GUIDELINES FOR ECOSYSTEM-SERVICE BASED URBAN PLANNING IN TANZANIA

Maximilian Petzold, Julia Bass, Leena Karrasch, Michael Kleyer

The "Guidelines for ecosystem service-based urban planning in Tanzania" have been prepared as part of the research project ECOSOLA ("Ecosystem-based solutions for resilient urban agriculture") that was conducted between 2017 and 2020. ECOSOLA involved partners from the University of Dar es Salaam, Tanzania, the Nelson Mandela University of George, South Africa, the University of Oldenburg, Germany and Planungsgruppe Grün GmbH, an environmental consultancy firm from Northwest-Germany. The project was funded by the German Federal Ministry of Education and Research (BMBF) and the German Academic Exchange Service (DAAD).

Authors, affiliation and contact details:

Maximilian Petzold
Planungsgruppe Grün GmbH
Rembertistr. 30
D-28325 Bremen, Germany
petzold@pgg.de, maxpetzold@posteo.de

Julia Bass
Institute of Evolutionary Ecology and Conservation Genomics
Ulm University
Albert-Einstein-Allee 11
D-89081 Ulm, Germany

Leena Karrasch
Centre for Environment and Sustainability Research
University of Oldenburg
Carl von Ossietzky Str. 9-11
D-26129 Oldenburg, Germany

Michael Kleyer
Landscape Ecology Group
University of Oldenburg
Carl von Ossietzky Str. 9-11
D-26129 Oldenburg, Germany

Suggested citation:

Petzold, M., Bass, J., Karrasch, L. & Kleyer, M. (2021): Guidelines for ecosystem service-based urban planning in Tanzania. E-Book (https://ecolution-africa.org/documents/)

Online available: https://ecolution-africa.org/documents/

ISBN: 978-3-00-070396-6 (E-Book)

Contents

List of figures

List of tables

List of boxes

Executive summary

Cities all around the globe provide enormous socio-economic and cultural opportunities, in combination with high availability of public services. These factors attract ever more people to live in urban centres. In Tanzania and many other African countries, this development is of extraordinary pace. For example, the population of Dar es Salaam, the largest city in the country, grew from 2.5 million in 2002 to almost 4.4 million in 2012, which adds up to an annual growth rate of 5,6 %. The rapid urbanization outpaces the capacities of urban planning authorities in Tanzania to adequately steer the future development of cities and their peri-urban fringes. As a consequence, two fundamentally important aspects for the successful implementation of plans are often not well considered: (1) benefits the urban population can draw from a diverse natural environment and (2) stakeholder integration into the planning process.

The missing attention to potential benefits and threats of the natural environment in and around urban areas often creates problems for growing cities, ranging from environmental degradation and biodiversity loss, through pollution and the lack of green spaces, to environmental hazards, a shortage of natural resources and ecological services, as well as poor public health. Insufficient stakeholder participation during the planning process often has negative effects on the acceptance of plans among crucial actors. This complicates implementation and might even cause failure of development projects.

As a contribution to tackling the aforementioned problems, these guidelines seek to increase the capacities of urban planners in Tanzanian government authorities and in the private sector by providing tools for an ecosystem service-based urban planning approach.

"Ecosystem services" refer to the direct and indirect benefits human populations derive from the ecosystems in a landscape. Depending on the predominant abiotic conditions, the composition of the plant, animal and fungal communities, major land use activities and interactions between these components, each ecosystem has specific capacities for the provision of different ecosystem services. These can be categorized into three main types: provisioning, regulating and cultural services. Provisioning services are direct material products obtained from ecosystems such as food, drinking water, forage, firewood, or fibres. Regulating services are the benefits obtained from the regulation of ecosystem processes such as climate regulation (e.g. clean air), natural hazard regulation (e.g. erosion control), water purification, and pollination. Cultural services include non-material benefits that people obtain from ecosystems, such as spiritual enrichment, intellectual development, recreation and aesthetic values.

In the context of urban development, it is important to note that the term 'ecosystems' is not restricted to pristine natural systems, but instead often refers to managed and cultivated land that is more or less influenced by human activities. Even within cities, several ecosystems exist, such as parks, roadside trees, hedgerows, private gardens, streams, ponds and beaches. These 'urban ecosystems' can provide a wide range of crucial ecosystem services for the urban communities.

Even though, compared to rural life, urban life is much less related to the natural environment, it is still heavily dependent on ecosystem services. For example, food production, provision of drinking water, air filtering, microclimate regulation and sites for recreation are essential to sustain the health and livelihoods of city populations. Due to the high density of built-up infrastructure in cities, the space for ecosystems with adequate capacity for the provision of the required ecosystem services is extremely limited, particularly in sub-Saharan Africa. Consequently, a substantial share of the ecosystem services that benefit urban populations must be obtained from peri-urban and rural areas.

This dependency is considerably higher where urban ecosystems are severely degraded or widely absent. Under these circumstances, the rural and peri-urban fringes remain the only sources for the ecosystem services required in these cities. The enormous demand for resources and services often causes the exploitation of surrounding ecosystems, strong environmental degradation and loss of biodiversity.

These problems can be mitigated if the potential benefits of urban ecosystems are considered in the urban planning and development processes. As a way forward, planning authorities should develop comprehensive physical plans to guide the spatial and temporal urban development, while minimizing environmental risks and safeguarding the ecosystem services that the present, undeveloped landscape can provide.

The legal framework that governs urban planning in Tanzania is mainly determined by the Urban Planning Act, 2007. It directs the major tasks to planning authorities at the District level and has established major planning tools to be applied at the regional (‘general planning schemes’) and local levels (‘detailed planning schemes’). As one of the guiding principles, the Urban Planning Act requires planners and developers to ensure an environmentally sustainable urban development. In this context, several amendments have been added to the Urban Planning Act that provide references and specifications for the integration of environmental issues into urban planning. Furthermore, consideration of environmental issues in urban planning and development is required by the regulations of the Environmental Management Act, 2004. In spite of the existing legal background, implementation of environmentally sustainable urban development in Tanzania is still challenging.

A planning process that adequately considers the needs of urban communities for different ecosystem services should pass the following steps:

- Identification of areas suitable for future urban development as well as of ecologically sensitive areas where any development should be banned
- Collection of environmental and ecological data in the planning area
- Spatially-explicit assessment of ecosystem services provision and risks of natural hazards in the planning area, based on expert evaluation and local stakeholder knowledge
- Development of a draft plan under consideration of potentials for ecosystem service provision
- Stakeholder consultation and revision of the draft plan; approval of the final plan
- Implementation

The application of this planning process has been tested in a case study area in Vikawe, a village in Kibaha District at the north-eastern boundary of Dar es Salaam. The study was conducted between 2017 and 2019 as part of the research project “Ecosystem-based solutions for resilient urban agriculture” (ECOSOLA). The results and experiences from the exemplary planning process in Vikawe provided a major basis for the development of these guidelines. They are used to illustrate the theoretical explanations of each planning step.

In the first step, the peri-urban and rural fringes around growing cities are screened for ecosystems and land use systems with high capacities for providing crucial ecosystem services. In order to avoid the loss of ecosystem services that cannot be substituted by urban ecosystems, ecologically sensitive areas that provide a multitude of ecosystem services as well as fertile agricultural land should be spared from urban development. Furthermore, areas with high risks for natural hazards, such as flood-prone flats along streams and at the coast, or erosive steep slopes, should be identified. Even though setting up urban infrastructure in hazardous land is not impossible, it commonly requires specific measures and induces high costs. Accordingly, areas without significant ecological and environmental value and with low natural hazards risk should be delineated as corridors for future urban growth.

Once a planning area for an urban development project has been delineated, a survey of the present environment has to be conducted, which should be as detailed as possible. Firstly, this involves the compilation of all relevant environmental and ecological data that are already available. These comprise, for instance, topographic maps, satellite imagery, geological and soil maps, climate data and vegetation maps. Secondly, a comprehensive habitat mapping must be conducted, to determine the distribution of different ecosystems and landscape elements in the planning area. This can be carried out using the mapping manual and the habitat mapping key for Dar es Salaam and Coast Regions that are part of this guideline. Additionally, field mapping of further biodiversity data, such as the distribution and species composition of mammal, bird, reptile and amphibian communities, as well as the sampling of abiotic conditions, such as soil properties, are recommended, to complement the information required for the assessment of ecosystem services provision.

Commonly, local residents in a planning area possess comprehensive knowledge about their environment. Utilizing this knowledge in planning processes brings several opportunities. For example, local stakeholders can significantly contribute to identifying those ecosystem services that are of high relevance for local livelihoods and to map the distribution of these ecosystem services in the planning area. However, this information can only be gathered if local stakeholders are integrated into the planning process. Additionally, stakeholder participation can contribute considerably to building awareness and acceptance of development projects among local communities, and therefore fosters successful implementation.

Based on the ecological and environmental data collected in the field, as well as the information provided by local stakeholders, ecologists and environmental planners assess the provision of all relevant ecosystem services in each part of the planning area.

The information on the configuration of the natural environment in the planning area and its capacity to provide various ecosystem services are then implemented into a draft planning scheme for the proposed urban development. Areas with high value for the provision of ecosystem services are integrated into the new settlement. For example, forests and woodlands can be transformed into parks and green spaces for leisure and recreation, or set aside as conservation areas or firewood reserves. Wetlands and floodplains can be used as water-retention spaces for the supply of water and to protect settlement areas from flooding. Fertile land can be allocated to urban farming and gardening, in order to support the food supply of the city population. Moreover, potential hazard risks are considered in the planning scheme. For example, floodplains are kept clear of inadequate infrastructure and measures are taken to prevent excessive erosion on slopes.

The draft planning scheme should be revised in consultation with the local stakeholders to identify issues that have not yet been sufficiently incorporated. Upon approval of the final planning scheme, it should be made public, in order to support proper implementation.

The tools provided in these guidelines assist urban planning experts in Tanzania to execute the different steps for ecosystem service-based urban planning as described above. However, what remains is the challenge of implementing approved planning schemes. Due to the lack of public funds for urban development projects, planning authorities in Tanzania are dependent on private investors or international development corporations such as the World Bank. These guidelines assist planning authorities in integrating environmental and ecological aspects into urban planning processes and can therefore help to ensure compliance with the standards for environmentally sustainable development of cities that have been set by many international investors.

Introduction and outline

There is a growing need for principles that guide decision makers in Tanzania towards sustainable urban development. To ensure environmentally sustainable urban development and resilience to climate change, this guidebook provides a framework to identify, protect and manage the natural environment of cities, including their biodiversity, land and natural resources. Strengthening environmental and socio-economic resilience, enhancing mitigation of and adaption to climate change contributes in the long term to human security and well-being.

This guidebook does not deal with mobility-related, architectural, infrastructural or engineering aspects of urban planning. Instead it covers ecological aspects of urban planning, specifically the provisioning of food, energy, drinking water, regulation and maintenance of biogeochemical fluxes, and protection of wildlife, the so-called ***ecosystem services***. One of the main reasons for developing this guidebook is the limited experience with ecosystem service-based urban planning in many developing countries. Our aim is to provide best-practice guidance for the preparation of ecosystem service-based urban development plans, including directions for the assessment of the ecological state of planning areas and the participation of stakeholders.

Even though specifically prepared for application in Tanzania, the tools presented in this guidebook can also be applied in other parts of the world. Special foci were developed on habitat mapping as a tool to quantify and map the provisioning of ecosystem services, and on participatory approaches to integrating local stakeholders' environmental knowledge and their preferences for future urban development into urban planning processes. The audience addressed by this guidebook comprises a broad range of stakeholders concerned with urban development, including individuals in governmental institutions, non-government organizations, and the private sector.

Ecosystem-service based urban planning is an integrative and participatory decision-making process addressing competing interests in land use. Urban and environmental planning policies at national, regional and local levels need to be reconciled with the interests of the relevant stakeholders. This guidebook aims to support the United Republic of Tanzania in developing new urban settlements and improving existing neighbourhoods by providing best practice guidance. It is designed to help decision makers to identify and learn techniques, practical knowledge and the necessary skills for environmentally sustainable urban planning that minimizes negative environmental impacts and increases benefits from ecosystem services.

Adapting urban planning and incorporating ecosystem services is gaining more importance, as growing populations and economies drive urban development, particularly in African countries. Increasing effects of climate change, including more extreme weather events with extended heat waves and heavy rainfall, reinforce this need.

Although this guidebook is focussing on urban development projects, most of the tools and methods presented here can also be applied to planning of large infrastructure projects, such as roads, railways, power plants, dams, waterways or harbour constructions.

The guidebook is divided into four thematic parts:

Part I outlines the challenges of urbanization, introduces the concept of ecosystem services and describes the legal framework for urban and environmental planning in Tanzania.

- **Chapter 1** discusses major challenges for urban development related to rapid urbanization and urban sprawl. It explains how urban communities rely on resources and services emerging from ecosystems and how urban development can benefit when ecosystem services are considered in planning processes.
- In **Chapter 2**, the legal framework for urban planning in Tanzania is analyzed, with particular consideration of regulations which demand sustainable environmental management and promotion of ecosystem services in urban development.

Part II describes how ecosystem services and stakeholder participation can be integrated into urban planning processes.

- **Chapter 3** presents the general structure of planning processes that consider ecosystem services and stakeholder preferences.
- **Chapter 4** points out the importance and benefits of stakeholder involvement in planning processes and provides a set of participatory planning tools.
- **Chapter 5** describes how information on ecosystem services and stakeholder preferences can be implemented into planning schemes.

In **Part III**, different options to access environmental background data are outlined and methods for the collection of ecological data in the field are explained.

- **Chapter 6** provides an overview over the necessary geographical background data for urban planning projects and the sources from which it can be obtained.
- **Chapter 7** lists field methods for the collection of environmental and ecological data.

Part IV provides a detailed habitat mapping catalogue for Dar es Salaam and Coast Regions that can be applied in planning projects as well as for other purposes.

The practical implementation of the tools for ecosystem service-based urban planning is illustrated by examples from a case study that was conducted in the village Vikawe (Kibaha Municipality, Coast Region) between 2017 and 2019 (Box 1).

Each tool presented in this guidebook makes a significant contribution to effective and successful ecosystem service-based urban planning. Consequently, planning projects should aim to make use of all the tools presented. Nevertheless, in cases where time and financial resources for urban planning projects are limited, it can be reasonable to focus only on a subset of the described tools. As such, selection of approaches should be undertaken on a case-by-case basis, accounting for local conditions, financial and time budgets.

Finally, this guidebook provides a detailed description of a model layout plan for the case study area in Vikawe, Kibaha District, Tanzania. A particular focus was set on practical solutions for the promotion of various ecosystem services and the prevention of environmental problems in urban planning schemes. This helps the reader to transfer the theoretical knowledge from the previous chapters into practice.

The guidebook makes clear that appropriate knowledge of the specific site conditions is a highly important prerequisite for successful urban planning. The more information about project areas is available, the more effective and integrated urban plans can be. It should be noted that the techniques described often need specific knowledge. Hence, a degree of scientific and technical guidance and assistance for urban planners from organizations with a well-developed science and technological base is likely to benefit urban planning in general and to support appropriate implementations of individual techniques.

Box 1: The ECOSOLA project and the case study area Vikawe

Throughout this guidebook, the reader will find boxes with examples from a case study to illustrate the guidelines. This case study was conducted as part of the project "Ecosystem-based solutions for resilient urban agriculture" (ECOSOLA) that was funded by the German Federal Ministry for Education and Research (BMBF) and the German Academic Exchange Service (DAAD). The project was a collaborative project involving the University of Oldenburg in Germany, the Nelson Mandela Metropolitan University of George in South Africa, the University of Dar es Salaam, and the Planungsgruppe Grün GmbH, an environmental consultancy firm based in Bremen, Germany.

The case study area is located in the village Vikawe, which belongs to the Kibaha Municipality in the Coast Region (Pwani) of eastern Tanzania (Fig. 1). The case study area has a total size of 239 ha and is located between latitudes 6°29′ - 6°40′ S and longitudes 39°03′ - 39°04′ E, most of the area lying at altitudes below 100 m (Fig. 1). In 2012, Kibaha Town had a population of 128,488 and an estimated annual growth rate of 5 % (2012 Population and Housing Census, NBS & OCGS 2013), which gives a current estimate of about 190,000 inhabitants. The majority of the residents in Vikawe are small-scale farmers cultivating cashew nuts, mango, cassava, rice and vegetables. Some people also practice animal husbandry, including poultry farming, and keeping cattle and goats.

Vikawe was selected as the case study area due to its rural character. Urban development had not commenced there and there were still various intact ecosystems which provided crucial services. This was a good basis for the exemplary ecosystem service-based urban planning project.

The study area in Vikawe directly borders on Kinondoni District of Dar es Salaam City and has been heavily influenced by urban sprawl during the study period. Plots of land had been sold, vegetation had been cut and houses were built. Due to its adjacency to Dar es Salaam, Kibaha District is facing rapid growth and major urban challenges in managing social and economic changes within the municipality.

Box 1 (continued)

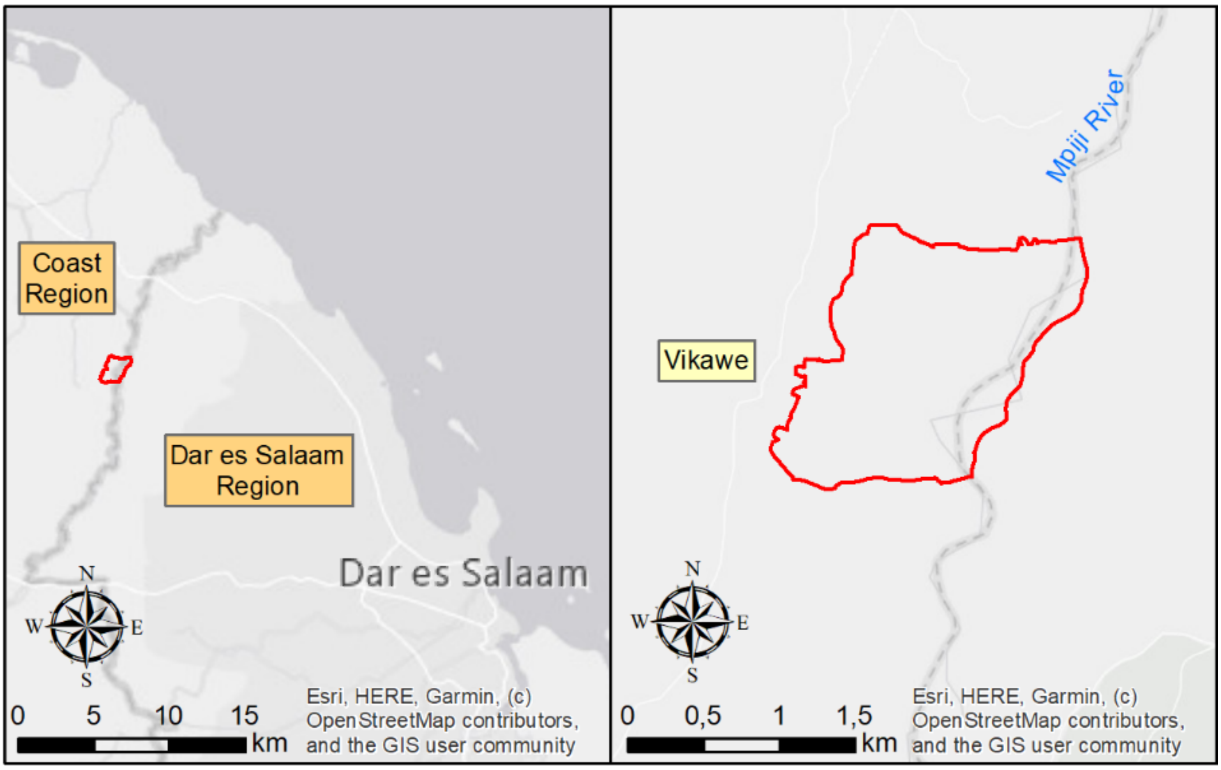

Fig. 1: Location of the case study area. Left: Overview of Coast and Dar es Salaam Region with the study area indicated in red. Right: Detailed map extract of the study area with the village Vikawe and the Mpiji River.

Part I: Background to urbanization and ecosystem services, and the urban planning framework

1 Background

1.1 Urbanization and urban sprawl

1.1.1 Problem statement

In Africa, urbanisation and urban sprawl are described as “megatrends of the 21st century”(Kukkonen *et al.* 2018). Unpredictedly rapid urbanization has been taking place in many parts of the world and it is anticipated that the pace of urbanisation will accelerate in the next few decades and that by 2050, two thirds of the world’s populations will be living in metropolitan centres (United Nations 2019). Especially on the African continent, economic growth, industrialization, and mass migration from countryside to cities has led to rapid urbanization and urban sprawl. A striking example is Dar es Salaam on the coast of eastern Tanzania, which is expected to reach the “megacity” status of 10 million inhabitants before 2030 (United Nations 2018).

The rapid physical expansion of urban areas on the African continent, often outpaces institutional urban planning capacities. Consequently, urban development processes are only partly controlled by the responsible government bodies. To a significant extent, urbanization is characterized by unregulated encroachment of settlements in the peri-urban fringe. In Tanzania, and particularly in Dar es Salaam, the phenomenon of informal settlement is not limited to slums for low-income residents, but – on the contrary – many sites are informally occupied by those belonging to middle- to high-income classes (Bhanjee & Zhang 2018).

Informal settlements commonly lack both security of tenure, and social and physical infrastructure (Rudic 2016). Apart from the socio-economic challenges, a number of environmental problems thus arise. Due to missing institutional guidance, informal urban sprawl often leads to fragmentation of landscapes, destruction of ecosystems, biodiversity loss and a waste of fertile agricultural land. As a result, the need for natural resources and services, such as the provision of food and water or the availability of natural sites for recreation, cannot be sufficiently met. Additionally, informal settlements often face environmental problems like pollution and are prone to natural hazards, including flooding and landslides.

Since growth and development of cities are likely to continue during the next decades, the problems related to informal urbanization processes need to be urgently resolved.

1.1.2 Urban sprawl

The growth of cities in the developing world is often dynamic, diverse and disordered – and increasingly land- and space-intensive, with the space taken up by urban localities increasing faster than the population itself (UNFPA 2007). This rapid urbanization requires large amounts of land and often adversely affects agricultural land in the urban periphery, which is converted into urban land use. Urban sprawl, also referred to as urban decentralization, is the physical outward expansion of cities, which is characterized by relatively low population densities and takes several forms. These are: (1) low-density development, with low-rise buildings, largely due to cheap land prices in the periphery; (2) strip or ribbon development, with transport arteries or corridors driving development; (3) uncontrolled outward development, with unregulated outward expansion due to weak planning and zoning regimes, and (4) leapfrog development, with urban development "jumping" over greenbelts and other growth boundaries (Fig. 2).

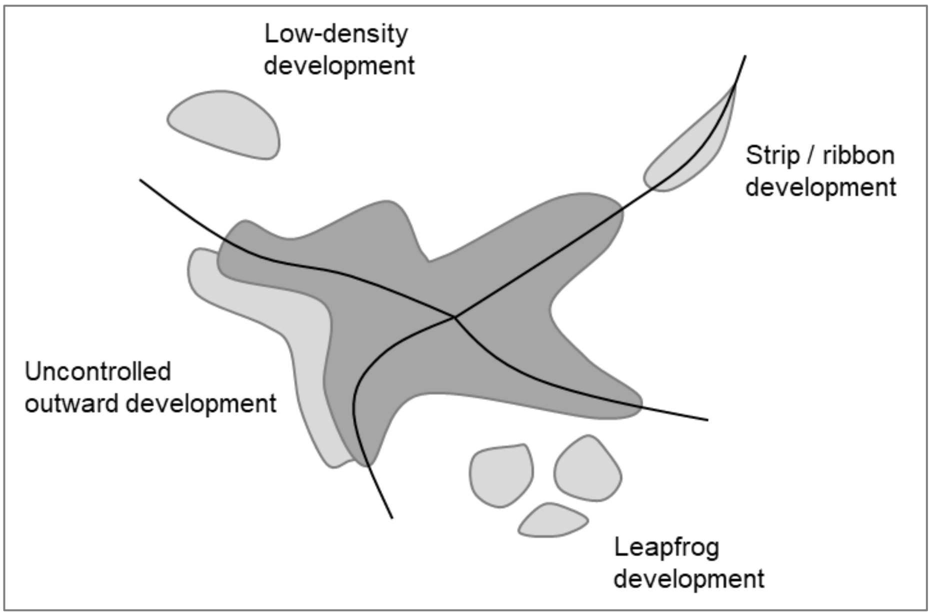

Fig. 2: Forms of urban sprawl

There are three main, broad causal and sometimes interrelated factors accounting for sprawl: natural evolution, flight from blight and the effects of land speculation. Natural evolution points to the fact that cities represent hubs of economic activity – people move from the countryside to the city in search of better employment and economic opportunities. This leads to an increase in size well beyond the limits of the city and a natural tendency for the outward expansion of cities. Thus, urban sprawl is not the result of a market system out of control, but follows an orderly natural growth process. Flight from blight means that decentralization of urban areas is to some extent driven by the repelling factors of higher tax rates, higher crime rates, crumbling infrastructure, poorly performing public schools, and a greater presence of the poor and lower class in central or inner-city neighbourhoods. Lastly, land speculation on urban sprawl is prevalent in cities of the developing world that have weak land markets and urban governance systems. This leads to a situation in which developers, who need land for housing and other productive activities, must find land far away from the city centre and the urban built-up area.

Urban sprawl entails many environmental, social and economic costs (see Fig. 3). The environmental costs include the loss of land, which is a limited resource. Sprawl has directly contributed to the degradation and decline of natural habitats, such as forests, woodlands and wetlands. It also reduces farmland and open spaces, and generally leads to the loss of flora and fauna. Increasing demand for roads is a crucial contributor to landscape fragmentation by a process of perforation, dissection, and isolation of ecosystems and species' populations. Fragmentation is seen as a major cause of the alarming loss of species all over the world. It is difficult to preserve large open spaces in low-density developments where the emphasis is on subdividing every piece of land, thus leaving little space for community use, recreation or basic services (Frank & Engelke 2001).

The economic costs of urban sprawl are driven by the low population densities at the peripheries in comparison to established economic centres and the separation of uses into distinct areas. This increases both demand for transportation and public-service costs. Sprawl leads to land use patterns that are unfavourable for the development of sustainable and efficient transport systems, but instead favour duplicative infrastructure at higher costs to society and a lack of choice in modes of travel.

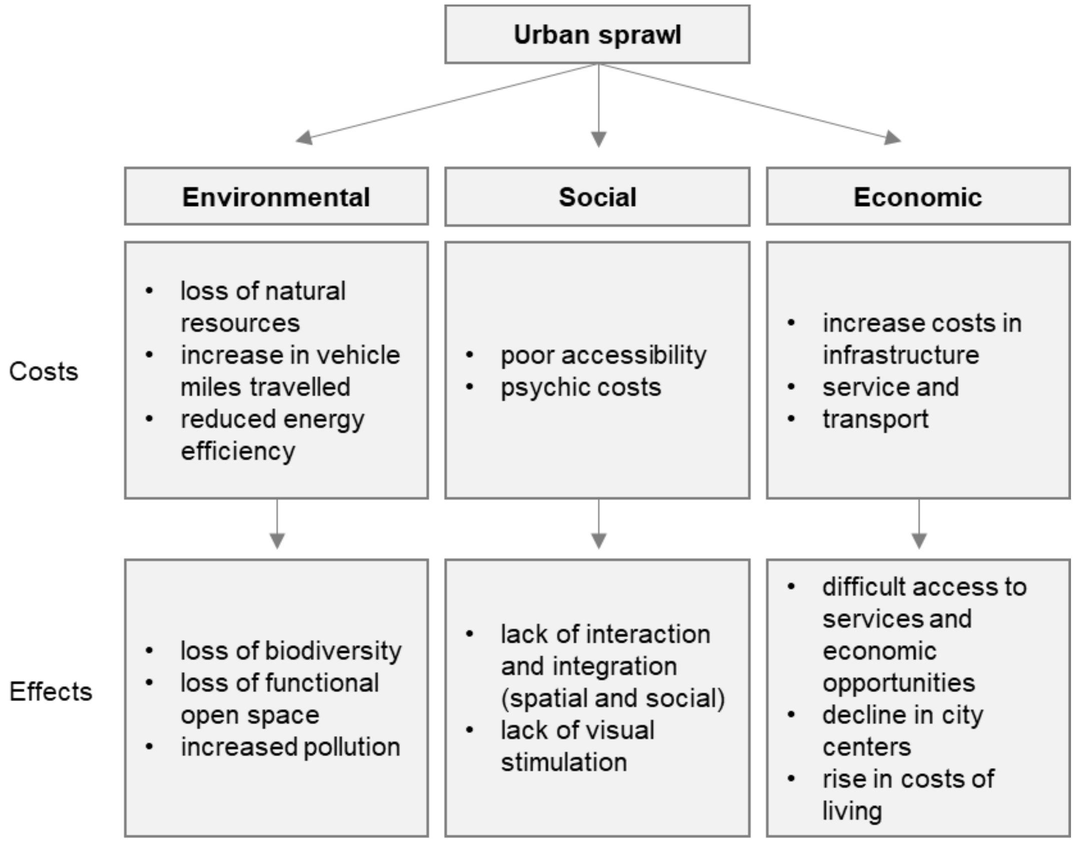

Fig. 3: Environmental, social and economic costs and effects of urban sprawl

1.1.3 The way forward

Against the background of the ongoing urban growth of most cities in Tanzania and beyond, institutionalized urban planning needs to be strengthened, to redirect the uncontrolled urban sprawl into sustainable development pathways. Sustainable urban development focuses on fostering adaptive capabilities and creating opportunities to maintain or achieve desirable social, economic and ecological systems for both present and future generations. It is a complex approach that integrates environment, society and economy with the objective of establishing self-sustaining progress. It is also often described as a potential pathway for achieving environmental conservation and stimulating socio-economic development at national, regional and local levels. Sustainable development should ensure that human development is consistent with the sustainable use of the natural and environmental resources. Such an understanding can help improve people’s welfare, ensure effective urban management and protect natural environments. There are many social, economic and infrastructural measures fostering sustainable urban planning. Here, we focus on environmental issues and on the services that landscapes could provide to the urban population. In order to consider these aspects, planning authorities should develop comprehensive physical plans to guide spatial and temporal urban development, while minimizing environmental risks and safeguarding the ecosystem services provided by the present rural landscape. This should take place before urbanization actually starts. It comprises a comprehensive survey of the environment, with its most relevant biotic and abiotic components, as well as stakeholder participation to identify conflicts between current and future land uses, and to increase public acceptance.

