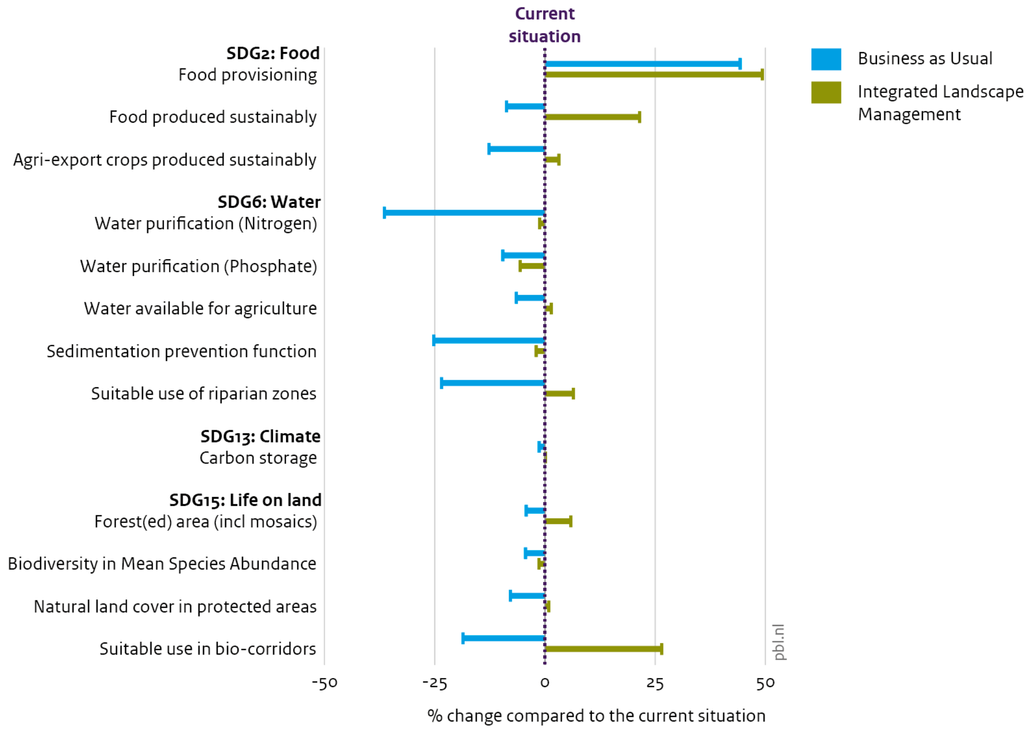
For **SDG6** the implementation of the riparian zone policy, protection of forest and the restoration of the bio-corridors clearly have a positive outcome the water quality and sedimentation prevention function, that controls soil erosion, for the Integrated Landscape scenario. The BAU scenarios are not showing any improvement and will not support the landscape in achieving this SDG. Due to increasing agricultural production the nitrogen and phosphate loads are increasing and affecting water quality most under the BAU scenario.

For **SDG13** only carbon storage was included. The BAU scenario shows a decrease of carbon storage in the landscape due to further loss forest, where also remaining patches of forest already surrounded by agricultural activities will be converted. Under the Integrated Landscape scenario the overall halt on deforestation in forest reserves and national parks minimizes the loss of forest. Also the focus on agricultural mosaics, where tree coverage is maintained or increased, and the protection of riparian zones is resulting in a (very small) increase of the carbon storage function in the landscape under this scenario compared to the current situation.

For **SDG15** the results for the Integrated Landscape scenario are obviously the most optimistic. Given the magnitude of the pressures affecting biodiversity in the landscape it is very promising that the Integrated Landscape scenario is able to reduce the loss in MSA occurring under the BAU scenario by 80%. The other indicators illustrate that under the Integrated Landscape scenario specific focus is on halting further loss of wetlands, forest and effectively protect forest and restore the role of the bio-corridors, also in relation to supporting indicators under SDG2, 6 and 13 as was also shown in section 6.2. This a potential synergy that is clearly turning into a trade-off under the BAU scenario.

Figure 6.16

Impact on selected SDGs under 2030 scenarios compared to the current situation



Source: PBL

7 Conclusions

The experience of the Kilombero landscape scenario modelling study was highly satisfactory for all of the partners, even as many lessons were learned to refine and improve the process for application in other landscapes.

