CREATING CO-HABITATS

Designing a landscape where elephants and local inhabitants co-benefit from the connection between Tsavo East and Tsavo West National Park, Kenya



Eline van der Vossen

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Colofon

Creating Co-habitats
Designing a landscape where elephants and local inhabitants co-benefit from the connection between Tsavo East and Tsavo West National Park, Kenya

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Image made by Ann Lo









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Looking back, I feel very grateful for the opportunity to travel through Kenya, experience its remarkable landscapes, see elephants in the wild and meet so many generous and welcoming people. The fieldwork was not only an important part of my research but also a valuable personal experience. The knowledge, conversations and encounters I had along the way have shaped my perspective on the relationship between people and nature, and I hope this thesis can contribute, in its own way, to a future in which both local communities and wildlife can thrive.

Abstract

Human–elephant conflict (HEC) is an increasing challenge in landscapes where wildlife conservation, agricultural activities and human settlements overlap. In the Kasigau region of southeastern Kenya, located between Tsavo East and Tsavo West National Parks, habitat fragmentation, land-use change and water scarcity force elephants and local communities to compete for space and natural resources. This results in crop damage, economic losses and risks to human and elephant safety, while restricting elephant movement and access to essential resources.

Using a research-through-design approach, this study explores how a regenerative spatial landscape framework can reduce HEC while creating co-benefits for elephants and local inhabitants. The research combines landscape analysis, literature research, fieldwork, interviews, observations and the exploration of existing conservation and community-based initiatives to identify the underlying causes of conflict and opportunities for intervention.

The proposed framework is based on two complementary principles: Prevent Contact and Reduce Impact. It divides the landscape into three interconnected zones: an elephant corridor, a buffer zone and community land. The elephant corridor follows historical migration routes and provides connected habitats, vegetation for food and shelter, and strategically located water sources. The buffer zone uses elephant-deterrent crops to discourage elephants from entering agricultural areas without creating additional barriers to their movement. In community lands, drought-resistant and elephant-compatible crops, improved water management, community farms and community-based organisations support food security and livelihood diversification. Additional opportunities, including agroforestry, local product development and ecotourism, further strengthen economic resilience.

The project demonstrates how landscape architecture can bring wildlife conservation and community development together within a multifunctional landscape. Rather than treating them as competing objectives, the design addresses the causes of HEC while creating a landscape in which both elephants and local communities can benefit.. Its long-term effectiveness depends on community participation, viable alternatives for affected inhabitants, sustained management and phased implementation.

"There are no walls between humans and the elephants except those we put up ourselves, and that until we allow not only elephants, but all living creatures their place in the sun, we can never be whole ourselves"

Lawrence Anthony, The Elephant Whisperer (2017)

Fascination

When I had the opportunity to conduct my research in Kenya, I was immediately drawn to it for several reasons. Kenya has vast natural landscapes where wildlife can move relatively freely, which contrasts with the Netherlands, where landscapes are often intensively managed and shaped by human activities. This difference made me interested in how people and nature share space, and what happens when human settlements and infrastructure increasingly occupy natural habitats. It also raises questions about how communities experience the consequences of these changes, sometimes generations after their families first settled in an area.

I was particularly interested in exploring possible solutions, not only to understand the challenges but also to see how both people and nature adapt to changing circumstances. Working in a different geographical and cultural context offered an opportunity to challenge my own perspective and gain new insights that could contribute to my development as a landscape architect. For example, many rural communities in Kenya depend directly on natural processes, such as seasonal rainfall, for agriculture and access to resources. Understanding this relationship helped me consider how landscape design can respond more closely to both ecological processes and people's everyday needs.

Lawrence Anthony's words in 'The Elephant Whisperer' reflect how I view the relationship between people and nature. I believe there needs to be a balance, and that we cannot continue to use natural resources as if they exist solely for human benefit. Healthy ecosystems are essential not only for wildlife but also for our own well-being and livelihoods. The consequences of environmental degradation, including the growing effects of climate change, show how strongly we depend on the natural systems around us. His words reinforce my belief that we need to make space for other living creatures and recognise that protecting nature is also important for our own future.

By treating elephants and local inhabitants as equally important stakeholders, I wanted to explore how landscape design could help restore this balance between human activities and natural systems. Rather than prioritising one over the other, my aim was to develop a framework in which both could benefit. This project gave me the opportunity to contribute to a landscape where ecological processes and human livelihoods are often in conflict, and to explore how design can help create the conditions for them to coexist.



Reading guide

PART I – Introduction
The first part introduces the global challenge of human–elephant conflict (HEC), the project location and the problem statement. It outlines the design assignment, research questions and methodology that guide the thesis. The theoretical framework is also introduced, establishing the concepts that underpin the research.

PART II – Understanding
The second part explores the site context through an analysis of different landscape layers, including ecological, social, spatial and environmental conditions. This analysis identifies the key challenges, relationships and opportunities within the Kasigau region. The findings provide the foundation for understanding the underlying causes of HEC and defining the issues that the design needs to address.

PART III – Finding solutions
Building on the findings of Part II, this part explores potential approaches to reducing HEC while supporting both local communities and elephants. Existing interventions, relevant theories and case studies are analysed to identify effective strategies and transferable lessons. These insights are used to develop a set of design principles and strategies.
The principles are then translated into design concepts and strategies that combine the findings and insights from the previous parts of the thesis. Through this process, the strategies are further developed into an integrated landscape framework that connects ecological restoration, conflict mitigation and local livelihoods.

PART IV – Implementation
This part demonstrates how the proposed landscape framework can be translated into practical design interventions. Two selected locations are explored in greater detail to illustrate how the framework can be applied in specific spatial contexts. Through detailed designs, abstract principles are translated into tangible proposals, showing how the interventions could function within the landscape. The feasibility of the proposals is also considered through a phased implementation plan and a financial timeline.

PART V – Lessons Learned
The final part reflects on the research and design process and brings together the main findings of the thesis. The discussion evaluates the proposed landscape framework in relation to the research questions and considers its potential contribution to reducing HEC while supporting local communities and elephants. The reflection critically examines the research approach, the design outcomes and their limitations. Finally, the conclusions summarise the key lessons learned and provide recommendations for future research and implementation.

Glossary

Agroforestry: A land-use system that integrates trees and shrubs with crops and/or livestock to improve productivity, biodiversity, soil quality, and ecosystem resilience.

Alternative Livelihoods: Additional or alternative ways for people to earn an income and meet their basic needs, reducing dependence on activities vulnerable to drought, crop losses, or other environmental pressures.

Buffer Zone: An area between two different land uses that creates a transition and helps reduce negative interactions between them.

Cash Crops: Crops cultivated primarily for sale to generate income rather than for direct household consumption.

Community-Based Organisation (CBO): An organisation established by members of a local community to address shared needs and interests. It can help organise activities, manage resources, support local initiatives, and develop opportunities for income generation.

Community Farm: An area of agricultural land managed collectively to produce food for members of a community.

Conservancy: An area of land managed to protect wildlife and natural habitats while potentially supporting other activities, such as livestock grazing and ecotourism. Conservancies can help maintain wildlife corridors, restore ecosystems, and support local livelihoods.

Drought-Resistant Crops: Crops that can tolerate periods of limited water availability and continue to grow under relatively dry conditions. They can help maintain agricultural production and food security in semi-arid regions with irregular rainfall.

Eco-tourism: Tourism that focuses on natural environments and local culture while supporting conservation and providing economic benefits to local communities. It can create employment opportunities and encourage the protection of wildlife and habitats.

Elephant-Compatible Crops: Crops selected for cultivation in landscapes shared by people and elephants, with the aim of reducing the risk of crop damage and supporting coexistence.

Elephant Corridor: A connected strip or area of habitat that allows elephants to move between larger habitats or protected areas.

Elephant Deterrent Crops: Crops or plants selected for characteristics such as an unpleasant smell, taste, or sharp leaves that may discourage elephants from entering agricultural areas. In the proposed design, these plants form part of the buffer zone.

Elephant-Friendly Fence: A fence designed to discourage elephants from entering certain areas, while minimising harm to the animals.

Habitat Fragmentation: The process by which continuous natural habitats become divided into smaller, isolated areas due to human activities such as agriculture, settlement expansion, fencing, and infrastructure development. This can restrict wildlife movement and access to essential resources.

Human–Elephant Conflict (HEC): Negative interactions between people and elephants that occur when their needs and activities overlap. These interactions can result in crop damage, economic losses, threats to human safety, and harm to elephants.

Livelihood: The resources, activities, skills, and sources of income that people rely on to meet their basic needs and support their daily lives.

Non-Palatable Crops: Crops that elephants generally find unappealing because of their taste, smell, or other characteristics. It is a form of elephant-compatible crop.

Rainwater Harvesting: The collection and storage of rainwater from surfaces such as rooftops or the surrounding landscape for later use. It can improve water availability during dry periods and reduce dependence on other water sources.

Ranch: A large area of land primarily used for raising livestock, such as cattle, goats and sheep. In the Kasigau region, ranches are typically characterised by Acacia–Commiphora bushland, which provides grazing, browse and shelter for livestock.

Water Pan: A shallow, often human-made water-storage basin that collects and holds water, typically from rainfall and surface runoff. In semi-arid landscapes, water pans can provide essential water for wildlife and local communities, particularly during dry periods.

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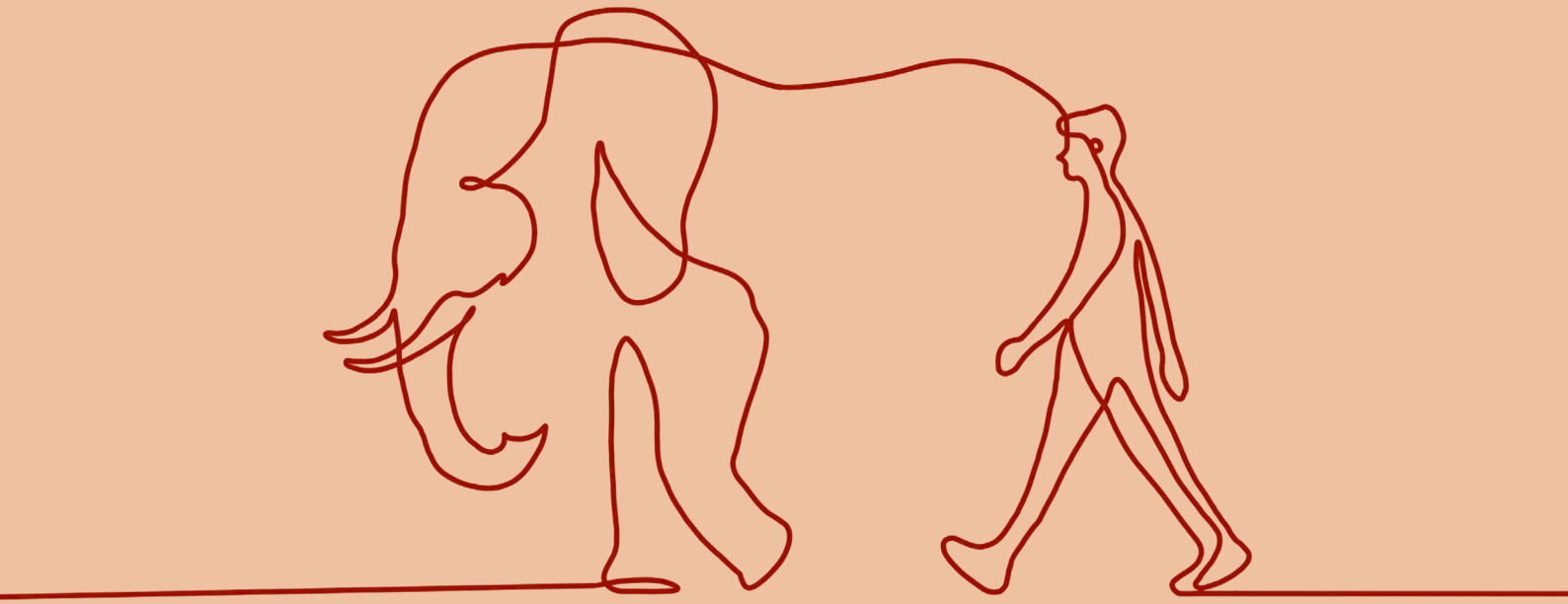


PART I

INTRODUCTION

1

Introduction

1.1 Global biodiversity challenge
1.2 Site context
1.3 Problem statement

1.1 Global biodiversity challenge

Biodiversity is essential to human survival and forms the foundation of our societies. However, all global indicators assessing the state of nature point to a continuing decline. Over the last five decades (1970–2020), the average size of monitored wildlife populations has decreased by 73%, according to the Living Planet Index (LPI), a rate that is alarmingly high and far exceeds natural extinction levels.

Habitat degradation and loss represent the primary drivers of this decline, largely as a consequence of current food production systems. Additional pressures on biodiversity include overexploitation, invasive species, disease, climate change, and pollution.

The ongoing loss of biodiversity poses a serious threat to vital ecosystem services such as pollination, soil fertility, and water purification, with direct implications for human health and well-being. Moreover, biodiversity loss reduces the availability of natural resources, including plant and animal species that may offer yet-undiscovered benefits for medicine and healthcare.