1.2 Ecosystem services

1.2.1 Definition of ecosystem services

“Ecosystem services” refer to the direct and indirect benefits that human populations derive from ecosystems. Ecosystems can be defined as networks of organisms responding to and affecting the environmental conditions in a specific area (e.g. energy, consumable resources such as water and nutrients or food, and non-consumable environmental factors such as temperature, salinity, disturbance and pH). In practice, ecosystems are often used as synonyms for habitats, landscape elements, or land cover units, i.e. any visibly different section of the earth’s surface, ranging from woodland to creek, orchard, field or garden. Each ecosystem is a habitat of certain plant and animal species. Each ecosystem also has different functions regarding water cycling (rainwater infiltration, water storage, evapo-transpiration), nutrient cycling (uptake, accumulation, storage and removal of nutrients) and carbon cycling (carbon sequestration, decomposition and storage as peat or humus). These functions translate in a range of services and benefits for the society, which can be categorized into three main types: provisioning, regulating and cultural services (Millennium Ecosystem Assessment 2003; UK National Ecosystem Assessment 2011; Haines-Young & Potschin 2018). Provisioning services are direct material products obtained from ecosystems such as food, drinking water, forage, firewood or fibres. Regulating services are the benefits obtained from the regulation of ecosystem processes, such as climate regulation (e.g. clean air), natural hazard regulation (e.g. erosion control), water purification and pollination. Cultural services include non-material benefits that people obtain from ecosystems, such as spiritual enrichment, intellectual development, recreation and aesthetic values. Cultural services also include the conservation of species and habitats for ethical reasons and for the experience of future human generations.

Ecosystem services can be available at a local, regional or global scale, according to the scope of the problem they are connected to and the possibility of transferring the service from its origin to the places where humans benefit from it. Such a transfer can take place both by man-made transport and by natural means (e.g. atmospheric transport). Easily transferred services with a global scope, like CO_2 sequestering, do not necessarily have to be provided close to the source of the problem. Services that are impossible to transfer should, however, be generated close to where they are needed (e.g. noise reduction, endemic species in rare habitats). Other services connect landscapes over larger scales. For instance, surface water provision depends on the physical state of catchment areas in which rain infiltrates into the soil, the groundwater flux and the state of the zone where groundwater exfiltrates into a river or lake.

1.2.2 Urban ecosystems services

While urbanization continues to increase worldwide, urban people continue to depend on nature. Cities are dependent on the internal ecosystems as well as on the ecosystems in surrounding rural areas. However, there are often no clear boundaries between different ecosystems. Here we use the term urban ecosystems for all natural green and blue areas in the city. Some important ecosystems within the urban area are street trees, hedgerows, parks, lawns, agricultural land and private gardens, wetlands, lakes/sea, and streams (see Habitat mapping key in Part IV). Street trees can be stand-alone trees, often surrounded by paved ground. Parks are managed green areas with a mixture of grass, shrubs and trees. Cultivated land and gardens are used for growing fruits and vegetables. Wetlands consist of various types of marshes, floodplains and swamps. Lakes/sea refers to open water areas while streams refers to flowing water. Some urban ecosystems originate during urbanization, such as lawns, urban gardens and parks, whereas others were already part of the former rural landscapes and either became enclosed or were transformed during urbanisation. Examples of enclosed ecosystems are streams and adjacent floodplains, ponds, wetlands, bush- and woodlands on steep slopes, orchards, or small-scale farms. Transformed ecosystems are, for example, sports grounds on former pastures, parks in former orchards or hedgerows used as property boundaries.

Ecosystem services with specific relevance to urban areas in Tanzania are:

1. **Food production.** Urban dwellers often depend solely on food production outside of the city, which leaves households dependent on local markets. Urban farming makes households less dependent on commercial food and market prices and gives people the opportunity to increase food security and access, combat malnutrition, and increase household income. Food production includes crops, spices, fruits and vegetables, as well as forage for reared animals. It also includes fish and other animals caught in ponds and rivers.
2. **Firewood production.** Most urban households in Tanzania rely on firewood or charcoal for cooking. The high demand for wood leads to exploitation of woodlands and forests in the urban fringes, which often results in degradation of these ecosystems and declines in wood production. Therefore, the forested areas from where firewood is supplied to cities commonly are far away (often more than 100 km).
3. **Drinking water.** People in Tanzanian cities often require local sources of drinking water, such as rainwater collected in cisterns, surface water fetched from rivers or lakes, or groundwater extracted through wells. This water must be unpolluted and available in sufficient amounts year-round. To ensure provisioning of such drinking water, the respective catchment areas have to be managed sustainably. For example, pristine vegetation should be preserved, use of fertilizers and biocides on farmland should be restricted and sewage should be treated appropriately.
4. **Medicines and other materials from plants.** Parts and extracts of wild or cultivated plants, such as leaves, roots, oil, resin and dye, are used as medicines and natural remedies, or for spiritual and religious purposes.
5. **Air filtering.** In cities, air pollution from traffic or industries is a major environmental and public health problem. Vegetation can reduce air pollution, whereby the reduction is primarily caused by vegetation filtering particles from the air. Higher leaf area increases filtering capacity, hence trees have a stronger effect than bushes or grass. Evergreens are

superior to deciduous trees, as they do not shed during dry seasons when the air quality is usually worst. However, some species might be sensitive to air pollution, leaving a mix of species as the best option. Additionally, the location and structure of vegetation is important for the ability to filter. Thick vegetation may simply cause turbulences in the air, while a thinner cover may let the air through and thus filter it more efficiently.

6. **Micro-climate regulation, at the street and city level.** Local climate and even weather are affected by the city. Differences between cites and the surrounding country-side include increased air temperature, and reduced solar radiation and wind speed. This phenomenon, sometimes called the urban heat-island effect, is caused by the large areas of paved, heat-absorbing surfaces of buildings and roads, in combination with high amounts of energy use in cities. Ecosystems in urban areas, both water bodies and vegetated areas, help to reduce these differences. Trees use heat energy to drive the transpiration process and thus lower surrounding temperatures. They also reduce the local temperature by shading.
7. **Noise reduction.** Noise from traffic and other sources creates health problems for people in urban areas. While distance to the noise emitter is one key factor, another is the character of the ground. Soft lawn decreases the noise level more than concrete pavement. Shrubby vegetation or trees decrease noise levels even more.
8. **Rainwater drainage and storage, and flood protection.** The built-up infrastructure, with concrete and tarmac covering the ground, alters water flow. A large proportion of rainfall becomes surface-water run-off. This results in increased peak-flow discharges and degraded water quality through the uptake of urban street pollutants. Additionally, groundwater recharge is impaired as water runs off. Vegetated areas can contribute to a solution of these problems in multiple ways. The soft ground of vegetated areas allows water to seep through and recharge groundwater. Furthermore, the vegetation takes up water and releases it into the air through evapo-transpiration. This affects the local climate and the groundwater levels. Excess rainwater, potentially leading to hazardous flooding, can be temporarily stored in wetlands and used during dry periods. Mangroves, reeds and gallery forests along rivers also minimize the risk of hazardous floods by slowing currents and providing water infiltration zones.
9. **Erosion control.** Cleared, unvegetated surfaces, especially on slopes, face the risk of erosion. This removes nutrients and reduces fertility of the area, and leads to eutrophication of nearby rivers. Particularly dense grassy and herbaceous vegetation can counteract this process for multiple reasons. The roots of grasses and herbs stabilize the soil, while their shoots and leaves decrease shear forces of surface water. Vegetation also increases infiltration capacity, which decreases surface run-off and its erosive effects.
10. **Sewage treatment and minimizing eutrophication in water.** Large cities face the problem of taking care of sewage. Nitrogen and phosphorous, originating from the natural decomposition of organic sewage in streams, contribute to nutrient enrichment of the surrounding water ecosystems, leading to algal blooms. Wetlands can be used to treat sewage water. The wetland plants and animals can assimilate large amounts of nutrients and slow down the water flow, thereby increasing organic particle settlement.
11. **Pollination.** Many plants relevant to nutrition, fibre, forage etc., rely on pollination by insects and bees in particular. Deploying beehives in vegetated urban areas increases the abundance

of bees and consequently pollination of plants. As an additional service, honey can be collected.

12. **Recreational and well-being values.** People living in cities need space for recreation and cultural activities. Urban ecosystems, as well as natural ecosystems in the urban fringe, provide aesthetic and cultural values to the city and give structure to the landscape. In addition, the appearance of fauna, e.g. birds and fish, should be accounted for in recreational values. Green spaces are also psychologically very important and increase the physical and mental well-being of urban citizens.
13. **Spiritual and holy places, cultural heritage, and identity.** Most landscapes now under urbanisation pressure have been inhabited for centuries or even millennia. Former generations have imprinted their cultural marks in the landscape of today. They used landscape structures for religious activities, as cemeteries, initiation grounds or holy places. Disturbing or even destroying these places in the process of urbanisation can mean hardship and emotional distress for the local population. On a wider scope, certain landscape features can stand as symbols for all the efforts that former generations have undertaken to cultivate the landscape for their livelihoods. The preservation of such heritage elements is important for the people´s identity, identification and land care.
14. **Preservation of wild plants and animals.** Nature conservation efforts often neglect urbanized landscapes. However, parks as well as gardens, trees with fruits, orchards, hedgerows, open vegetated areas, ruderal sites and abandoned areas in cities can host an enormous diversity of plant and insect species. Many monkey, bird and bat species are adapted to urban environmental conditions and their populations should be preserved for the joy and experience of current and future generations.

1.2.3 Benefits of integrating ecosystem services into urban planning

Ecosystem services build an important basis for human health, nutrition, shelter and other aspects of livelihoods. This applies particularly to urban areas with their high population densities, even though many of the habitats within cities that provide these services are barely noticed. An environmentally sustainable development of cities that supports the livelihoods of all their inhabitants can only succeed if the provision of relevant ecosystem services is promoted.

The first step has to be taken in the process of urban planning, since it determines the direction and design of urban development. If ecosystem services are disregarded in development plans, valuable habitats on undeveloped land may be destroyed by the construction of roads and buildings, and existing potential to establish beneficial urban ecosystems may be gambled away. In urban environments, the restoration of habitats to provide ecosystem services that have been lost is challenging and often impossible. Apart from environmental difficulties (pollution, soil sealing, reduced water availability, extreme micro-climate, habitat fragmentation, etc.), restoration efforts are impaired by the scarcity of available land, high land prices and conflicting interests.

To avoid this situation, planners should preserve and integrate existing habitats that provide crucial ecosystem services into urban development plans. Furthermore, they should identify potentials and needs for the establishment of new urban ecosystems like parks, gardens or roadside trees. If urban ecosystems are conserved and established right from the start of urban development processes, they become valued components of the new neighbourhoods. Furthermore, the potential for future ecosystem service provision in cities is maximized when intact ecosystems are conserved and when sites with favourable environmental conditions are reserved for agriculture or for the establishment of parks and other "artificial" habitats.

The integration of ecosystem services into urban planning requires in-depth knowledge of their availability in the undeveloped, peri-urban or rural landscape. Moreover, the preferences and needs of the resident rural population and the future urban inhabitants for specific ecosystem services have to be identified. This guideline provides the methodological basis for the collection of the necessary environmental and ecological data, for the evaluation of the capacities for ecosystem services provision, and for the assessment of stakeholder preferences.

2 Urban planning framework

2.1 Legal and institutional framework for urban planning in Tanzania

Urban development in Tanzania is governed by a set of national laws, regulations and local bylaws. The most relevant and comprehensive legislation on urban planning is provided by the Urban Planning Act and the Land Act. This chapter seeks to provide a rough overview over these two acts and their relevance for urban development processes.

2.1.1 Urban Planning Act

Scope

The most important and comprehensive law to regulate urban development processes in Tanzania is the Urban Planning Act, 2007. The Urban Planning Act, with its subsequent regulations and guidelines, defines the policy and institutional framework for urban planning in the country, stipulates the layout of the planning process, and regulates the acquisition of land in urban areas.

Urban planning procedures and responsible government authorities

Each urban planning process is initiated by the joint efforts of a local planning authority and the Minister responsible for urban planning, resulting in the declaration of a planning area (§ 8 UrbPlAct). Within each planning area, urban planning is organized hierarchically in two consecutive procedures. At the regional, city-wide level urban development and re-development are coordinated through **general planning schemes** (§§ 9-14 UrbPlAct). The urban development at ward- and neighborhood-level is controlled by **detailed planning schemes** (§§ 15-27 UrbPlAct).

For each step to prepare, review and implement urban planning schemes in Tanzania, the Urban Planning Act prescribes responsible government authorities (see Table 1).

Table 1: Urban planning authorities in Tanzania and their responsibilities

Government authority	Responsibilities
Minister for Lands, Housing and Human Settlements Development (§ 5 UrbPlAct)	– declaration of planning areas (§ 8 UrbPlAct) – publication of approved general planning schemes – control and enforcement of incorporation of the principles for urban planning according to § 3 UrbPlAct into plans at all planning levels
Director of Urban Planning (§ 6 UrbPlAct)	– review and approval of planning schemes – monitoring and evaluation of their implementation – coordination of research on urban planning – preparation of guidelines for urban planning – development of standards for the most appropriate uses of land
Regional secretariats	– link between planning authorities and Director of Urban Planning – review of planning schemes prepared by planning authorities and submission to the Director of Urban Planning – recommendation of planning areas

Government authority	Responsibilities
Planning authorities at the Municipal level (§ 7 UrbPlAct)	– prepare, review and implementation of general and detailed planning schemes – recommendation of planning areas

General planning schemes

The purpose of general planning schemes is to "*coordinate sustainable development of the area to which [they relate]*". They have to "*promote health, safety, good order, amenity, convenience and general welfare*" and to facilitate an efficient development process (§ 9 (1) UrbPlAct). Furthermore, general planning schemes are supposed to "*provide for proper physical development*" and to "*secure suitable provision*" of relevant infrastructure, public services and urban land uses (§ 9 (2) UrbPlAct). To this effect, general planning schemes represent the regional planning level at which relatively large planning areas are structured into different zones with individual land use preferences, to organize their long-term future development.

The process of preparing and implementing general planning schemes, as well as specifications of their main content, are determined in the "*Guidelines for the preparation of general planning schemes and detailed planning schemes for new areas, urban renewal and regularization*" (GPPS) (United Republic of Tanzania 2007). The following information on forms of general planning schemes, as well as the preparation and implementation process, have been extracted from these guidelines.

There are two major approaches for the preparation of general planning schemes in Tanzania: (i) Master Plans and (ii) Strategic Urban Development Plans (SUDPs). Master Plans are distinct land use plans that provide a long-term spatial vision for the development of the respective municipality. However, the preparation of Master Plans often lacks stakeholder involvement and therefore risks overlooking important sectoral issues. In contrast, SUDPs comprise extensive participation of stakeholders in the planning and implementation process but their outputs often lack the explicitness of future land use plans. As a way forward, the GPPS proposes preparing general planning schemes by combining the advantages of Master Plans and SUDPs. The steps that have to be taken to prepare general planning schemes are illustrated in Fig. 4.

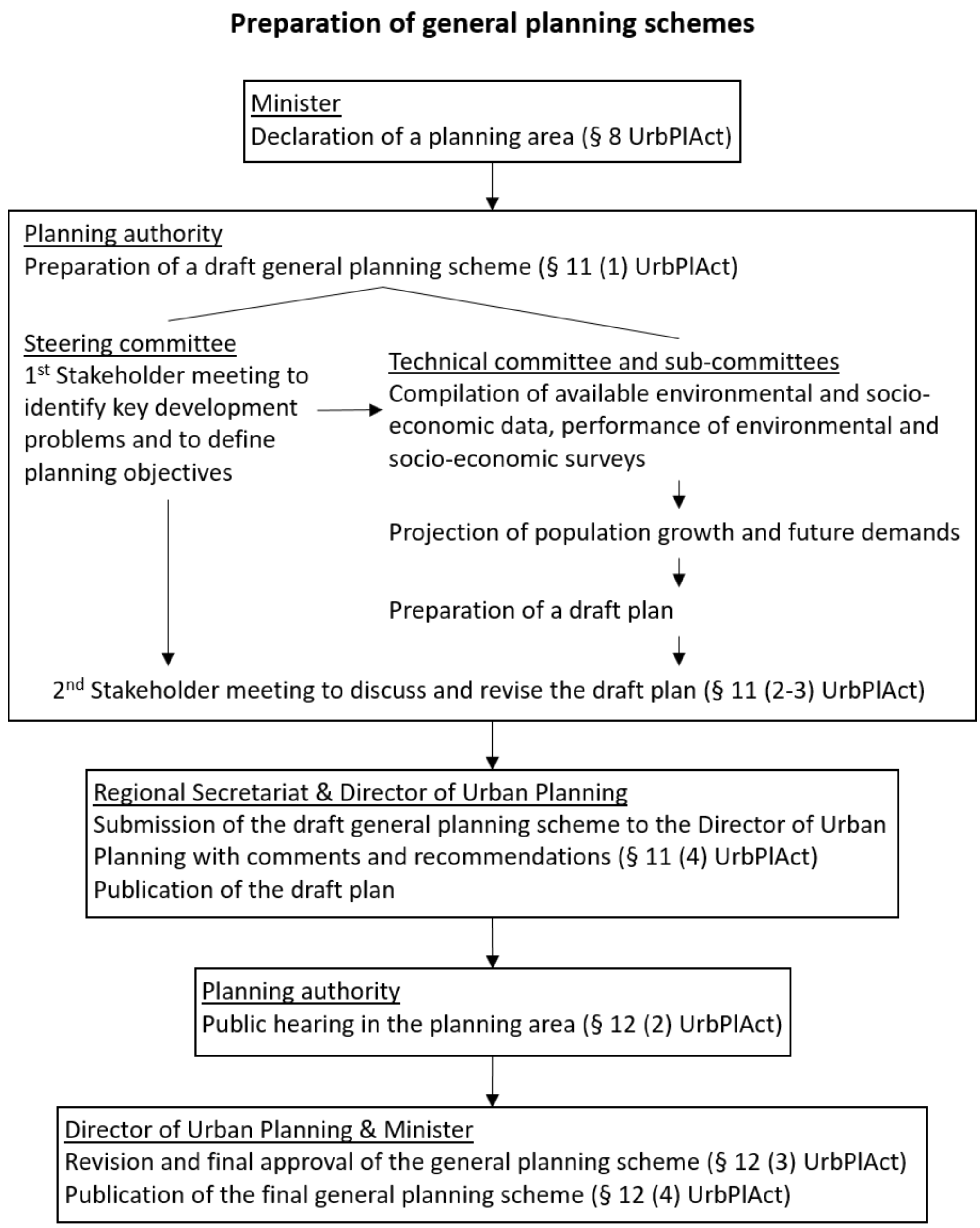

Fig. 4: Preparation of general planning schemes according to the GPPS and the Urban Planning Act

The implementation of approved general planning schemes lies in the responsibility of the Planning Authorities (§ 40 UrbPlAct). In order to facilitate the realization of general planning schemes, the GPPS promote stakeholder participation and partnerships with the private sector. In order to translate a general planning scheme to the specific development at plot scale, the Planning Authorities have to prepare detailed planning schemes (see next section).

Detailed planning schemes

The Urban Planning Act prescribes detailed planning schemes to manage development at neighbourhood- and plot-scale. The main purpose of detailed planning schemes is to "*coordinate all development activities, to control the use and development of land*" (§ 16 (1) UrbPlAct). They are "*physical development schemes*" for undeveloped land as well as for renewal or re-development of built-up areas (§ 16 (2) UrbPlAct).

Detailed planning schemes are demand-driven (§ 15 (4) UrbPlAct) and are prepared by one or more (collaborating) Planning Authorities (§ 15 (1 & 3) UrbPlAct). As long as they "*conform to the general planning scheme*", land holders are also authorized to prepare detailed planning schemes for their own land, even if the Planning Authority has already prepared a detailed planning scheme (§ 15 (2) UrbPlAct).

In general, each detailed planning scheme has to comply with the superior general planning scheme of the respective area (§ 15 (5) UrbPlAct). Nevertheless, Planning Authorities are entitled to prepare detailed planning schemes "*within a planning area notwithstanding that a general planning scheme has not been prepared*" (§ 15 (1) UrbPlAct). This regulation enables Planning Authorities to keep pace with the development needs of rapid urban growth in cases where the completion of the respective general planning scheme is delayed. This approach, however, might cause a number of problems. When detailed planning at the local scale is not embedded into a general planning scheme on a regional scale, coordination between different detailed planning schemes is complicated. This fosters the formation of unsystematic mosaics of individual urban development strategies that may fall short of implementing regional planning objectives like the development of suburban centres or infrastructure networks. Therefore, Planning Authorities should put concentrated efforts into the completion of general planning schemes, to facilitate the coordination of urban planning at local levels.

The procedure for preparing detailed planning schemes (see Fig. 5) does not differ much from general planning schemes. It is governed by § 19 UrbPlAct and details concerning the individual planning steps are provided by the GPPS (United Republic of Tanzania 2007).

Each detailed planning scheme shall contain a layout plan with accompanying detailed cluster plans and 3D-models, as well as a report that provides information concerning problems in the target area, objectives of the scheme, the present environment, population, land use and economic base, and the requirements for future land uses (Second Schedule UrbPlAct, United Republic of Tanzania 2007).

Approved planning schemes "*have the force of law*" (§ 18 UrbPlAct). The Planning Authorities have the duty to enforce planning schemes (§ 42 UrbPlAct) and are therefore mandated to control the development of land in accordance to the approved planning schemes (§ 28 UrbPlAct). In this respect, the Planning Authorities decide on applications for consent to develop land, which developers are required to obtain. Planning Authorities are supposed to disapprove consent to develop land if proposed developments do not conform to approved schemes and, additionally, they shall withhold consent for proposed developments which "*may render abortive any scheme in course of preparation*" (§ 41 UrbPlAct).

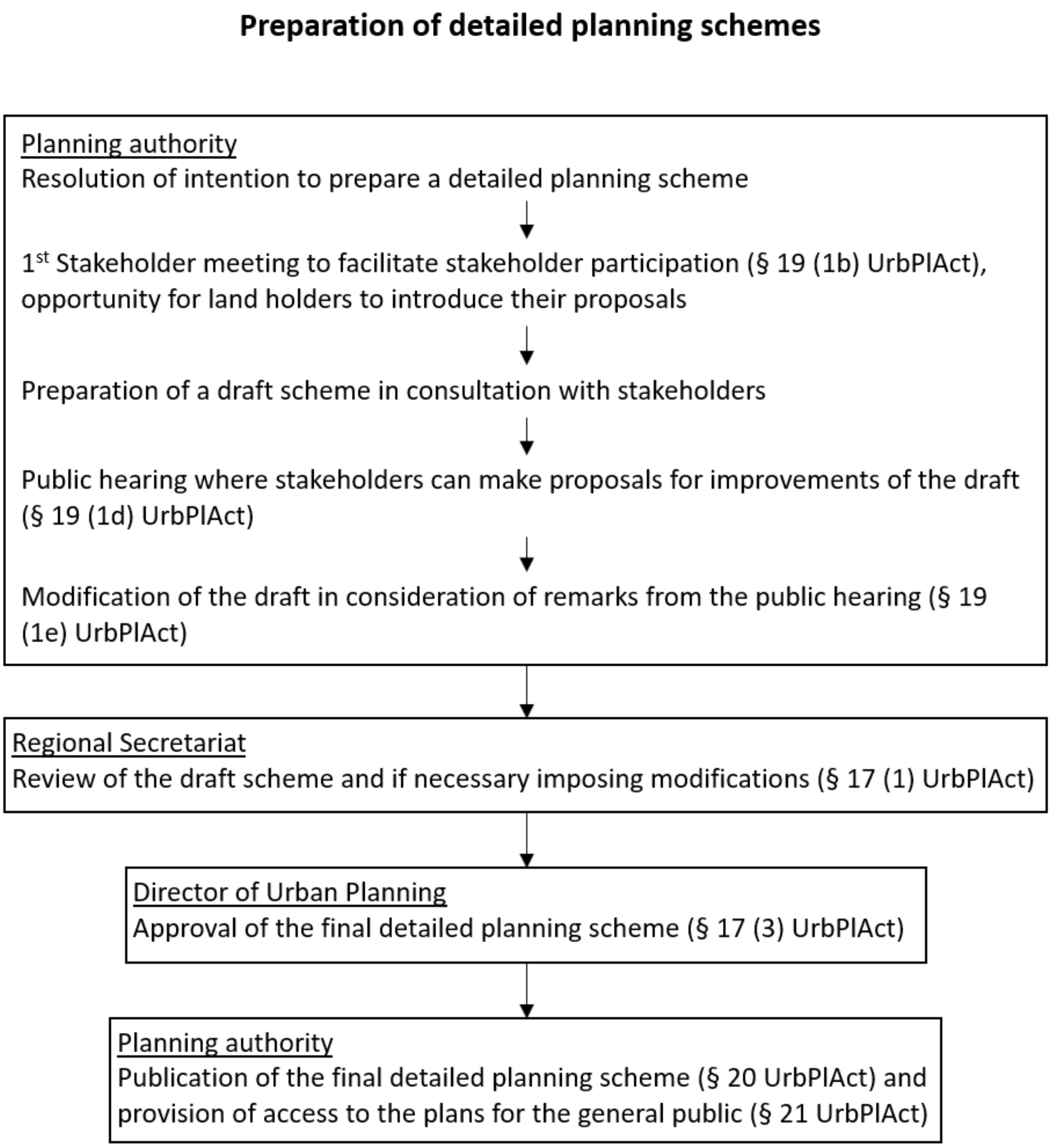

Fig. 5: Preparation of detailed planning schemes according to the GPPS and the Urban Planning Act

Schemes of regularization and urban renewal schemes

In informal settlements and other areas where unplanned development is taking place, **schemes of regularization** can be prepared to readjust plot boundaries and the urban fabric, register land occupancy, provide lawful land titles, improve deficient infrastructure networks and provide for better access to public services. Schemes of regularization are special types of detailed planning schemes that are regulated by § 23 UrbPlAct and §§ 56-60 Land Act.

Urban renewal schemes are another special type of detailed planning schemes. Their purpose is to refurbish and rehabilitate unsanitary urban areas and to redevelop the existing urban fabric. Details about the process of preparing urban renewal schemes are provided by the GPPS.

Special planning areas

The Director of Urban Planning can "*declare any area with unique development, potentials or problems, as a special planning area*" (§ 24 (1) UrbPlAct). The responsible planning authority is mandated to prepare a planning scheme for the special planning area "*irrespective of whether such area lies within* *a planning area or not*" (§ 24 (1) UrbPlAct). Any development within a special planning area can be suspended by the Director for a period of up to two years in order to allow finalizing and approving the detailed planning scheme (§ 24 (2) UrbPlAct). Moreover, the Minister can declare small islands, beaches, coastlines, wetlands and mountainous areas as special planning areas and shall make regulations for their proper use (§ 24 (5 & 6) UrbPlAct).

2.1.2 Land Act

<u>Scope</u>

The Land Act of 15th May 1999 represents the most comprehensive legislation on the administration of land, rights of land occupancy and the use of land in Tanzania. It provides a general legal framework for all types of land use and applies to both urban and rural areas.

<u>Principles of land policy in Tanzania</u>

The Land Act defines fundamental principles for the national land policy, which have to be taken into account for urban planning and all other issues concerning land in Tanzania. The primary convention for land policy in Tanzania is set by § 3 (1a): "*[…] all land in Tanzania is public land vested in the President as trustee on behalf of all citizens*". Consequently, the national legislation does not allow private ownership of land. However, all citizens have the right to occupy and use land. In this context, the law has to ensure equitable distribution of land and to regulate the amount of land that each citizen can occupy or use (§ 3 (1b, 1c & 1d) Land Act). Of specific relevance for all types of land use planning (including urban planning) is the fifth fundamental principle of land policy in § 3 (1e), as it requires land use to be productive and in compliance "*with the principles of sustainable development*". Further fundamental principles of land policy in Tanzania deal with matters of compensation, good governance in land administrations, land market, accessibility of land laws, settlement of land disputes and gender equality (§ 3 (1f-m & 2) Land Act).

<u>Classification of land</u>

Land in Tanzania is classified into three legal categories: village land, reserved land and general land (§ 4 (4) Land Act). Currently, 70% of the land in Tanzania Mainland is classified as village land, 28% as reserved land and 2% as general land (Massay 2016). Only the President has the power to change the category of a piece of land (§ 4 (7) Land Act).

Village land is land in rural areas that is allocated to villages and governed by the village councils. It is split into communal village land for public and shared uses on the one hand and land that is occupied by individuals under customary law on the other.

Land which is allocated to specific public purposes, such as conservation, infrastructure development (roads, railways etc.), urban development or public utilities, is classified as reserved land (§ 6 (1a & c) Land Act). It is commonly set aside under the provisions of sectoral laws like the National Parks Act, the Wildlife Conservation Act or the Highway Act. Additionally, headwaters as well as hazardous land are deemed reserved land (§ 6 (1b & d) Land Act). Hazardous land comprises fragile ecosystems that would be damaged or destroyed by development activities, as well as areas in which environmental dangers are posed to inhabitants

(§ 7 (1) Land Act). Typical examples are mangrove swamps, floodplains, wetlands, steep slopes or waste disposal sites.

All areas that are neither village land nor reserved land are specified as general land. The land in this category is managed by the President.

New urban planning is commonly conducted on general land. In the periphery of growing cities, however, village land might fall under the jurisdiction of city, municipal, town or township councils. and therefore also become relevant for urban planning. Village land or reserved land for which a resolution to prepare a detailed planning scheme has been passed by the planning authority is transferred into general land (§ 26 UrbPlAct).

2.2 Legal regulations for environmental management and stakeholder participation in urban planning

The necessity of limiting negative impacts of urban development on the environment, and to sustainably manage urban and peri-urban ecosystems, has been acknowledged by the national legislation. The Urban Planning Act and the Land Act contain multiple standards and references for the consideration of the environment, natural resources and biodiversity in urban development processes. In addition, legislation specifically concerned with environmental management and nature conservation provides rules and guidelines that have to be considered by urban planners as well. The most relevant law in this context is the Environmental Management Act, which applies to all cases of urban development and land use. In specific cases the Forest Act, National Parks Act or the Wildlife Conservation Act might also be relevant.