7.1 Value of scenario modelling for strategic planning in the Kilombero landscape

The scenario models' ability to generate insights about the landscape

The modelled findings presented for the BAU scenario in section 6 helped Kilombero focus the stakeholder discussions on their key ambitions and actions for the landscape that will help them to achieve SDGs by 2030. The scenario modelling also suggests that integrated analysis and strategic planning across sectors has real benefits. Some of the key insights that may not have been fully recognized in conventional sector-specific planning include:

Engagement and influence of relevant policymakers

The scenario modelling process demonstrates the importance of public and private land and resource use decisions on a range of economic, social and environmental objectives. When policymakers are actively engaged in these processes they are motivated to clarify their assumptions and expectations around a range of development pathways along with the other landscape stakeholders. Director General of the National Land Use Planning Commission (NLUPC) attended the March workshop and facilitated some of the sessions. His interest was finding more effective ways to develop village and district land use plans throughout Tanzania that synched with the SDGs, and he saw this framework as a potential way to do that.

Linking scenario modelling with other tools

The March workshop was implemented along with the Landscape Investment and Finance Tool (LIFT). LIFT is designed to support stakeholders in translating landscape ambitions into investable ideas and then accessing appropriate sources of finance to fund these investments. By joining these two tools in a single workshop the participants could clearly see how their discussions around landscape ambitions in the scenario modelling component to directly lead to a landscape finance strategy which would help them achieve these ambitions. There are a range of additional tools that are available and others that are under development whose impact can be amplified if used in coordination with scenario modelling. These include tools for assessments of landscape governance, financial sources and flows, as well as systems for landscape-scale monitoring and certification assessments.

Catalyst for the development of a landscape platform

When the scenario modelling process began, while AWF was implementing a variety of activities within landscape there was no landscape scale multi-stakeholder process, no clear vision for what a sustainable Kilombero landscape looks like, or a roadmap for how to get there. The workshop provided an opportunity for them to explore landscape ambitions and to discuss the types of actions that will be needed to achieve them. By the end of the March workshop, which also included on introduction to financial planning, the participants recognized that without a multi-stakeholder platform they would not be able to achieve the ambitions that they had articulated. Therefore, during the last session of the workshop they developed the plan to formalize a landscape platform and made specific commitments for next steps

7.2 Next steps in refining landscape scenario modelling methodology

The methodology developed for landscape scenario modelling found a balance between detail and accessibility, made significant advances in linking land use choices to ecosystem values, and has uniquely framed the achievement of SDGs at a landscape-scale. However, there are a variety of improvements on this process that can be made in the next phase of work. This methodology has also been tested in Honduras and Ghana, and a final synthesis paper on lessons learned will be produced.

The business models that could be generated by landscape stakeholder as a result of the Landscape Investment and Finance Tool (LIFT) process that was introduced immediately following the scenario model sessions, at the same workshop, could provide more rigorous estimates of economic costs and benefits that could be used in subsequent studies. With additional data on average per hectare revenues and labour use from different land use systems, the model results on land use and productivity could be used to roughly compare the impacts of different scenarios on income and employment. Adding data on spatial patterns of poverty and malnutrition could help to illuminate the impacts of investment in different parts of the landscape and different activities on social well-being.

8 References

Asselen, S. and Verburg, P. H. (2013), Land cover change or land-use intensification: simulating land system change with a global-scale land change model. Glob Change Biol, 19: 3648-3667. doi:10.1111/gcb.12331

Benítez-López, A., R. Alkemade, A. M. Schipper, D. J. Ingram, P. A. Verweij, J. A. J. Eikelboom, M. A. J. Huijbregts, (2017), The impact of hunting on tropical mammal and bird populations, Science 14 Apr 2017: Vol. 356, Issue 6334, pp. 180-183, DOI: 10.1126/science.aaj1891

Bleeker, D, Grosso, L and Paskewicz, E. (2013) Magombera Wildlife Corridor and Development Plan, Pennsylvania State University, Stuckeman School, landscape architecture and graphic design. https://stuckeman.psu.edu/studyabroad/tanzania and document at: https://stuckeman.psu.edu/sites/default/files/studyabroad/magombera_wildlife_corridor_and_development_plan_-_2013_student_project.pdf

Denier, L., S.J. Scherr, S. Shames, P. Chatterton, L. Hovani and N.Stam. (2015) Little Sustainable Landscapes Book. Global Canopy Programme: Oxford.

Heiner, et al. Buck Gross Hart Stam. (2017) Public-private-civic partnerships for sustainable landscapes: A convener's guide. EcoAgriculture Partners and IDH-The Sustainable Trade Initiative: Washington, D.C.