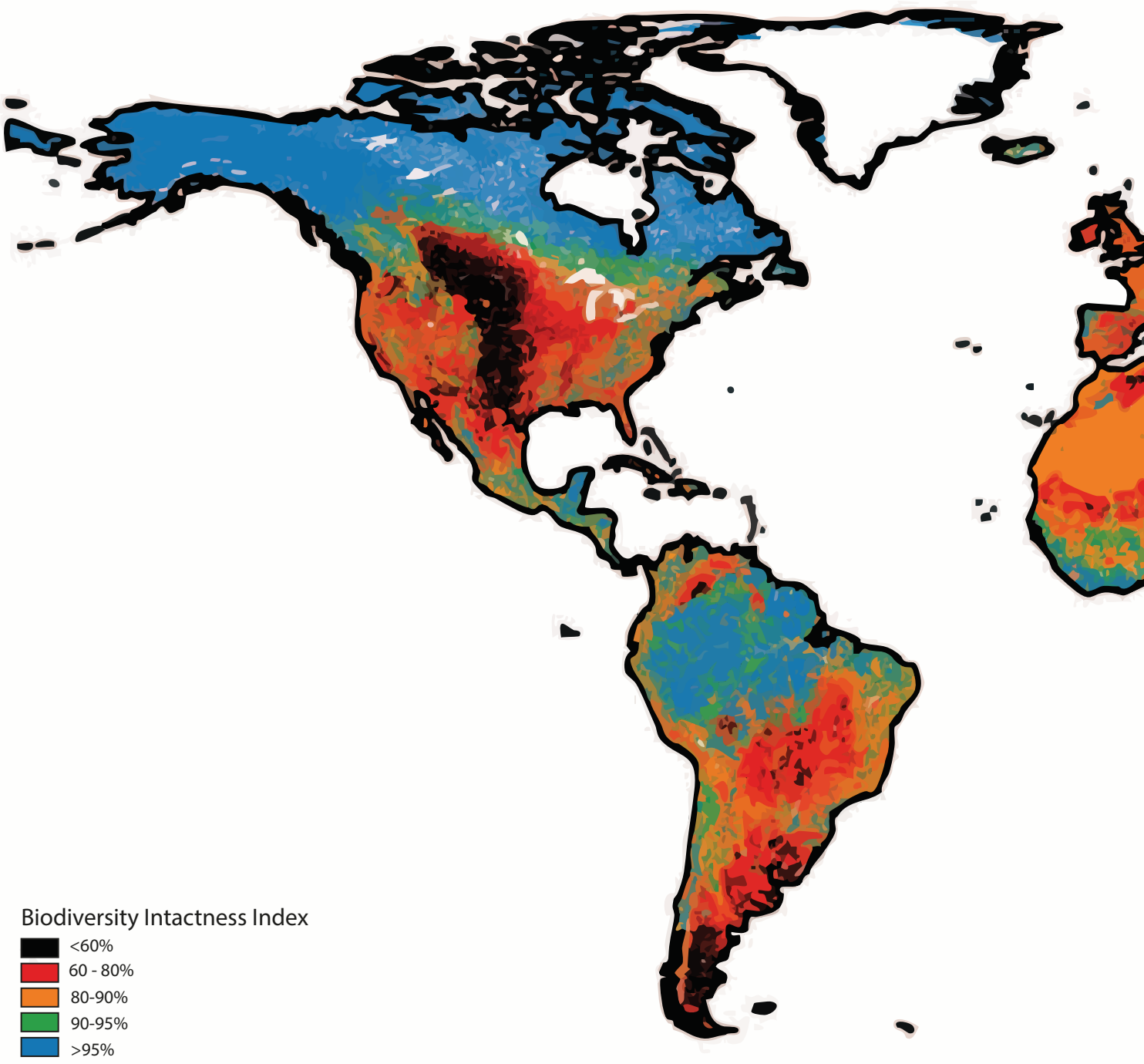


Figure 2: Biodiversity intactness of ecological assemblages, from Newbold et al. (2016)

Ensuring a planet where both people and nature can thrive requires increased and more effective conservation efforts, alongside systematic action to address the principal drivers of biodiversity loss. Immediate intervention is necessary to enhance ecosystem resilience and to mitigate the impacts of climate change and other stressors. Achieving this goal demands integrated solutions, implemented from local to global scales, that simultaneously tackle multiple drivers of environmental change (WWF, 2024).

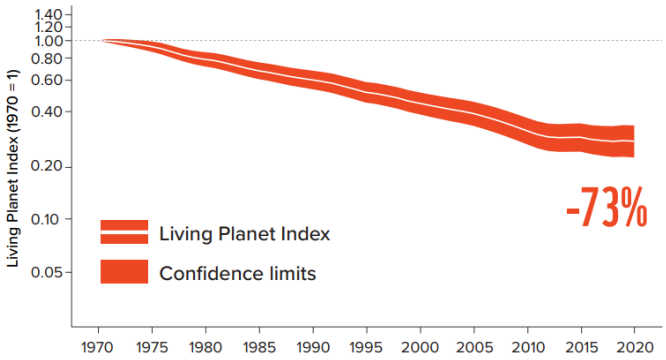
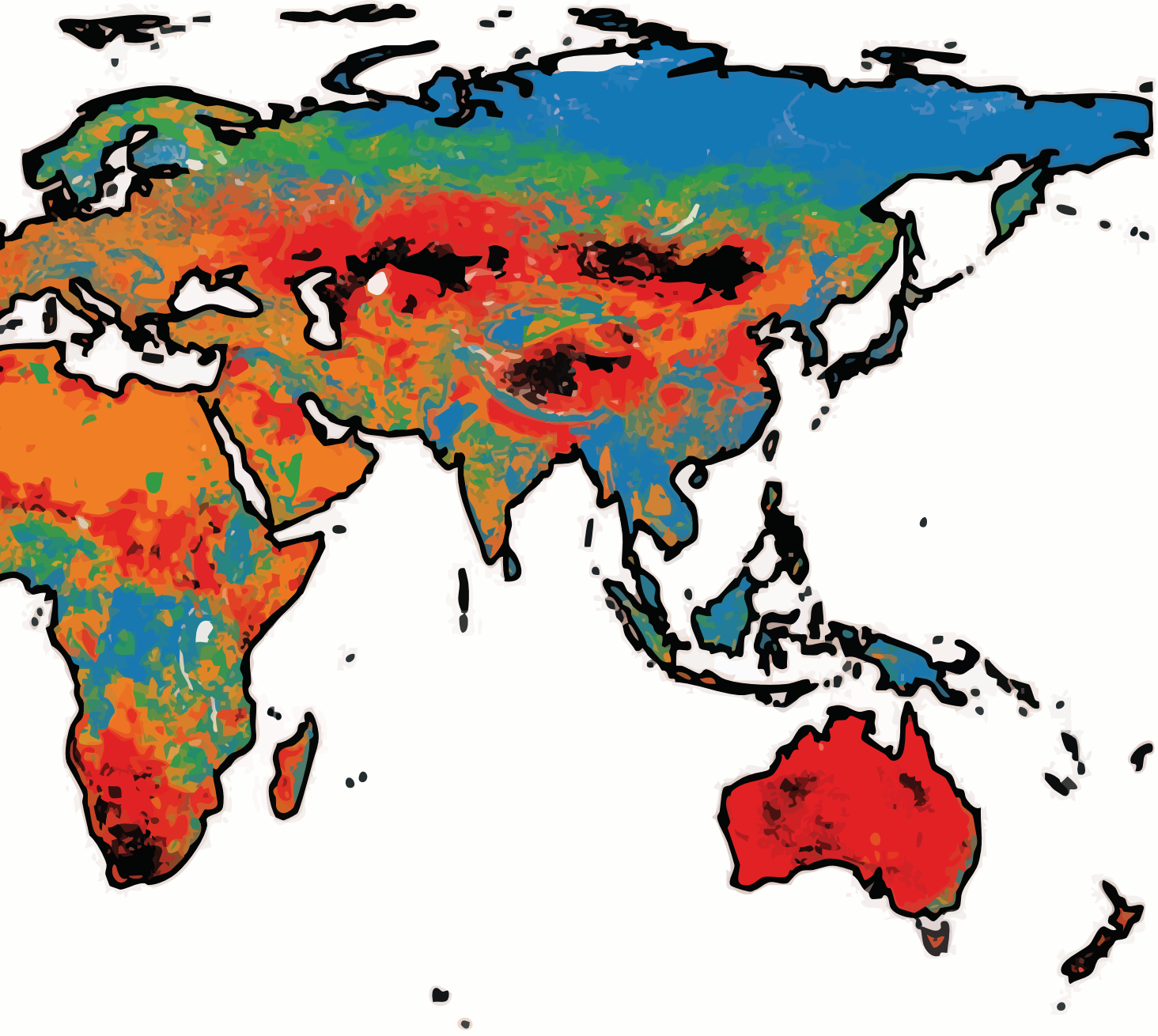
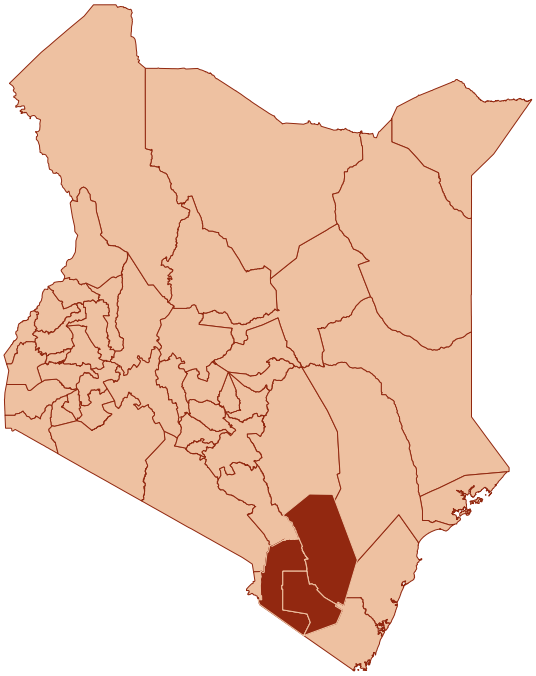


Figure 1: Global Living Planet Index, from WWF (2024)

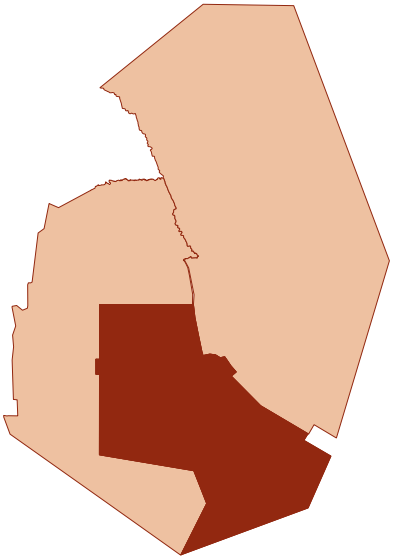




Kenya



Tsavo National Park &
Kasigau region



Kasigau region

Figure 3: Design site location, made by author

1.2. Site context

1.2.1 Kenya

Kenya, located in East Africa, is home to more than 57 million people. The country hosts an exceptional diversity of ecosystems, ranging from savannas and deserts to forests and marine protected areas, which support a wide array of wildlife. More than 8% of Kenya's land area is designated as protected, making it one of the premier destinations for observing the "Big Five" (lion, leopard, elephant, buffalo, and rhinoceros) in their natural habitats (KWS, n.d.).

In recent years, Kenya has emerged as one of the most dynamic economies on the African continent, despite persistent structural challenges. The country is a leader in renewable energy and has made substantial investments in sectors such as climate-resilient agriculture (Government of the Republic of Kenya, 2007). In 2024, Kenya welcomed a record 2.4 million international visitors, and the government is planning to further expand the tourism sector (Tourism Research Institute, 2025).

1.2.2 Tsavo National Park

Tsavo National Park, consisting of Tsavo East and Tsavo West, is one of the largest and oldest protected areas in the world. Together, the two parks cover more than 20,000 square kilometres, representing around 4% of Kenya's total land area. Established in 1948, the park is managed by the Kenya Wildlife Service (KWS), which is responsible for wildlife conservation and management in Kenya. Tsavo plays an important role not only ecologically, but also historically and economically within the country's protected areas network (KWS, n.d.).

Tsavo is a major wildlife stronghold, providing habitat for the "Big Five" and over 500 bird species (KWS, n.d.). The park is particularly important for elephant conservation, it hosts the largest elephant population in Kenya of almost 13.000 elephants (Ngene et al., 2017). Tsavo's elephants are well known for their red colour, which they get from their mud bads in the iron-rich soils. The park is also one of the last remaining refuges for rare "super tuskers": elephants with exceptionally large tusks.

The landscape of Tsavo National Park is highly varied and is dominated by vast semi-arid savannas and grasslands, intermitted with rivers and geological features. Between the two National parks, Tsavo East and Tsavo West, there are clear differences in the landscape.

Tsavo East National park is characterised by wide, flat, and dry plains. The red, iron-rich soil gives the landscape its distinctive colour. Key features include the Yatta Plateau, considered one of the longest lava flows in the world, and the Galana River, which forms a vital water source for wildlife in the region.

Tsavo West National park, by contrast, is more hilly and greener, with volcanic cones, rocky outcrops, and denser vegetation due to higher rainfall. The area contains several volcanic features, including old lava flows such as the Shetani Lava Flow. One of its most notable features is Mzima Springs, a series of clear freshwater springs that provide an essential and permanent water supply for wildlife, including hippos and crocodiles (Ermak Vagus, 2024).

1.2.3 Kasigau corridor

De Kasigau region, an area in the Taita Taveta county, is the area situated between Tsavo East and Tsavo West National Park. It is around 300 square kilometers and is typified by a dryland forest ecosystem. Because it connects the two national parks, the area functions as an important wildlife corridor. However, almost all the land is divided in ranches, where the land is mostly used for agricultural purposes. Having livestock and crop farming is challenging, since the area is suffering from drought and a fragile ecosystem.

Attempting to improve the livelihoods of the local inhabitants and restrengthen the wildlife corridor, the Reducing Emissions from Deforestation and Degradation (REDD+) project was founded in 2005. The long term project uses a market based approach, where it gains income through selling carbon credits. Self-governance and community based approaches are the core of creating a successful project (Wildlife Works Carbon 2022).