The integration of local stakeholders into urban planning processes is crucial for the identification of environmental risks and potentially valuable ecosystems, as well as demands for future ecosystem service provision. Furthermore, stakeholder involvement creates ownership of urban development processes among local communities and considerably increases the chances for successful implementation of urban planning schemes. This has been recognised by the national legislation and stakeholder involvement is prescribed, particularly by the Urban Planning Act.

2.2.1 Regulations for environmental management in urban planning legislation

One of the fundamental principles for urban planning defined by the Urban Planning Act is to "*protect the environment of human settlements and ecosystems from pollution, degradation and destruction in order to attain sustainable development*" (§ 3 (f) UrbPlAct). In accordance to this principle the Urban Planning Act declares efficient utilization of urban space (§ 4 (1) a and § 16 (1) UrbPlAct) and "*sustainable land use practices*" (§ 4 (1) c UrbPlAct) as important objectives of urban planning.

These goals have to be implemented by the planning authorities. Their tasks are to "*secure the orderly and environmentally sustainable development [...]*", "*ensure that schemes are geared towards vertical growth rather than horizontal growth*", "*control density of buildings on land*" and "*conserve buildings, premises or land, open spaces, recreational areas, hazardous land and parks*" (§ 7 (5) b, c, f & s UrbPlAct). To ensure implementation, the law gives powers to the planning authorities to "*control the use of land*" and "*reserve and maintain all land planned for […] urban agriculture, urban forests and* *green belts, open spaces and parks [...]*" (§ 28 a & f UrbPlAct). The planning authorities are entitled to demand environmental impact assessments from developers (§ 29 (3) UrbPlAct), to designate conservation areas where works have to be in consent with the planning authorities (§§ 50 & 51 UrbPlAct) and to prepare lists of areas of unique biodiversity or special trees (§ 58 UrbPlAct). Demolition and alteration of objects on these lists can be restricted by the planning authorities (§ 59 (2) UrbPlAct).

Besides the planning authorities, the Minister responsible for urban planning can indirectly influence the sustainability and environmental compatibility of urban development by regulating plot size and the proportion of built-up area versus open spaces in planning areas (§ 77 (1) b & d UrbPlAct).

Several amendments have been made to the Urban Planning Act, which provide further references and specifications for the integration of environmental issues in urban planning. As part of the Urban Planning Act of 2007, five schedules have been passed. Three of these schedules determine the matters that have to be considered in planning schemes, including the current state of soils and other natural resources, existing environmental degradation and pollution, potential future environmental problems, as well as the reservation of open spaces, nature protection sites and areas for agriculture.

In 2018, further regulations with respect to the Urban Planning Act were passed by the government (Urban Planning Regulations, 2018). These include regulations concerning planning space standards, urban farming and zoning of land use.

The Urban Planning (Planning Space Standards) Regulations, 2018 sets standards for the size of plots for different urban land uses. For example, buffer zones around the high-water marks of water bodies are prescribed (15 to 30 m along seasonal rivers, streams, ponds and swamps and 60 m along rivers, lakes and the ocean).

The Urban Planning (Urban Farming) Regulations, 2018 address challenges of urban farming, which is a widespread land use practice in most Tanzanian towns and cities. Even though urban farming significantly contributes to food security, income generation and the management of fragile urban ecosystems, it is rarely considered in urban planning and often forced into informality. The new regulation entitles planning authorities to formally reserve zones for urban farming within towns and cities, and at the same time imposes environmental management restrictions for urban farmers.

The Urban Planning (Zoning of Land Uses) Regulations, 2018 determines 11 land use zones that are permitted in local planning areas. Four of the land use zones represent important urban ecosystems, which are "*Beach, Open Spaces and Recreational*", "*Agricultural*", "*Water bodies*" and "*Conservation*". Consequently, this regulation acknowledges the necessity to set aside green spaces in urban areas.

The central reference for the consideration of ecosystems in land use planning in the Land Act provides § 7, which is concerned with hazardous land (see Chapter 2.1.2). This specific category of reserved land commonly comprises sensitive ecosystems like wetlands, mangroves or woodlands on steep slopes, where no development is permitted.

2.2.2 Environmental management legislation with relevance for urban planning

The major national law that regulates the assessment of environmental impacts and necessary environmental management measures for development projects and land use planning is the Environmental Management Act, which was passed by the Government of the United Republic of Tanzania in 2004. It promotes the "*enhancement, protection, conservation and management of the environment*" (§ 7 (1) EnvManAct).

Planning authorities as well as urban planners in the private sector perform public functions. In this context, the Environmental Management Act requires them to "*have regard to the principles of environmental management*" (§ 8 EnvManAct). Among these, the principle to prevent adverse effects by "*long-term integrated planning*" (§ 7 (3b) EnvManAct) and the precautionary principle (§ 7 (3c) EnvManAct) are of specific relevance for urban planning. Furthermore, the consideration of ecosystem services in development decisions is established in the principle of sustainable use of "*the environment and natural resources*" which are acknowledged as requirements for peoples' livelihoods (§ 7 (3i) EnvManAct).

Local government authorities, as well as sector Ministries, are required to prepare environmental action plans that identify prevalent environmental problems and recommend solutions (§§ 42 & 43 EnvManAct). Urban development projects should employ these environmental action plans as guidance for the preparation of planning schemes. Beyond that, according to § 45 EnvManAct, the Minister responsible for environment can direct how environmental action plans have to be adopted and implemented.

The Environmental Management Act gives powers to the Minister responsible for environment to declare environmental protected areas (EPA) (§ 47 EnvManAct) as well as environmentally sensitive areas (ESA) (§ 51 EnvManAct), following recommendation of the National Environmental Management Council (NEMC). EPAs are managed by NEMC (§ 47 (4) EnvManAct), whereas the law has not specified a responsible authority for the management of ESAs. Nevertheless, ESAs have to be managed in accordance to guidelines set by the Minister (§ 51 (2) EnvManAct). Areas that qualify to be protected in accordance to §§ 47 and 51 include waterbodies and the adjacent 60 m buffer zone (see also § 57 EnvManAct), swamps, wetlands, hills and mountainous areas at risk of environmental degradation, and others (see §§ 52, 54, 56 and 58 EnvManAct). The law has not set any further restrictions concerning the location of EPA and ESA, hence §§ 47 and 51 EnvManAct provide tools to protect ecologically sensitive sites in urban areas.

Probably the most important link to urban planning in the Environmental Management Act is established by § 71. In consultation with the Minister responsible for land, the Minister responsible for environment can issue "*… general and specific environmental and land use planning directives …*". These directives shall be taken into account by the responsible urban planning authorities at regional and local levels (§ 71 b & d EnvManAct).

Developers of specific projects are required to conduct environmental impact assessment (EIA) studies and to prepare EIA statements prior to the commencement of their enterprises (§ 81 (1 & 2) EnvManAct). As defined in the Third Schedule, "*Urban Development*" is among the project types for which an EIA is mandatory. Consequently, the implementation of urban planning schemes has to be preceded by an EIA.

According to § 104 (2) EnvManAct "*development plans shall include a strategic environmental assessment (SEA) statement*". General planning schemes determine the urban development at the district level and therefore qualify as development plans that require SEA statements that analyse the likely effects of the proposed development on the environment. The Minister responsible for Environment reviews the SEA statements (§ 104 (5) EnvManAct) and makes recommendations for the promotion of environmental management, which have to be integrated into the development plans (§ 104 (6) EnvManAct).

The Environmental Management Act allocates a wide range of powers to the Minister responsible for Environment, as well as to NEMC, to take considerable influence on urban development projects by imposing conditions to minimize negative environmental impacts. It is therefore crucial to consider sustainable environmental management in planning schemes and to consult the institutions responsible for Environment during urban planning processes.

Environmental regulations with relevance to specific cases

For urban areas located in the neighbourhood of nature reserves, a set of conservation-specific legislation has to be considered in urban development processes. This comprises the Forest Act, the Wildlife Conservation Act, the Marine Parks and Reserves Act and the National Parks Act. These four acts regulate the protection and management of different types of nature reserves in Tanzania. The construction of infrastructure and buildings is commonly prohibited in nature reserves, and obstacles to exemptions are high. In any case, each of the four acts requires an environmental impact assessment for any kind of development within nature reserves. Since the conservation-specific legislation is not of general relevance to urban planning and only applies in exceptional cases, this guideline refrains from further discussion of this issue.

2.2.3 Regulations for stakeholder integration in urban planning legislation

Similar to the integration of environmental issues into urban planning, the national laws and regulations in Tanzania provide room for stakeholder participation in planning processes.

As stated in § 3 (e) UrbPlAct "*the participation of the private and popular sectors, community based organisations, non-governmental organisations, co-operatives and communities in land use planning*" is among the fundamental principles of urban planning. In line with this ensuring "*public participation in the preparation and implementation of land use policies and plans*" (§ 4 (e) UrbPlAct) is defined as an objective of urban planning. In this regard, the Urban Planning Act demands the integration of local stakeholders into urban planning processes at different planning stages. Stakeholders have to be involved right from the start of each planning process. In accordance to § 8 (3a) UrbPlAct planning authorities are required to conduct public hearings prior to the declaration of planning areas. Furthermore, the law requires stakeholder participation during preparation and evaluation of drafts of general and detailed planning schemes through public hearings (see §§ 11 (2 & 3), 12 (2) and 19 (1) UrbPlAct) (see Fig. 5).

In many Tanzanian cities, public urban spaces are informally occupied by small-scale farmers, pastoralists and other land users. Their activities have been affected by huge insecurity in terms of land tenure. The Urban Planning (control and management of public open spaces) Regulations, 2018 now equip local stakeholders and community organizations with special powers to care and maintain public open spaces. Interested persons and groups can apply to the responsible planning authority for grant of permission to take care or maintain public open spaces (§ 3). The permit is granted for a period of five years (§ 7 (1)).

Apart from the actual urban planning legislation, a "*public participation principle*" has been established in the Environmental Management Act for all policies, strategies and plans that are concerned with environmental management (§ 7 (3e) EnvManAct). Particularly in environmental impact assessments public participation of people affected by a project is mandatory (§ 89 EnvManAct). Additionally, § 178 EnvManAct provides the public with the right to participate in decision making processes for the preparation of policies, strategies and plans that relate to the environment. Participation has to be ensured by "*early and accessible notice*" about the intention to prepare a policy or plan relating to the environment (§ 178 (4a) EnvManAct), by providing opportunities to comment on drafts (§ 178 (4b) EnvManAct) and by granting access to environmental information (§ 178 (4c) EnvManAct).

2.3 Challenges for the implementation of environmental management and stakeholder participation

As highlighted above, the Urban Planning Act, the Land Act and the Environmental Management Act acknowledge the importance of sustainable management of urban ecosystems. Likewise, the national laws and regulations provide room for stakeholder participation in different stages of urban planning processes. The schedules amended to the Urban Planning Act and the GPPS (United Republic of Tanzania 2007) provide a concise overview of the planning process, responsible planning authorities for the different planning tasks and required outputs for the different planning schemes (see Chapter 2.1.1). Nevertheless, guidance for town planners on how urban ecosystems can be integrated into urban development schemes and recommendations for adequate forms of stakeholder integration are still lacking. Consequently, the implementation of regulations and planning principles promoting environmentally sustainable planning and participation of stakeholders remains challenging.

Additionally, some municipal planning authorities lack sufficient capacities to satisfy the ever-increasing need for new planning schemes and to steer the rapid urbanization processes of urban centres in Tanzania. As a consequence of the high workload and missing guidelines, several issues with relevance for planning schemes, such as environmental problems, the natural resource base, local community needs or neighbouring planning schemes, are sometimes insufficiently considered. Likewise, in many cases there is only a rudimentary involvement of different stakeholders in the planning process. This can lead to a lack of acceptance and ownership of plans among the local communities and cause serious problems for the implementation process.

In this context, these guidelines are a first effort to provide practical solutions for ecosystem-service based urban planning and to demonstrate different approaches to support stakeholder participation.

Part II: Ecosystem service-based planning process, stakeholder participation and implementation of ecosystem service assessments in urban planning schemes

3 The ecosystem service-based planning process

Prior to the preparation of planning schemes for urban development, planning authorities should consider that the original, undeveloped landscape hosts valuable resources and provides ecosystem services that may benefit the future urban population. Therefore, development should avoid or minimize impacts in the existing environment as much as possible.

As a first step in the urban planning processes at regional levels, the area of municipalities and districts should be separated into sectors that are either suitable or unsuitable for urbanisation, based on mapped assessments of wildlife habitats requiring protection, water availability, soil fertility, erosion susceptibility, groundwater tables and hazards such as flash floods or landslides. This is facilitated by complementing general planning schemes (Chapter 2.1.1) with landscape plans that detail the present and the desired state of ecosystem structure, functions and services at municipal or district level. A landscape plan is a governmental planning instrument that is committed to supporting public interests in the environment and reconciling competing land uses while sustaining natural processes and significant cultural and natural resources. The landscape plan should indicate where wildlife habitats should be conserved, where touristic and recreational sites should be developed, where agricultural and silvicultural activities should be continued or promoted, and where settlements, commercial sites and industries would cause the least harm to the environment. This plan should further show conflicts between ecological functions and present as well as future land uses. For instance, it could reveal whether present agricultural land uses lead to soil erosion and if erosion would increase when fields are converted to settlements. This would then lead to the question as to whether present and future land uses are in accordance with legal targets and thresholds set to prevent species extinction, pollution, erosion, flooding, or other negative consequences of land use. Finally, the landscape plan should give spatially explicit information on management options to conserve valuable ecosystems, to minimize detrimental impacts by present and future land use, and to restore degraded environments. Conservation, impact minimization and restoration do not only apply to the preservation of habitats for wildlife, but also to sites that provide pure water for drinking, fertile soils, a healthy atmosphere, beautiful scenery and other ecosystem services (Table 2). Impact minimization and mitigation seek to identify environmental impacts by land uses and construction projects, to select sites or routes where impacts by construction projects are minimized as compared to other, more sensitive environments, and to mitigate and compensate unavoidable impacts by increasing environmental values in the neighbourhood of the construction site.

Once areas for urban development have been delineated by a general planning scheme and the preparation of detailed planning schemes for specific neighbourhoods at local levels is proposed, the habitats and services of this area should be mapped in more detail. Rather than eradicating all present elements of the former forested or agricultural landscape, some landscape elements providing valuable functions and services should be integrated into the layout of the new urban setting. The planning steps that need to be taken to integrate the ecosystem service-approach into urban planning at regional and local levels are illustrated in Fig. 6 and outlined in the following paragraphs. A typical planning process starts with an administrative decision to set up a planning scheme for a specific municipality or neighbourhood (declaration of a planning area, see Chapter

2.1.1). This decision should include securing the funds necessary to carry out the environmental assessments that provide the required information for ecosystem service-based planning. This includes funds for data collection, evaluation in terms of ecosystem service provision, and demarcation of ecologically and agriculturally valuable areas against sites suitable for buildings and technical infrastructure. Administrations may not wish to maintain appropriate personnel to carry out these assessments, but rather commission external consultants specialised in environmental mapping and planning.

Table 2: Environmental planning goals with respect to major ecosystem compartments

Ecosystem compartment	**Environmental planning goals**		
	Conservation of…	**Impact minimization**	**Restoration of…**
Atmosphere	Sites producing clean air	Air pollution prevention	Sites for carbon sequestration
Biosphere	Species and functional relationships	Prevention of habitat destruction or disturbance	Habitats and migration corridors
Surface water	Uncontaminated water bodies, water retention sites to collect storm water, water courses with self purification capacity, water for irrigation	Prevention of pollution and destruction of swamps and water courses	Surface waters including waste water treatment
Soils	Natural soils, rare soils, fertile soils	Prevention of pollution and erosion	Degraded, sealed and polluted soil, mining sites
Groundwater	Uncontaminated sites with groundwater tables suitable for drinking water abstraction	Pollution prevention	Groundwater recharge

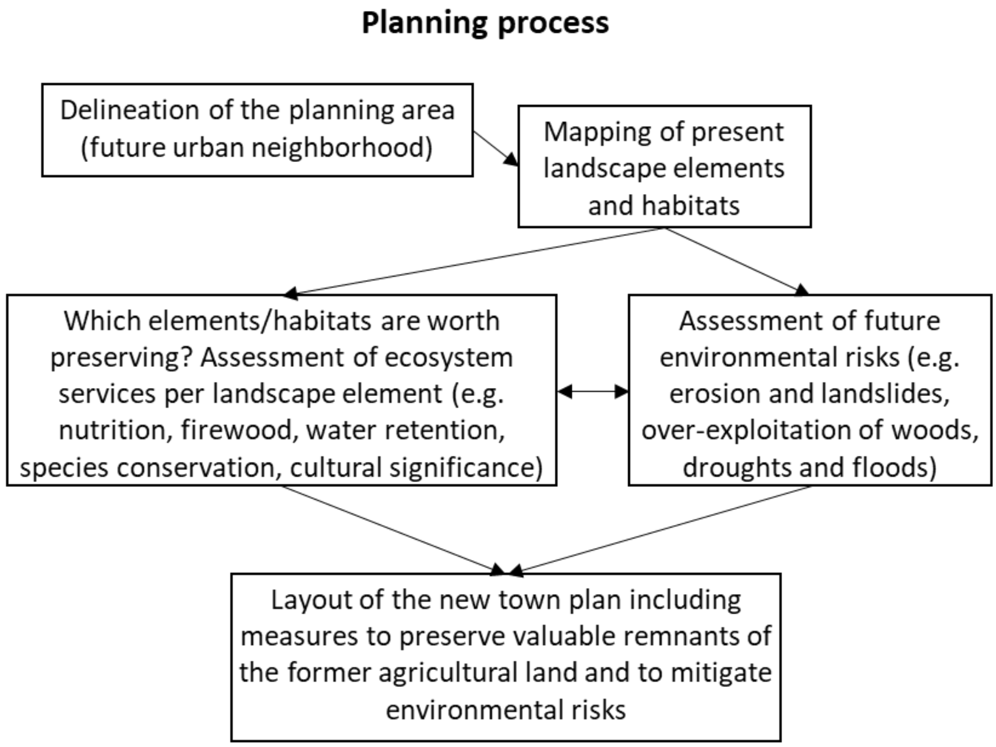

Fig. 6: Flowchart of the planning process.

Step 1: Screening

The first step of the environmental assessment is to identify the natural conditions that shape the planning area, particularly climate, topography, soils, surface waters and prevailing land uses. Furthermore, the predominant ecosystems should be determined. This screening should be based on available data like satellite imagery, topographic maps, soil maps, geological maps, land use maps and digital terrain models, as well as on an initial site inspection in the planning area. Governmental offices, such as the Environment Division of the Vice President's Office, the National Environment Management Council, the Wildlife Division and the Forest and Beekeeping Division of the Ministry of Natural Resources and Tourism, the Surveys and Mapping Department of the Ministry of Lands, Housing and Human Settlements Development or the Geological Survey of Tanzania may be consulted for additional information regarding the state of the local environment. More details on the collection of environmental background data are provided in Chapter 6.

The screening is concluded by determining the extent and details of the required environmental field surveys. These should provide sufficient information to answer the major environmental and ecological issues that are raised in the planning project. Furthermore, the necessary scope of the field survey is dependent on the general environmental characteristics of the planning area as identified by the screening. For instance, in planning areas that comprise lakes, rivers and other wetlands, water-related issues are probably the most relevant. Consequently, investigations of water quality, flood prone areas, water-bearing capacity of the soil, or wetland habitats for endangered water-bound plant and animal species should be of high priority. By contrast, in hilly and mountainous areas, issues like topography, soil erosion, water availability or the distribution of pristine forests, which provide a wide range of important regulatory ecosystem services, are of major relevance. In some cases, it may be necessary to extend surveys beyond the planning area itself, to also integrate external ecosystems into the assessment. For example, if parts of the planning area are flood prone, it is helpful to investigate the capacity of upstream ecosystems to buffer extreme rainfall events. When consensus has been reached about the extent of the study area and the details of the survey, the inventory of ecosystems and their functions can begin.

Step 2: Mapping

In the context of the environmental assessment, different components of ecosystems and the environment are mapped. Most insights for an evaluation of the state of the environment and the ecosystem services can be gained from habitat maps. A well established method to prepare these maps is to categorize each visible habitat (landscape element, ecosystem) according to a pre-defined catalogue and to outline its spatial boundaries on a map. The level of detail in environmental and ecological data that is required for a thorough analysis of planning areas in many cases cannot be met by surveys that are exclusively based on remote sensing. Results at sufficient detail can only be achieved if the mapping is conducted in-situ by ecological experts.

Depending on the relevant issues in the planning area, further field surveys may be necessary. These could comprise for instance soil surveys, measurements of important water cycle metrics or mapping of plant and animal species. In soil surveys relevant chemical and physical soil properties could be mapped, such as soil fertility, erodibility, infiltration capacity and water holding capacity. Measurements of stream flow, groundwater levels, local rainfall distribution and other hydrological metrics provide information about frequency and magnitude of flooding or the groundwater supply in the planning area. Species distribution maps can help to identify biodiversity hotspots that require special protection but also can be used as indicators of environmental and ecological conditions.

The field work to map habitats and other environmental features of the planning area should be thoroughly prepared. The time frame for the field work should be arranged in consideration of the seasonality of vegetation (particularly relevant for annuals and deciduous plants), fauna (particularly reproduction and seasonal migrations) and abiotic conditions (e.g. flooding of wetlands). Local government authorities need to be informed about the field work programme to avoid conflicts with local residents and land users. More details about the field methods are explained in Chapter 7. Additionally, Part IV provides a habitat catalogue for Dar es Salaam and Coast Regions.

Box 2: Habitat map for Vikawe

In Vikawe, habitats were mapped between October and November 2017 in an area of 293 ha. Mapping was completed within 3 weeks. To avoid high air temperatures and intense solar irradiation, the field work commonly was started early in the morning. At the beginning, the surveyors informed land users and the local administration, familiarized themselves with the landscape, identified the habitats in the area and related them to the habitat categories in the predefined habitat catalogue (see Part IV). Subsequently, the surveyors went methodically over the whole area to register and map all habitats present. The boundaries of the different habitats were drawn onto field map sheets (see Fig. 7) and orientation in the field was supported by GIS devices.

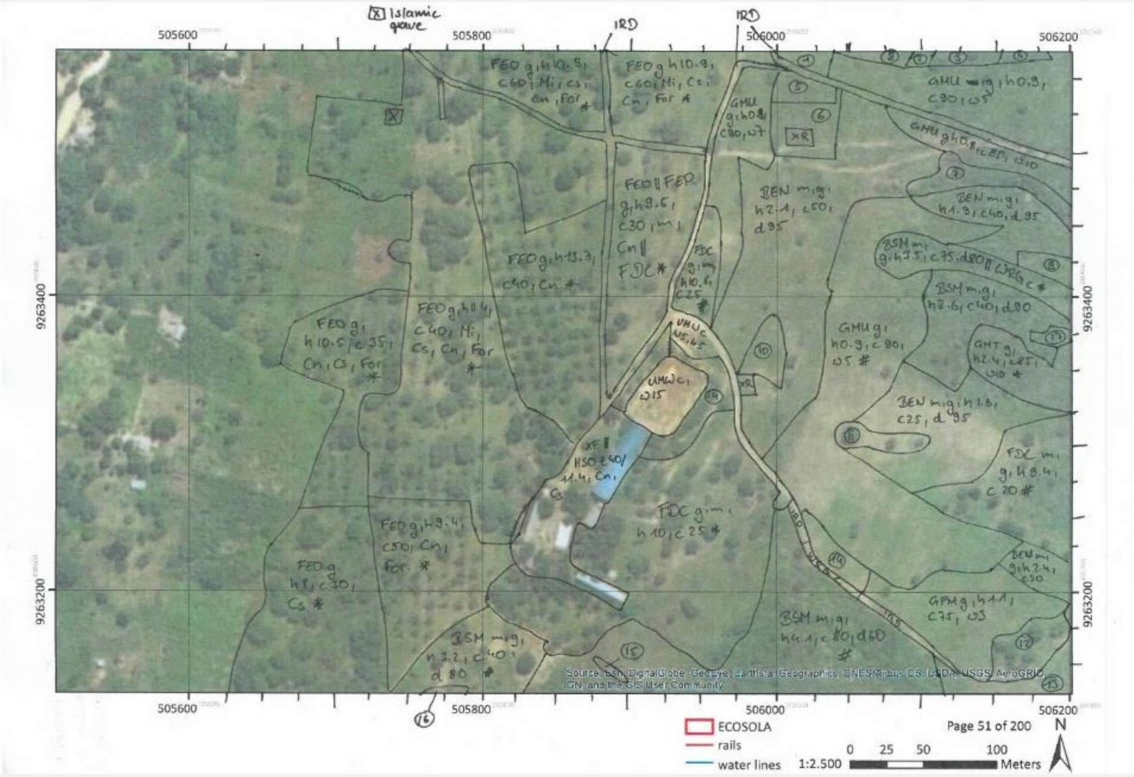

Fig. 7: Example of a field map sheet

Box 2 (continued)

After finalization of the field work, the field maps were digitized and transferred to a GIS shapefile containing all relevant information collected in the field (habitat type, predominant plant species, land use and disturbances). The habitat map illustrated in Fig. 8 is a generalized version of the much more detailed original habitat map.

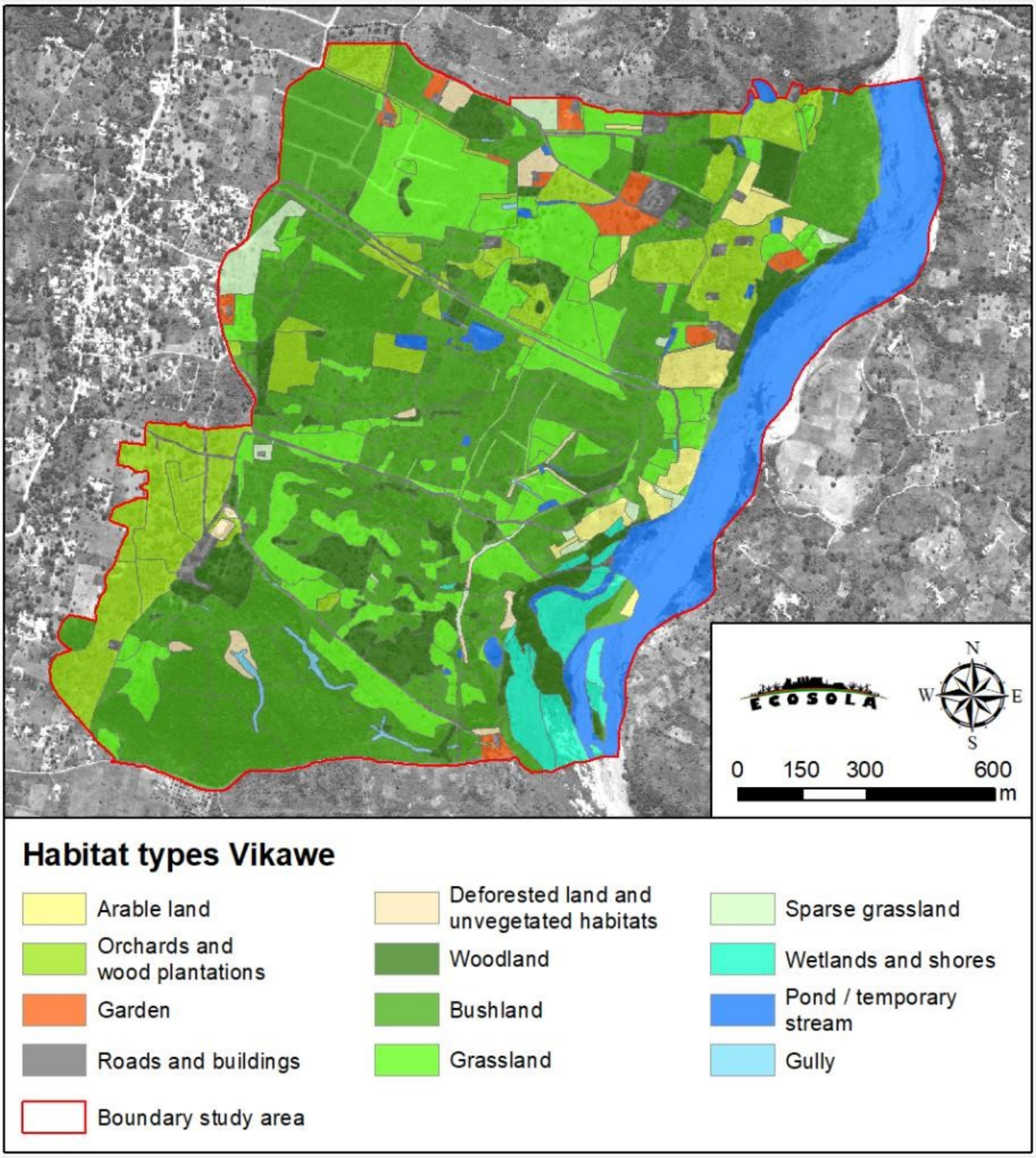

Fig. 8: Habitat map for the study area in Vikawe. The map legend has been aggregated for brevity.

Step 3: Evaluation of service provisioning per habitat or landscape element

To foster informed planning, mapped habitats and landscape elements need to be ranked according to their provision of multiple ecosystem services. Each habitat type or landscape element receives a rank between no fulfilment of a service and ideal fulfilment of the service. The evaluation requires a comprehensive understanding of ecosystem functioning and may benefit from local environmental knowledge. Therefore, it should be carried out by expert ecologists supported by local stakeholders. This calls for appropriate stakeholder participation processes (Chapter 4). To assess the degree of service provisioning by each habitat type and landscape element, different criteria need to be applied. For provisioning services, these typically are yields of crops and forage, fish catch, or the amount of timber or fibre that can be produced on the habitat. Criteria to assess regulatory services are listed in Table 3. Cultural services regarding physical access of landscapes and their heritage, cultural, aesthetic or religious relevance are best described by local people. Preservation of plants and animals for the experience of future generations can be assessed by quantifying rarity and endangerment, using e.g. Red Lists of the IUCN (www.iucnredlist.org).