Johnson J, Jones S, Wood S, Chaplin-Kramer B, Hawthorne P, Mulligan M, Pennington D, DeClerck F (in prep). Mapping Ecosystem Services to Human Wellbeing (MESH): a new toolkit to support integrated landscape management for sustainable development. In submission process.

Jones, T, Caro, T and Davenport, T (2009) Wildlife corridors in Tanzania, Tanzania Wildlife Research Institute (TAWIRI).

Jones, T, Bamford, A, Ferrol-Schulte, D, Hieronimo, P, McWilliam, N and Rovero, F. (2012) Vanishing Wildlife Corridors and Options for Restoration: A Case Study from Tanzania http://journals.sagepub.com/doi/pdf/10.1177/194008291200500405

Kashaigili (2013) Rapid Environmental Flow Assessment for IRRIP2 Rivers in Kilombero River Basin, Consultancy Report submitted to CDM, Rufiji Basin Water Office, Tanzania.

Kolding, J., Mombo, F., Temu, B., Nyanghura, Q. and Cunliffe, R. (2017) Technical Advisory Services For Biodiversity Conservation And Wetland Management In Kilombero Valley Ramsar Site (Service Contract BTC/TAN094/2015), Kilombero and Lower Rufiji Wetlands Ecosystem Management Project (KILORWEMP)

Ladislaus B. Chang'a, A, Kijazi, L, Luhunga, P, Ng'ongolo, H, Mtongori, H. (2017) Spatial and temporal analysis of rainfall and temperature extreme indices in Tanzania, Atmospheric and Climate Sciences, 7, 525-539. https://doi.org/10.4236/acs.2017.74038

Leemhuis, C, Thonfeld, F, Näschen, K, Steinbach, S, Muro, J, Strauch, A, López, A, Daconto, G, Games, I, and Diekkrüger, B. (2017) Sustainability in the food-water-ecosystem nexus: the role of land use and land cover change for water resources and ecosystems in the Kilombero wetland, Tanzania. Sustainability 2017, 9, 1513; doi:10.3390/su9091513

Lehner, B., Grill G. (2013): Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15): 2171–2186. Data is available at www.hydrosheds.org

Malopola (2006) Ecological and socio-economic impact of changing land use in Kilombero valley, Tanzania, master thesis, Sokoine University of agriculture, Tanzania

Msinde, J, Urassa, J and Nathan, I. (2016) Off-farm employment and income poverty in favourable agro-climatic areas of Tanzania: evidence from Kilombero Valley, Developing Country Studies, ISSN 2224-607X (Paper) ISSN 2225-0565, Vol.6, No.6, 2016

Nindi, S, Maliti, H, Bakari, S, Kija, H, Machoke, M (2014) Conflicts over land and water resources in the Kilombero valley floodplain, Tanzania, African Study Monographs, Suppl. 50: 173–190

Milder J, Buck L, Hart A and Scherr S (2013). The SAGCOT greenprint: a green growth investment framework for the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), EcoAgriculture Partners, Washington D.C.

Rowhania,P, Lobellb, D, Lindermanc, M and Ramankuttya, N. (2011) Climate variability and crop production in Tanzania, Agricultural and Forest Meteorology 151, 449–460

SAGCOT (2011). Southern Agricultural Growth Corridor of Tanzania: Investment blueprint. SAGCOT, Dar es Salaam.

Scherr, S. J., Shames, S., & Friedman, R. (2012). From Climate-Smart Agriculture to Climate-Smart Landscapes. Agriculture & Food Security, 1, 12.

Schipper, A., Bakkenes, M., Meijer, J., Alkemade, R., Huijbregts, M. (2016) The GLOBIO model. A technical description of version 3.5., PBL Netherlands Environmental Assessment Agency, The Hague, PBL publication number: 2369

Sharp, R., Tallis, H.T., Ricketts, T., Guerry, A.D., Wood, S.A., Chaplin-Kramer, R., Nelson, E., Ennaanay, D., Wolny, S., Olwero, N., Vigerstol, K., Pennington, D., Mendoza, G., Aukema, J., Foster, J., Forrest, J., Cameron, D., Arkema, K., Lonsdorf, E., Kennedy, C., Verutes, G., Kim, C.K., Guannel, G., Papenfus, M., Toft, J., Marsik, M., Bernhardt, J., Griffin, R., Glowinski, K., Chaumont, N., Perelman, A., Lacayo, M. Mandle, L., Hamel, P., Vogl, A.L., Rogers, L., Bierbower, W., Denu, D., and Douglass, J. (2018). InVEST +VERSION+ User's Guide. The Natural Capital Project, Stanford University, University of Minnesota, The Nature Conservancy, and World Wildlife Fund.