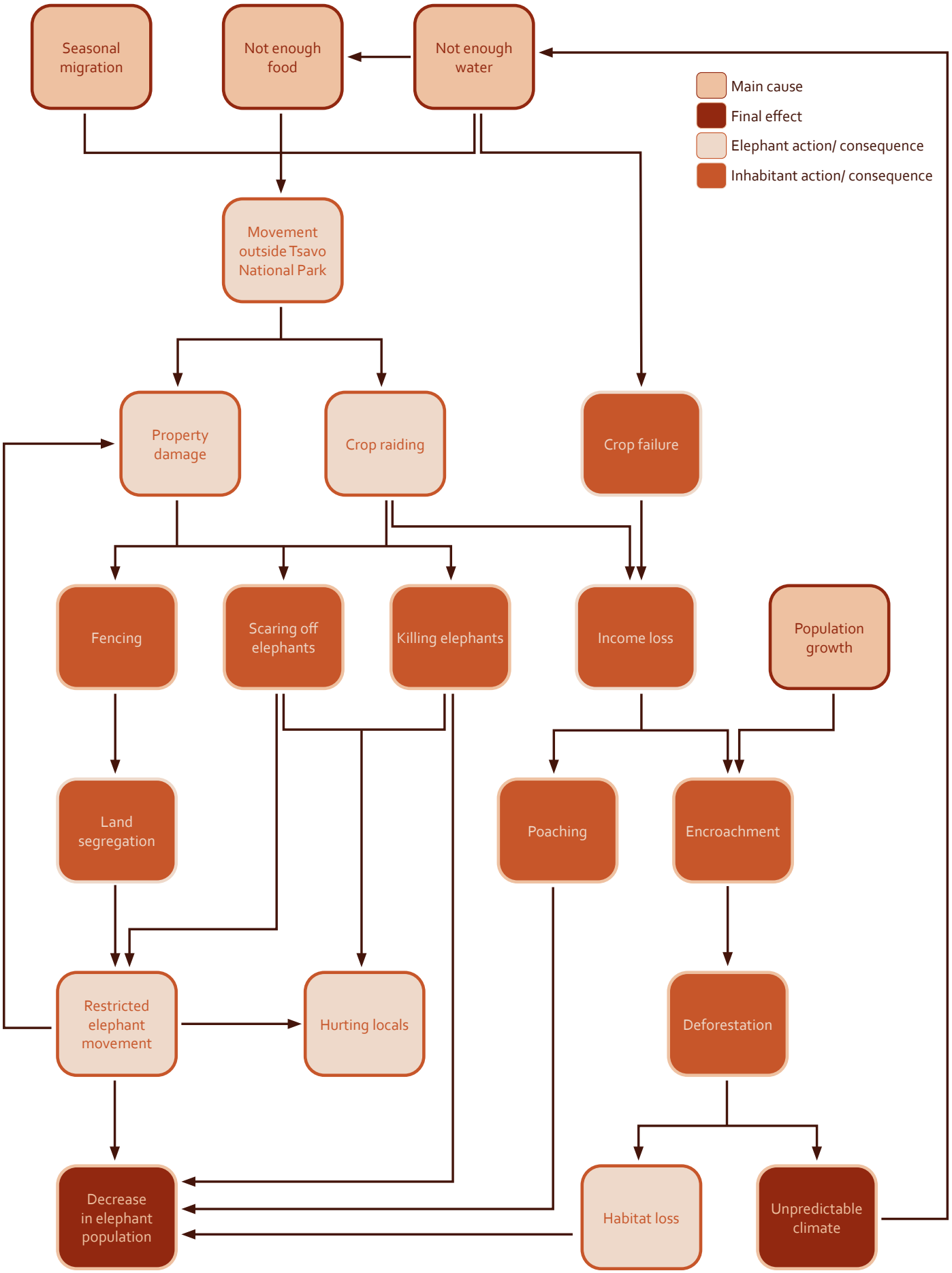


Figure 4: Negative cause and effect model explaining the problem statement, made by author

1.3 Problem statement

African elephants are known as "ecosystem engineers" because they create unique habitats for other species by physically altering the environment, fertilizing the soil and spreading seeds. In Kenya, the Tsavo ecosystem, which includes Tsavo East and Tsavo West National Park, supports one of the largest populations of African elephants in the country. Despite this importance, elephant numbers in the Tsavo and Tsavo West National Park, just like the rest of Kenya, have declined over recent decades (IUCN, 2016). This decline is driven by human interventions resulting in habitat loss and poaching, but are also climate change related.

Habitat loss in and around Tsavo is mainly caused by the expansion of human settlements, agriculture, and infrastructure, which fragments once-continuous landscapes (Wildlife Works Carbon, 2022). Poaching for ivory has historically had a severe impact on elephant populations, despite improved law enforcement efforts in recent years (IUCN, 2016). At the same time, climate change has resulted in more frequent and severe droughts, reducing the availability of water and forage within protected areas. Kenyan wildlife officials recently reported that drought now kills 20 times more elephants than poaching, with 179 elephants passing due to dehydration in just the first half of 2022 (Wildlife Works, 2025). Searching to find food and water, elephants are increasingly forced to move beyond the national park boundaries, disrupting traditional migration routes and altering how elephants use the broader Tsavo landscape (Douglas-Hamilton et al., 2005).

The movement of elephants outside park boundaries has serious ecological, social, and economic consequences. Elephants increasingly come into contact with human settlements, particularly in the Kasigau corridor, which serves as a migration route between Tsavo East and Tsavo West National Park: an estimated 11,000 elephants use the corridor as a key migratory route, and over 2,000 elephants use the space as a permanent home (Wildlife works, 2025). However, rapid land-use change and human encroachment have reduced the corridor's functionality. Farmers in the Kasigau region frequently experience crop damage and property loss caused by elephants searching for food. To protect their lands, farmers scare away the elephants with fire or even kill them. These negative interactions where humans and elephants harm each other, is called the human–elephant conflict (HEC).

Human–elephant conflict places significant pressure on local livelihoods by threatening food security and increasing economic vulnerability. At the same time, elephants face higher risks of revenge killings, car and train collisions, and additional habitat stress. This creates a negative feedback loop in which conflict contributes to further population decline and undermines conservation efforts (Munyao, et al., 2020).

A major challenge in addressing these issues is the fragmented nature of the Kasigau corridor. Large parts of the corridor are divided into private ranches and farmland, often fenced in ways that restrict elephant movement. These physical barriers disrupt natural migration routes and increase the likelihood of encounters between people and elephants when animals attempt to move around fenced areas (Mukeka, et al., 2020). While current conservation strategies focus mainly on protected-area management, anti-poaching measures, and community awareness, they often fail to address elephants' broader spatial needs across the landscape. There is therefore a strong need for a landscape-level spatial framework that balances elephant conservation with the socio-economic needs of local communities. Such an approach would involve restoring key habitat patches, reducing barriers to movement, and integrating wildlife considerations into land-use planning (Douglas-Hamilton et al., 2005).

Although the importance of wildlife corridors is widely recognised, there is still limited research on how to implement them effectively in heavily human-modified landscapes like the Kasigau corridor. Successful corridor planning requires an integrated understanding of elephant movement ecology, land tenure systems, and community perceptions of wildlife. Without this approach, corridor interventions risk being ineffective or creating new sources of conflict.

This research therefore addresses a key knowledge gap: how can a spatial landscape framework be designed to support safe elephant movement between Tsavo East and Tsavo West National Park, while also sustaining local livelihoods? The problem involves interconnected ecological, social, and infrastructural challenges, including habitat loss, drought, poaching, and physical barriers such as fenced ranches. Addressing these challenges is essential not only for the long-term conservation of elephants in the Tsavo ecosystem, but also for promoting sustainable coexistence between people and wildlife in shared landscapes.

2

Research base

2.1 Design assignment
2.2 Reseach question
2.3 Methodology
2.4 Project relevance
2.5 Research approach
2.6 Theoretical framework

2.1 Design assignment

The design assignment will be conducted through a research-through-design approach to generate new, explorative, and applicable knowledge that can be implemented in the Kasigau corridor, connecting Tsavo East and Tsavo West National Park. The assignment will focus on creating a landscape-based spatial strategy that facilitates elephant movement while simultaneously supporting the livelihoods and well-being of local inhabitants. The main goal of the design is to establish a functional wildlife corridor that balances ecological connectivity with human land-use needs, enabling both elephants and communities to coexist in a mutually beneficial landscape.

During the design process, it will be examined how fragmented landscapes and fenced ranches in the Kasigau corridor can be reframed as design opportunities for creating functional wildlife corridors that also benefit people. This includes identifying critical habitat patches, connecting existing water sources, and integrating land uses that reduce human-elephant conflict. Spatial analysis and ecological mapping will guide the positioning of these corridors, while participatory design methods will incorporate local knowledge into the landscape strategy.

This process will ultimately lead to a landscape framework that improve the ecological, social, and infrastructural challenges. For elephants, the design will provide secure and continuous migratory pathways, access to food and water resources, while minimizing fragmentation and restoring the ecosystem. For local communities, the design will integrate strategies to mitigate crop damage, support sustainable agriculture, and enhance resilience through generating alternative livelihoods. Rather than treating the needs of elephants and local inhabitants separately, the design seeks to establish the spatial conditions for long-term coexistence.

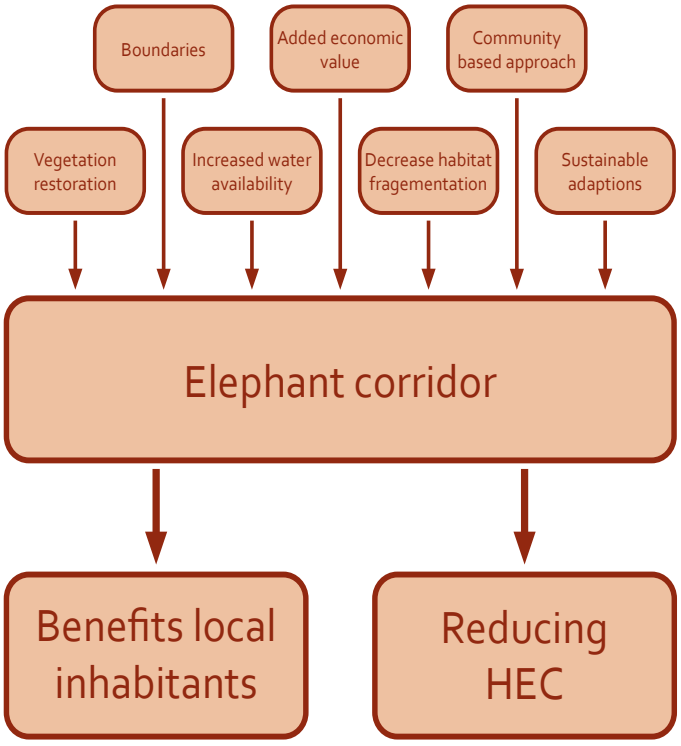


Figure 5: Factors needed to create the multi functional landscape network functioning as elephant corridor, made by author

2.2 Research questions

To guide the design assignment, the following research question is formulated: **How can a regenerative spatial landscape framework reduce human–elephant conflict in the area between Tsavo East and Tsavo West National Parks, while creating co-benefits for both local inhabitants and elephants?**

This question is supported by five sub-questions (Figure 6), moving from problem analysis to design. Elephants and local inhabitants are treated as equally important stakeholders, recognising that reducing human–elephant conflict requires a landscape-wide approach that addresses their interconnected needs.
Sub-question 1 investigates the underlying causes of human–elephant conflict and how these contribute to livelihood stress among local inhabitants and affect elephants in the Tsavo ecosystem. This establishes why the conflict occurs.

- **Sub-question 2** examines the social and environmental impacts of human–elephant conflict on inhabitants, elephants, and the wider ecosystem. Together, the first two sub-questions establish the key problems and challenges the design must address.
- **Sub-question 3** explores regenerative design principles that could reduce human–elephant conflict in semi-arid regions affected by water and food scarcity and vulnerable livelihoods. By examining existing approaches and potential solutions, it identifies opportunities to restore ecological processes, improve habitat conditions, and strengthen livelihood resilience, translating these needs into spatial design principles.
- **Sub-questions 4 and 5** form the design phase, addressing each stakeholder separately. SQ 4 focuses on spatial interventions to restore historical elephant migration routes between Tsavo East and Tsavo West National Parks. SQ 5 explores interventions that strengthen local livelihood resilience while contributing to reducing human–elephant conflict.

Together, the five sub-questions provide the foundation for a regenerative landscape framework that supports elephant movement, strengthens local livelihoods, and promotes long-term co-existence between elephants and inhabitants in the Kasigau region.