Table 3: Criteria to assess regulatory ecosystem services

Regulatory ecosystem services	**Criteria**
Sewage treatment, water eutrophication minimization	Pollution reduction by habitats (e.g. heavy metals uptake by reeds), peak standing biomass to indicate CO2 sequestration from the atmosphere.
Control of erosion rates	Slope, dense vegetation cover, soil texture
Rainwater drainage, storage and flood protection	Infilitration capacity, depth of permeable soil, soil water storage capacity to protect against droughts presence of mangroves, reeds, gallery forests
Air filtering, micro-climate, ventilation and transpiration	Tree shadows in e.g. agroforestry, abundance of plant cover
Pollination and seed dispersal	Land cover types supporting bees, birds, nomadic pastoralists
Species and habitat conservation	Red Lists of threatened species, region-wide inventories of habitats describing their rarity in space and reduction over time
Global climate regulation by reduction of greenhouse gas concentrations	Fixing of CO2 in growing woody vegetation

The final output of the assessment can be a table listing habitats in rows and ecosystem services in columns, and where each entry shows the rank of a habitat in fulfilling a specific service (see Box 7). Based on the habitat map and the individual rank of ecosystem service provision that is assigned to each habitat type, the spatial distribution of multiple ecosystem services can be determined. This allows planners to identify areas of high capacity for the provision of ecosystem services that should be conserved as well as sites of less relevance for ecosystem services provision that may be preferred for infrastructure development.

Step 4: Planning urban settlements while conserving valuable elements of the present landscape

The ranks that were assigned to each habitat type in Step 3 are directly associated with planning targets. Priority sites for implementation of these targets can be identified on the evaluation map, which also was prepared in Step 3. In principle, habitats with high ranks should be conserved to preserve their ability for ecosystem services provisioning, whereas habitats with low ranks can be either converted to settlements or improved by restoration measures.

However, in practice integrating habitats that provide ecosystem services into planning schemes requires a thorough assessment by planners, ecologists and other relevant experts. For instance, conservation action such as prohibition / regulation of human use or fencing off people usually cannot be applied in densely settled areas. Instead, habitats with high conservation value must be managed in a way that allows urban people to use them sustainably while acknowledging their value for the community. Furthermore, many ecosystem services trade off with others, which forces the planner to weight some services higher than others, according to the general targets for the planning area. For example, if a field is located in a region designated for agricultural production, its service to produce nutrition may be weighted higher than its habitat value for wildlife. Conversely, if the field is located within or close to a conservation site, the habitat value of this piece of land may be weighted higher than its agricultural value.

The procedure to integrate the promotion of key ecosystem services into urban planning schemes is explained more comprehensively in Chapter 5.

4 Stakeholder participation in ecosystem services-based urban planning

A relevant component of ecosystem services-based urban planning is the early participation of stakeholders. The aim is to integrate representatives of diverse groups and opinions. A broad spectrum of stakeholders provides information, knowledge, and feedback on various needs and concerns with regard to planning activities. In the broadest sense, the term "stakeholder" covers all people impacted by a project, whether they are involved, affected, or simply have an interest in the outcome. This includes all groups, such as representatives of institutions (with self-interest), experts (insider knowledge) and society (the public).

The involvement of various stakeholders can improve project outcomes by providing local, cultural and practical knowledge, and by advancing assessments of potential benefits and risks. Reducing uncertainty and identifying the positive and negative impacts of interventions on different interest groups and the landscape are also of key interest. Stakeholders involved should have access to information on the scope of the planned intervention or project, the main issues, participants, areas, resources used and constraints. Participating stakeholders recognize that they are noticed, that their expectations, interests, wishes and fears are taken into account and, above all, that they are actively involved in the processes of change. It is particularly important to include stakeholders in the process at an early stage. In urban planning, the involvement of stakeholders increases trust in decisions and the chance that projects will be politically accepted and supported by communities.

Areas for future urbanisation are often selected at high political levels. Decision-makers may not be informed about local conditions and may design new urban neighbourhoods without consulting the local inhabitants who are affected by the outcomes of these decisions. The interests of the local population and their knowledge of available environmental resources are often not taken into account. As a result, these schemes and projects fail to consider existing valuable habitats and ecosystem services that are thus irretrievably lost upon implementation. In a classical sense, this can be described as a top-down planning approach. Even though stakeholder involvement in urban planning is directed by the law (see Chapter 2.2.3), participatory processes only take place to a very limited extent. In addition, stakeholder participation is commonly limited to information gathering and consultation. Financial aspects often play a major role, whereas the interests, desires, or fears of the population are hardly considered. Due to lack of involvement and cooperation, the acceptance for change among the local population might be missing.

Two other very important reasons for participatory processes are place attachment and regional belonging. Local stakeholders identify with the landscape in which they live and have a feeling of local solidarity and belonging. People who grew up in the area have a deeply rooted emotional connection with the landscape through their individual and shared history and experiences. This includes traditions, culture, thoughts, feelings and memories. In particular, the sense of place, i.e. the relationship between people and landscape, makes a place unique and supports regional belonging. Regional belonging is reflected in the social ties that are established, as well as in the communication and interaction within the community. The incorporation of local knowledge in the context of participatory processes helps to describe these characteristics as well as opportunities and problems on site and helps to develop suitable measures.

The stronger the connection to the landscape, the higher is the demand and interest in information regarding changes. Place attachment, regional belonging, and (ecological) local knowledge are of great importance for a sustainable development of landscapes. It is important to consider the relevance of landscapes for the community, as their identity develops through the experiences gained and is reflected in the cultural and social significance of the landscape. This is particularly relevant for cultural ecosystem services, such as landscape aesthetics, spiritual places or the recreational value of the landscape. If locals identify distinct areas as protectable, and it is exactly these areas that will be designated as protected areas, the success of protection measures increases through the local support.

4.1 Stakeholder analysis

A stakeholder analysis is the first step to start a participatory process and a key component of stakeholder management. It aims to identify stakeholders as potential participants in a project. The identification and selection of stakeholders is a critical task, as it entails opportunities and risks for the project, depending on the influence and interests of the selected stakeholders. In general, the selection of participants should reflect a wide and comprehensive spectrum of interests to prevent one-sided results. The composition of the stakeholder group can change over the course of the project, as some become involved and others leave at advanced stages of the project. Within the dynamic process, attitudes, goals, interests or influential strengths can also change. A stakeholder analysis is a step-wise process, conducted either once or multiple times, that fits in the wider stakeholder participation process (Fig. 9).

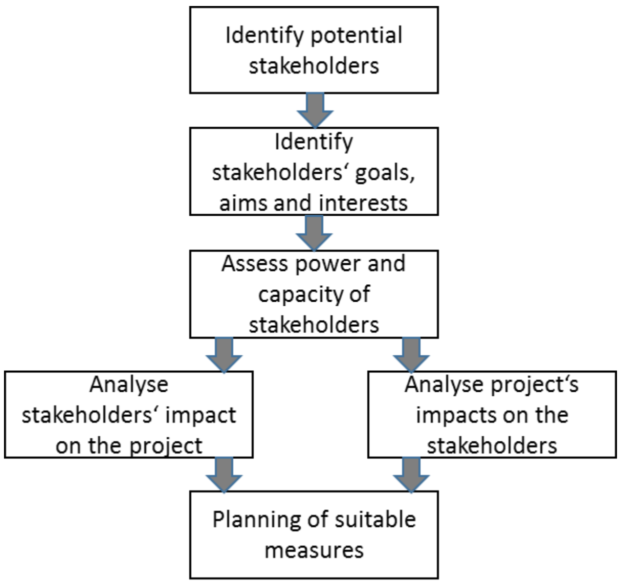

Fig. 9: General procedure of a stakeholder analysis

The first step is to identify potential stakeholders. To determine who should be included, the following questions are helpful:

- Who is affected?
- Who promotes the project work?
- Who may interfere with the project work?
- Who is interested in the project?
- Who has additional knowledge?
- Who is needed for cooperation?

The identification of stakeholder goals, aims, and interests can be performed via questionnaires, interviews, focus group discussions and workshops. In this way, the desires, needs, expectations and fears of the individual stakeholders can be identified and addressed.

Box 3: Stakeholder analysis in Vikawe

We introduced the research project ECOSOLA and discussed the aims of the investigation in a meeting with the local government authority in Vikawe. The village chairman was asked to recommend possible participants for a workshop to be part of an exemplary participatory, ecosystem service-based urban planning process. The participants should cover a broad spectrum of different professions and ages, and gender should be balanced. In consideration of these criteria, the council selected 25 participants for the workshop. The invitations for the workshop were delivered personally to each invitee by the village chairman and the ECOSOLA team, in order to explain the workshop background and objectives.

Invitation

Workshop
„Transformation of landscape in Vikawe"

Location: Free Port Vikawe
Start: 15.03.2018, 10:00 h – 15:00 h

This workshop aims to make use of your knowledge of the environment in Vikawe and at the same time to increase your awareness of environmental issues.
It will provide opportunities for you to get involved in a showcase planning process to manage the development of your village and provision of ecosystem services that matter to you.

Ecosystem services are the benefits you derive from the nature. This workshop aims to figure out, which locations in your village have a specific value for you and should be maintained. We are interested how you perceive your environment and what is important for your life.

The workshop and material will be delivered in Swahili
Drinks and food will be provided

The ECOSOLA project supports sustainable agriculture in urban and peri-urban areas in Tanzania. The projects develops innovative solutions for ecologically sustainable development. Furthermore, it examines how landscape structures can be made more resilient towards social, ecological and economic challenges.

MUALIKO

Mkutano
„Mabadiliko ya mazingira Vikawe"

Mahali: Free Port Vikawe
Mwanzo: 15.03.2018, 10:00 h – 15:00 h

Mkutano huu unadhamiria kutumia elimu uliyonayo kuhusu Mazingira ya Vikawe, na wakati huohuo kuongeza ufahamu wako kuhusiana na masuala ya kimazingira.
Itakupa fursa ya kuhusishwa na utayarishaji wa mpango kimaendeleo ya kijiji chako na kukuletea huduma za kimazingira ambazo ni muhimu kwako.

Huduma za kimazingira ni faida unazozipata kutokana na mazingira halisia. Mkutano huu unadhamiria kutambua ni maeneo gani katika kijiji chako yana faida maalumu na yanatakiwa kutunzwa. Tuna nia ya kufahamu ni jinsi gani unayaelewa mazingira na kuona ni kipi bora ziaidi kwa maisha yako.

Makabrasha ya mkutano huu yatakua kwa lugha ya Kiswahili.
Chakula na vinywaji vitakuwepo pamoja.

Mradi wa ECOSOLA unaunga mkono kilimo endelevu katika miji na pembezoni mwa miji ya Tanzania. Mradi huu unasaidia kubuni utatuzi wa kimazingira na kiuchumi. Hali kadhalika, unachunguza ni kwa jinsi gani mazingira halisia yanaweza kustahimili changamoto ya kijamii, kimazingira na kiuchumi.

Fig. 10: Invitation letter for the participants of the workshop in Vikawe

The next two steps include the assessment of power and capacity of the stakeholders, as well as an analysis of the stakeholders' impact on the project and the project's impact on the stakeholders. This can be carried out in various ways. For example, a stakeholder ranking showing the stakeholders' hierarchies, needs and importance can be prepared, or stakeholder expectations and their (un-)willingness to cooperate in the project can be mapped in relation to their position. With the help of a checklist, the type and magnitude of project and stakeholder impacts (positive or negative / strong, medium or weak), as perceived by the stakeholders, can be analysed.

Finally, in cooperation with the stakeholders, measures are developed and integrated into the planning scheme that foster positive and minimize negative impacts. This can only be achieved if all affected groups, experts and institutions are involved in the planning process. In most cases these are representatives from the fields of agriculture, nature conservation, economy, politics, planning, tourism, water management, forest management and civil society. In ecosystem service-based urban planning processes, it additionally involves actively considering natural resources and ecosystem services, and analysing and evaluating their use and conservation.

4.2 Participatory process

Participatory processes differ in their levels and influence. They start with informing stakeholders and move from consultation, through involvement and cooperation, i.e. finding common solutions, to empowerment, i.e. the transfer of responsibility and co-determination. In general, the most benefits for planning projects can be gained from stakeholder involvement if the participatory process traverses through all five stages. Nonetheless, stakeholder involvement can considerably contribute to the success of planning projects even if not all stages of the participatory process can be implemented.

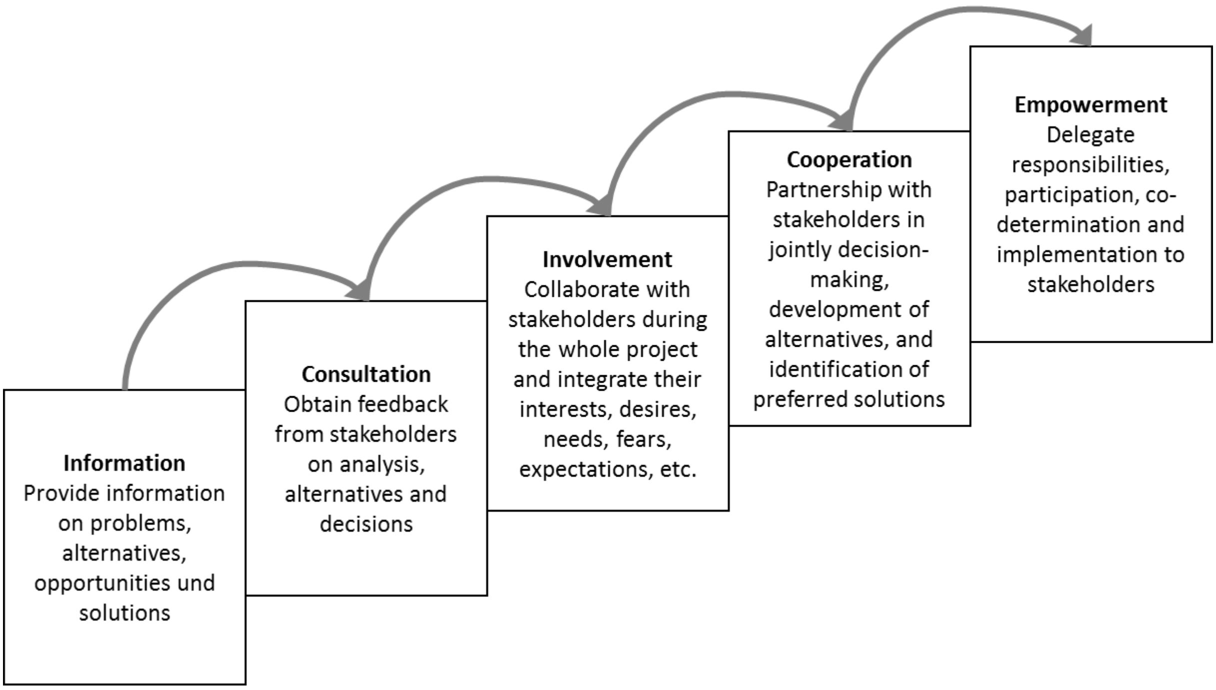

Fig. 11: Stages of participation processes. The degree of participation increases with each stage.

Box 4: Participatory process in Vikawe

Information: Key stakeholders were informed and invited to the workshop (Box 3, Chapter 4.1). The communication language during the workshop was Swahili. In total, 17 residents of Vikawe participated in the workshop, ten men and seven women between 25 and 83 years. The community members represented farmers, traders and people with occasional jobs. At the beginning of the workshop, the ECOSOLA project partners explained the project goals and workshop activities in detail. First, a satellite map of Vikawe was presented to the participants in order to localise the study area and to identify familiar places on the map. Second, the habitat types that had been mapped by the ECOSOLA team prior to the workshop (see Box 2, Chapter 3), were explained by using photographs of each habitat type. Third, the concept of ecosystem services was outlined. Different photographs were combined to illustrate each ecosystem service.

Consultation: The relevance of ecosystem services for the daily life of Vikawe residents was discussed with the participants. They expressed their opinions and attitudes towards the proposed urban development in their village. Additionally, they filled in a questionnaire that contained questions about their socio-cultural background, place attachment and regional belonging, observation of environmental and landscape changes, how they use the landscape, and importance and main problems of change.

Involvement: All participants were asked to fill in two questionnaires about their preferences for different habitat types and ecosystem services (Chapter 4.3, Box 5).

Cooperation: Subsequently, a participatory mapping was conducted with the workshop participants to assess the distribution of various ecosystem services in the study area according to the local stakeholder’s knowledge (Chapter 4.4, Box 6). Afterwards, the ECOSOLA team prepared a first draft of an exemplary layout plan for the study area in Vikawe based on the stakeholder preferences and the ecosystem services map (Chapter 4.5, Box 7). Six months after the first workshop, a second workshop was conducted with the same participants. The draft plan was discussed and proposals for modification were incorporated into the final plan.

4.3 Stakeholder Preferences

Ecological and structural changes of landscapes should ideally not result in restrictions for the users of these landscapes. However, acceptance is crucial for the success of projects; if it is lacking, successful implementation may fail. Acceptance includes the subjective willingness of people to help shape and implement the newly set goals.

In the wake of urban development processes, extensive changes in the provision of various ecosystem services occur that are crucial for the livelihoods of stakeholders (see Chapter 1.2). It is essential to identify these crucial ecosystem services in order to define reasonable planning goals. One way to do this is to investigate the preferences of the people for different habitat types and ecosystem services. Preference assessment aims at creating a data basis that captures and combines as many stakeholder perspectives as possible. The results show whether people with different expertise and interests prefer the same service values of a landscape. If this is the case, the preservation value of the habitat types or services is high. These preferences can be taken into account in new planning processes and thus lead to an increased acceptance among the stakeholders involved.

Preferences can be surveyed with simple questionnaires listing the habitats and services to be evaluated. A so-called Likert scale can be used, allowing respondents to indicate the degree of preference for a particular service (Fig. 12) and the relevance of a certain habitat type in providing the service.

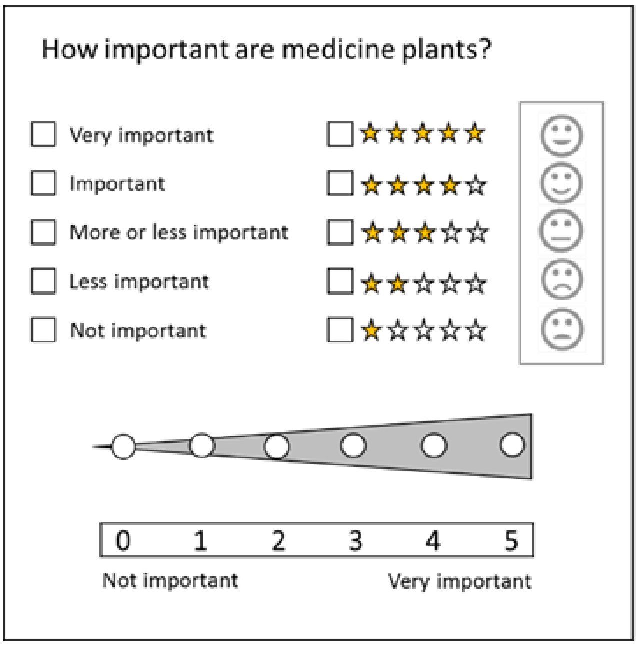

Fig. 12: Examples of different designs of a Likert scale

For most stakeholders it is relatively easy to estimate the relevance of habitat types for the provision of specific provisioning and cultural ecosystem services. The former are often related to agricultural activities, such as food production or grazing land, or the extraction of natural resources like firewood. The habitat types that are important for local traditions or spiritual experiences are commonly well known to local residents, and planners rely on this local knowledge to identify these sites. Local stakeholders can play a very strong role here, as they determine exact locations with a high landscape aesthetic, traditional or religious value, or where the landscape is particularly attractive for tourism. On the other side, it is quite difficult for most stakeholders to link regulatory ecosystem services to specific habitat types, since this requires ecological expert knowledge. For example, the link between plant roots and erosion control, the contribution of wetlands to flood control or the shade provided by trees is not immediately obvious. Consequently, in addition to the involvement of local stakeholders, the consultation of environmental experts is of great importance as well.

The survey data can be used to assess how each stakeholder group values the different ecosystem services and the importance of different habitat types for service provision. For example, farmers' preferences for certain services often differ from those of nature conservationists. The more all stakeholder groups agree on the value of an ecosystem service or habitat type, the more emphasis should be set on its preservation.

In a subsequent step, the stakeholders can directly and spatially locate important ecosystem services in the planning area on a map. A possible way to do this is explained in the following Chapter.

Box 5: Assessment of stakeholder preferences in Vikawe

The participants received two questionnaires to evaluate the importance of both, habitat types and ecosystem services. The questions were: How important are these ecosystem services provided by the landscape for you? How important are these habitat types for you? The grading was arranged with stars: five stars for "very important", one star for "not important". In total, 23 different habitat types and 18 different ecosystem services were evaluated.

All ecosystem services were rated with high scores and showed little variance, except for livestock grazing and fodder from wild plants. Most important were ecosystem services providing natural resources used in daily life, like drinking water, cultivated crops, fruits and medicinal plants, but also regulating services, such as shade and cooling, erosion control, soil fertility and flood protection. Intermediate scores were assigned to water for irrigation, wild vegetables and firewood, but also cultural services such as beauty of nature, nature conservation and tourism activities. Places considered least important were those for ancestors, places for traditions, and areas for livestock grazing and fodder from wild plants.

The scoring of land cover types showed that built environment, riparian woodland, gardens, orchards, woodland, wood plantations and arable land with mixed crops were rated as the most important habitat types. Less important were tall and mesic grassland and forb stands, bare tilled land, vegetated habitats, bushland and gullies.

4.4 Participatory mapping

In general, participatory mapping describes the preparation of maps embedded within a participatory process. These maps visualize local spatial knowledge and, in particular, specific landscape features. They serve to create new, spatially explicit knowledge and open new communication pathways. Additionally, participatory mapping helps to explicitly locate certain topics in space, to prioritize ideas spatially, to discuss conflicts and to visualize spatial planning activities. Such maps provide innovative and spatially meaningful planning ideas, and help to solve development problems.

Participatory mapping always takes place around a specific objective or strategy development for the landscape being planned. For an ecosystem service-based urban planning process, this means including all types of ecosystem services that are relevant to a wide range of stakeholders.

The degree of stakeholder participation in participatory mapping ranges from information to involvement and cooperation. In the course of participatory mapping, the first step is to provide information to stakeholders, for example, which elements, services and opportunities occur in the landscape and how they appear in the basal map. In the next step, the stakeholders project their local knowledge onto the basal map by delineating areas or sites with specific values for ecosystem services.

Box 6: Participatory evaluation and mapping of ecosystem services in Vikawe

Two groups were formed and both were provided with a map of the habitat types in Vikawe, which had been surveyed by the ECOSOLA team (Chapter 3, Box 2). The participants were instructed to prepare an ecosystem services map for the study area. They were asked to place buttons with symbols of the different ecosystem services on the map, to indicate where in the study area they expect the respective ecosystem services. Additionally, the participants decided to indicate potential areas for new settlements. The results of the participatory mapping were digitized in GIS and the results of both groups were combined.

Table 4: Ecosystem services assessed in the participatory mapping process

Provisioning ES	Regulating ES	Cultural ES
Crop production Wood production Water supply Medicinal plants Fodder and pastures	Erosion control Flood protection Balancing microclimate (shade and cooling) Nutrient cycling	Recreation Beauty of the landscape Sites for traditions Sites for ancestors Sites for tourism

Most parts of the region are covered by mesic grassland, bushland and woodland. The large areas of *mesic grassland* are particularly important for the provision of fodder, as the area is used for livestock grazing. It provides the most traditional places, compared to the other habitat types. B*ushland* is important for the provision of fruits and firewood and provides places where wild vegetables are harvested. The landscape is covered with many, but comparatively small, areas of *woodland*. Even though the number of ecosystem services is lower compared to extensive forests, this habitat type provides the greatest diversity of ecosystem services in the study area: fodder from wild plants, medicinal plants, fire wood, soil fertility, shade and cooling, nature conservation, and traditional and tourism activities.

Box 6 (continued)

The participatory mapping enabled the ECOSOLA team to integrate local knowledge into the development of an exemplary layout plan (Chapter 5, Box 8). In particular, the spatially explicit indication of spiritual and traditional places to maintain, and areas with provision of multiple ecosystem services, were of importance.

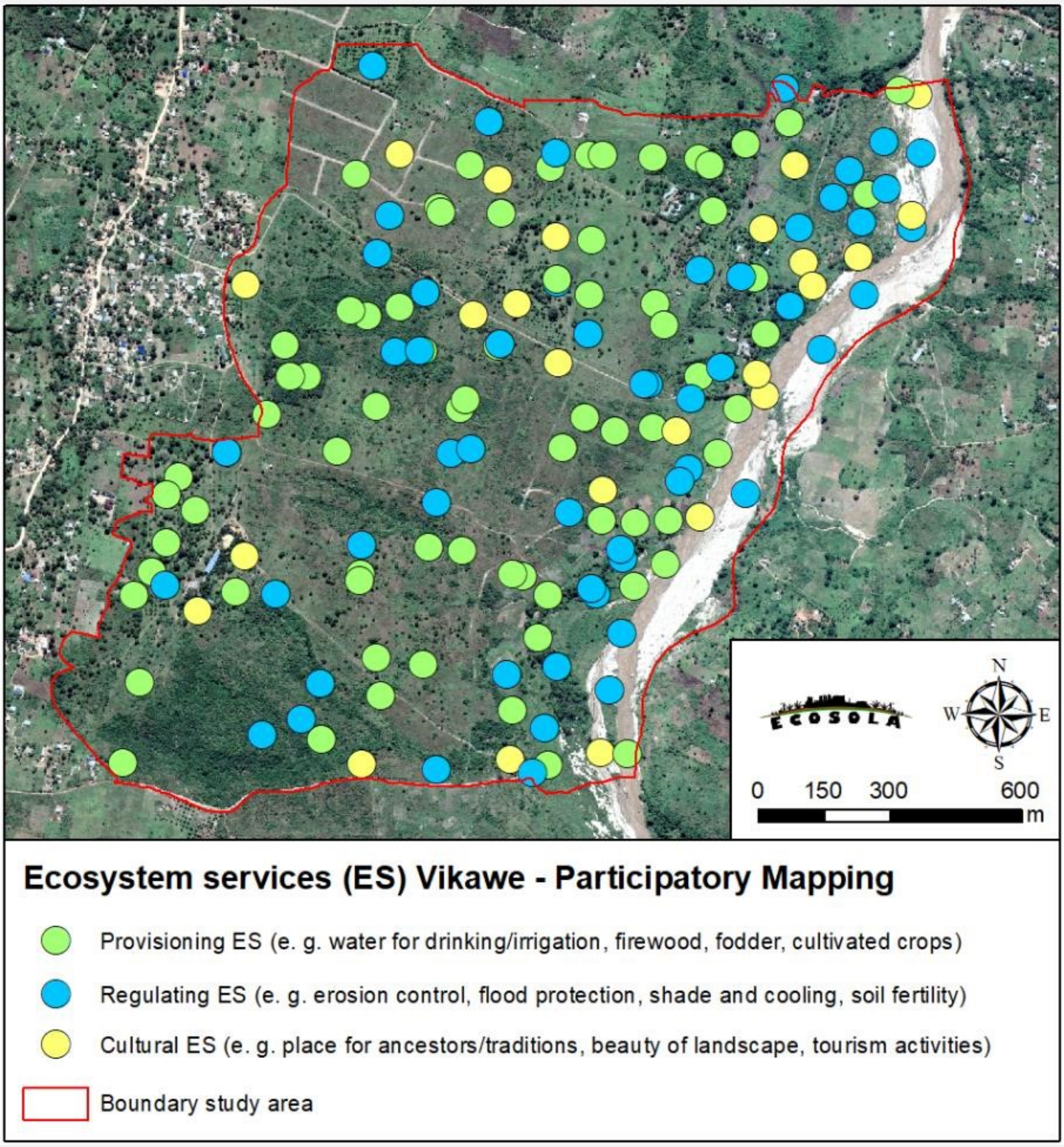

Fig. 13: Distribution of ecosystem services in Vikawe, as evaluated by the local participants. The circles indicate the general service sections. At the participatory mapping event, the circles were small buttons or chips with symbols of individual ecosystem services that were attached to the map by the participants.

4.5 From participatory mapping to the final evaluation map

If participatory mapping is included in the evaluation process, the results need to be checked in terms of spatial and ecological consistency. Spatial consistency means that all habitats must be covered in space and no patches left without information regarding the evaluation. Ecological consistency means that evaluations should not deviate from legal standards and scientific facts, and, if different stakeholder groups came to different evaluations, must be aggregated to a single final evaluation. Furthermore, local stakeholder knowledge is often very precise when provisioning service are concerned, even invaluable when cultural services such as traditional, religious or spiritual values are concerned, but often poor regarding regulatory services (e.g. water retention, flood protection, climate regulation) and species endangerment. The whole process can be accommodated by providing a spreadsheet, with habitats in rows and services in columns, in which each cell shows the rank of a habitat type in providing a certain ecosystem services (see Box 7). These ranks are then weighed with the stakeholders´ preferences of the services and averaged for each habitat type across all services. The average rank can then be visualized on an evaluation map showing the position of the most valuable habitats in terms of ecosystem service provisioning.

Planners should consider that the preferences of the rural population for a certain ecosystem service might not align with the preferences of the urban population that will benefit from the habitats in the future. These deviances cannot be generalized, since they depend strongly on the background of the future inhabitants, their income and occupation, and their opinions, among other aspects.

Box 7: Stakeholder preferences in Vikawe

Table 5 lists aggregated ranks of all habitats in terms of their capacity to provide multiple ecosystem services, weighted by the preferences of the stakeholders. The table shows the total area [m²] of each habitat type and the rank of each habitat type in providing a certain ecosystem service on a scale of 0 to 3. Each rank was weighted with the preference of the rural population for the respective ecosystem service. For each habitat type, the weighted ranks were summed and divided by the number of services, resulting in the aggregated rank that is displayed in the last column.