Thaxton M. et al. (2015). Landscape Partnerships for Sustainable Development: Achieving the SDGs through Integrated Landscape Management. Landscapes for People, Food and Nature initiative (LPFN).

Wilson, E, McInnes, R, Mbaga, DP and Ouedraogo, P. (2017) Kilombero Valley, United Republic of Tanzania, Ramsar Site No. 1173, Ramsar Advisory Mission Report.

Wood, Sylvia, Sarah K. Jones, Justin A. Johnson, Kate A. Brauman, Rebecca Chaplin-Kramer, Alexander Fremier, Evan Girvetz, Line J. Gordon, Carrie V. Kappel, Lisa Mandle, Mark

Mulligan, Patrick O'Farrell, William K. Smith, Louise Willemen, Wei Zhang, Fabrice A. DeClerck, (2018) Distilling the role of ecosystem services in the Sustainable Development Goals, Ecosystem Services 29 (2018) 70–82.

9 ANNEXES

9.1 Data sources used in modelling

Data source	Description of usage
Census and district level data and projections: Tanzania Bureau of Statistics: http://www.nbs.go.tz/	Population data, current and 2030 projections at district level Administrative boundaries for regions, districts and wards
AWF/ABCG/CIAT consortium ESA Sentinel2 base landcover 2016 via RCMD: http://geoportal.rcmrd.org/layers/servir%3Atanzania_sentinel2_lulc2016	Land cover/use
FAO, Harmonized World Soil Database, Fischer, G., F. Nachtergaele, S. Prieler, H.T. van Velthuizen, L. Verelst, D. Wiberg, 2008. Global Agro-ecological Zones Assessment for Agriculture (GAEZ 2008). IIASA, Laxenburg, Austria and FAO, Rome, Italy. http://www.fao.org/soils-portal/soil-survey/soil-maps-and-databases/harmonized-world-soil-database-v12/en/	Soil characteristics used for suitability layers for CluMondo
Lehner, B., Grill G. (2013): Global river hydrography and network routing: baseline data and new approaches to study the world's large river systems. Hydrological Processes, 27(15): 2171–2186. Data is available at www.hydrosheds.org	Watersheds, check for comparison with other data.
Oak Ridge National Laboratory, LandScan	Population counts and density per 30 arcsecond (~1x1km) raster used in CluMondo suitability layers
WorldClim, Robert J. Hijmans, Susan Cameron, and Juan Parra, at the Museum of Vertebrate Zoology, University of California, Berkeley, in collaboration with Peter Jones and Andrew Jarvis (CIAT), and with Karen Richardson (Rainforest CRC): http://www.worldclim.org/	Global mean annual temperature and precipitation rasters at 30 arcsecond resolution, used in CluMondo suitability layers
World Database on Protected Areas (WDPA), 2017, UN Environment and the International Union for Conservation of Nature (IUCN): http://www.protectedplanet.net	Protected areas used for forest reserves and RAMSAR sites
Global forest watch,Hansen, M. C., P. V. Potapov, R. Moore, M. Hancher, S. A. Turubanova, A. Tyukavina, D. Thau, S. V. Stehman, S. J. Goetz, T. R. Loveland, A. Kommareddy, A. Egorov, L. Chini, C. O. Justice, and J. R. G. Townshend. 2013. "High-Resolution Global Maps of 21st-Century Forest Cover Change." Science 342 (15 November): 850–53. http://www.globalforestwatch.org	Global treecover timeseries data (2000-2014) on a 30m resolution. Used for re/deforestation estimation and analysis
NASA, JPL, SRTM, Farr, T. G., et al. (2007), The Shuttle Radar Topography Mission, Rev. Geophys., 45, RG2004: https://lta.cr.usgs.gov/SRTM1Arc	Global relief data at 90m resolution, used for elevation and slope suitability layers in CluMondo
GRIP Global roads: Meijer, J.R., Huijbegts, M.A.J., Schotten, C.G.J. and Schipper, A.M. (2018): Global patterns of current and future road infrastructure. Environmental Research Letters, 13-064006. Data is available at www.globio.info	Global database of road infrastructure. Data used in CluMondo and GLOBIO models.
Tanzania Ministry of Agriculture, livelihood baselines: http://www.kilimo.go.tz/index.php/en/resources/category/	Agricultural and other district level statistics.

tanzania-livelihood-baseline-profiles Agricultural suitability maps: http://www.kilimo.go.tz/index.php/en/maps	

9.2 Land systems classification procedure