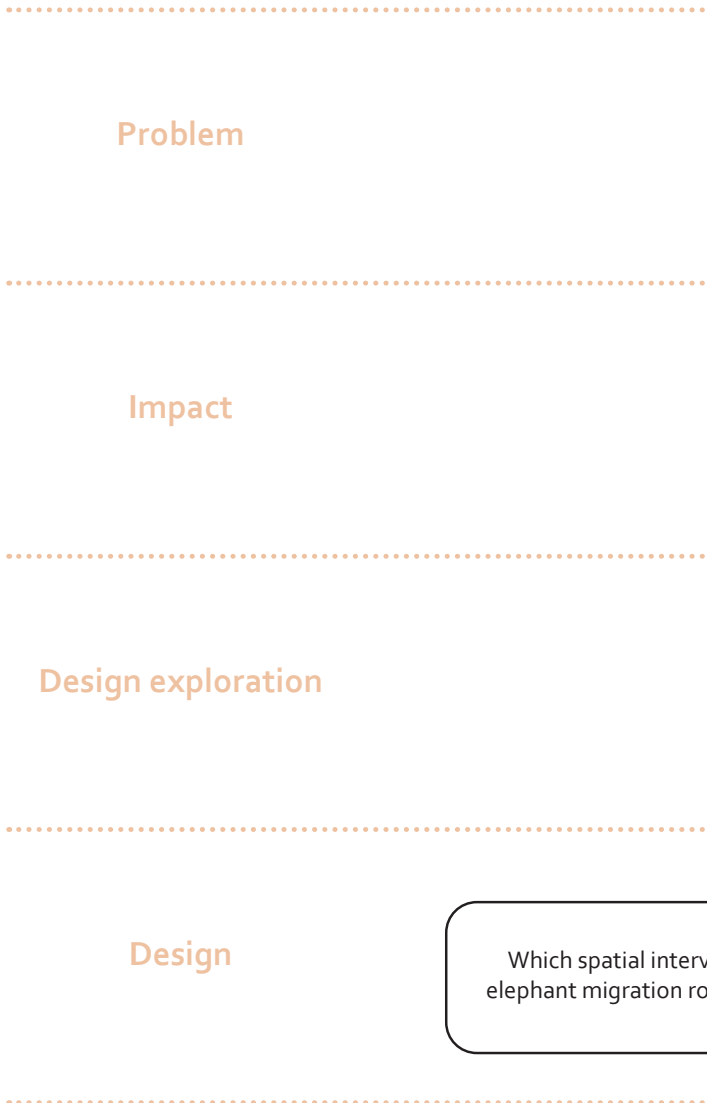
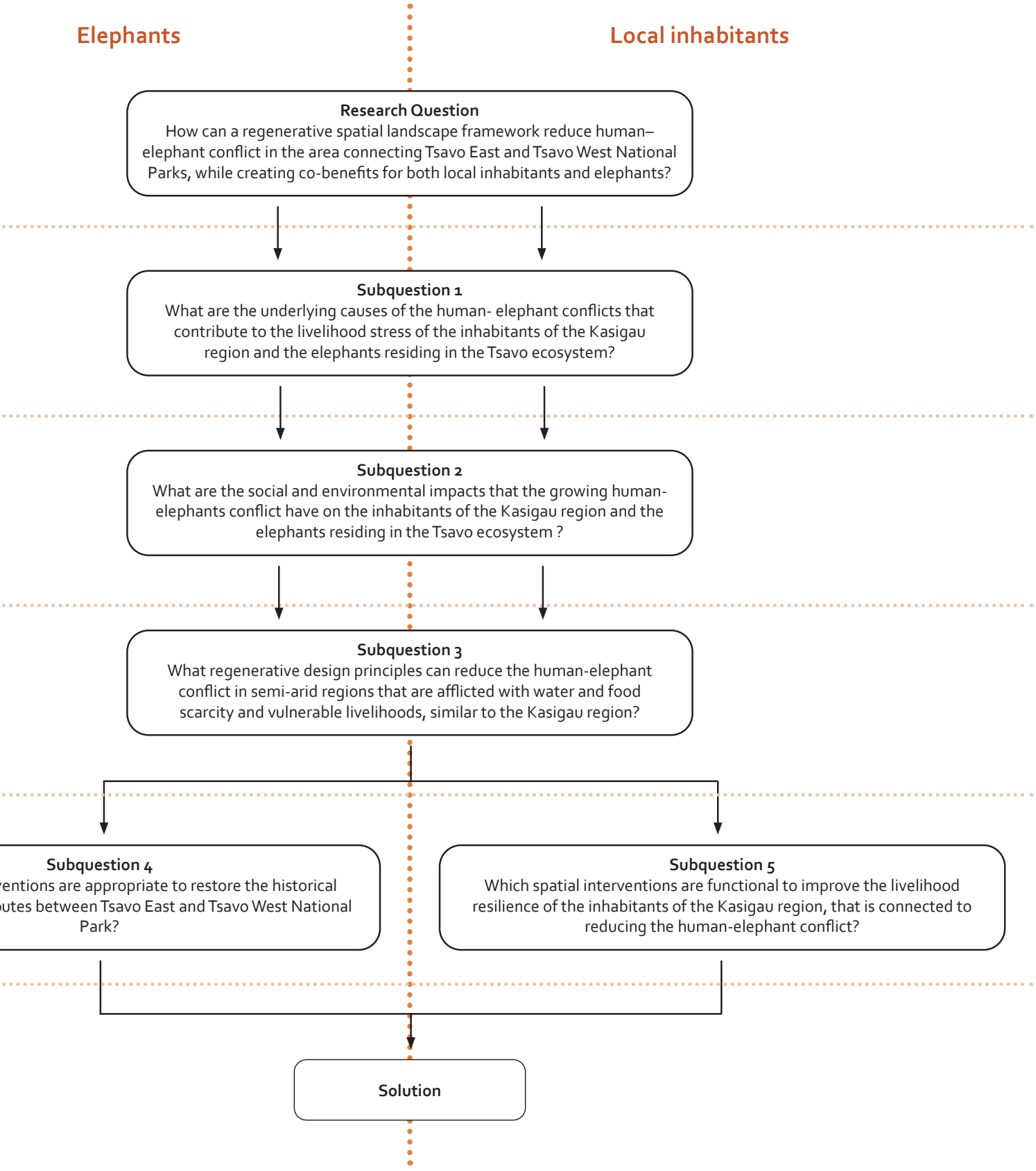


Figure 6: Scheme explaining the research- and subquestions following



the Urban Ecology Design theory

2.3 Methodology

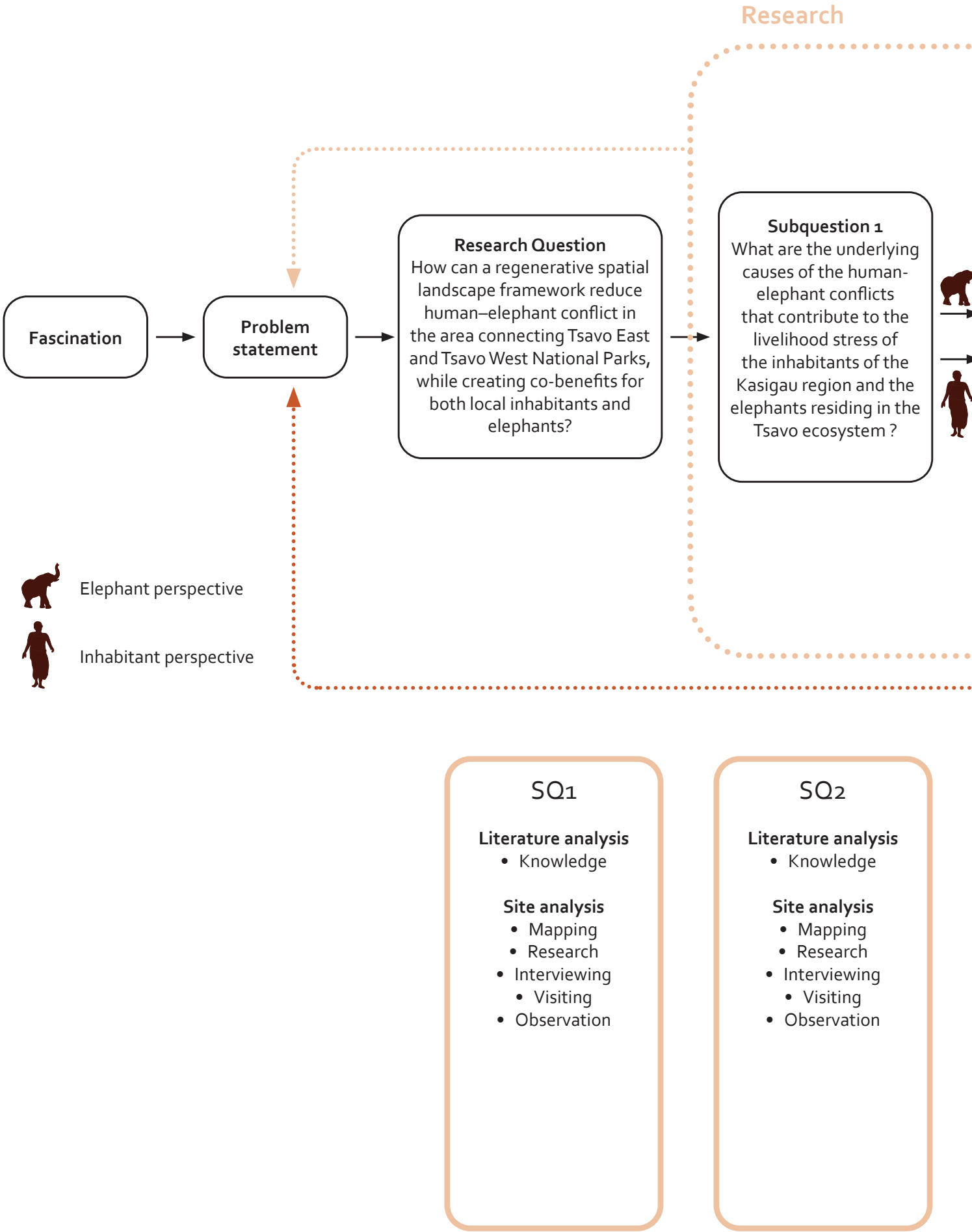
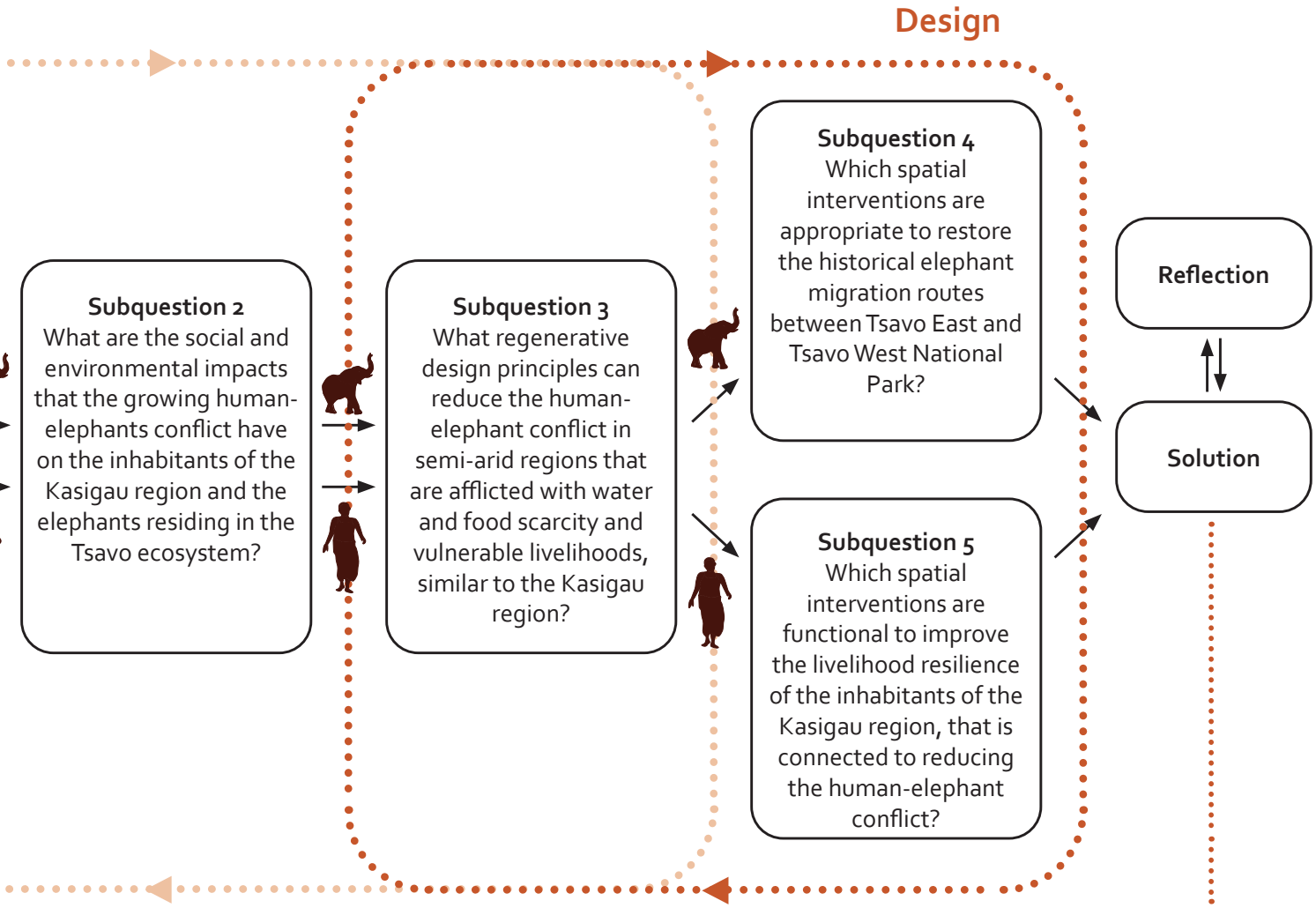


Figure 7: Research methodology scheme, drafted according the RTD method from Nijhuis & De Vries (2020) and methods per subquestio



SQ3

Literature analysis
- Knowledge

Site analysis
- Research
- Interviewing
- Observation

Precedent study
- Experimental
- Narrative
- Comparative
- Technical

Design experiments
- Explaining
- Scheme

SQ4

Literature analysis
- Knowledge

Site analysis
- Research
- Interviewing
- Observation

Design experiments
- Drawing
- Scheme
- Explaining
- Workshops

SQ5

Literature analysis
- Knowledge

Site analysis
- Research
- Interviewing

Design experiments
- Drawing
- Scheme
- Explaining
- Workshops

2.3 Methodology

The methodoly is created with the adaption of Research through Design (RTD) method by Nijhuis & De Vries (2020). The approach is suitable for addressing complex problems, which cannot be solved through linear or purely analytical methods, as they involve multiple interacting factors, uncertainties, and competing interests. RTD is particularly valuable in design-based research because it allows knowledge to be generated through the act of designing itself.

A design process within RTD typically follows three closely connected phases: analysis, synthesis, and evaluation. These phases are used together throughout the whole process and form a reflective process. The process begins with a clearly formulated design objective, which helps guide the exploration and provides direction for the search. It concludes with a design solution that responds to this objective, while also contributing new insights and knowledge.

- T**he analysis phase** focuses on collecting, interpreting, and understanding relevant information. This phase aims to build a strong understanding of the design context, identify key challenges, and explore potential opportunities. Rather than seeking definitive answers, analysis helps frame the problem and define the conditions within which design interventions can arise.
- **The synthesis phase** translates insights from the analysis into spatial ideas and partial solutions. This phase is mostly creative and involves a cycle of idea generation and development. Initial concepts often emerge as incomplete ideas, which take shape through design exploration. These early ideas are then refined, combined, and developed into more coherent and integrated design proposals.
- **The evaluation phase** involves assessing design outcomes in relation to the original objective. Design solutions are tested, compared, and refined, and alternative approaches are explored. Evaluation often leads back to earlier phases, allowing objectives, assumptions, and solutions to be adjusted.

As a result, the design process is not linear but consisting of several cycles, relying on continuous feedback between problem and solution as showed in Figure 8.

Throughout the RTD process, analytical thinking and design thinking work together (Figure 9). Analytical thinking turns data translation and interpretation into knowledge, while design thinking enables the creation of new knowledge into invention.

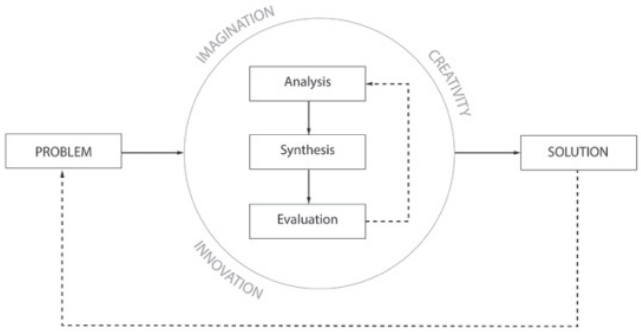


Figure 8: RTD design process, from Nijhuis & De Vries (2022)

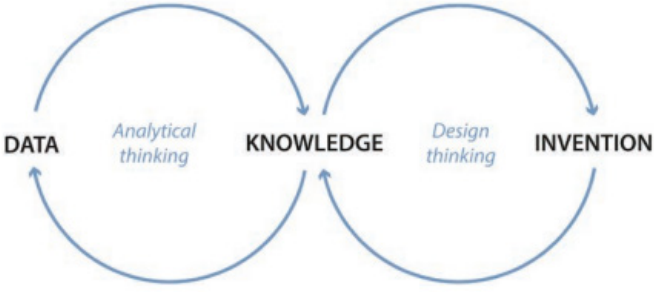


Figure 9: Connection analytical and desing thinking, from Nijhuis & De Vries (2022)

2.4 Project relevance

This research aims to develop a spatial landscape framework for the Kasigau region that enables safe elephant movement between Tsavo East and Tsavo West National Park while supporting the livelihoods and well-being of local communities. By combining ecological connectivity with human land-use needs, the project seeks to reduce human–elephant conflict and promote long-term coexistence in a climate-stressed and increasingly fragmented landscape.