Table 5: Stakeholder evaluation of the capacity of different habitats to provide multiple ecosystem services

Habitats	Area [m²]	Crop production	Fruit and nut production	Forage production and	Fodder from wild plants	Wild vegetables (food)	Medicinal plants	Fire wood	Drinking water	Water for Irrigation	Erosion control	Soil fertility	Flood protection	Shade and cooling	Recreation	Place for traditions	Place for ancestors	Nature conservation	Touristic activities	**Rank**
Relevance of service for the stakeholders		3	3	1	1	2	3	2	3	2	3	3	2	3	2	1	2	2	2	
Arable w/ mixed crops	34319	3	1	2	1	1	1					2				1				**0.5**
Arable w/ unmixed crops	13295	3	1	2	1	1						2				1				**0.4**
Bare tilled land	945	3										2								**0.3**
Deforested land	21046	1		1	1	1	1	1	1			1								**0.3**
Garden	33598	3	2	2	1	1	1	1	1		2	3			3	2		1		**1**
Orchards	212481	1	3	3	1	1	1	1	1		3	2		3	3	2		2		**1.1**
Mesic grassland	337668		1	3	1	1	1		1		3	2		1	1	1		2		**0.7**
Tall mesic grassland s	52832		1	3	1	1	1		1		3	2		1	1	1		1		**0.7**
Bushland	815159		1	1	1	2	2	2	2	1	2	1		2	1	1		2		**0.9**
Wood plantation	62223						1	3	1	1	3	1		2						**0.6**
Woodland	137137					1	2	3	2	1	3	1		3	2	3	3	3		**1.1**
Riparian bushland	68346		1	1	1	2	2	2	2	2	3	3	3	2	1	2	3	3	3	**1.5**
Riparian woodland	50478		1		1	2	2	3	2	2	3	3	3	3	3	3	3	3	3	**1.7**
Temporary stream	209636								2	3			2	2	3			3	3	**0.7**
Gully	13581								2	3			3	1						**0.4**
Reeds	20794			1	2	1			3	3				2				2	1	**0.6**
Pond / pool	16253			1	2				1	3				2	2			1		**0.4**
Sparsely vegetated river banks	45332				1				2	1				2	3			1	2	**0.5**
Trampled grassland	31196																			**0**
Unvegetated habitats	7001																			**0**
Roads	38558																		1	**0**
Factory	8095																			**0**
Residential building	14018															1			1	**0.1**

Box 7 (continued)

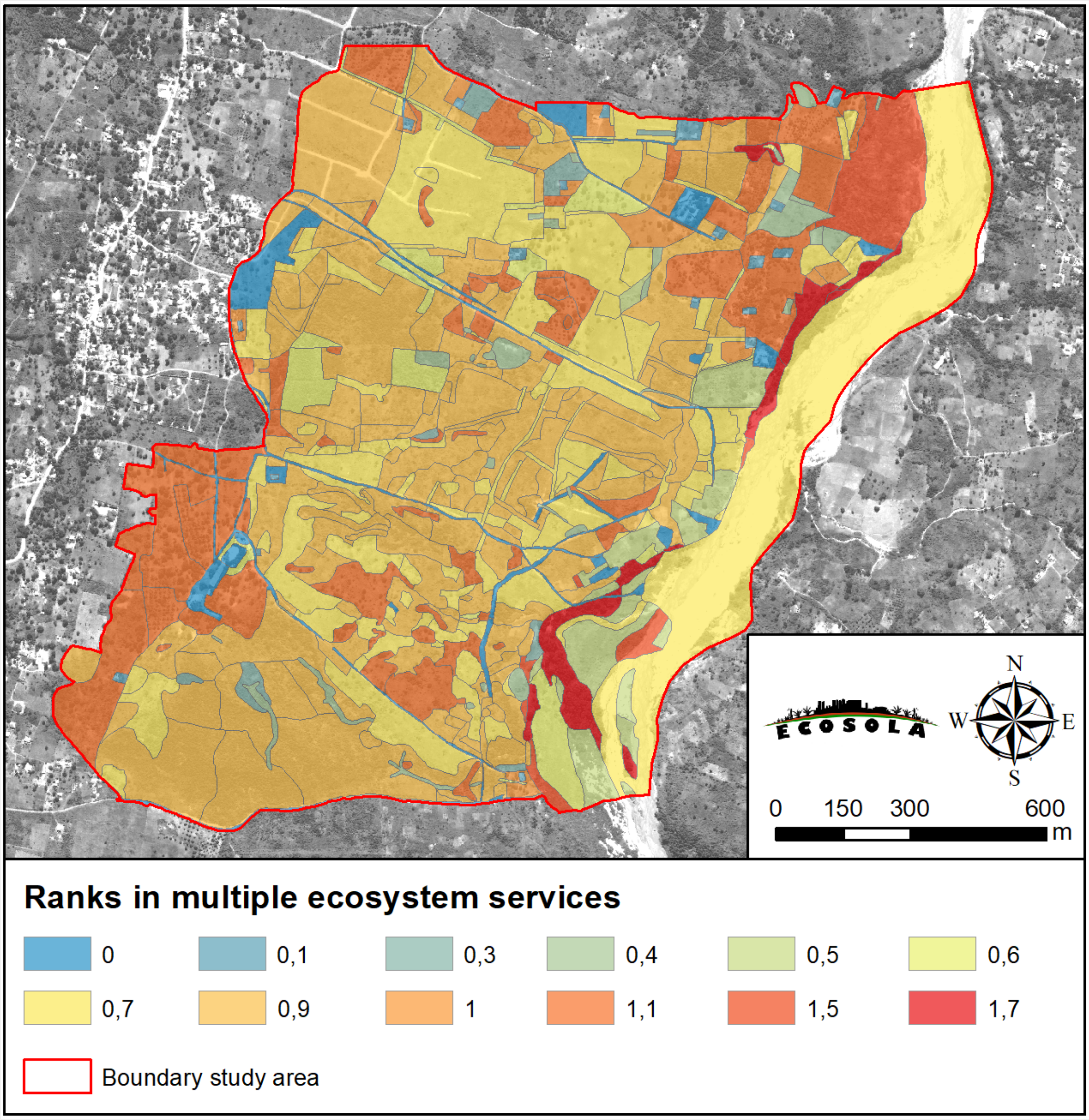

Fig. 14: The aggregated ranks of service outputs displayed as an evaluation map. Riparian forests, agricultural areas and orchards had the highest ranks, whereas bushland had intermediate values. Trampled grasslands, unvegetated areas, bare tilled land, roads and paved areas received the lowest ranks in the provision of ecosystem services.

5 Implementation of ecosystem service assessments in urban planning schemes

For the preparation of sustainable, integrated and ecosystem service-based urban planning schemes, planners have to consider multiple aspects of the biophysical, economic and social context in addition to the requirements set by planning laws and regulations. A broad basis for this task is provided by assessments of ecosystem services based on environmental and ecological data from the respective planning area as well as on local stakeholder knowledge as described in the two previous chapters. Such assessments facilitate the identification of the most relevant project-specific socio-ecological challenges as well as of ecosystem service hotspots that should be integrated into the planning areas as so called “green and blue infrastructure”.

To utilize the knowledge about ecosystem services in planning areas for environmentally sustainable urban development, effective measures that minimize environmental impacts and that promote the provision of crucial ecosystem services have to be integrated in planning schemes. In this Chapter the procedure of this last planning step is explained and several examples for sustainable measures that can be incorporated in urban plans are provided.

5.1 Identification of key ecosystem services

As soon as the required data has been collected in field surveys and through stakeholder participation, a set of ecosystem services should be identified that will be prioritized in the proposed urban development process. The selection of these key ecosystem services allows planners to focus on the major socio-ecological issues in the planning areas. The following criteria should be applied to determine the key ecosystem services.

<u>General planning goals</u>

First of all, ecosystem services need to be identified that serve the general planning goals set by the planning authority for the respective planning area. For example, if the aim is to develop a residential area, ecosystem services that support recreation, comfortable micro-climate, erosion control and flood protection may be important. If the aim is the establishment of an industrial estate, relevant ecosystem services could be water recharge and purification, air filtering and carbon sequestration.

<u>Urgent socio-ecological problems in the planning area</u>

Based on the collected environmental and ecological baseline data as well as on the reports that were recorded from local stakeholders in interviews and workshops, urgent socio-ecological problems prevailing in the planning area have to be identified. Moreover, new environmental problems that could arise following the proposed urban development should be projected as far as possible. When all issues have been identified, planners should determine those ecosystem services that can contribute to reduce existing socio-ecological problems in the planning area and help to prevent or at least mitigate projected challenges.

Stakeholder preferences and potential conflicts

The preferences of individual stakeholders for different ecosystem services have to be evaluated to determine those ecosystem services that are most valued by the local community. Furthermore, ecosystem services that are rated differently by different stakeholders are of specific interest, since a one-sided promotion of controversial ecosystem services in the wake of urban development could provoke serious conflicts between stakeholders. Therefore, planners have to find solutions that satisfy the needs of multiple stakeholders.

Finalisation of the list of key ecosystem services

At the end, all ecosystem services that were identified by applying the three criteria named above should be critically evaluated by the planners. For example, if there are ecosystem services on the list that cannot be realistically provided in the context of the proposed urban development, they should be removed. The final list of key ecosystem services should be determined by the responsible planning authority. Nevertheless, it is strongly advised to discuss the decision with the involved stakeholders.

5.2 Analysis of trade-offs in ecosystem services

Most ecosystems, including those in urban area, have the capacity to provide various ecosystem services. For example, an inner-city park can serve as space for recreation and traditions, filter dust and pollutants from the air, regulate the local climate, provide a living space for endangered species, and contribute to flood protection and erosion control. However, very often not all of the ecosystem services that planners wish to promote can be provided by a single habitat type. Instead, many ecosystem services are mutually exclusive and cannot be provided at the same place. For example, food production and the provision of fresh water may be identified as key ecosystem services for a planning area. Ecosystems that foster water filtration and fresh water recharge, like forests, wetlands and reeds, cannot be used for food production. On the other hand, farms and animal husbandry, which are crucial for food production, can cause pollution of freshwater sources by effluents from fertilizers, pesticides and dung. Therefore, different priority areas have to be delineated to ensure that both services will be available.

This in mind, before starting the actual preparation of an ecosystem service-based planning scheme, the key ecosystem services, which were determined in the previous step, have to be assessed with regard to the following questions:

- Which habitat types and landscape elements can provide several key ecosystem services at once and therefore serve as ecosystem service hotspots?
  This question can be answered by an assessment of the capacity of different habitat types in the planning area to provide ecosystem services as described in Chapter 3. The integration of ecosystem service hotspots into planning schemes allows to maximize ecosystem service provision while minimizing land consumption. Therefore, planners need to identify these habitats.
- Which key ecosystem services trade-off with each other and therefore require contrasting habitat types?
  Based on the answer to this question, planners can identify those habitat types that are

required at least to ensure the availability of all key ecosystem services in the planning area.

- How much of the available space in the planning area is required for habitats providing the key ecosystem services?
  The extent to which each ecosystem services can be provided depends on the size of the required habitats. Therefore, the amount of space that planners assign to the different habitat types should be sufficient to reach the desired level of ecosystem service provision.

A large portion of the available land in urban areas is occupied by buildings, roads and other infrastructure, which do not provide ecosystem services and often have negative environmental impacts. On the other hand, the space remaining for habitats and landscape elements providing key ecosystem services is strongly limited. An effective utilization of this rare space is important to ensure that the ecosystem service needs of the urban community can be sufficiently met. This can only be achieved if planners get profound and reliable answers to each of the three questions listed above. Therefore, the assessment of trade-offs in ecosystem services should be assigned to ecological experts.

5.3 Preparation of ecosystem service-based planning schemes

After the key ecosystem services have been determined and their potential trade-offs have been assessed, the planning scheme can be prepared. The preparation process should be organized in four steps: (1) identification of specific planning objectives, (2) demarcation of land use zones, (3) layout of the road network and division of lots, and (4) designation of site-specific landscape management measures supporting the provision of the key ecosystem services.

<u>Identificaton of specific planning objectives</u>

In order to embed the promotion of the key ecosystem services in the planning area, specific planning objectives have to be identified. Primarily, the specific planning objectives should be based on the legal and technical requirements that have to be met. Consequently, the planning scheme has to comply with the general planning standards defined by the Urban Planning Act (see Chapter 2.1.1) and it has to satisfy the individual needs in the respective planning area for infrastructure (transportation, water, sewage, electricity, etc.), housing, public services, commercial facilities and industries. Within this framework of necessary urban development, the specific planning objectives should additionally target the promotion of the key ecosystem services and the prevention of serious environmental hazards.

<u>Demarcation of land use zones</u>

Based on the distribution of different habitat types providing the key ecosystem services in the undeveloped landscape, the planning area is subdivided into different land use zones that shall be optimized for the provision of specific ecosystem services. Examples for different land use zones from an ecosystem service-orientated perspective would be parks, wetlands, farms and gardens that are apart from settlement areas and commercial/industrial zones.

The ecosystem service map, which was derived from habitat type mapping (see Chapter 3 and 7.1) and the participatory evaluation (see Chapter 4.4), is vital for the demarcation of land use zones. Firstly, it can be used to identify habitats that provide multiple key ecosystem services (ecosystem service hotspots). As far as possible, these areas should be reserved as conservation zones. If these habitats are cleared away in the wake of urban development, significant efforts will be required to replace lost ecosystem services. Artificial urban ecosystems have to be developed at comparably high cost, that commonly will not gain the same capacity to provide ecosystem services as the original habitats in the undeveloped landscape. However, nature conservation within cities that is based on strict limitation of entry and land use can only be realized in rare cases (e. g. Nairobi National Park). Alternatively, ecosystem service hotspots may be opened for specific land uses that allow an ecologically sustainable management ensuring the preservation of the key ecosystem services. Ideas and examples how this can be realized are provided in Chapter 5.4.

Furthermore, the collected information on the distribution of different habitat types and ecosystem services in the planning area should be evaluated, to identify sites with high potential for the development of ecosystems that can provide the key ecosystem services within the new urban settlement. For instance, places with soils well suited for farming should be designated as farming zones, rather than settlement zones, in order to not sacrifice the primary resource base, i.e. the best soils, to housing. In this manner, the future urban population can benefit from the existing nutrition services in a cost-effective way. Zoning is also crucial to avoid potential environmental hazards, which means that areas prone to flooding, erosion, landslides, etc. should be reserved for land uses that can easily adapt to the potential hazards and make direct use of the available ecosystem services (e.g. reservation of these areas for nature conservation or establishment of parks).

Finally, those sites in the planning area, where the capacity to provide ecosystem services is poor and where no serious environmental hazards can be expected, should be demarcated as zones for housing, roads and other built-up structures.

<u>Layout of the road network and demarcation of lots</u>

The layout of the future settlements, streets and other infrastructure primarily has to support the urban development needs for the planning area as defined in the specific planning objectives (see above) and must comply with the regulations set by the Urban Planning Act (see Chapter 2.1.1). Additionally, it should be designed in a way that supports the output of ecosystem services for the new urban community and minimizes risks for environmental hazards. This can be achieved through consideration of the prevailing environmental conditions and ecosystem service potentials in the planning area. As provided by the land use zoning, ecosystem hotspots and areas that are prone to environmental hazards should not be occupied. Moreover, the design of the settlement layout and infrastructure network itself can contribute to the provision of ecosystem services, for example if housing lots provide enough space for private gardens or if allotment through roads is optimized to reduce traffic congestion in settlement areas. Generally, the layout of the infrastructure and road network and the division of neighbourhoods and lots should ensure short distances between settlements, shops, working places and leisure areas. It should be focused on pedestrians, bicycles and public transport, as these are by far the most relevant modes of transport in the cities of sub-Saharan Africa. Moreover, the infrastructure network should be equipped with the capacity to cope with natural hazards like rain storms.

Designation of site-specific landscape management measures

Finally, a wide range of landscape management measures that support the provision of the key ecosystem services in the planning area should be integrated in the planning scheme. This includes the ecologically compatible transformation of valuable habitats in the undeveloped landscape into sustainably used urban ecosystems, the development of new urban ecosystems for ecosystem service provision in sites with suitable environmental conditions, the safeguarding of hazardous land and utilization of its ecosystem service potentials and the upgrading of built-up areas by trees, hedgerows, lawns and other green infrastructure. More details and specific examples for appropriate landscape management measures in urban development schemes are provided in Chapter 5.4.

Relevance of stakeholder participation

Each of the four steps for the preparation of ecosystem service-based planning schemes should be carried out in close collaboration between urban planners and local stakeholders, to ensure that the proposed measures are understood and supported by the local communities (see Chapter 4). Furthermore, stakeholder participation reduces the risk to overlook important issues in the planning area and can considerably contribute to the development of solutions for the major planning challenges.

5.4 Measures to minimize environmental impacts and to promote ecosystem services

Urban planners should develop a cluster of innovative landscape management measures to ensure that the needs of urban communities for ecosystem services can be sustainably and sufficiently met. In the following some examples are mentioned to illustrate the wide range of potential measures minimizing environmental impacts and promoting ecosystem services that can be stipulated in planning schemes. It is, however, important to note that in each planning project specific landscape management actions have to be developed. Consequently, some of the examples listed below might be useful in one project but are inapplicable in another.

When ecosystem service hotspots occur in a planning area and nature conservation is not a desired option, the provision of ecosystem services could be preserved to a limited extend by transformation of the original habitat into an ecologically-sustainably managed urban ecosystem as the following examples show:

- Forests, woodlands or old orchards can be transformed into public parks where multiple ecosystem services are provided. Threatened indigenous tree species as well as dependent animal species can be conserved and re-established. People can recreate, collect fruits and traditional medicines, or practice religious and traditional rites. The parks contribute to regulate the local climate, clean air, reduce noise from traffic and industries and buffer water cycling.
- Regulated by local forest authorities, a sustainable management can be imposed on shrub- and woodlands at the edges of urban areas, which allows firewood collection by the local community. Apart from the provision of firewood these ecosystems can contribute to the

conservation of endangered plant and animal species, regulate local climate and water cycling, and additionally provide a clear boundary to the built-up area.

- If forests or woodlands cannot be transformed into parks, at least solitary indigenous trees may be conserved to provide shade and space for recreation.
- Small-scale farms, particularly those applying agroforestry can be transformed into private or public gardens, where local residents can grow food and recreate. Furthermore, these gardens contribute to the regulation of local climate and water cycling, and provide shelter for endangered species.

Some of the key ecosystem services that are required in the proposed urban settlement might not be available in the original agricultural or natural landscape since the relevant habitat types are missing. To facilitate the provision of these ecosystem services, it is therefore necessary to develop new urban ecosystems. Preferably, these ecosystems should be placed in sites that hold appropriate environmental conditions and that are close to the locations where the targeted services are needed most. However, it should not be ignored that the establishment of new ecosystems to provide specific ecosystem services is not always successful and, in any case, requires continuous intensive management. Some examples for possible developments of new urban ecosystems are listed below:

- As outlined in Chapter 5.3, areas with fertile soils should be demarcated as farming or gardening zones. Ideally these zones should be used for small-scale farming and gardening, as the mosaic-pattern that is characteristic for this land use type fosters provisioning of multiple ecosystem services.
- Larger settlement areas should be loosened up by the establishment of small parks and community gardens in regular spacing as sites for assembly, recreation and leisure close to people’s homes. Depending on the location of the proposed settlement area, woodlands or forests that could be transformed into parks and gardens might not be available at the desired locations. In these cases, the parks and gardens have to be established from scratch.
- As a contribution to reduce the sewage problem, which large cities like Dar es Salaam are facing, constructed wetlands can be established in natural depressions or floodplains for waste-water treatment in settlement areas.

Hazardous land, including floodplains, eroding slopes or gullies, cannot be used for buildings, roads and other urban infrastructure. Nevertheless, planners should not disregard hazardous land since in many cases these areas require specific management to avoid negative effects on neighbouring settlements. Furthermore, hazardous land can hold considerable potentials for the provision of key ecosystem services. If the right management measures are applied, these potentials can be utilized for the urban community as the following examples illustrate:

- Floodplains along streams and rivers as well as in natural depressions that are affected by regular flooding commonly hold highly fertile soils and sufficient water supply even during dry seasons. If flooding is relatively rare, these areas are predestined for farming. Even without a regulation of the flooding by dams and culverts, crops with short life cycles as well as crops that can cope with high water levels (e. g. rice, sugarcane) can be grown in floodplains. Where flooding is frequent or erosive, gallery forests should be preserved or planted.

- In the higher parts of floodplains, where the frequency of flooding is lower (e. g. only once in a decade), parks can be established using indigenous riparian tree species.
- Gullies are active erosion channels of enormous dimensions that threaten neighbouring plots due to ongoing extensive erosion. A possible option to stop this process and to make use of the deeply incised gully channels is to install micro-dams that capture sediments and level the slope. The sedimentary bodies behind the micro-dams can hold water, that can be used by nearby dwellers for irrigation.

Where settlements, infrastructure, commercial sites or industries will be established, a poor provision of ecosystem services has to be expected. Therefore, planners should pay special attention to integrate green structures into these areas to improve service provisioning. Some examples are listed below:

- Along roads in the planning area green spaces should be established such as grasslands, hedgerows and roadside trees to provide shade, air filtering, noise reduction and erosion control.
- Lot boundaries can be marked by hedgerows and trees.
- Green spaces such as lawns, trees or small parks should be established around public service facilities (schools, hospitals, markets) and government offices.
- Private house owners could be imposed with regulations to reserve parts of their lots for gardens and other green spaces

Further possible landscape management measures that foster the provision of ecosystem services in urban areas were developed in the ECOSOLA project and are listed in Box 8.

Box 8: Key environmental problems, relevant ecosystem services and ecosystem service hotspots governing the design of the exemplary layout plan for Vikawe

In the case study region, the following environmental problems were identified:

- Erosion and gully development on the hillslope on bare land, leading to loss of land for settlement etc.
- Strong biodiversity loss due to clearing of riparian forests
- Future need for fire wood could spark further exploitation of adjacent woodland

The following ecosystem service hotspots were identified:

- Riparian forest along Mpiji River
- Farmland on floodplains along Mpiji River
- Large orchards on the hilltop and slopes
- Woodland that can be used for sustainable firewood production

The following ecosystem services were chosen as the most relevant for the proposed urban area:

- Food production
- Firewood production
- Erosion control and soil fertility
- Nature conservation

The following trade-offs where considered: Areas for food production can only marginally serve for firewood production and nature conservation. Likewise, nature conservation can only be facilitated where food or firewood production is, at most, a secondary benefit at a low level. Consequently, the development plan should provide different vegetated zones optimized for different ecosystem services, as well as settlements, transportation and commerce.

The following specific planning objectives were developed:

1. Development of a new urban settlement that accommodates a similar population size as the existing legal layout plan for the study area
2. Prevention of erosion and gully development, management of existing gullies
3. Minimization of land consumption by urban development
4. Promotion of regulating ecosystem services (e.g. shade and natural cooling, water cycling)
5. Designation of areas for farming, gardening and firewood collection
6. Conservation of areas with high ecological and/or cultural value
7. Conservation of farming land with agricultural value near the river

A layout plan for the future settlement was designed to resolve the conflicts and environmental problems that would arise if urban development did not account for the services provided in the present landscapes (Fig. 15).

To meet the specific planning objectives, the following measures were integrated into the final layout plan for Vikawe:

1. Designation of areas where no or only limited building development should take place: sites unsuitable for construction (reeds, large gullies) and valuable habitats (riparian woodland, soils of agricultural value, woodland with large trees, large individual trees providing shade, and orchards)

Box 8 (continued)

2. Layout of a road network facilitating erosion prevention: only two paved roads running downwards, which connect to the roads accessing the houses. The latter roads all run parallel to the slope, which restricts erosion and running water after strong rains. The road size is in accordance with the existing layout plan and the Urban Planning and Space Standards Regulations (2011).
3. Arrangement of public buildings while taking into account accessibility (spatial proximity) and environmental impacts (e.g. waste collection point in adequate distance to settlement plots and sensitive ecosystems, play ground on flat terrain and in walking distance to schools).
4. Promotion of larger housing units (housing estates) to reduce space consumption: One important element of these housing estates are private gardens available for the residents of the apartments.
5. Vegetative barriers between settlement plots and around existing gullies to control erosion and stop gully development. These barriers are either hedgerows, grass or herb strips (such as lemon grass).
6. Conversion of large gullies to small water reservoirs by installing micro-dams to decelerate gully enlargement and to provide irrigation water during the dry season.
7. Redevelopment of a green belt along the Mpiji River: protection of the riparian evergreen forest and reforestation of former forest sites, safeguarding continued use of sacred sites for traditional and cultural purposes.
8. Designation of farmland for small-scale farmers and gardeners on fertile soils in the valley of the Mpiji River, to provide local food for the community.
9. Designation of woodland for sustainable firewood production. The whole woodland is divided into 15 lots. Each lot will be available for firewood extraction for just one year. After this year, another lot is made available for firewood extraction, while the trees on previously used lot are allowed to regrow for 14 years. This will lead to a shifting mosaic of regrowth stages with a single lot per year for firewood extraction.
10. Development of parks within the settlement area: Particularly remaining woodlands were selected as sites where future parks should be developed to make use of the indigenous tree species inventory and to preserve the biodiversity of the area.
11. Continued cultivation of old orchards.

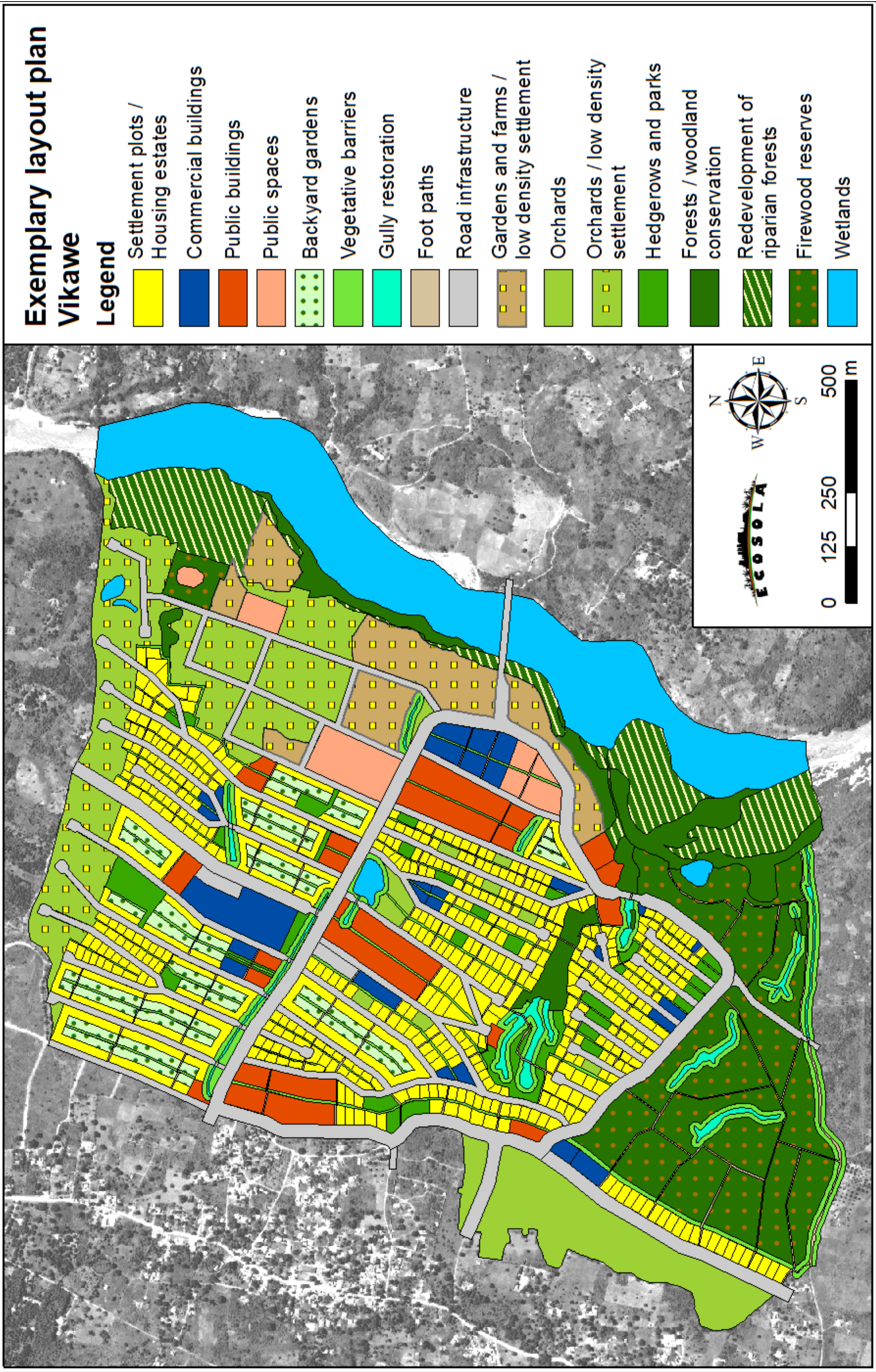

Fig. 15: Exemplary layout plan for the case-study region

Part III Background data and environmental data recorded on site

6 Background data

To determine the most important environmental characteristics of urban planning areas, a variety of existing background data should be taken into account. This helps to identify major ecosystems and landscape features as well as vulnerable locations, such as steep slopes, floodplains or degraded soils. Here, landslides, floods or other natural hazards might occur that can cause extensive damage to buildings and infrastructure, disruption of social and economic networks, and lead to the loss of human lives and property. To avoid the aforementioned effects, planning authorities, consultants and engineers need to assess available data on the geo- and bio-physical conditions of planning areas, including information on land use and land cover, topography, geology, soils and climate. The different types of relevant background information and options to acquire the respective data are discussed in this chapter.

6.1 Satellite imagery and aerial photographs

6.1.1 Purpose and aims

Accurate data on current land use and land cover are essential information required by planners and policy makers for carrying out various activities in urban planning and management. Many cases have shown that satellite images and aerial photographs are valuable tools for urban planning purposes. Both can be used to prepare preliminary land use and land cover maps without having to visit the area. This allows making (preliminary) decisions about the management of large areas on a small budget. In addition, base maps using satellite imagery or aerial photographs can serve as a vital source for on-site mapping (see Chapter 7.1). High-resolution imagery makes it possible to extract man-made features, such as roads and buildings, and to develop maps of existing infrastructure. Further, habitat types such as woodlands, grasslands/bushlands and waterbodies, can be distinguished and located on satellite images and aerial photographs. These kinds of initial land use and land cover maps provide an overview of the major ecological features in planning areas. High-resolution satellite imagery and aerial photographs incorporated into GIS (Geographic Information Systems) and CAD (Computer Aided Drafting) have gained popularity among planners, developers and engineers for large scale mapping of any region for most urban and land development applications.

6.1.2 Data sources and purchase options

There is a number of data centres that offer **satellite imagery data**. Imagery of high resolution from commercial satellites must be purchased at relatively high cost, while medium to low resolution imagery can be freely accessed. A third option are free satellite maps provided by Google Maps and Bing Maps. These data are of relatively high resolution, covering the entire world. Here, users do not need to pay for fine resolution or download free images one by one from a satellite data base. All three options have advantages and disadvantages, and planners should make their choice based on the specific needs of each planning project.

Satellite imagery has different spatial resolutions. Spatial resolution refers to the size of one pixel on the ground. A pixel is the smallest 'dot' that makes up an optical satellite image and basically determines how detailed a picture is. Landsat data, for example, have a 30 m resolution, meaning each pixel stands for a 30 m x 30 m area on the ground. There are three major ranges of spatial resolution: low resolution with more than 60 m / pixel, medium resolution with 10-30 m / pixel and high resolution with less than 5 m / pixel. The highest available resolution as of now is 30 cm provided by very high-resolution commercial satellites.

(1) Open-source low and medium-resolution satellite data. There is a wealth of open source satellite imagery with global coverage. Some of the best free GIS data sources are: USGS Earth Explorer, LandViewer, Copernicus Open Access Hub, Sentinel Hub, Nasa Earthdata Search, Remote Pixel. Advantages are: firstly, the huge imagery selection free of charge. The web satellite data service LandViewer alone gives access to 8 free Earth observation datasets. The imagery varies in spatial resolution (10–500 m/pixel), revisit periods (2–16 days) and spectral bands contained (4 to 12 bands). Sentinel 2 data, Landsat 8 OLI and TIRS, Landsat ETM+ data, MODIS data are generated by operational satellites, regularly updated and immediately available for viewing, analysis or download. The second advantage is the availability of spectral image bands for remote sensing analysis. Various combinations of these bands and spectral indices allow for image pre-processing (atmospheric correction, pan-sharpening) and specific assessments (land use, land cover classification, etc.). Thirdly, these resources provide an archive of historic image data. LandViewer offers access to various historical images starting from 1982 until now and provides value-added services for extracting insights from old images such as time series analysis or time-lapse animation.

Disadvantages of low and medium-resolution satellite data is the low level of detail. The best resolution comes from Sentinel satellite data with 10 to 20 m per pixel. This is enough for monitoring general features such as woodlands, waterbodies or urban areas but single houses, roads and most habitat types will not be visible. Therefore, these data may be used for general planning schemes in large municipalities, but they are not suited for detailed planning schemes at a local level.

(2) Commercial high-resolution satellite images. The advantages of these images are firstly the high level of detail. Even small objects such as individual houses can be identified. The resolution ability of 8 datasets available in LandViewer varies between 5 m (SPOT 5) and 40 cm (Kompsat-3A). A second advantage is the ability of assigning tasks. Modern commercial satellites are able to collect data according to the very concrete customer requests. It means that – unlike government satellite missions whose satellites follow consistent paths – commercial satellites can be tasked to capture a certain location at a certain time.

The main disadvantages are, firstly, the high costs. Commercial satellites carry the most advanced technology sensors, which require large investments. That is why satellite image data of high resolution is expensive. To make it more affordable, reselling platforms like LandViewer let customers pay only for the part of an image that covers the desired area. This is a great value-for-money option, considering the price one would pay for an entire image. The second disadvantage is the small area coverage. Generally speaking, the better the resolution, the less total ground area can be seen in an image. That is why high-resolution satellite data is more suitable for small-scale monitoring or analysis. A third downside is the limited availability. With any satellite data, there is always a risk that an image will be of little to no use due to cloudiness. Medium-resolution satellites, which follow a consistent path and revisit areas at regular intervals, provide you with a better chance of finding a good image. Commercial satellites are sometimes tasked by customers or pointed to collect specific areas instead of areas directly in their route; this means that one could end up waiting for an image that will not be collected at all.

(3) Satellite data in Google Earth and Bing maps. The clear advantages of these data bases are first that both services are free of charge. Secondly, a highly detailed satellite map of the entire globe that is comprised of various high-resolution datasets (aerial photographs, commercial high-resolution data, open source imagery, etc.) is provided. Buildings, vehicles, and trees can be distinguished. Thirdly, historic data is available. Google Earth has a historical imagery feature, so that one is not limited to just the imagery shown by default in Google Earth. Google has archives of imagery from many sources and dates. For many places, up to 30 different images over time are available. The data used to create a specific part of the image is always given at the bottom of the page. The limitation of Google Earth and Bing maps is that it may not be possible to obtain the original multispectral band data. That means it is not possible to get the actual pixel numbers or the brightness/reflectance values and hence image classification using unsupervised or supervised techniques cannot be carried out.

If cost of purchasing a high-resolution satellite image is a major constraint, then one could consider utilizing free Google Earth images. Most popular image processing and GIS software like ERDAS IMAGINE, ENVI, ArcGIS, QGIS etc. provide tools to visualize and import Google Earth and Bing map images. For preparing a land use map from satellite images from Google Earth or Bing map the steps are as followed:

(1) downloading/importing of the Google earth images to GIS software, (2) mosaicking of many tiles to a single image, (3) clipping the required area, (4) on-screen digitizing of land use classes. The land use classification needs to be adjusted according to the characteristics of the target area, but should at least include built-up areas, shrubs and woodlands, open land, agricultural areas, and water bodies. The built-up areas include all buildings and roads. Shrubs and woodlands include densely vegetated shrubs and forests. Open land includes bare land or grasslands. Water bodies consist of lakes, rivers, ponds and pools. Mapping categories can be chosen according to the main groups of the habitat mapping key (see Part IV): mangroves, woodland, bushland, grassland and built-up areas.

In comparison to satellite pictures, **aerial photographs** are commonly of higher resolution and less affected by cloud cover. However, the production of aerial photographs depended until recently on elaborate survey flights with aircrafts, which resulted in revisiting periods of several years. Consequently, aerial photographs often suffered from poor timeliness. In contrast, the currently evolving drone technology provides a new, appealing source of high-resolution aerial pictures. These systems have several striking advantages compared to satellite pictures and conventional aerial photographs taken from aircrafts. Any specified area can be mapped at high detail, on any date as requested by the client and at relatively low cost. Due to relatively low flight height, aerial photographs made by drones are not affected by cloud cover. Furthermore, different types of cameras and sensors can be used on drones, which allows surveying a wide range of landscape features. Revisiting periods, to illustrate development processes like urban sprawl, can be set as demanded by the client. In Dar es Salaam, drone technology has already been successfully applied in the Ramani huria project (https://ramanihuria.org/en/).

Box 9: Satellite imagery from Vikawe

Google Earth images from the case-study region were obtained to get an overview of the predominant land use and land cover types (Fig. 16). The main part of the study area is covered by bushland and grassland. Only a few small patches of woodlands and forests can be identified on the satellite picture. These are especially found along the bed of the Mpiji River. Moreover, orchards are visible as stands of trees uniformly planted in rows. The settlement structures of Vikawe directly adjacent to the study area, including houses and streets, are also clearly visible.

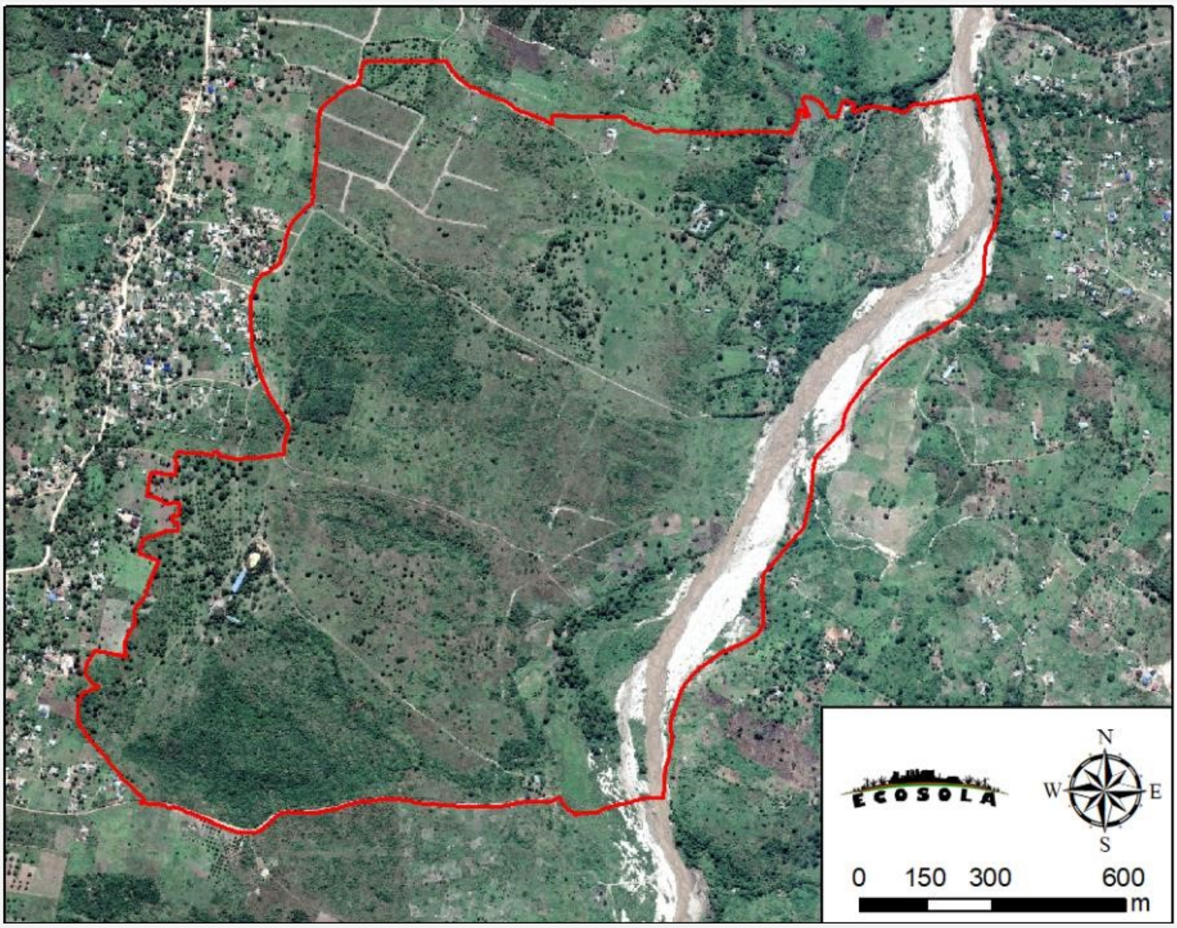

Fig. 16: Google Earth image of the case study region Vikawe

6.2 Topographic maps

6.2.1 Purpose and aims

Planning and designing of settlements require accurate understanding of the land surface. This information is contained in topographic maps and digital elevation models. Topographic maps illustrate the relief of the land surface (using contour lines), major land use and land cover types, man-made features, and administrative borders in great detail. They allow a three-dimensional understanding of the terrain on a two-dimensional map. Topographic maps are available as physical map sheets and, in increasing numbers, as digital datasets.

Based on topographic maps, as well as on remote sensing measurements, digital elevation models (DEM) have been prepared for use in GIS applications. DEMs allow calculations of inclination, slope directions, delineation of water sheds, flow channels and floodplains, and other important topographic features in GIS.

The use of topographic maps and DEMs can be a rich source of basic data that can be used in a variety of planning and management applications. Some of the main restrictive factors for urban development, such as topography, slope, erosion susceptibility, water table depth, and flooding susceptibility, can be assessed based on topographic maps and DEMs.

6.2.2 Data sources and purchase options

The available inventory of **conventional topographic maps** for Tanzania is seriously outdated and limited to a few series on different map scales. Topographic maps covering the entire country are only available in the scales 1 : 250,000 and 1 : 50,000 and date back more than 30 years. For a few parts of the country maps at a scale of 1 : 2,500 are also available. These maps can be obtained through the Surveys and Mapping Division of the Ministry of Lands, Housing and Human Settlements Development in Dar es Salaam or, alternatively, as digital map sheets from commercial geodata providers. However, due to their limitation to relatively small map scales and missing timeliness, conventional topographic maps for Tanzania are often insufficient to support planning projects, particularly at local scales. For some parts of the country, open-source digital mapping products, such as Open Street Map (https://www.openstreetmap.org/) can help to close this gap.

During the Shuttle Radar Topography Mission (SRTM) in February 2000, elevation data of the land surface for the entire globe were obtained. **DEMs** prepared by the SRTM have an aerial resolution of 30 m/pixel and an elevational accuracy of 1 m. All data can be freely obtained from the USGS (https://earthexplorer.usgs.gov/) and directly processed with GIS software.

Box 10: Topographic map for Vikawe

The topographic map of the case study region on the scale of 1 : 50,000 dates back to 1987 (Map sheet 186/1 “Kawe”). Important features of the study area are not visible on the topographic map and therefore it was not used. The digital elevation model based on SRTM data for the study area was obtained from the USGS. It clearly indicates the hillside situation of the area. The higher parts in the western study region are 115 m a.s.l while elevation drops to 50 m a.s.l. in the eastern part of the study region along the Mpiji River.

6.3 Geological and soil maps

6.3.1 Purpose and aims

Geological and soil maps provide a valuable source of information on the soil characteristics of planning areas. Geological maps illustrate the distribution of near-surface parent materials, like basic rock formations or unconsolidated sediments. These parent materials form the topography and the foundation of minerals in a region and considerably influence soil conditions. Depending on detail and resolution, soil maps describe the patterns of major soil associations, soil classes and soil types. Furthermore, soil maps contain spatially-explicit information about physical and chemical soil conditions. Findings with relevance for planning projects that can be derived from geological maps and soil maps include susceptibility to erosion or flooding, soil fertility and productivity, and the bearing capacity of the soil.

6.3.2 Data sources and purchase options

Geological maps for major parts of Tanzania can be obtained from the Geological Survey of Tanzania in Dodoma (https://www.gst.go.tz/). These are available as print outs, scans and digital raster maps on the scales of 1 : 100,000, 1 : 125,000 or 1 : 250,000. However, for large parts of the country, geological maps have not yet been published.

Maps of general soil associations can be derived from the Ministry of Agriculture for most Districts in Tanzania (https://www.kilimo.go.tz/index.php/en/maps/category/soil-resources) or from the Soil Atlas of Tanzania. However, these maps have small scales and do not provide sufficient information for urban planning.

A great free-access online geodatabase that provides information of soil profiles and maps of physical and chemical soil properties for the entire world is hosted by ISRIC – World Soil Information under https://soilgrids.org/.

If more detailed information on soil features is required for the planning process, soil surveys should be conducted in the planning area (see Chapter 7.3).

6.4 Climate data

6.4.1 Purpose and aims

Information on the climate constitutes a valuable background data resource for a variety of planning decisions. It gives an overview of local climate conditions, which helps to decide upon strategies and measures to control local microclimate in urban settlements. Urban heat island effects, such as thermal stress and high radiation values, are key issues for many cities around the world, which are becoming increasingly relevant due to climate change. Climate data also provides information about the frequency, magnitude and duration of extreme weather events in a specific region. With the progression of climate change, these events will most likely occur at higher frequency and become more severe. Climate data also helps to decide which plant species are appropriate to plant in a planning area.

It is rare that detailed site-specific observational climate data exist. More commonly, data from the nearest available weather station are employed as a substitute. For many purposes, this information is processed in the form of a Typical Meteorological Year (TMY) that is best suited for answering most questions. However, climate data sometimes need to be adjusted. For some purposes, meteorological data must be processed to make a design day or a typical meteorological year that incorporates averages and extremes. These data are often required by building-simulation programmes and form the basis for decisions on heating and cooling needs and the capacity of the system for dealing with extremes. For other purposes, such as the design for extreme winds or precipitation events, return periods that identify the rate of recurrence of an event of a given magnitude are employed.

Moreover, for many purposes (such as planning for public health during excessive summertime heat), detailed microscale climate information is needed on a neighbourhood level to assess risk and vulnerability, and to respond accordingly.

6.4.2 Data sources and purchase options

The major source for climate data in Tanzania is the Tanzania Meteorological Agency (http://www.meteo.go.tz/). This government institution collects and manages climate data from meteorological stations in Tanzania. Data can be purchased from the main office in Dar es Salaam. Alternatively, climate data can be downloaded from various databases such as climate-data.org. In most cases, data on the exact location will not be available but data from locations nearby can be used.

Box 11: Climate data for Vikawe

The case study area has a tropical climate with an average annual temperature of 25.5 °C. About 990 mm of precipitation falls annually. Precipitation is the lowest in July, with an average of 21 mm. The greatest amount of precipitation occurs in April, with an average of 219 mm.

It is worth mentioning that flash floods are very common in the study area. Regularly, these events cause extensive damage to infrastructure and result in loss of life.

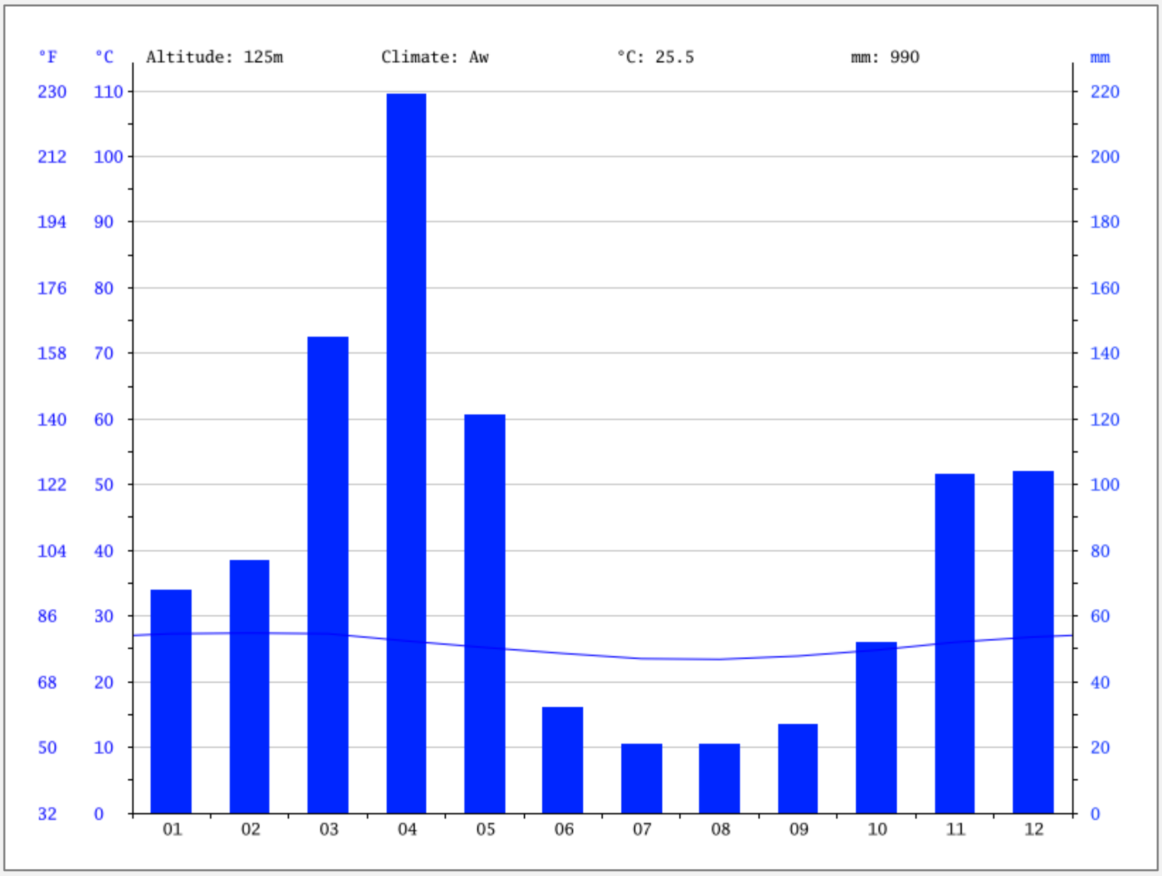

Fig. 17: Climate graph and weather by month for Kibaha (data from climate-data.org). The blue line shows the mean daily temperature, the bars show the monthly rainfall amount.

7 Environmental data recorded on site

For most planning projects, the available geographical background data will not be sufficient to assess the availability and distribution of ecosystem services in the respective planning area in the desired detail. Consequently, detailed, on-site surveys are necessary as well. The aim of this chapter is to present methods to assess ecosystems and their services in Tanzania, to inform and direct urban planners. Addressing these aims, this chapter borrowed extensively from the field of conservation planning, where mapping biodiversity patterns and processes proved to be very useful for spatially-explicit decision making. For example, conservation biologists often use well-studied taxa as surrogates for poorly studied groups. This chapter relies on these ideas of surrogacy, where mapped ecosystem components are often used as the surrogate or proxy for mapping the distribution of different ecosystem services.

7.1 Habitat mapping

7.1.1 Purpose and aims

A habitat map is a useful tool for urban planning as it gives planners and decision-makers an in-depth understanding of the distribution of various ecosystem services in the area of interest. Vegetation and habitat mapping have a long history in Europe. Earlier maps focused on vegetation mapping, and were usually produced for scientific purposes and to increase our knowledge of the natural world. More recently, habitat maps have been used and increasingly produced to address policy-related issues, also during urban planning processes.

The term 'habitat' is widely, but inconsistently, used, since there are various interpretations of its meaning. It is associated with the optimal abiotic conditions required by individual species or the physical environment that surrounds, influences, and is utilized by a species or population. However, the term also refers to a combination of species (both fauna and flora) and physical factors (e.g. climate, topography, soil type) that occur together. In this work, we follow the definition from the EEA's European Nature Information System (EUNIS) and the EU Habitat Directive and refer to the latter meaning (https://www.eea.europa.eu/data-and-maps/data/eunis-habitat-classification). Habitat mapping aims to delineate areas with particular environmental conditions that are sufficiently uniform to support a characteristic assemblage of organisms. A few habitats, such as built-up areas and highly artificial standing waters may be devoid of living organisms other than microbes. These features, although not strictly habitats, are included for completeness.

A habitat is an area of uniform environmental conditions, clearly separated from its surrounding, providing a living place for a specific assemblage of plants and animals. As animals are mobile and plants sessile, habitat mapping categories mainly refer to the vegetation that is more or less permanently present in a certain location. A habitat often conforms to a certain vegetation type and should be recognizable in the landscape. As plants and animals interact and depend on resource supplies, disturbances, and non-consumable environmental factors in a habitat, the term habitat also translates to an ecosystem with specific service outputs. Therefore, knowledge about the spatial distribution of habitats in a planning area is of great value for planners.

Habitat types are used as abstract recording units, which summarise biotopes that are similar in essential characteristics. Since ultimately every habitat is unique, the level of detail of the description has theoretically almost no limits. To keep mapping keys convenient, a limitation of the number of habitat types is necessary.

Habitats can be of different scale. Generally, the scale selected for the habitat classification is that occupied by small vertebrates, large invertebrates and vascular plants, and is comparable to the scale applied to the classification of vegetation in traditional phytosociology. Habitats commonly occupy at least 100 m^2, with no upper limit to the scale of the largest. Habitats can be grouped as 'habitat complexes', which are frequently-occurring combinations or mosaics of individual habitat types, usually occupying several hectares, which may be inter-dependent. Some habitats, such as beaches or bushlands, may be extremely large. Others, such as gullies or ponds, are much smaller. Mapping keys should also consider habitats of very small size, which are more likely to be classified as structural elements, as long as they are present in different habitat types and are clearly separated from the surrounding (e.g. single trees or lines of trees).

7.1.2 Methodology

The preparation and implementation of habitat mapping should be carried out by ecological experts. If these experts are not available in planning authorities, external consultants should be commissioned.

For preparation of the field work, the following steps must be taken:

(1) Delineation of the study area: The area that needs to be mapped has to be delineated based on the scope of the particular planning scheme. All sites that presumably will be affected by a proposed development project should be covered. This can imply mapping an area that is larger than the planning area itself, because planners may wish to assess potential effects of the project on the habitats surrounding the planning area. To support the decision about the delineation of the study area and to get familiar with the landscape, a preliminary site inspection is strongly recommended.

(2) Definition of the mapping scale: Depending on the size of the study area and the available manpower, different levels of mapping detail can be achieved. Large areas for regional planning (e.g. general planning schemes) have to be mapped at smaller mapping scales, whereas small areas for local planning projects can be surveyed at large mapping scales. Apart from mapping feasibility it should be kept in mind that small mapping scales carry less detailed information and can impair the evaluation of ecosystem service provision based on such habitat maps. In most cases, the best results will be achieved at mapping scales of about 1 : 2,000 to 1 : 5,000. The mapping resolution may vary according to the scale of the map. Usually, all elements smaller than 5 x 5 mm on the field map are disregarded, except for those with special environmental relevance. Linear elements, such as water courses, grass strips or hedgerows can be indicated on the map as coloured lines.

(3) Development of a habitat classification key: There is not much literature available describing vegetation formations and communities in Tanzania (e.g. Greenway 1973; White 1983; Hawthorne 1984, 1993; Burgess & Clarke 2000). The existing work is not suitable for habitat mapping in planning contexts, since the suggested vegetation classifications are either too

generalized or site-specific. A project-specific habitat classification might be a way forward in some cases, but would not provide a satisfactory basis for a common ecosystem service-based planning approach. Therefore, a habitat classification key for Tanzania needs to be developed. This cannot be the task of the consultants engaged in planning projects, since they often have to keep to tight time frames. In this respect, this guideline provides a first version of a habitat classification key for Dar es Salaam and Coast Regions (see Part IV). It could be used as a basis for the preparation of a nationwide key.

(4) Selection of the mapping period: In areas with distinct dry and rainy seasons, the vegetation pattern changes considerably during the year. In most cases, the optimal period for habitat mapping is at the beginning of rainy seasons, when annual and deciduous plants are foliate and flowering (important for species identification), and when water levels in wetlands are not yet too high (important for accessibility). In large study areas, it might be useful to start during the dry seasons in wetland areas with perennial vegetation and shift to the dryer sites when the rainy season starts.

(5) Technical preparation of the field work: Field maps have to be prepared that cover the entire study area. Each field map sheet should be set to the mapping scale, provide some overlap to the neighbouring map sheets and have a format that ensures good usability in the field (e.g. A4). Recent satellite pictures or aerial photographs should be used as a background on each map sheet to assist orientation in the field. If available, a very comfortable alternative to print-outs are outdoor tablet PCs with GIS receivers on which base maps can be downloaded and direct digital drawing of habitat boundaries is possible.

(6) Administrative preparation of the field work: Depending on the scope of the study, research permits may be required. In any case, local government authorities have to be informed prior to the commencement of the field work.

During the field work, the main task is to identify different habitat units based on the habitat classification key and to draw their boundaries onto the field maps. For this purpose, the study area is crossed systematically by foot. The identification of boundaries in farmland areas is often rather easy, whereas in undisturbed natural habitats, it can be complicated. Therefore, in natural habitats more time has to be calculated for the mapping work. Additionally, information relevant to characterizing the environmental quality of individual habitats, such as occurrences of particular species, structures for nesting, feeding or resting of animals, the land use intensity, or environmental degradation, may also be recorded.

Commonly, not much technical equipment is needed during field work, but a GPS device for orientation and a camera to take reference pictures of habitat types are recommended.

7.2 Additional biodiversity data

One priority of ecosystem service-based urban planning should be maintaining and enhancing the abundance and diversity of native and naturalised species in urban areas. The rationale for this is not only species conservation, but also their contribution to provisioning, regulatory and cultural ecosystem services. Information on species occurrences sheds light on aspects not highlighted by habitat maps, such as biotic networks between different habitats or biodiversity hotspots. However, biodiversity can only be substantially considered in planning if relevant, accurate and spatially-explicit biotic data are available. In many cases, such data are lacking, which restricts the quality of decision-making. Consequently, as far as the financial and time budgets of planning projects allow, field studies should be carried out to record the species composition of the present biotic communities. As plant species are partly covered by habitat mapping, it may often be sufficient to focus on a few well-studied taxonomic groups of particular ecological significance, such as plants, mammals, birds, amphibians, reptiles and larger insects (e.g. butterflies). Moreover, surveys may be limited to characteristic or indicator species and species assemblages characterizing groups of sites, rather than mapping every species. Charismatic species can enhance the motivation for conservation efforts. Research has shown the benefits of integrating biodiversity information at an early stage in development planning.

Tanzania signed the Convention on Biological Biodiversity (CBD) in 1992 and ratified the same in March, 1996; thereby committing the country to join other global partners aspiring to conserve biological diversity and enhance development opportunities, banking on more sustainable use of biological resources and promoting more equitable measures of sharing accrued benefits across local, regional, national, and global stakeholders. Tanzania is characterized by an extraordinary floristic and faunistic biodiversity. There are about 10,000 vascular plant species, 302 mammal species, including 97 species of bats, 1,065 bird species, 133 amphibian species and 293 reptile species. Against this background, it is clear that species identification and recording in the field can only be done by specialists with a broad knowledge of the respective taxonomic groups. Biodiversity data has to be collected on site and is required to be up-to-date. Detailed explanations of field methods to survey the species composition in planning areas are beyond the scope of this guideline.

Different biodiversity measures can inform spatial planning. The most commonly used is species richness, which is simply measured as the number of species living in a specific area. However, this index varies in a nonlinear way with the size of the elementary sampling units, the diversity of habitats and the extent of the study area. Also, the effect of sampling effort can artificially increase the perceived biological richness of an area. Thus, species diversity is a questionable criterion. Better criteria are (i) species endemism, rarity and endangerment based on IUCN Red Lists, and (ii) species representativeness of pristine, endangered or culturally valuable habitat types. An alternative option is to measure biodiversity in terms of functional diversity. This concentrates on the diversity of specific traits that species developed in response to environmental conditions, and on biotic inter- and intraspecific interactions. Functional diversity is particularly interesting, as it directly links to ecosystem services.

Biodiversity data can support decision making in urban planning processes, for instance by the identification of biodiversity hotspots and habitats of endangered species that are sensitive to disturbance or by the evaluation of the potential of urban ecosystems as habitats for native species. In addition, biodiversity data are crucial for environmental impact assessments of urban development projects, to develop planning measures that avoid or minimize impacts on biodiversity.

7.3 Soil data

Soil is a mix of mineral particles, organic matter, water and air, which forms through long-term soil evolutionary processes of bedrock weathering, organic matter decomposition, humus accumulation, material transport and others. Physical and chemical soil properties are considered to be crucial determinants of plant diversity and the vegetation distribution pattern. Soils largely influence land use activities through fertility, water availability, drainage capacity or bearing capacity. Furthermore, soil-development processes can take several thousand years, and disturbances, such as excavation or compacting, can cause irreversible changes in predominant soil conditions, with negative effects on soil fertility or physical soil stability.