2.4.1 Social relevance

The project is socially relevant because it addresses the direct impacts of human–elephant conflict on local communities, including crop damage, economic losses, and threats to food security. By proposing spatial strategies that reduce conflict, integrate sustainable land uses, and improve the water shortage, the project supports more resilient livelihoods and safer living conditions for people in the Kasigau region. Additionally, the transformed land should, directly and indirectly, generate an increased income. This strengthens the economic growth within the community and contributes to financial independence.

2.4.2 Scientific relevance

Scientifically, this research contributes to landscape-based conservation by addressing the lack of practical frameworks for implementing wildlife corridors in human-dominated landscapes. While the ecological importance of corridors is well documented, their spatial design often remains underexplored. Through a research-through-design approach, this study integrates ecological knowledge, spatial analysis, and local insights to generate new, place-based understanding of how elephant movement can be supported within fragmented landscapes.

2.4.3 Professional relevance

Professionally, the project is relevant for landscape architects, planners, and conservation practitioners working in complex socio-ecological contexts. It demonstrates how spatial design can bridge conservation and development goals by translating ecological processes into concrete planning strategies. The resulting spatial framework provides a transferable design approach that can guide future corridor planning and land-use decision-making in Kenya and other regions facing similar challenges.

2.4.4 Personal relevance

This research will deepen the author's understanding of the importance of local communities and how they can be positively used in landscape-based solutions. It will provide insight into farming practices in southern Kenya, particularly how farmers cope with recurring drought and environmental uncertainty. In addition, the research will build knowledge on the causes of human–wildlife conflict and possible strategies to reduce it. Engaging with local perspectives will also broaden the author's worldview and encourage a more open and culturally sensitive approach to design.

2.5 Research approach

The process is guided by Urban Ecology Design theory, which examines the relationships between ecological processes, habitats, species, and human activities. By working through different spatial scales, the research moves from understanding the wider landscape system to developing specific design interventions.

The first step focuses on the system level, analysing the wider landscape of the Tsavo ecosystem and the Kasigau region. This includes the physical conditions, such as climate, topography, soil, and water systems, as well as vegetation, wildlife movement, land use, settlements, and infrastructure. The aim is to understand the relationships between these elements and identify the underlying causes of human–elephant conflict.

The second step focuses on the habitat level, examining how habitats are distributed and connected across the landscape. Particular attention is given to historical elephant migration routes between Tsavo East and Tsavo West National Parks, habitat fragmentation, and the availability of food, water, and shelter. This analysis helps identify opportunities to restore ecological connectivity and establish a functional elephant corridor.

The third step focuses on the species level, considering the needs and behaviour of elephants alongside the needs and activities of local inhabitants. This includes understanding elephant movement, the impact of crop damage on farmers, and the challenges communities face in accessing water and maintaining their livelihoods. These insights help identify interventions that can reduce conflict while supporting both wildlife and local communities.

The findings from these three levels are translated into a spatial design framework that combines ecological restoration, water management, conflict mitigation, and livelihood development. The framework is developed through design exploration, moving from a landscape-scale vision towards specific interventions and their potential implementation.

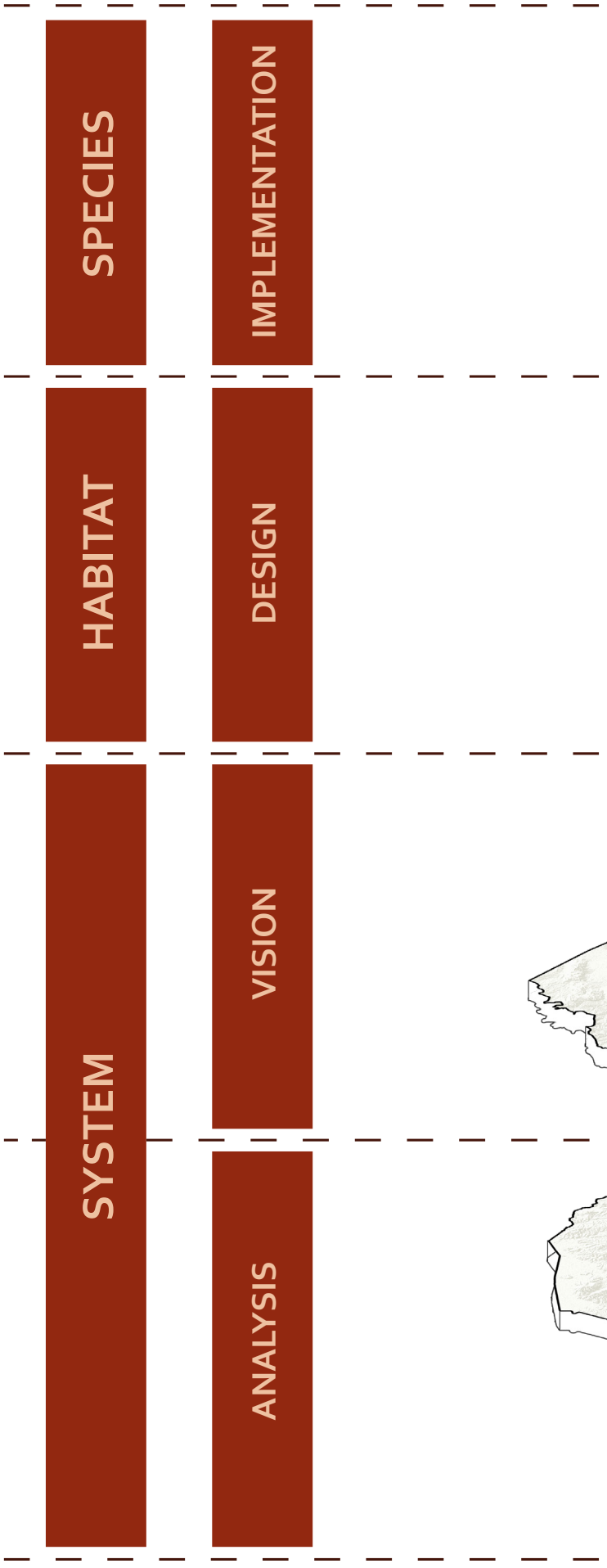
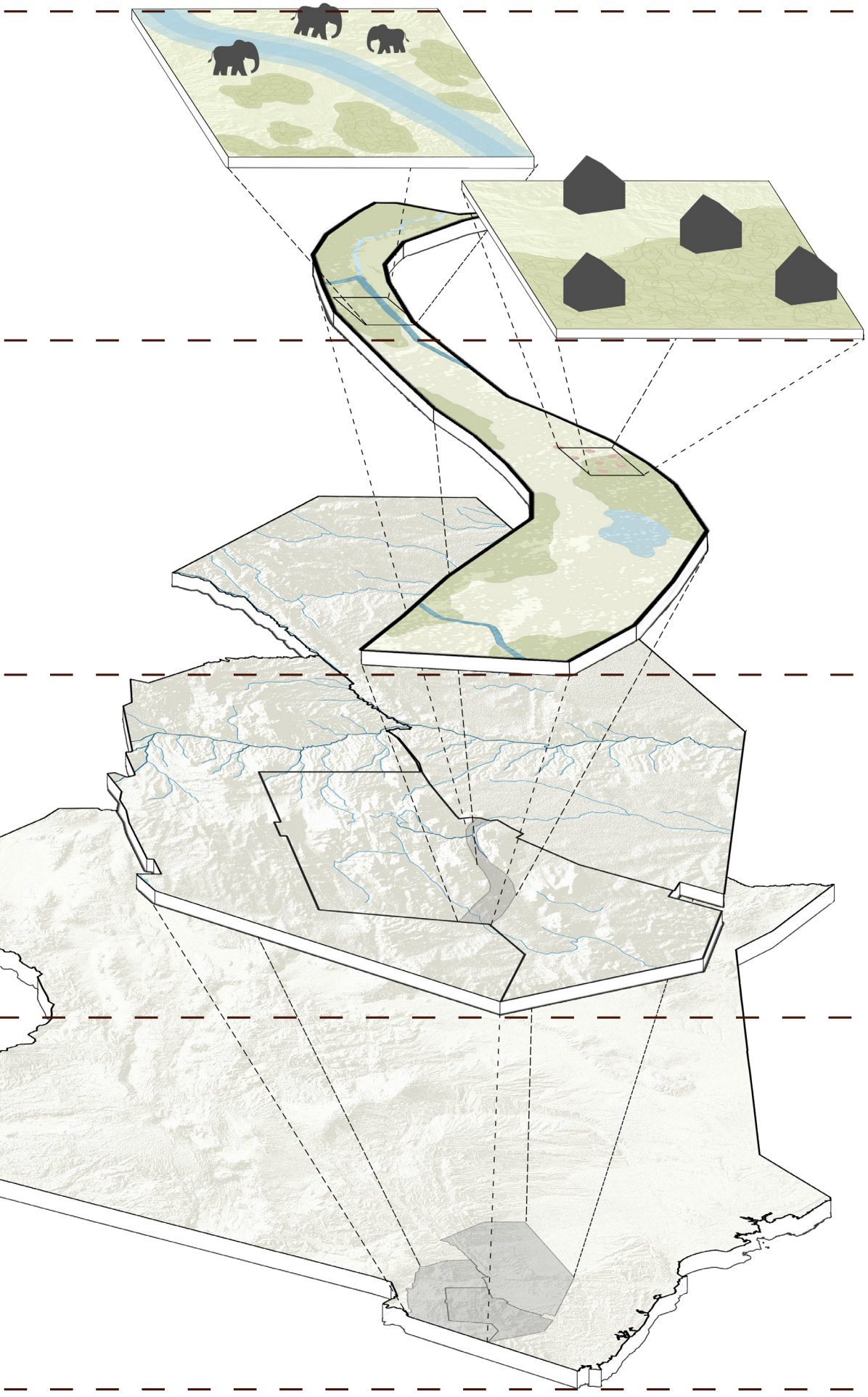


Figure 10: Working through the scales: a research approach, ma



ade by author

2.6 Theoretical framework

2.6.1 Urban Ecology Design

Urban Ecology Design combines principles from ecology and spatial design to create biodiverse, regenerative, and resilient living environments. It focuses on understanding cities as hybrid socio-ecological systems in which humans, other species, and the built environment continuously interact. Urban ecology therefore examines not only relationships between organisms, including people, but also interactions with non-living urban elements such as buildings, water systems, soil, and infrastructure.

As outlined by Tillie (2025), Urban Ecology Design operates at three interconnected levels: system, habitat, and species.

- **At the system level**, design interventions focus on understanding and regulating flows of water, energy, materials, and organisms. By intervening in these processes, designers can create the conditions that allow habitats to develop and evolve over time. This systems-based approach recognises that resilient environments depend on well-functioning ecological processes rather than isolated design elements.
- **At the habitat level**, Urban Ecology Design actively creates and connects habitats through spatial interventions such as ponds, green edges, corridors, and landscape structures. These networks support biodiversity while also enhancing human well-being by providing healthy and attractive living environments. Connectivity between habitats is essential for species movement and long-term ecological resilience.
- **At the species level**, design explicitly considers the needs of individual species, including food availability, shelter, safety, reproduction, and connectivity. Interventions may include planting and sowing, creating nesting or refuge structures, and even introducing key species such as soil organisms. Humans are also considered a species within this framework, ensuring that ecological design supports social health and everyday use.

Urban Ecology Design contributes not only to biodiversity conservation but also to climate adaptation, public health, water and energy management, and circular resource use. Regenerative landscapes play a key role by regulating ecological flows, recycling resources, and supporting self-renewing systems. Tillie emphasises a shift from nature-based to landscape-based solutions, highlighting the importance of integrating local ecological processes with cultural knowledge to achieve a balance between urban development and ecological vitality.

Urban Ecology Design forms the backbone of the research in this project, providing a framework to understand the complex interactions between humans, wildlife, and the landscape in the Kasigau region. By applying the three levels of Urban Ecology Design (system, habitat, and species) to this context, it becomes possible to identify where, how and why human-elephant conflict arises. This understanding provides a foundation for developing targeted design interventions to create a functional elephant corridor.

2.6.2 Triplex model

The Triplex Model originates from the work of Ian McHarg, who argued in his book 'Design with Nature' (1967) that urban development had become disconnected from natural systems. McHarg proposes that land-use suitability should be determined through a detailed analysis of nature and landscape processes. This involves systematically mapping physical-geographical and ecological processes and separating them into distinct map layers. These layers are organised according to the speed at which processes occur, ranging from slow-forming processes, such as deep geological structures, to faster processes like ecological and anthropogenic change.

In the 70s, this approach was simplified by Bijhouwer and Vroom into what became known as the Triplex Model. This model distinguishes three interconnected layers: the abiotic, the biotic layer, and the anthropogenic layer.

- **The abiotic layer** forms the physical foundation of the landscape, consisting of soil, topography, hydrology, and climate. It sets the conditions and limitations for both ecological and human processes, determining what types of vegetation can grow, where water accumulates, and how land can be used.
- **The biotic layer** encompasses all living organisms and ecological interactions, including plants, animals, and ecosystems. It highlights biodiversity, habitat connectivity, and ecological functions, showing how species interact with the physical environment and each other.
- **The anthropogenic layer** represents human influence on the landscape, including settlements, infrastructure, agricultural practices, and cultural or historical features. This layer reflects how people modify and manage the landscape and ensures that planning considers social, economic, and cultural realities.

The Triplex Model provides a structured framework for analysing landscapes and for understanding the relationships between physical conditions, vegetation patterns, and historical and cultural land use (H+N+S Landschapsarchitecten, 2023).