Soils affect a variety of human activities from agriculture to the engineering and construction of roads, buildings, and sewage-disposal systems. They are critical in determining plant productivity and the viability of operations such as farming, gardening, construction, or erosion control. Soil maps can be used to identify areas suitable for future development of homes, industry, agriculture, and recreation. For example, a soil map may indicate poorly drained areas, which should not be used for residential development because of the need for costly drainage facilities. Soil maps can also be used to assess the likelihood of finding suitable sites for individual, on-site, sewage-disposal systems.

Soil information gained from the available soil maps in Tanzania is often insufficient to support planning projects (see Chapter 6.3). Consequently, soil data have to be recorded directly in the planning area. Generally, soil can be described in terms of texture and through its depth and layers (horizons). Even though several indicators of chemical and physical soil conditions require extensive soil sampling and laboratory measurements, a lot of information can also be gathered directly in the field. Methods for soil assessments in the field have been described, for example by the National Soil Survey Center at the United States Natural Resources Conservation Service[1]. Without costly laboratory analysis, several measurements can be done directly in the field, for example: estimation of soil texture classes, vertical sequence of soil horizons, assessment of the predominant soil development processes, such as (temporary) water logging, silt or humus dislocation, assessment of root density, measurement of soil density, and estimation of humus content through soil colour.

[1] https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/research/guide/?cid=nrcs142p2_054184

Box 12: Soil data for Vikawe

In the study area, soil was sampled in different habitat types and at different locations. Simple field methods were applied to determine texture classes (in accordance to the soil mapping guide for Germany, Ad-hoc-Arbeitsgruppe Boden 2005). The results show that clay content is particularly high on the floodplains of the Mpiji River, whereas the slopes are partly characterised by sandy soils and partly by loamy soils.

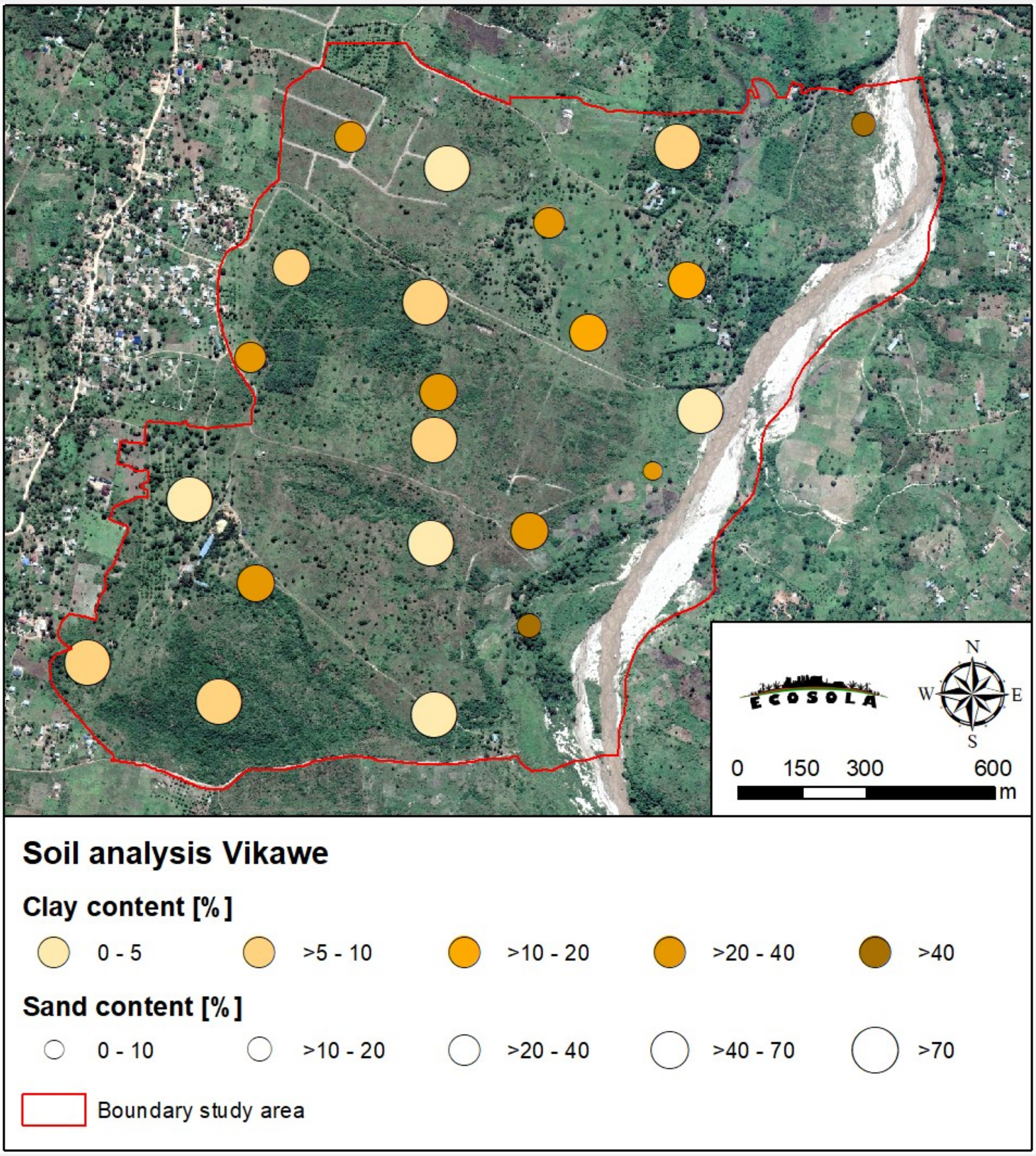

Fig. 18: Soil distribution in the study area. The clay content is indicated by colour, the sand content by the size of the circle.

Part IV: Habitat mapping key for Dar es Salaam and Coast Region

Habitat mapping key

This habitat classification key covers habitats found in Dar es Salaam and Coast Region of Tanzania. It does not cover habitat types from other areas such as mountain forests or savannas. The mapping key should not be considered as a final version, but as a first draft of a habitat catalogue for Tanzania which can be extended bit by bit. If a certain project requires mapping in other areas of Tanzania with other habitat types that are not yet included in the current manual, these should be included in the hierarchy of the existing habitat types.

The classification of habitats was carried out according to the following criteria:

(1) Mapping feasibility: The units should be recognizable in the field without major examination and time effort. Very small-scale or short-lived units, such as individual trees in woodlands or regularly flooded and replacing sand banks, are not individually mapped – excluding units such as ponds.

(2) Unambiguous definition: Each area should be assigned as unambiguously as possible to only one specific type.

(3) Site reference: The site characteristics of the habitat (e.g. water supply, nutrient supply, relief, exposure, site specifics such as salt or heavy metals) are important criteria for habitat mapping. A habitat type should be characterized by site-specific criteria. This also includes the type of origin and land use pattern. These site characteristics are mostly not directly recorded, but derived from the composition of the vegetation. For some habitat types, however, the collection and evaluation of data on the location is required. Habitats which are always or frequently unvegetated, are exclusively structured according to site characteristics (e.g. rocks, flowing waters). Small or linear habitats (e.g. hedges) are mapped according to their structure. Build up areas are mapped according to their primary use.

(4) Evaluation: The habitat types should be homogeneous with respect to characteristics relevant for vulnerability and management assessment. To have a good basis for evaluation vulnerable and particularly endangered habitat types are classified in a more differentiated manner than those without further significance for nature conservation. Additionally, for habitats to be protected additional features such as species composition or detailed information on vegetation structure should be recorded. Any habitat of special concern or of conservation interest should be marked directly on the map by a specific symbol (e.g. #). Wherever possible, the dominant species of the mapped habitat units should be recorded.

The habitat mapping key is structured by a hierarchy of three levels: superordinate units (e.g. 6 Inland surface waters), main units (e.g. 6.1 Surface standing waters) and subunits (e.g. 6.1.1 Permanent lakes, ponds and pools). In the enumeration given here, most habitats are listed down to level 3. To facilitate categorization, for several subunits common plant species are listed. For several tree and shrub species Swahili names according to MNRT (2010) are listed as well, highlighted by underline characters. The habitat types are sorted by integrity and anthropogenic influence. In the beginning, largely undisturbed habitats such as woodland and coastal habitats are listed and it ends with strongly modified types such as arable land and settlements. Additional criteria (e.g. grazing, recently burnt) can be used to describe almost all habitat types more precisely.

Depending on the specific requirements and the spatial extend of the area to be mapped, main units or subunits are mapped. If the study area is very large and time and money restrictions do not allow for a detailed mapping of subunits, main units could be addressed. However, vulnerable habitats should be addressed by the subunits to get a clear picture of the current state.

1 Seashore and estuarine habitats

Terrestrial and semi-terrestrial habitats on the seashore and in estuaries. Influenced by coastal dynamics, such as tides, permanent sediment relocation, flooding and salt water intrusion. Plant communities are dominated by halophil and salt-tolerant species. Mid-eulittoral and sublittoral habitats, such as seagrass beds, lagoons, coral patches within lagoons, or coral reefs fringing lagoons with exposed flats, crests and submerged slopes are not included.

Additional criteria

Vegetation height and cover

h00 = height of main vegetation layer in dm

c00 = cover of main vegetation layer in %

d00 = ground cover in %

Coding example

MSAh40,c70,d80	=	*Avicenna marin*a belt with height of tree layer 4 m, cover of tree layer 70% and ground cover 80%
SMh2,c30	=	Salt marsh with height of main vegetation layer 20 cm and cover of 30%
CSSh55,c90,d10	=	Scrub forest on coral rag with height of shrub layer 5,5 m, cover of shrub layer 90% and ground cover 10%

1.1 Mangroves (MS)

Mangrove vegetation on seashores and estuaries subject to daily tidal flooding. Many species develop aerial roots (pneumatophores) to cope with inundation. Depending on the coastal topography, mangrove species follow a zonation from the upper eulittoral (mean sea level elevation) to the level of high spring tide. On linear riverine banks in estuaries or in small mangrove stands, insufficient space may prevent the formation of a zonation.

***1.1.1 Sonneratia alba* belt (MSS)**: Mangroves dominated by *Sonneratia alba* (Mliana) on the seaward side (upper eulittoral), often on sandy soils.

***1.1.2 Rhizophora mucronata* belt (MSR)**: Mangroves dominated by *Rhizophora mucronata* (Mkoko magondi) accompanied by *Bruguiera gymnorrhiza* (Mui) in estuaries, on tidal creeks and seashores, often on muddy soils, between the *Sonneratia alba* belt and the *Avicenna marina* belt.

***1.1.3 Avicennia marina* belt (MSA)**: Mangroves dominated by *Avicennia marina* (Mchu) often associated with *Ceriops tagal* (Mkandaa mwekundu) and *Bruguiera gymnorrhiza* (Mui).

***1.1.4 Lumnitzera racemosa* belt (MSL)**: Mangroves dominated by *Lumnitzera racemosa* (Kikandaa) on the landward side (littoral fringe or riverine), associated with *Xylocarpus granatum*

(Mkomafi), *Xylocarpus moluccensis*, *Pemphis acidula* (Kiyaya-mbapwa) and *Heritiera litoralis* (Msikundazi). The *Avicenna marina* and *Lumnitzera racemosa* belt may not always be clearly distinguishable.

1.2 Salt marshes (SM)

Herbaceous plant communities periodically inundated during spring tides or storm surges, sheltered from wave action by mangroves. Salt marshes typically host plant species such as *Sesuvium portulacastrum*, *Arthrocnemom indicum*, *Salicornia* spp., *Acrostichum aureum.*

1.3 Sandy shores (SS)

Sandy beaches with or without vegetation.

1.3.1 Bare beaches (SSB): Beaches devoid of any vegetation frequently occur near settlements and sites with touristic activities. They may also occur in areas exposed to strong surf. Vegetation is absent due to trampling, other disturbances or high wave energy.

1.3.2 Vegetated beaches and sandy shores (SSV): More or less densely covered with *Ipomoea pes-caprae* or related species, binding sand and thus stabilising the beach. Additional species include *Launaea sarmentosa, Sophora tomentosa, Colubrina asiatica, Hibiscus tiliaceus, Cyperus crassipes, Sporobolus virginicus.*

1.3.3 Coastal scrub on the supralittoral fringe of sandy shores and beaches (SSS): Dense communities of shrubs dominated by *Scaevola plumieri* or *Scaevola sericea*, sometimes with *Pandanus kirkii*.

1.3.4 Coastal strips with introduced trees (SST): Planted or regenerated in mixed or single species stands, for fruit production, fuelwood, windbreaks, or as shade trees: *Cocos nucifera* (Mnazi), *Casuarina equisetifolia* (Mvinje), *Terminalia boivinii*, *Terminalia catappa* (Mkungu).

1.4 Coralline shores (CS)

Coralline structures at the shore.

1.4.1 Sparsely vegetated cliffs of fossil coral rock (CSR): Coral rock regularly exposed to wave action. Unvegetated or only sparsely vegetated with short herbs and shrubs.

1.4.2 Scrub forests on coral rag (CSS): Dense and nearly impenetrable shrub thickets on shallow soils over fossil coral limestone. Occasionally with emergent trees. Common species are *Adansonia digitata* (Mbuyu), *Diospyros consolatae, Grewia glandulosa, Lannea schweinfurthii, Manilkara sulcata* (Msezi), *Pandanus kirkii*, *Pemphis acidula*, *Guettarda speciosa*, *Polysphaeria multiflora*, *Sideroxylon inerme*.

2 Woodlands and forests

Communities dominated by single-stemmed woody plants (trees) with a coverage of at least 20%. Tree coverage can be relatively sparse (less than 75%: woodlands) or dense (over 75%: forests). Height of trees commonly above 5 m, but might be lower at water-logged, nutrient-poor or dry sites.

Additional criteria

Vegetation height and cover

h00 = height of main tree layer in m

c00 = cover of main tree layer in %

d00 = ground cover in %

Vegetation structure

c = deciduous communities with proportion of sclerophyllous and other evergreen trees below 20% (only applicable for FPF, FPO, FPC, FHT)

x = mixed communities with proportion of sclerophyllous and other evergreen trees above 20% (only applicable for FR, FPF, FPO, FPC, FHT)

e = evergreen communities with proportion of deciduous tree species below 20% (only applicable for FR, FPF, FPO, FPC, FHT)

Land use

g = grazed

m = managed (regular branch trimming)

b = recently burnt

__ = acronyms for major species (only for tree plantations 2.4 & 2.5)

Coding example

FDC,h8,c30,m	=	Deciduous coastal woodland with height of main tree layer 8 m, cover of main tree layer 30%, signs of regular branch trimming.
FPF,h5,c20,g,Mi	=	Orchard with height of main tree layer 5 m, cover of main tree layer 20%, signs of grazing, dominant tree species Mango.
FHT,h7,c70,c	=	Lines of trees with height of main tree layer 7 m, cover of main tree layer 70%, mainly deciduous trees.

2.1 Riparian gallery woodlands and forests (FR)

Woodlands and forests on banks and floodplains of permanent or temporary streams, on lakesides and fens and on moist valley bottoms. Vegetation height commonly above 5 m. Due to deforestation, only narrow strips remain in many regions. Commonly dominated by evergreen trees and shrubs but often mixed with deciduous species. Characteristic tree species: *Acacia robusta ssp. usambarensis, Barringtonia racemosa, Bridelia micrantha* (Mkarati), *Ficus* *sycomorus, Sorindeia madagascariensis* (Mpilipili doria), *Syzygium cumini* (Mzambarau), *Vitex doniana* (Mfuu). Characteristic shrub species: *Antidesma venosum*, *Barringtonia racemosa, Ehretia bakeri, Mimosa pigra, Pluchea dioscoridis, Ricinus communis*.

2.2 Deciduous woodlands and forests (FD)

Woodlands and forests dominated by deciduous trees. The proportion of sclerophyllous and other evergreen trees is below 20%.

2.2.1 Deciduous swamp woodlands and forests (FDS): Woodlands and forests of deciduous trees located in seasonal swamps.

2.2.2 Deciduous (coastal) woodlands and forests (FDC): Woodlands and forests of deciduous trees typically found in areas with low land use intensity in the coastal region. Characteristic tree species: *Acacia robusta ssp. usambarensis, Afzelia quanzensis, Brachystegia spiciformis, Croton jatrophoides, Dalbergia melanoxylon* (Mpingo)*, Hyphaene compressa, Lamprothamnus zanguebaricus, Manilkara discolor, Markhamia obtusifolia* (Mtarawanda)*, Spirostachys africana, Tamarindus indica* (Mkawju)*, Thespesia danis.* Characteristic shrub species: *Acacia nilotica, Acalypha fruticosa, Bridelia scleroneura, Carpodiptera africana, Dalbergia obovata, Diospyros loureiroana, Dombeya acutangula, Flueggea virosa* (Mkwamba)*, Grewia bicolor, Grewia conocarpa, Gymnosporia heterophylla, Harrissonia abyssinica* (Kucha la simba)*, Monodora grandidieri* (Mchofu)*, Ochna mossambicensis, Pteleopsis myrtifolia, Strychnos innocua* (Mtonga)*, Xylotheca tettensis.*

2.2.3 Small remnant deciduous woodlands and forests (FDR): Isolated woodland and forest patches of less than 0,5 ha formed by characteristic tree and shrub species of the primary deciduous forests (see 2.2.2).

2.3 Broadleaved mixed and evergreen woodlands and forests (FE)

Woodlands and forests with a proportion of broad-leaved sclerophyllous or lauriphyllous evergreen trees or palms of at least 20%.

2.3.1 Broadleaved mixed and evergreen swamp forest (FES): Woodlands and forests of evergreen and deciduous trees located in seasonal or perennial swamps. **2.3.2 Eastern African coastal dry forest (FEC)**: Woodlands and forests formed by sclerophyllous evergreen trees and shrubs commonly dominated by legumes. Due to relatively dense canopy of trees, herb layers are commonly sparse. Primary vegetation of the undulating coastal region, but currently restricted to a few forest reserves. Characteristic tree species: *Baphia kirkii, Bombax rhodognaphalon, Craibia zimmermannii, Cussonia zimmermannii, Cynometra webberi, Erythrina sacleuxii, Hymenaea verrucosa* (Msandarusi), *Julbernardia magnistipulata, Manilkara sansibarensis, Manilkara sulcata* (Msezi)*, Millettia usaramensis, Paramacrolobium coeruleum, Scorodophloeus fischeri, Sorindea madagascariensis* (Mpilipili doria)*, Vitex zanzibarensis.*

Characteristic shrub species: *Asteranthe asterias, Blighia unijugata* (Mkivule), *Brachylaena huillensis, Carpodiptera africana, Dombeya acutangula, Drypetes arguta, Gardenia transvenulosa, Lamprothamnus zanguebaricus, Manilkara mochisia, Margaritaria discoidea, Monodora minor, Nesogordonia holtzii, Pteleopsis myrtifolia, Rothmannia macrosiphon, Suregada zanzibariensis* (Mdimu msitu), *Uvaria pandensis.*

2.3.3 Small remnant mixed and evergreen woodlands and forests (FER): Isolated woodland and forest patches of less than 0,5 ha formed by characteristic tree and shrub species of the primary coastal dry forests (see 2.3.2).indigenous mixed or evergreen trees within a matrix of grassy or cultivated land; often consisting of species of the primeval forests; size less than 1 ha.

2.3 Early stages of natural and semi-natural woodland and forest regrowth (FR)

Early stages of woodland and forest regrowth or newly colonized woodlands dominated by young individuals of forest species that are still less than 5 m in height. Includes replanted woodlands of young native trees and naturally-colonizing stands of non-native trees.

2.4 Tree plantations (FP)

Plantations and intensively managed woods for fruit or wood production with regular harvesting or for ornamental purposes.

2.4.1 Deciduous tree plantations for leaf, branch or whole-plant harvest (FPD): Plantations of deciduous trees cultivated for use as fodder and mulch (leaves), firewood (twigs and branches) and timber (stems).

2.4.2 Broadleaved evergreen and mixed tree plantations for leaf, branch or whole-plant harvest (FPE): Plantations of broadleaved evergreen trees or mixed plantations of evergreen and deciduous trees for use as fodder and mulch (leaves), firewood (twigs and branches) and timber (stems).

2.4.3 Coniferous tree plantations for branch or whole-plant harvest (FPP): Plantations of conifers (commonly pines) cultivated for use as firewood (twigs and branches) and timber (stems).

2.4.4 Fruit and nut tree orchards and groves (FPF): Orchards cultivated for fruit and nut production.

2.4.5 Ornamental tree plantations (FPO): Plantations of trees cultivated for ornamental purposes.

2.4.6 Coppice and early-stage tree plantations (FPC): Early stages of tree plantations that were (re-)planted recently.

2.5 Lines of trees (FHT)

Continuous planted rows of trees within a matrix of grassy or cultivated land or along roads or property borders. Lines of trees differ from hedgerows (5.4) in being composed of planted trees growing higher than 5 m that are not regularly cut.

2.6 Recently deforested areas (UDF)

Forests or woodlands that have recently been cleared through cutting or slash-and-burn. No or very sparse ground cover. Secondary vegetation like herb, forb and fern stands has not yet developed or is still in its initial stages.

3 Bushlands and scrublands

Communities of multi-stem, woody plants, height of main vegetation layer commonly less than 5 m but might be higher; woody cover over 20%.

Additional criteria

Vegetation height and cover

h00 = height of main bush layer in m

c00 = cover of main bush layer in %

d00 = ground cover in %

t00 = cover of solitary trees in %

Vegetation structure

s = structurally rich with multiple vegetation layers, at least a well-developed grass/herb layer and two distinct bush layers

c = deciduous communities with proportions of sclerophyllous and other evergreen bushes below 20% (only applicable for BSP, BSR, BP, and BH)

x = mixed communities with proportions of sclerophyllous and other evergreen bushes above 20% (only applicable for BSP, BSR, BP and BH)

Land use

g = grazed

m = managed (regular branch trimming)

b = recently burnt

Coding example

BRD,h4,c70,d50,s,m,g	=	Deciduous gallery with height of main bush layer 4 m, cover of main bush layer 70%, ground cover 50%, regular branch trimming and grazing, structurally rich with multiple vegetation layers.
BSR,h2,c30,d70,T05,g	=	Early-stage natural bushland regrowth with height of main bush layer 2 m, cover of main bush layer 30%, ground cover 70%, coverage of trees 5%, grazing.
BHN,h4,c90,d20	=	Hedgerow of native species with height of main bush layer 4 m, cover of main bush layer 90%, ground cover 20%.

3.1 Riparian thickets (BR)

Regularly flooded or perennially wet riversides, lakesides, fens and floodplains dominated by woody vegetation with multiple stems, vegetation height often less than 5 m but might be higher at sites with good nutrient supply.

3.1.1 Deciduous riparian thickets (BRD): Deciduous bush and shrub vegetation forming thickets along permanent or temporary streams and wetlands. Often at sites with distinct seasonal water regimes (e.g. seasonal flooding).

3.1.2 Mixed riparian thickets (BRM): Deciduous and evergreen bush and shrub vegetation forming thickets along permanent or temporary streams and wetlands. Might occur at sites with distinct seasonal water regimes or with perennial wet conditions (e.g. shores of perennial lakes). Characteristic are species-poor stands of *Pluchea dioscoridis* sometimes with *Mimosa pigra* and *Ricinus communis.*

3.2 Bushlands (BS)

Communities of multi-stem, woody plants on inland sites that do not border surface water bodies.

3.2.1 Deciduous scrub bushlands (BSD): Bushlands dominated by deciduous or semi-deciduous scrubs where the proportion of sclerophyllous and other evergreen bushes does not exceed 20%. Characteristic shrub species: *Acacia mellifera, Acacia zanzibarica, Albizia petersiana, Catunaregam nilotica, Commiphora africana, Dalbergia melanoxylon* (Mpingo), *Dichrostachys cinerea, Fluegga virosa* (Mkwamba), *Harrssonia abyssinica* (Kucha la simba), *Pteleopsis myrtifolia, Xylotheca tettensis.*

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM): Bushlands of mixed deciduous, sclerophyllous and other evergreen bushes where the proportion of evergreen bushes exceeds 20%. Occasionally with individual emergent trees. Commonly high density of lianas. Characteristic shrub species: *Annona senegalensis* (Mtopetope), *Antidesma venosum, Bombax rhodognaphalon, Brachylaena huillensis, Brachystegia spiciformis, Combretum harrisii, Combretum iliaris, Dalbergia melanoxylon* (Mpingo), *Dalbergia obovata, Deinbollia borbonica, Dichapetalum mossambicense, Dichrostachys cinerea, Dombeya acutangula, Ehretia bakeri, Grewia forbesii, Harrssonia abyssinica* (Kucha la simba), *Hyphaene compressa, Manilkara mochisia, Margaritaria discoidea, Markhamia obtusifolia* (Mtarawanda), *Millettia usaramensis, Ochna mossambicensis, Pteleopsis myrtifolia, Rourea orientalis* (Mhombo), *Saba comorensis* (Mbungo), *Salacia madagascariensis, Scorodophloeus fischeri, Suregada zanzibariensis* (Mdimu msitu), *Thespesia danis, Uvaria acuminata, Uvaria pandensis, Xylotheca tettensis, Zanthoxylum chalybeum* (Mjafari). Emergent tree species: *Adansionia digitata* (Mbuyu), *Dalbergia melanoxylon* (Mpingo), *Erythrina sacleuxii, Sterculia appendiculata.*

3.2.3 Small scrub and thicket patches (BSP): Small remaining patches of scrubs within a matrix of grassy or cultivated land.

3.2.4 Pioneer natural and semi-natural bushland and regrowth (BSR): Early stages of bushland regrowth or colonization composed predominantly of young individuals. Characteristic shrub and tree species: *Commiphora africana, Dalbergia melanoxylon* (Mpingo), *Dichrostachys* *cinerea, Flueggea virosa* (Mkwamba)*, Harrissonia abyssinica* (Kucha la simba)*, Hyphaene compressa, Solanum incanum, Strychnos innocua, Thespesia danis, Xylotheca tettensis, Zanthoxylum chalybeum* (Mjafari).

3.3 Shrub plantations (BP)

Intensively managed plantations of shrubs or espaliers, cultivated for fruit or wood production with a regular part- or whole-plant harvesting regime or for ornamental purposes.

3.3.1 Shrub plantations for leaf, branch or whole plant harvest (BPH): Plantations of bushes and shrubs for wood production with regular leaf, branch or whole plant harvest regime.

3.3.2 Shrub orchards (BPF): Orchards of bushes and shrubs cultivated for fruit or flower production.

3.3.3 Ornamental shrub plantations (BPO): Plantations of bushes and shrubs for ornamental purposes.

3.3.4 Coppice and early-stage shrub plantations (BPC): Early stages of bush and shrub plantations which have been (re-)planted recently.

3.4 Hedgerows (BH)

Planted woody vegetation forming stripes within a matrix of grassy or cultivated land, along roads or at the boundaries of private properties. Hedgerows differ from lines of trees (6.6) in being composed of shrub species, or if composed of tree species being regularly cut to a height of less than 5 m.

3.4.1 Hedgerows of non-native species (BHA): Hedges composed of species not native to the area.

3.4.2 Hedgerows of native species (BHN): Hedges composed mainly of native species.

3.5 Recently cleared bushlands (UDB)

Bushlands which have recently been cleared through cutting or slash-and-burn. No or very sparse ground cover. Secondary vegetation such as herb, forb and fern stands has not yet developed or is in its initial stages.

4 Dense and large herbaceous communities on fallow land

Stands of tall herbs, forbs, or ferns occurring on disused urban or agricultural land, on the banks of waterbodies, or at the edges of woodlands. Usually on eutrophic sites.

Additional criteria

Vegetation height and cover

h00 = height of main vegetation layer in cm

c00 = ground cover in %

w00 = cover of emerging woody plants in %

Vegetation structure

e = dominated by herbs

o = dominated by forbs

a = dominated by ferns

Land use

b = recently burnt

f = regularly effected by fires (information should be obtained from the local land users)

t = previously tilled (abandoned farmland)

g = previously grazed (abandoned meadow)

Coding example

CFF,h50,c95,w15,o	=	Woodland and forest fringe with herbs and forbs, height of main vegetation layer 50 cm, ground cover 95%, cover of emerging woody plants 15%, dominated by forbs.
CFB,h120,c100,w02,e	=	Stand of tall herbs, forbs and ferns on banks of inland water bodies, height of main vegetation layer 120 cm, ground cover 100%, cover of emerging woody plants 2%, dominated by herbs.
CFM,h70,c75,w05,t	=	Mesic herb and forb stand, height of main vegetation layer 70 cm, ground cover 75%, cover of emerging woody plants 5%, previously tilled.

4.1 Woodland and forest fringes with herbs and forbs (CFF)

Woodland and forest edge (seam) vegetation composed of species profiting from shade and humidity provided by the forest trees. Additional nutrient supply due to additional inputs from leave-fall.

4.2 Stands of tall herbs, forbs and ferns on banks of inland water bodies (CFB)

Communities of relatively large herbs, forbs and/or ferns on banks of streams and standing water bodies. On eutrophic, moist and disturbed but currently fallow sites (e.g. former farmland).

4.3 Moist or wet herb, forb and fern stands (CFW)

Tall-herb, forb and fern vegetation on disturbed but currently fallow sites (e.g. former farmland) with good nutrient and water supply. Main vegetation layer usually dense and close, height of main vegetation layer over 1.5 m.

4.4 Mesic herb and forb stands (CFM)

Stands of tall herbs and forbs on disturbed but currently fallow, mesic sites. Main vegetation layer usually dense and close, height of main vegetation layer larger than 1 m.

4.5 Dry herb and forb stands (CFD)

Herb and forb vegetation on disturbed but currently fallow dry sites. Main vegetation layer usually sparse, height of main vegetation layer less than 1 m.

5 Wetlands

Wetlands next to water bodies where the water table lies at or above ground level at least throughout the rainy seasons. Dominated by herbaceous or shrubby vegetation. Note that habitats that intimately combine waterlogged swamps and vegetation rafts with pools of open water are considered as habitat complexes.

Additional criteria

Vegetation height and cover

h00 = height of main vegetation layer in m

c00 = cover of main vegetation layer in %

w00 = cover of emerging woody plants in % (only applicable for SHS, SHR and SHG)

r00 = cover of herbaceous plants in % (only applicable for SB)

Seasonality of ground water levels

s = water table falls below ground level during dry season (seasonal)

p = water table is at or above ground level throughout the year (permanent)

Coding example

SHS,h0.6,c85,p = Sedges on permanently waterlogged ground with a height of 60 cm and a cover of 85%.