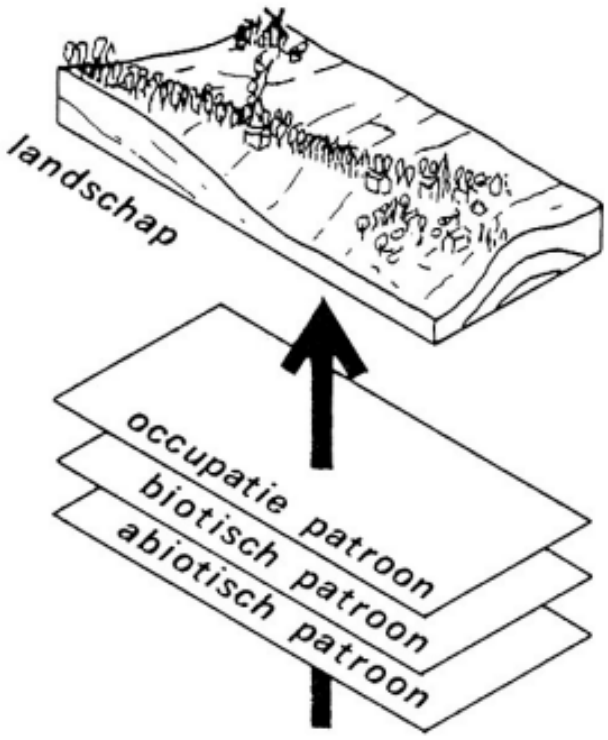


Figure 11: Triplex model scheme, from H+N+S Landschapsarchitecten (2023)

2.6.3 The 5 V's of ecology

In ecology, the Five V's represent the basic conditions that plants and animals need in order to survive and persist in a given area. These principles are widely used in ecological design and green management to support and enhance biodiversity, particularly in human-influenced landscapes. The model provides a practical framework for assessing habitat quality and identifying opportunities for ecological improvement.

The five factors, that starts with a V in Dutch, are:

- **Food:** sufficient and diverse food resources must be available throughout the year, such as nectar for insects, seeds and berries for birds, or forage for larger species.
- **Water:** success to clean drinking water and moist habitats is essential for many species, particularly during dry periods and breeding seasons.
- **Safety:** species require shelter from predators and human disturbance. This can be provided through dense vegetation, undisturbed areas, or structural cover.
- **Reproduction/ shelter:** suitable places for nesting, resting, or overwintering are necessary to sustain populations. Examples include nest boxes, hollow trees, burrows, or undisturbed corners with natural debris.
- **Connection:** ecological connectivity is crucial. Green corridors and stepping stones allow species to move safely between habitats, supporting migration, genetic exchange, and long-term resilience.

The Five V's form a conceptual model rooted in practical ecology and spatial planning in the Netherlands. While the framework does not have a single identified author, it is widely adopted and promoted by nature conservation organisations, landscape designers, and knowledge institutes. Its strength lies in its simplicity and applicability: by ensuring that these five conditions are met, designers and land managers can systematically improve habitat quality and create landscapes that better support biodiversity.

The Five V's is both useful in the research and design phase. During the research it functions as a guideline to gather information of the elephants and inhabitants needs. While during the design it can be used as a way to check if the proposed design interventions include all the conditions for both groups to thrive, thus being able to create a successful elephant corridor (Timmermans & De Zwarte, 2024).

2.6.4 Theory U

Social and participatory skills are essential for successful landscape restoration because ecological challenges are closely connected to social dynamics. Lessons from foresters, farmers, development organisations, and conservation practitioners show that managing land effectively goes hand in hand with engaging communities. This means restoration isn't just about technical solutions—it requires involving people, learning together, and making decisions collectively.

Scharmer and Kaufer's Theory U (2013) offers a helpful way to approach this. It shows how the awareness and attention of people in a system directly influence the quality of the outcomes they create. Theory U encourages stakeholders to reflect not only on the external social–ecological system but also on their own assumptions, values, and roles. By moving through the stages of the U-process, participants can spot blind spots, question old habits, and open up to new perspectives and possibilities.

By integrating the U-methodology, space is created for inclusive dialogue and co-creation, enabling communities, institutions, and individuals to jointly develop viable, place-based responses to complex environmental challenges. Theory U therefore supports a shift from ego-system thinking toward eco-system awareness, that is socially inclusive, reflective, and aligned with shared values like fairness, inclusion, and long-term resilience (Ferwerda, 2015).

Theory U emphasises the importance of involving local inhabitants in the design process from the earliest stages. The community forms the backbone of a successful project, as local people hold valuable knowledge about the landscape and play a crucial role in implementing and maintaining the proposed interventions over time.



Figure 12: Theory U: Collective awareness, strategic approach and collective action, from Ferwerda (2015)

2.6.5 Ecological niche

The ecological niche theory is centuries old but it's still the best way to explain and understand nature. It states that every species has his own position within the ecosystem, which is determined by abiotic and biotic factors. The theory clarifies how different species are able to live together in one environment, the structure of ecosystems, how species adapt to be able to survive when the environment changes.

The theory is divided in three different approaches:

- **Niche as the description of a species' habitat requirements:** an ecological niche is determined by different factors that fit the species needs. This knowledge is important to be able to understand why a species occurs in a certain area.
- **Niche as ecological function of the species:** also known as the functional nice. It describes the particular role a specie has within its ecosystem, such as food webs and tropic chains.
- **Niche as a species position in a community:** niches are dynamic, as the presence of one species can limit the presence of another through interspecific competition, causing to alter the position of the other species' niches within their environment. The concept combines the functional role of a species in its community and their ecological requirements.

As explained before, the theory helps understand the habitat and importance of interaction between other species (Polechová & Storch, 2018). It can be used when mapping the elephants' needs and It forms a backbone in arguing why elephants are important to keep the community healthy and in balance.

2.6.6 Ecopolis

The concept of Ecopolis, developed by Sybrand Tjallingii (1995), presents a vision of cities evolving from resource-consuming systems into self-sustaining ecosystems. Rather than viewing cities as separate from nature, Ecopolis frames urban areas as dynamic ecosystems that are embedded within larger biotic and abiotic systems. This perspective emphasizes that ecological preservation is only possible when human activities actively support and care for the environment. Ecopolis encourages a shift in urban planning toward ecological principles, aiming for regenerative systems that operate within ecological limits while contributing positively to their surroundings.

The ecodevice model, originally developed by Van Wirdum and Van Leeuwen (1982), is the theoretical foundation of Ecopolis is. This model describes ecosystems through four regulating mechanisms: input, output, resistance, and retention. All ecosystems depend on inputs such as solar energy, water, and minerals, while also managing outputs. At the same time, they possess the capacity to resist disturbances and retain resources, for example through flood protection or water storage. Tjallingii applies this model to cities and argues that urban systems have become structurally imbalanced because they rely on artificially amplified input and output flows, leading to environmental problems such as pollution, depletion, and ecological disruption.

The Ecopolis framework translates these insights into a planning strategy that supports decision-making at the local level and helps set priorities for research, design, and policy.

From this approach emerge three key areas of attention:

- **The Responsible City**, which accounts for environmental impacts beyond its boundaries
- **The Living City**, which provides healthy habitats for both people and urban nature
- **The Participating City**, which emphasizes the active involvement of citizens in shaping and caring for their urban environment.

Together, these principles form a foundation for ecologically responsible and socially inclusive urban development.

Even though the Kasigau corridor is not an urban environment, the land is still heavily influenced by human interventions, causing the same disbalance as explained for the urban environment. The Ecopolis framework is therefore appliable for the design location, and can function as a strong guideline when creating design concepts.

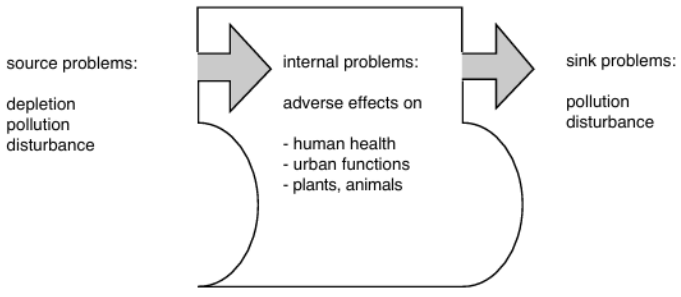


Figure 13: The 'ecodevice' model, from Tjallingii (1995)

2.6.7 How to apply

The collected theories are valuable for different aspects withing the project, which can be divided into theoretical background, research phase, and design phase. Some theories can be applied for multiple aspects.

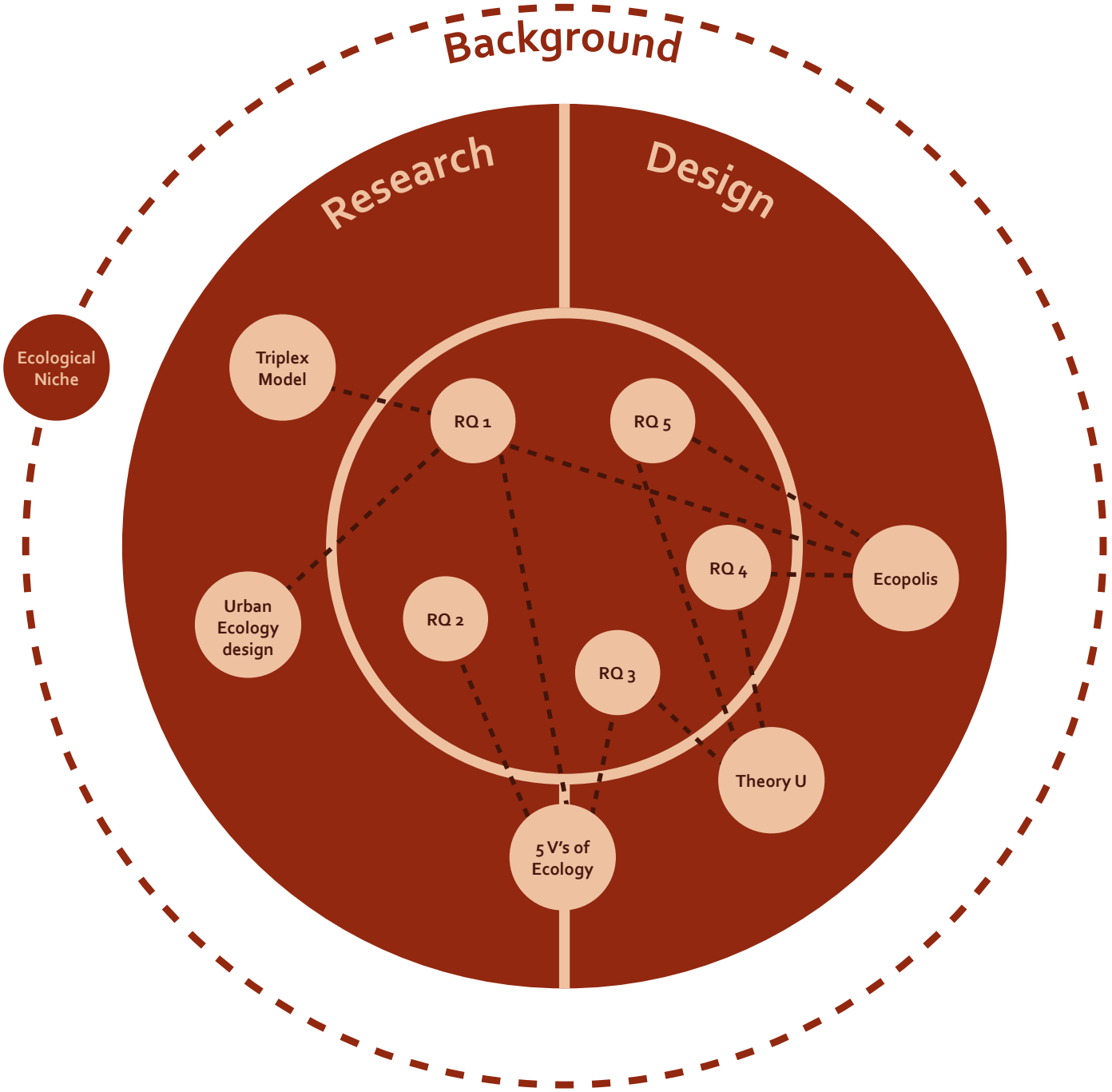
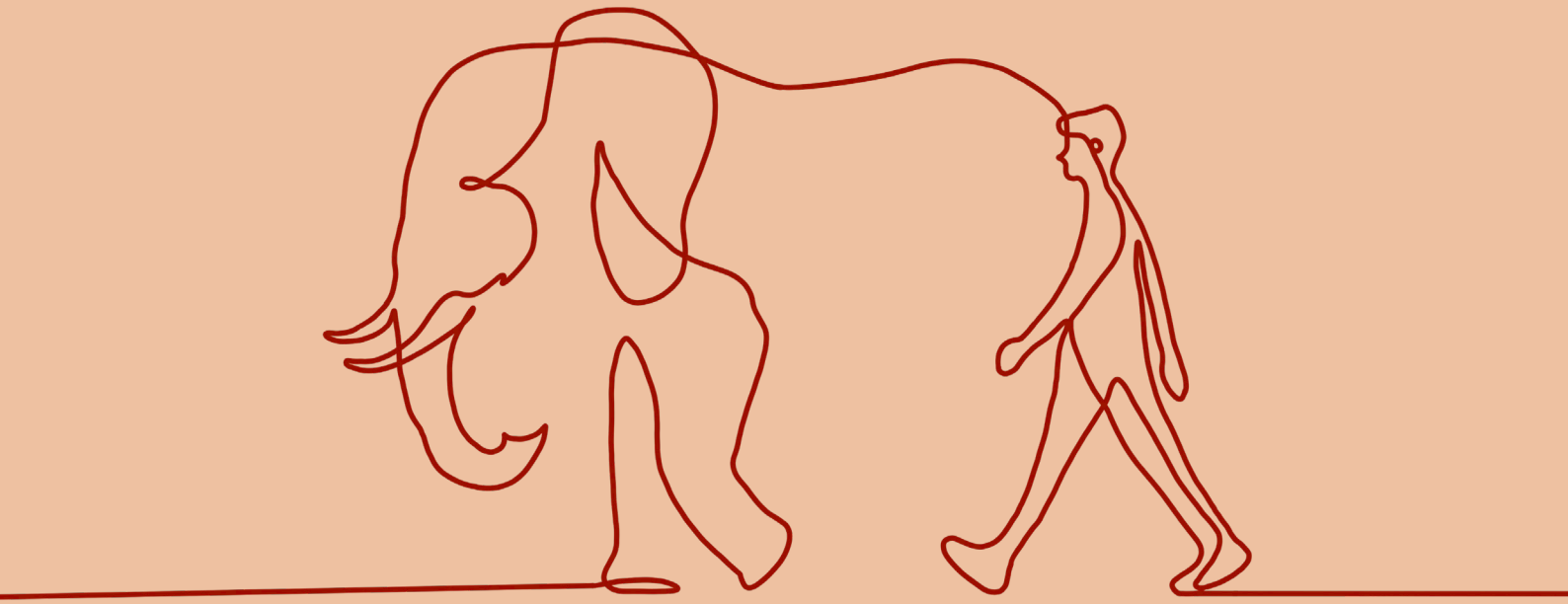


Figure 14: Theoretical framework approach, made by author



PART II

UNDERSTANDING

3

Analysis

3.1 System
3.2 Habitat
3.3 Species

3.1 System

The system-level analysis examines the wider landscape and the ecological processes that shape it. This part of the analysis is divided into three interconnected layers based on the Triplex Model: the abiotic, biotic, and anthropogenic layers. The abiotic layer examines the physical conditions, such as soil, topography, hydrology, and climate. The biotic layer focuses on vegetation, wildlife, and ecological processes, while the anthropogenic layer considers human activities, land use, settlements, and infrastructure. Analysing these layers and their interactions helps identify the underlying causes of human–elephant conflict and opportunities to improve the resilience of the Tsavo landscape.

3.1.1 Abiotic layers

Kasigau region - Elevation

Tsavo National Park has generally low to moderate relief, with broad semi-arid plains interrupted by volcanic hills, plateaus, and isolated mountain ranges. Elevations in much of Tsavo East National Park range between approximately 200 and 700 meters above sea level. The landscape is relatively flat and open, dominated by gently undulating plains and the Yatta Plateau, a long volcanic lava flow that rises slightly above the surrounding terrain. In contrast, Tsavo West National Park has more rugged relief, with rocky ridges, volcanic cones, lava fields, and higher elevations approaching 1,800 meters near the Chyulu Hills.

The Kasigau region is dominated by Kasigau Mountain, an isolated inselberg that rises steeply from the surrounding plains. While nearby lowlands lie around 500–700 meters in elevation, the mountain reaches over 1,600 meters, creating strong local relief.

The higher elevations of the Chyulu Hills and Kasigau Mountain intercept moist air from the Indian Ocean, forming montane and cloud forests that support unique biodiversity and act as critical water catchments. The Chyulu Hills are especially important because rainfall infiltrates the porous volcanic rock and feeds permanent springs and rivers such as Mzima Springs.

Tsavo region - Climate

The climate in the Kasigau region is hot, semi-arid with consistently high temperatures throughout the year. It has two distinct rainy seasons with a total annual precipitation of around 400 to 600 mm. Tsavo West is generally cooler and receives more rainfall than Tsavo East due to its higher elevation and mountains (Prince et al., 2024).

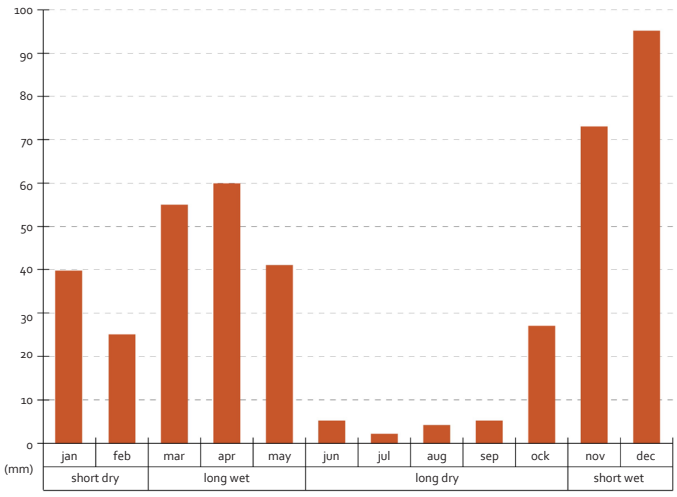


Figure 15: Annual precipitation Tsavo, made by author with information from Tsavo Climate (n.d)

Tsavo region - Rivers

Tsavo National Park is crossed by several important rivers and water sources that are essential for the survival of wildlife in this semi-arid ecosystem. The main waterways in the park are the Tsavo River, Athi River, Galana River, Voi River, and Tiva River, together with permanent freshwater springs such as Mzima Springs.

The Tsavo River flows eastward from the western part of Tsavo West National Park near the border with Tanzania. The Athi River enters the park from the north and flows through Tsavo East National Park. Together, the Athi and Tsavo Rivers form one of Kenya's largest river systems. In the central part of the park, both rivers merge to form the Galana River, a permanent river that flows through Tsavo East before eventually reaching the Indian Ocean.

Important seasonal rivers include the Voi River and the Tiva River. The Voi River flows through the southern part of Tsavo East and feeds Aruba Dam, an artificial reservoir that becomes a crucial water source during the dry season. The Tiva River is another seasonal watercourse and is especially important in the northern part of Tsavo East, where it may be the only available water source over large distances. In Tsavo West, Mzima Springs forms a major permanent freshwater source where millions of liters of clear water emerge daily from underground volcanic rocks.

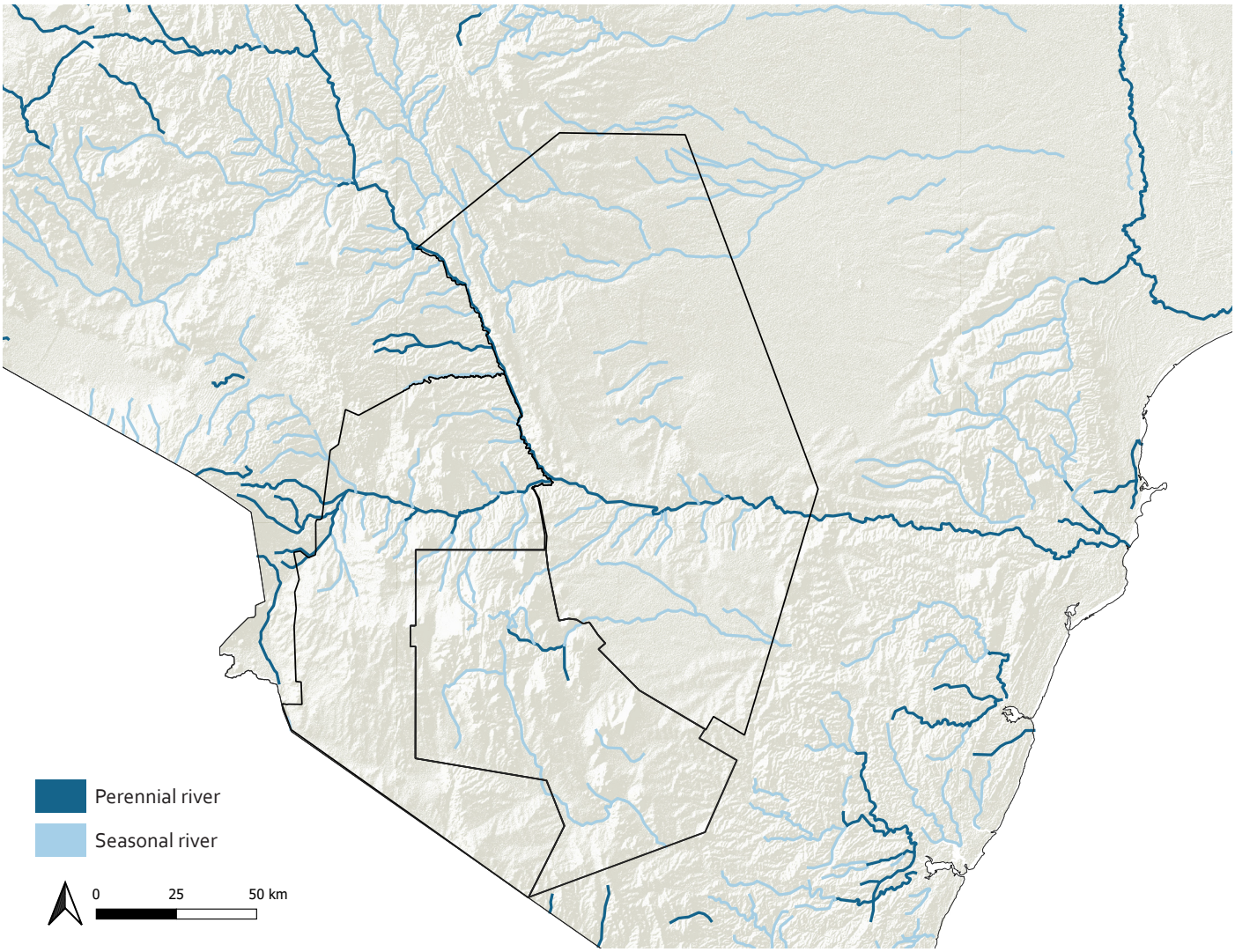


Figure 16: Rivers of Kausigau, made by author with GIS data from Kenya GIS Data (n.d.)

Kasigau region - Soil

The primary soil type in Tsavo is ferralsol, an old and highly weathered tropical soil with a limited capacity to store water for plants. Because these soils cannot retain moisture for long after rainfall, the ecosystem dries out quickly once the rainy season ends. Ferralsols are also poor in fertility and contain high levels of iron oxide, which gives Tsavo its characteristic red color. Combined with the harsh semi-arid climate, these conditions made much of Tsavo unsuitable for farming.

Other soil types in the region include cambisols, luvisols, and fluvisols, which are generally more suitable for agriculture.

Soil type	Main characteristics	Water retention	Fertility
Ferralsols	Deep, reddish, highly weathered soils. Well-drained but naturally low in nutrients.	Low–moderate	Low
Cambisols	Moderately developed soils, often shallow and gravelly in hilly areas.	Variable	Moderate
Luvisols	Soils with clay accumulation in the subsoil. Generally fertile and well-drained.	High-moderate	High-moderate
Acrisols	Acidic, highly weathered soils with low nutrient levels.	Moderate	Low
Arenosols	Sandy soils with rapid drainage and poor water and nutrient retention.	Very low	Low
Regosols	Young, weakly developed soils, often shallow and stony.	Low	Low–moderate
Fluvisols	Young, fertile soils formed from river deposits, mainly found in river valleys.	Variable	High-moderate
Nitisols	Deep, clay-rich, well-drained soils with a stable structure.	High	High-moderate
Vertisols	Heavy clay soils that expand when wet and crack when dry.	High	High
Rendzinas	Shallow, dark soils developed over limestone, often rich in organic matter.	Low–moderate	High-moderate
Rankers	Shallow, stony soils developed over non-calcareous rock.	Low	Low–moderate
Kastanozems	Dark, humus-rich soils typically found in dry grassland regions.	High-moderate	High

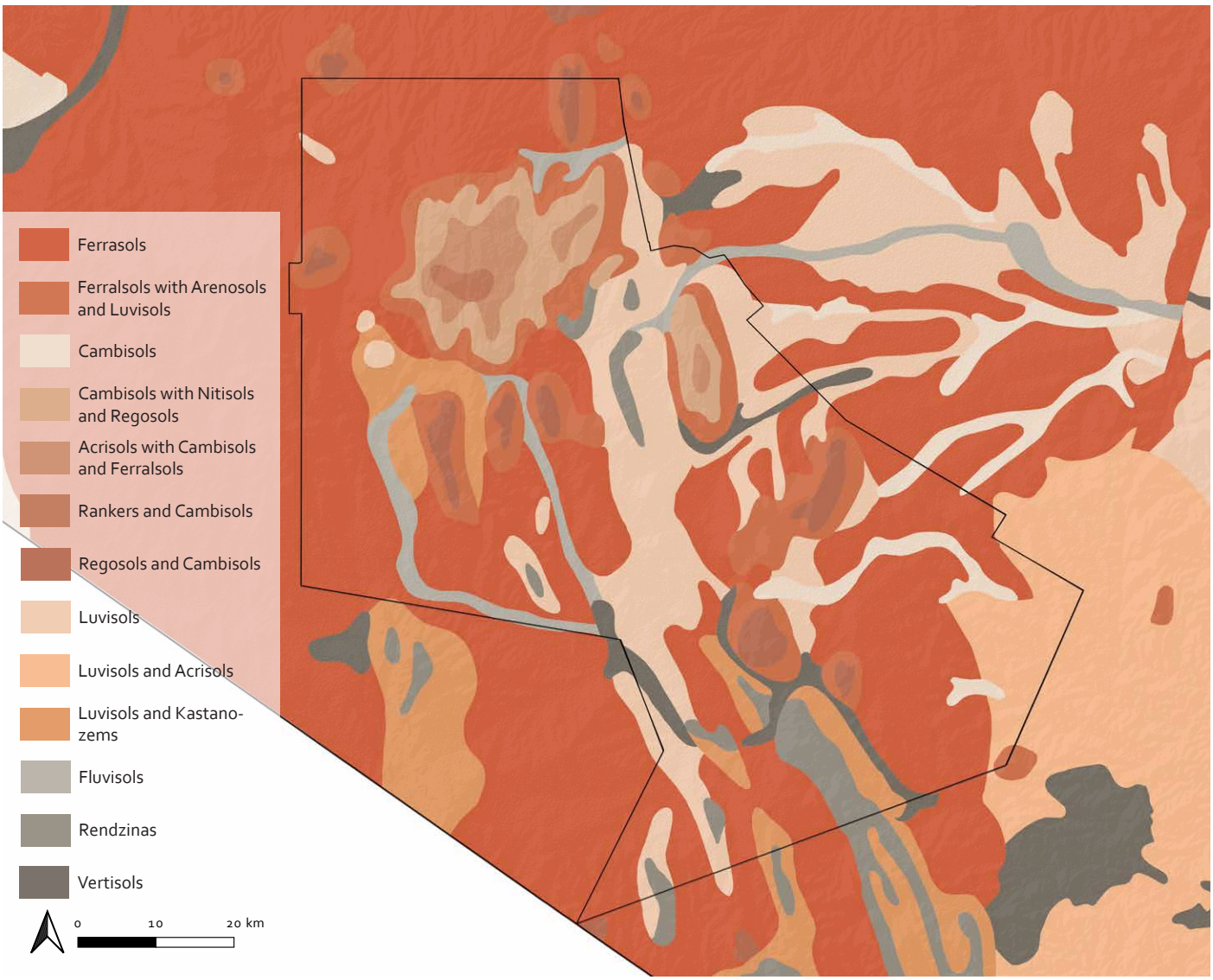


Figure 17: Soil types Kasigau region, made by author, with GIS data from Kenya GeoPortal (n.d.)