SHR,h1,c75,w05,p = Reeds on permanently waterlogged ground with a height of 1 m and a cover of 75%; 5% emerging woody plants.

SB,h0.50,c25,r50,s = Swamp bushland on seasonally waterlogged ground with a height of 50 cm and a cover of 25%; 50% herbaceous plants.

5.1 Swamps dominated by herbaceous helophytes (SH)

Helophyte communities on waterlogged ground which are dominated by herbaceous vegetation. Shrubs and bushes may emerge but their cover is below 20%.

5.1.1 Sedges, normally without free-standing water (SHS): Stands of sedges and other herbaceous helophytes, growing on (seasonally) waterlogged ground.

5.1.2 Reeds and tall canes, normally without free-standing water (SHR): Stands of reeds and tall canes, usually species-poor and often dominated by one species, growing on (seasonally) waterlogged ground.

5.1.3 Grasslands on frequently or permanently flooded sites (SHG): Tall *Echinochloa pyramidalis* stands, sometimes cultivated for forage production.

5.2 Swamps dominated by bushes and scrubs (SB)

Swamp bushlands with bush cover over 20%, growing on (seasonally) waterlogged ground.

6 Inland surface waters

Non-coastal fresh, brackish or saline waterbodies such as springs, rivers, streams, lakes, and pools. Includes constructed inland waterbodies such as canals or ponds which may support semi-natural communities of plants and animals. Includes seasonal water bodies which may dry out part of the year, forming temporary or intermittent rivers and lakes and their littoral zones. Freshwater littoral zones are those parts of banks or river shores where frequent inundation prevents the formation of closed terrestrial vegetation. Note that habitats that intimately combine waterlogged mires and vegetation rafts with pools of open water are considered as habitat complexes of inland surface waters and swamp vegetation, i.e. mires (2) and wet grasslands (3.2).

Additional criteria

Location of littoral vegetation

b = in stream bed

u = on river shore

Predominant substrate of streambeds and littoral zones

s = sand

c = cohesive materials (loam, clay)

p = pebbles

r = stones and rocks

a = artificial materials (e.g. concrete)

Frequency and duration of periods with surface water (applicable for temporary water bodies)

e = ephemeral: surface water occurs only for short periods following singular rainfall events

i = intermittent: surface water remains for longer periods (usually throughout the entire rainy season)

w = runlets / puddles remain at the surface also during dry seasons

Coding example

WSP,c = Permanent lake with cohesive material as predominant bed substrate.

WRT,s,e = Ephemeral stream with sand as predominant bed substrate.

WLH,u = Species-rich helophyte community located on river shore.

6.1 Surface standing waters (WS)

Lakes, ponds and pools of natural origin containing fresh (i.e. nonsaline), brackish, or salt water. Man-made freshwater bodies, including artificially created lakes, reservoirs and ponds which have developed natural characteristics (natural bank structures, bank vegetation) or which are still fully anthropogenically influenced.

6.1.1 Permanent lakes, ponds and pools (WSP): Standing water bodies which are filled with water all year around. Standing waters with seasonally fluctuating water-levels are included if surface water remains throughout dry seasons. Mostly rimmed with bank vegetation. Water bodies can be man-made (indicated by additional criteria 'a') or of natural origin.

6.1.2 Temporary lakes, ponds and pools (WST): Standing water bodies which regularly dry out during dry seasons. Water bodies where sporadic small puddles remain at the ground throughout the dry seasons are included. Periods without surface water might be limited to the end of the long dry season (intermittent water bodies) or extent almost throughout the entire year and are only interrupted following heavy rainfall events (ephemeral water bodies). Mostly free of vegetation or vegetation adapted to changing moisture conditions, normally lack of perennial aquatic species. Water bodies can be man-made (indicated by additional criteria 'a') or of natural origin. Habitats of the dry phase are treated under section 1.3.

6.2 Surface running waters (WR)

Running water bodies with fresh water (streams and rivers). Includes man-made freshwater bodies, such as artificially created canals and ditches, which have developed natural characteristics (natural bank and bed structures, bank vegetation) or which are still fully anthropogenically influenced.

6.2.1 Springs and spring brooks (WRS): Natural, permanent or periodical groundwater surface discharge. Spring vegetation may or may not exist. Springs may have been shaped and changed through construction measures with no or little spring vegetation left.

6.2.2 Permanent watercourses (WRP): Streams and rivers with seasonally fluctuating but perennial water flow. Natural watercourses with structurally rich lateral and longitudinal profiles and bank vegetation as well as watercourses that have been straightened and have a mostly uniform morphology and lack the characteristic copse. Includes slow-flowing rivers, streams, brooks, rivulets, and rills as well as fast-flowing rivers with laminar flow. Artificial watercourses such as canals and ditches are included. Streambeds mostly composed of sand or mud. Temporary or permanently emerging sand or mud islands are treated under 1.3.

6.2.3 Temporary running waters (WRT): Streams and rivers which regularly dry out during dry seasons. Water bodies where sporadic small puddles or runlets remain in the streambed throughout the dry seasons are included. Periods without considerable surface stream flow might be limited to the end of the long dry season (intermittent streams) or extent almost throughout the entire year and are only interrupted following heavy rainfall events (ephemeral streams). Natural watercourses or anthropogenically influenced streambeds. Artificial watercourses such as canals and ditches are also included.

6.2.4 Deeply incised, temporary running waters formed by gully erosion (WRG): Ephemeral running waters that form deeply incised stream beds. Usually the banks are extremely steep, unvegetated and instable.

6.3 Littoral zone of inland surface water bodies (WL)

Transition zones between aquatic and terrestrial habitats at the river shores and banks of standing and running water bodies. Characterized by periodical to seasonal flooding and/or groundwater supply from the neighbouring water bodies. Commonly water-fringing pioneer communities of helophytes, reeds or scrubs. River shores and banks without vegetation cover are also included.

6.3.1 Emergent-floating hydrophyt communities (WLF): Aquatic vegetation of hydrophytes with emergent-floating leaves in the shallow-water-zones of lakes and ponds.

6.3.2 Regularly inundated pioneer communities of low-growing, water-fringing or amphibious helophytes (WLP): Stands of low-growing semi-aquatic herbaceous vegetation of seasonally to periodically inundated river shores and banks. Usually species-poor pioneer communities.

6.3.3 Regularly inundated pioneer scrubs (WLS): Stands of semi-aquatic scrubs of seasonally to periodically inundated river shores and banks. Usually species-poor pioneer communities.

6.3.4 Water-fringing communities of tall Cyperaceae (WLC): Stands of tall sedges (*Carex* spp., *Cyperus* spp.) and other Cyperaceae, usually species-poor and often dominated by one species. Located on water-fringing seasonally or periodically flooded river shores and banks as well as in shallow-water-zones of lakes and ponds.

6.3.5 Water-fringing reed beds (WLR): Stands of tall reeds (*Phragmites* spp.) or bulrush (*Typha* spp.), usually species-poor and often dominated by one species. Located on water-fringing seasonally or periodically flooded river shores and banks as well as in shallow-water-zones of lakes and ponds.

6.3.6 Water-fringing species-rich wetland plant communities (WLH): Diverse wetland plant communities located on only periodically inundated river shores and banks. Wetland species are characterized by their aerenchyma that allows them to grow on water-logged sites.

6.3.7 Small annuals on dry-out beds of inland waterbodies (WLA): Beds of lakes, ponds, streams and rivers which dry-out seasonally and are sparsely vegetated with annual plants.

6.3.8 Unvegetated or sparsely vegetated river shores (WLU): River shores and banks of standing and running water bodies which are mostly bare or only sparely vegetated. Includes river shores and banks which are seasonally vegetated.

7 Grasslands

Herbaceous communities dominated by perennial and/or annual grasses (Gramineae), on dry to mesic and seasonally wet sites. Woody vegetation might be present but only coverage less than 20%. Usually grasslands are managed by regular burning, grazing or mowing. Includes semiarid steppes and intensively managed grasslands such as lawns. Excludes regularly tilled habitats dominated by herbaceous crops such as rice or maize (see chapter 8, cultivated habitats).

Additional criteria

Vegetation height and cover

h00 = height of main vegetation layer in cm

c00 = ground cover in %

w00 = cover of emerging woody plants in %

Land use

g = grazed

m = mown

b = recently burnt

f = regularly effected by fires (information should be obtained from the local land users)

n = regular application of fertiliser

x = regular application of herbicides

Coding example

GMM,h0.25,c60,w05,g	=	Moist mesotrophic grassland, height of grasses 25 cm, ground cover 60%, cover of emerging woody plants 5%, grazed.
GW,h0.65,c85,w10	=	Wet grassland, height of grasses 65 cm, ground cover 85%, cover of emerging woody plants 10%.
GID,h0.20,c95,f,n	=	Dry intensive grassland, height of grasses 20 cm, ground cover 95%, regular fires and regular application of fertiliser.

7.1 Mesic grasslands (GM)

Dry to moist mesotrophic pastures and hay meadows of natural or anthropogenic origin with relatively high species richness. The intensity and frequency of grazing and/or mowing is moderate, sometimes resulting in patchy vegetation structure. Usually in habitat complexes with bushland and woodland.

7.1.1 Dry mesic grasslands (GMD): Mesotrophic grasslands in relatively dry locations usually grazed at low-intensity and regularly burning during dry seasons. Length of growing seasons per year often less than 6 months due climate or edaphic reasons.

7.1.2 Moist mesic grasslands (GMM): Mesotrophic grasslands of moderate height with main grass layer up to 1.5 m. Located in relatively humid locations. Usually grazed at low-intensity or used as hay meadows. Length of growing seasons per year at least 6 months.

7.1.3 Tall mesic grasslands (GMT): Mesotrophic grasslands predominated by tall grass species with height of main grass layer above 1.5 m. Located in relatively humid locations. Usually grazed at low-intensity or used as hay meadows. Length of growing seasons per year at least 6 months due to climate reasons or connectivity to ground water.

7.2 (Seasonally) wet grasslands (GW)

Unimproved or lightly improved meadows on wet or seasonally wet sites with high levels of groundwater or backwater that can be flooded temporarily. Usually grazed at moderate intensity. Habitat complexes with swamps (2) and water-fringing vegetation (1.3) exist.

7.3 Intensively managed grasslands (GI)

Intensively managed grasslands of natural or anthropogenic origin. May or may not be fertilised, reseeded and treated by selective herbicides. The high grazing and/or mowing intensity usually causes homogenous vegetation structure and low species-diversity. Intensive grasslands are used for grazing, landscaping or recreation.

7.3.1 Species-poor, intensively managed lawns (GIL): Intensively managed lawns on public open spaces in settlement areas. Usually reseeded species-poor grass-communities which are regularly mown, fertilised and treated by selective herbicides. Used for landscaping and recreation.

7.3.2 Dry intensive grasslands (GID): Intensively used grasslands in relatively dry locations, regularly grazed or mown. May or may not be regularly burned during dry seasons. Length of growing seasons per year considerably less than 6 months.

7.3.3 Moist intensive grasslands (GIM): Intensively used grasslands in relatively humid locations, regularly grazed or mown. May or may not be regularly burned during dry seasons. Length of growing seasons per year at least 6 months.

7.3.4 Intensively grazed, trampled grasslands (GIT): Communities of low annual and perennial grass species with poor coverage resulting from extensive grazing pressure by large herbivores or heavy foot traffic.

7.4 Unmanaged fallow grasslands (GF)

Recently abandoned grasslands with the cover of dominant grasses above 60%. Competitive herbs and forbs as well as woody plants occur in considerable density following cessation of grazing or other anthropogenic management.

8 Terrestrial unvegetated or sparsely vegetated habitats

Non-coastal and non-aquatic habitats with less than 20% vegetation cover. The poor vegetation cover commonly is caused by intensive land use.

Additional criteria

Vegetation height and cover

w00 = woody plants cover in %

h00 = herbaceous plants cover in %

Predominant soil substrate

s = sand

c = cohesive materials (loam, clay)

Land use

g = grazed

b = site prepared for building and other infrastructure development

e = sheet erosion surface

Coding example

UMH,w05,h02,s	=	Sparsely vegetated area with isolated trees with a cover of 5%, cover of herbaceous plants 2%, predominant soil substrate sand.
UFS,w00,h02,c	=	Recently burnt area with very spares vegetation, no woody plants, herbaceous plant cover 2%, predominant soil substrate loam.
UFA,w00,h10,s	=	Burnt area with annual vegetation, no woody plants, herbaceous plant cover 10%, predominant soil substrate sand

8.1 Miscellaneous terrestrial habitats with very sparse or no vegetation (UM)

Terrestrial habitats with spares woody or herbaceous vegetation of less than 20% or no vegetation.

8.1.1 Terrestrial habitats with very sparse vegetation (mainly woody plants) (UMW): Mainly unvegetated ground with scattered woody plants. The total vegetation cover is less than 20%.

8.1.2 Terrestrial habitats with very sparse vegetation (mainly herbaceous plants) (UMH): Mainly unvegetated ground with scattered herbaceous plants. The total vegetation cover is less than 20%.

8.1.3 Bare areas without vegetation cover (UMX): Bare ground without any vegetation.

8.2 Burnt areas with very sparse or no vegetation (UFS)

Burnt ground with sparse or no vegetation.

8.3 Burnt areas with annual vegetation (UFA)

Burnt ground with regrowth of pioneer species.

9 Regularly or recently cultivated agricultural, horticulture and domestic habitats

Intensively cultivated land for crop production with frequent management of soils (influencing soil properties like fertility, humidity or permeability by regular tilling, fertiliser application, mulching, irrigation, etc.) and pests (application of pesticides and herbicides, weeding, etc.), Includes farmland with one or multiple crops, multi-layered agroforestry, as well as domestic gardens. Does not include shrub and tree plantations (5.3 & 6.5) where soil management is rudimentary and sporadic.

Additional criteria

Vegetation height and cover

t00/00 = tree cover in % / height in m

b00/00 = bush cover in % / height in m

p = sparse or poor cover of crops (<80%)

r = dense or rich cover of crops (>80%)

Farm size

l = large-scale farm (>25 ha)

m = medium-scale farm (1-25 ha)

s = small-scale farm (<1 ha)

Miscellaneous

__ = acronyms for major crop species

Coding example

AUP,b15/3, p,s,Ca	=	Arable land with unmixed perennial crops (Cassava), bush cover 15%, bush height 3 m, sparse crop cover, small-scale farm with plot size below 1 ha.
AFW, t05/4,m	=	Fallow un-inundated field with weed communities, tree cover of 5%, tree height 4 m, medium scale plot with 10 ha size.
HSM, t10/9,b10/2, p,Ac,Ba,Ca,Gv,Mi	=	Multi-layered subsistence garden area, tree cover of 10%, tree height 9 m, bush cover of 10%, bush height 2 m, sparse cover of crops, main crops are pineapple, banana, cassava, green vegetables, maize.

Dominant crop species

Ac = Pineapple (*Ananas co*mosus)

Ba = Banana (*Musa* spp.)

Bn = Beans (*Vigna spp. and others*)

Ca = Cassava (*Manihot esculenta*)

Cn = Coconut (*Cocos nucif*era)
Cs = Cashew (*Anacardium occidentale*)
Gv = Green vegetables
Ma = Maize (*Zea mays*)
Mi = Mango (*Mangifera indica*)
So = Millet (*Sorghum* spp. and others)
Ok = Okra (*Abelmoschus esculentus*)
Or = Orange (*Citrus sinensis*)
Pe = Peanut (*Arachis hypogaea*)
Sa = Sugarcane (*Saccharum officinarum*)

9.1 Rain-fed smallholder farmlands with unmixed crops (AU)

Rain-fed croplands where only one crop species is cultivated during each planting season.

9.1.1 Rain-fed smallholder farmlands with unmixed annual crops (AUA): Croplands where only a single dominant annual crop is cultivated (e.g. maize or okra).

9.1.2 Rain-fed smallholder farmlands with unmixed perennial crops (AUP): Croplands where only a single dominant perennial crop is cultivated (e.g. cassava).

9.2 Rain-fed smallholder farmlands with mixed crops (AM)

Rain-fed croplands where multiple crops are cultivated in one plot, commonly in several storeys.

9.2.1 Rain-fed smallholder farmlands with mixed annual crops (AMA): Croplands where multiple annual crops are cultivated, frequently a mix of grains and legumes (e.g. maize and beans).

9.2.2 Multi-layered rain-fed smallholder farmlands with mixed annual crops, shrubs and/or trees (Agroforestry) (AMF): Croplands where multiple annual crops like grains, legumes and vegetables are cultivated beneath shrubs, large forbs like bananas and trees.

9.3 Irrigated smallholder farmlands (AI)

Croplands which are regularly supplied with water from streams or ponds through furrows or pipes. Commonly located in floodplains and used for cultivation of water-demanding crops (e.g. vegetables, rice).

9.3.1 Irrigated smallholder farmlands with annual crops (AIA): Irrigated croplands for the cultivation of a wide range of annual crops, particularly vegetables.

9.3.2 Paddy rice fields (AIR): Regularly inundated croplands for the cultivation of rice.

9.4 Bare tilled farmlands (ABB)

Bare farmlands without vegetation because crops have been harvested and land has been tilled recently in the course of preparing for the new planting season.

9.5 Fallow or recently abandoned arable land (AF)

Temporary abandoned arable land with planted or naturally regrown herbs and forbs for soil protection, stabilization, fertilization or reclamation. In contrast to competitive herbaceous communities on fallow land (4) signs of former farming activity still clearly visible (remaining crops, patches of bare tilled soil, poor vegetation cover or visible planting rows). The fallow period commonly does not last for longer than two years.

9.5.1 Fallow fields with weed communities (AFW): Temporary abandoned cropland overgrown by pioneer weed communities.

9.5.2 Fallow fields with herb, forb, and shrub communities (AFS): Temporary abandoned cropland overgrown by herb, forb, and shrub communities. Commonly remaining woody plants are crops like cassava.

9.5.3 Fallow inundatable fields (AFI): Temporary abandoned croplands which are seasonally inundated and overgrown by pioneer weed communities.

9.6 Small-scale ornamental garden areas (HO)

Cultivated areas of ornamental gardens and small parks beside houses or in city squares.

9.6.1 Poorly-structured ornamental garden areas (HOP): Areas of land adjacent to houses, planted with only one vegetation layer.

9.6.2 Multi-layered ornamental garden areas (HOM): Areas of land adjacent to houses, planted with ornamental grass, shrubs, trees, flowers, resulting in multiple vegetation layers.

9.7 Subsistence garden areas (HS)

Areas of land adjacent to dwellings used for the cultivation of fruits and vegetables.

9.7.1 Poorly-structured subsistence garden areas (HSP): Areas of land adjacent to dwellings with fruit trees or vegetables growing in a single vegetation layer for subsistence use.

9.7.2 Multi-layered subsistence garden areas (HSM): Areas of land adjacent to dwellings with fruit trees and vegetables growing in multiple vegetation layers for subsistence use.

9.7.3 Mixed, multi-layered subsistence and ornamental garden areas (HSO): Areas of land adjacent to dwellings with fruit trees and vegetables growing in multiple vegetation layers for subsistence use and ornamental purposes.

9.8 Sacred and religious sites (RS)

Sites of spiritual or religious significance for local communities that are integrated into villages and the farmland.

9.8.1 Graveyards (RSG): Small graveyards embedded into farmland.

10 Built-up areas and traffic infrastructure

Primarily human settlement, industrial developments, and infrastructure.

Additional criteria

Vegetation height and cover

h00 = woody plant height

c00 = woody plant cover

Miscellaneous

a = agriculture production units (stables)

Coding example

IRD = Unsealed road.

XR = Residential house.

XF,a = Building with industrial use, stable.

10.1 Roads and traffic infrastructure (I)

Transport networks and other constructed areas.

10.1.1 Dirt roads (IRD): Unsealed roads for pedestrians or vehicles.

10.1.2 Tarmac roads (IRT): Tarmac roads for pedestrians and/or vehicles.

10.1.3 Unsealed parking lots and squares (ISU): Unsealed spaces without vegetation.

10.1.4 Paved parking lots and squares (ISP): Sealed spaces used for parking.

10.2 Buildings (X)

Buildings of various purposes.

10.2.1 Simple single huts (XH): Small huts with often only one room.

10.2.2 Residential houses (XR): Houses in built-up areas for residential purposes.

10.2.3 Public buildings (XP): Buildings with public access. Including school, governmental buildings, and places of worship.

10.2.4 Commercial buildings (XC): Buildings with commercial use. Including warehousing and offices.

10.2.5 Factories (XF): Buildings with industrial use. Including office blocks, factories, industrial units, animal-rearing batteries, and farms.

Photos of selected habitat types

In the following photos of selected habitat types are presented. Photos of individual habitat types as well as habitat complexes, frequently-occurring combinations or mosaics of individual habitat types, are included. This serves as an additional support for the identification of habitat types in the field, but it does not represent a comprehensive photo documentation of all habitat types mentioned.

2 Woodlands and forests

2.2.2 Deciduous (coastal) woodlands and forests (FDC)

2.2.3 Small remnant deciduous woodlands and forests (FDR)

2.3.2 Eastern African coastal dry forest (FEC)

2.3.3 Small remnant mixed and evergreen woodlands and forests (FER)

2.3.3 Small remnant mixed and evergreen woodlands and forests (FER) / 6.2.4 Deeply incised, temporary running waters formed by gully erosion (WRG)

2.4.2 Deciduous tree plantations for leaf, branch or whole-plant harvest (FPD)

2.4.2 Broadleaved evergreen and mixed tree plantations for leaf, branch or whole-plant harvest (FPE) / 9.5.2 Fallow fields with herb, forb, and shrub communities (AFS)

2.4.4 Fruit and nut tree orchards and groves (FPF)

2.4.4 Fruit and nut tree orchards and groves (FPF) / 2.2.2 Deciduous (coastal) woodlands and forests (FDC)

2.4.4 Fruit and nut tree orchards and groves (FPF) / 8.1.2 Terrestrial habitats with very sparse vegetation (mainly herbaceous plants) (UMH)

2.5 Lines of trees (FHT)

2.6 Recently deforested areas (UDF)

3 Bushlands and scrublands

3.1.2 Mixed riparian thickets (BRM)

3.1.2 Mixed riparian thickets (BRM) / 8.1.2 Terrestrial habitats with very sparse vegetation (mainly herbaceous plants) (UMH)

3.1.2 Mixed riparian thickets (BRM) / 6.2.4 Deeply incised, temporary running waters formed by gully erosion (WRG)

3.2.1 Deciduous scrub bushlands (BSD)

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM)

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM) / 9.5.2 Fallow fields with herb, forb, and shrub communities (AFS)

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM) / Broadleaved evergreen and mixed tree plantations for leaf, branch or whole-plant harvest (FPE)

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM) / 6.2.4 Deeply incised, temporary running waters formed by gully erosion (WRG)

3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM) / 6.2.3 Temporary running waters (WRT)

3.2.3 Small scrub and thicket patches (BSP)

3.2.4 Pioneer natural and semi-natural bushland and regrowth (BSR)

3.2.4 Pioneer natural and semi-natural bushland and regrowth (BSR) / 2.4.2 Broadleaved evergreen and mixed tree plantations for leaf, branch or whole-plant harvest (FPE)

3.2.4 Pioneer natural and semi-natural bushland and regrowth (BSR) / 4.4 Mesic herb and forb stands (CFM)

3.2.4 Pioneer natural and semi-natural bushland and regrowth (BSR) / 7.1.3 Tall mesic grasslands (GMT)

3.4.2 Hedgerows of native species (BHN)

3.5 Recently cleared bushlands (UDB)

4 Dense and large herbaceous communities on fallow land

4.4 Mesic herb and forb stands (CFM)

5 Wetlands

5.1.1 Sedges, normally without free-standing water (SHS)

5.1.2 Reeds and tall canes, normally without free-standing water (SHR)

5.1.2 Reeds and tall canes, normally without free-standing water (SHR) / 6.1.1 Permanent lakes, ponds and pools (WSP)

6 Inland surface waters

6.1.1 Permanent lakes, ponds and pools (WSP)

6.1.2 Temporary lakes, ponds and pools (WST)

6.2.3 Temporary running waters (WRT)

6.2.4 Deeply incised, temporary running waters formed by gully erosion (WRG)

6.3.4 Water-fringing tall wetland plant communities (other than reeds) (WLR)

6.3.8 Unvegetated or sparsely vegetated river shores (WLU)

7 Grasslands

7.1.1 Dry mesic grasslands (GMD)

7.1.3 Tall mesic grasslands (GMT)

7.2 (Seasonally) wet grasslands (GW)

7.2 (Seasonally) wet grasslands (GW) / 9.5.2 Fallow fields with herb, forb, and shrub communities (AFS)

7.3.4 Intensively grazed, trampled grasslands (GIT)

7.3.4 Intensively grazed, trampled grasslands (GIT) / 3.5 Recently cleared bushlands (UDB)

7.3.4 Intensively grazed, trampled grasslands (GIT) / 8.1.2 Terrestrial habitats with very sparse vegetation (mainly herbaceous plants) (UMH)

8 Terrestrial unvegetated or sparsely vegetated habitats

8.1.1 Terrestrial habitats with very sparse vegetation (mainly woody plants) (UMW)

8.1.2 Terrestrial habitats with very sparse vegetation (mainly herbaceous plants) (UMH)

9 Regularly or recently cultivated agricultural, horticulture and domestic habitats

9.1.1 Rain-fed smallholder farmlands with unmixed annual crops (AUA)

9.1.2 Rain-fed smallholder farmlands with unmixed perennial crops (AUP)

9.1.2 Rain-fed smallholder farmlands with unmixed perennial crops (AUP) / 9.2.2 Multi-layered rain-fed smallholder farmlands with mixed annual crops, shrubs and/or trees (Agroforestry) (AMF)

9.2.1 Rain-fed smallholder farmlands with mixed annual crops (AMA)

9.2.2 Multi-layered rain-fed smallholder farmlands with mixed annual crops, shrubs and/or trees (Agroforestry) (AMF)

9.4 Bare tilled farmlands (ABB)

9.4 Bare tilled farmlands (ABB) / 9.5.1 Fallow fields with weed communities (AFW)

9.4 Bare tilled farmlands (ABB) / Fallow fields with herb, forb, and shrub communities (AFS)

9.4 Bare tilled farmlands (ABB) / 9.2.1 Rain-fed smallholder farmlands with mixed annual crops (AMA)

9.5.1 Fallow fields with weed communities (AFW)

9.5.2 Fallow fields with herb, forb, and shrub communities (AFS)

9.5.2 Fallow fields with herb, forb, and shrub communities (AFS) / 3.2.2 Mixed scrub bushlands ('Coastal scrub forest') (BSM)

9.6.1 Poorly-structured ornamental garden areas (HOP)

9.7.1 Poorly-structured subsistence garden areas (HSP)

10 Build-up areas and traffic infrastructure

10.1.1 Dirt roads (IRD)

10.2.2 Residential houses (XR)

10.2.5 Factories (XF)

References

Ad-hoc-Arbeitsgruppe Boden (Ed.). (2005). *Bodenkundliche Kartieranleitung*. 5., verbesserte und erweiterte Auflage. Bundesanstalt für Geowissenschaften und Rohstoffe, Hannover.

Bhanjee, S. & Zhang, C.H. (2018). Mapping Latest Patterns of Urban Sprawl in Dar es Salaam, Tanzania. *Pap. Appl. Geogr.*, 4, 292–304.

Burgess, N.D. & Clarke, G.P. (Eds.). (2000). *Coastal Forests of Eastern Africa*. IUCN, Gland and Cambridge.

Frank, L.D. & Engelke, P.O. (2001). The Built Environment and Human Activity Patterns: Exploring the Impacts of Urban Form on Public Health. *J. Plan. Lit.*, 16, 202–218.

Greenway, P.J. (1973). A classification of the vegetation of East Africa. *Kirkia*, 9, 1–68.

Haines-Young, R. & Potschin, M. (2018). *Common International Classification of Ecosystem Services (CICES) V5.1. Guidance on the Application of the Revised Structure*. Fabis Consulting Ltd., Barton in Fabis, Nottingham.

Hawthorne, W.D. (1984). Ecological and biogeographical patterns in the coastal forests of East Africa. PhD Thesis. University of Oxford, Oxford.

Hawthorne, W.D. (1993). East African coastal forest botany. In: *Biogeography and ecology of the rain forests of Eastern Africa* (eds. Lovett, J.C. & Wasser, S.K.). Cambridge University Press, Cambridge.

Kukkonen, M.O., Muhammad, M.J., Käyhkö, N. & Luoto, M. (2018). Urban expansion in Zanzibar City, Tanzania: Analyzing quantity, spatial patterns and effects of alternative planning approaches. *Land Use Policy*, 71, 554–565.

Massay, G.E. (2016). Tanzania's Village Land Act 15 years on. *Rural 21*, 18–19.

Millennium Ecosystem Assessment. (2003). *Ecosystems and human well-being: A framework for assessment.* Island Press, Washington, DC.

MNRT. (2010). *National Forest Resources Monitoring and Assessment of Tanzania Mainland (NAFORMA) - Species List sorted by Latin names*. Ministry of Natural Resources and Tourism - Forestry and Beekeeping Division, Dar es Salaam.

NBS & OCGS. (2013). *2012 Population and Housing Census - Population distribution by administrative areas*. Ministry of Finance, Tanzania and President's Office, Finance, Economy and Development Planning, Zanzibar, Dar es Salaam and Zanzibar.

Rudic, C. (2016). *Housing Finance Strategies of Informal Settlement Dwellers. Factors of Influence and Impacts of Planned Interventions in Dar es Salaam*. Lit Verlag, Zürich.

UK National Ecosystem Assessment. (2011). *UK National Ecosystem Assessment: Understanding nature's value to society. Synthesis of key findings*. UNEP-WCMC, Cambridge.

UNFPA (Ed.). (2007). *Unleashing the potential of urban growth*. State of world population. United Nations Population Fund, New York.

United Nations. (2018). *The World's Cities in 2018. Data booklet ST/ESA/ SER.A/417*. United Nations - Department of Economic and Social Affairs - Population Division, New York.

United Nations. (2019). *World Urbanization Prospects: The 2018 Revision (ST/ESA/SER.A/420).* United Nations - Department of Economic and Social Affairs - Population Division, New York.

United Republic of Tanzania. (2007). *Guidelines for the preparation of general planning schemes and detailed schemes for new areas, urban renewal and regularization*. Ministry of Lands, Housing and Human Settlements Development, Dar es Salaam.

White, F. (1983). *The vegetation of Africa*. UNESCO Press, Paris.