3.1.2 Biotic layers

Kenya - Elephant Population

Elephants in Kenya live distributed across several major ecosystems, mainly in the southern and central parts of the country. The largest populations occur in the Tsavo–Amboseli ecosystem in southeastern Kenya, the Laikipia Samburu ecosystem in central-northern Kenya, and the Maasai Mara region in the southwest. Smaller populations also occur around Mount Kenya, Meru, Marsabit, and coastal forest areas. Their distribution is strongly linked to the availability of water, vegetation, migration corridors, and protected areas. Elephants move seasonally between national parks, conservancies, and community lands in search of food and water. In dry seasons, they concentrate near permanent rivers, swamps, and springs, while during wetter periods they disperse more widely across savanna habitats (Ngene et al., 2013).

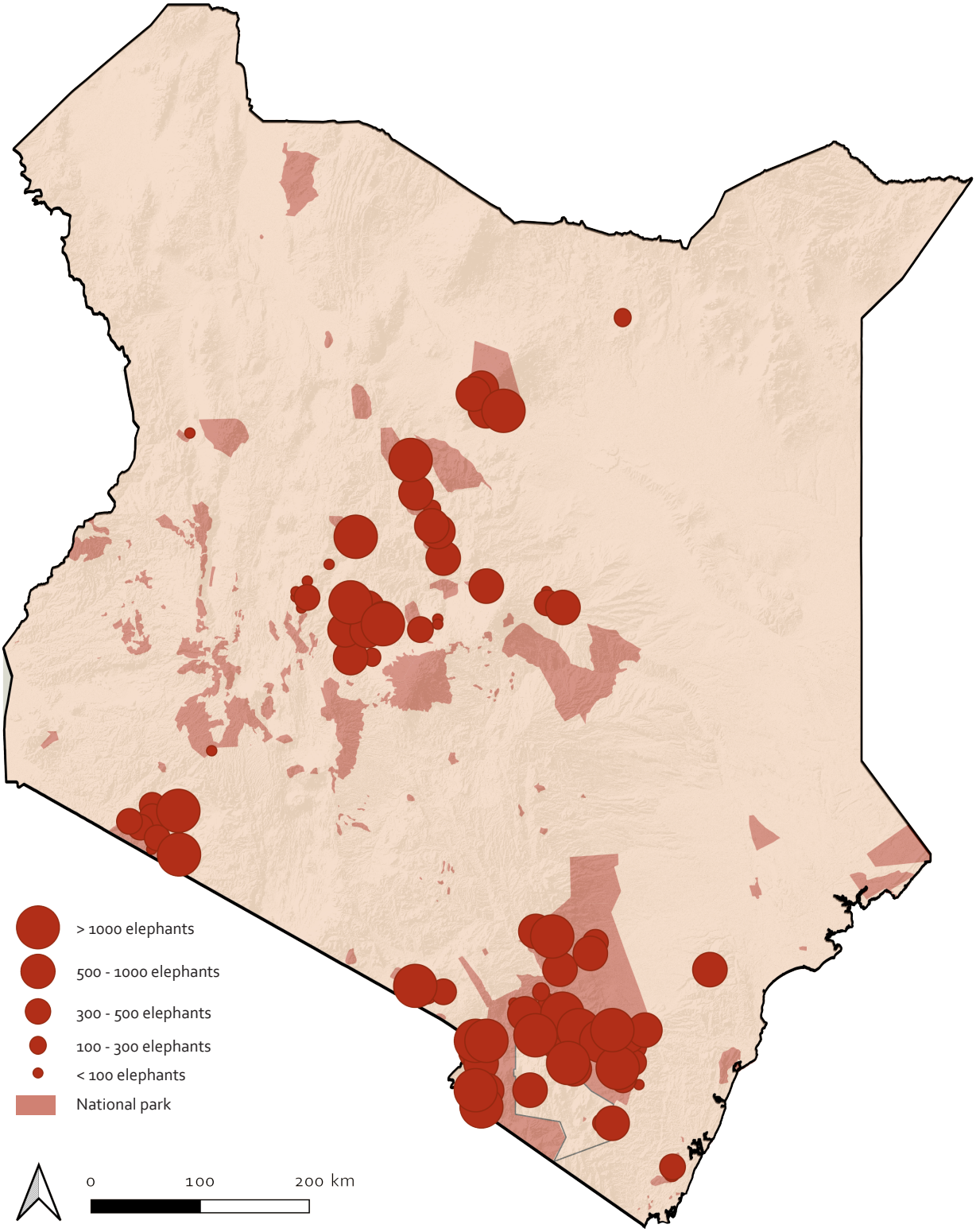


Figure 18: Distribution elephant population in Kenya, made by author, with GIS data from Kenya GIS Data (n.d.)

Tsavo region - Ecosystem

Tsavo National Park contains one of the largest semi-arid savanna ecosystems in East Africa, covering a mosaic of grasslands, Acacia–Commiphora bushland, riverine forests, volcanic hills, wetlands, and seasonal rivers. The ecosystem is divided into Tsavo East National Park and Tsavo West National Park, which together form part of the larger Tsavo Mkomazi ecosystem extending into Tanzania.

The dominant vegetation consists of dry savanna and thorn scrub, mainly composed of various Acacia and Commiphora species adapted to low and unpredictable rainfall. Permanent water sources such as the Galana River, Tsavo River, and Mzima Springs create important riverine habitats with denser vegetation and higher biodiversity. Tsavo is internationally important for its large populations of African elephants, as well as lions, giraffes, zebras, antelope, and endangered species such as the African wild dog and black rhinoceros. Elephants play a major ecological role as ecosystem engineers by modifying woodland structure through browsing, bark stripping, and tree removal, which can convert dense bushland into more open savanna. The ecosystem also includes volcanic landscapes such as the Chyulu Hills and lava flows, which create diverse soils and microhabitats. Ecological connectivity between Tsavo, Amboseli, and surrounding community conservancies is essential for wildlife migration and genetic diversity. (Van Wijngaarden, 1985).

Kasigau region - Ecosystem

The Kasigau region is characterised by four main Potential Natural Vegetation (PNV) groups, represented by five vegetation classifications: Somalia-Masai Acacia-Commiphora deciduous bushland and thicket (Bd), Acacia-Commiphora deciduous wooded grassland (Wd), Combretum wooded grassland (Wc), Afromontane rain forest (Fa), and riverine wooded vegetation (R). Together, these vegetation types reflect the region's diverse environmental conditions, ranging from the hot, semi-arid lowlands to the cooler, wetter mountain slopes and river valleys. PNV types describe the vegetation that would naturally develop in a particular area based on its environmental conditions, such as climate, rainfall, soil and elevation, without significant human influence (Kindt et al., 2013).

The lowlands are predominantly characterised by a dryland bushland ecosystem, represented mainly by Bd and Wd/Wc vegetation. This landscape consists of drought-resistant trees, shrubs and grasses adapted to the semi-arid climate and seasonal rainfall. Acacia and Commiphora species are particularly characteristic of the dry bushland, alongside baobab, desert date and Grewia species. In areas with more open vegetation, Combretum and Terminalia species occur alongside a more prominent grass layer. These vegetation types provide important food and habitat for wildlife, including elephants and other large herbivores.

Along rivers and watercourses, the vegetation changes into riverine wooded vegetation (R). Greater water availability from rivers, groundwater and seasonal flooding supports denser vegetation, ranging from open woodlands to dense forests and thickets. These areas often remain greener for longer during the dry season and provide important sources of food, shade and habitat for wildlife.

Around Mount Kasigau, Taita Hills, and other hills, vegetation changes significantly with elevation, creating distinct ecological zones. The lower slopes are characterised by dryland bushland, while increasingly moist conditions at higher elevations support different forest types. Afromontane rain forest (Fa) is associated with the cooler and wetter mountain environments. Above approximately 1,400 metres, undisturbed cloud forests occur towards the mountain summit. These forests are particularly important biodiversity refuges, providing habitat for native and endangered species. (Ylhäisi, 2004).

The Taita Hills and Mount Kasigau are important ecological features within the greater Tsavo ecosystem because they provide cooler, wetter and more topographically complex habitats than the surrounding semi-arid savanna. Their isolated mountain environments support specialised and endemic flora and fauna that are not found in the surrounding lowlands. Mount Kasigau supports endangered species such as the Taita white-eye (*Zosterops silvanus*) ,the Taita thrush (*Turdus helleri*) and African violet (*Saintpaulia teitensis*). The endemic plant *Euphorbia classenii* is also found exclusively on the mountain. Due to their ecological isolation, these mountain habitats function as important biodiversity refuges and have high conservation value (Bytebier, 2001).

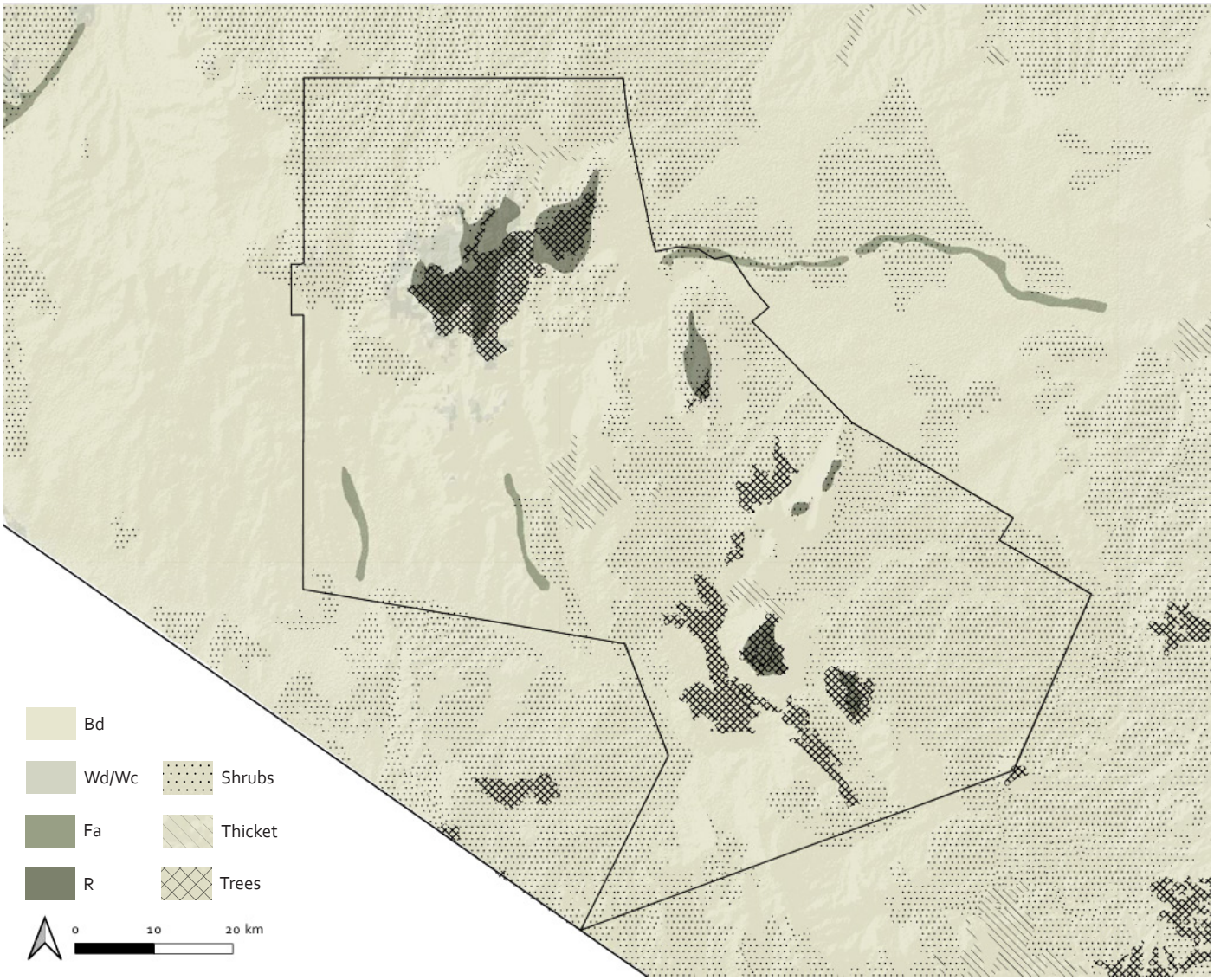


Figure 19: PNV types and wooded vegetation characteristics, made by author, with GIS data from Kenya GIS Data (n.d.)

Wooded grassland (Wd/Wc)



Afromontane rain forest (Fa)



Deciduous bushland and thicket (Bd)



Figure 20: Collection of different PNV types in the Kasigau region, made by author

3.1.3 Anthropogenic layers

Kasigau region - Infrastructure

Infrastructure in the region is relatively limited. The Nairobi–Mombasa transport corridor, including the A109 highway and the Standard Gauge Railway (SGR), crosses the area and plays an important role in trade and regional development. However, these transport routes also contribute to habitat fragmentation and barriers to wildlife movement. Most local roads are unpaved and may become difficult to access during heavy rains (Okita-Ouma et al., 2016).

Kasigau region - Land division

The Kasigau corridor, situated between Tsavo East National Park and Tsavo West National Park, is largely divided into privately or communally managed ranches. These extensive semi-arid lands are mainly used for livestock grazing or wildlife conservation. Ranches function as large land-management units where cattle, goats, and sheep are raised. Several ranches within the Kasigau corridor also support conservation initiatives aimed at maintaining wildlife migration routes between the two national parks.

The remaining communal land mainly consists of smallholder farms and rural settlements. Agriculture is dominated by herbaceous crops, which are adapted to the semi-arid climate. Farming is mostly rain-fed and concentrated around villages where soils and water availability are more favorable.

Kasigau region - Population distribution

The region is sparsely populated, with most people concentrated in small rural villages and trading centers around Kasigau Mountain, the Taita Hills, and along the main transport corridor. Settlements generally consist of dispersed homesteads surrounded by agricultural land. Villages typically contain local shops, kiosks, open-air markets, schools, churches, health clinics, water points, and administrative offices. Larger trading centers may also include fuel stations, small restaurants, mobile money services, and transport stops connecting communities to towns (Wildlife Works, 2022).

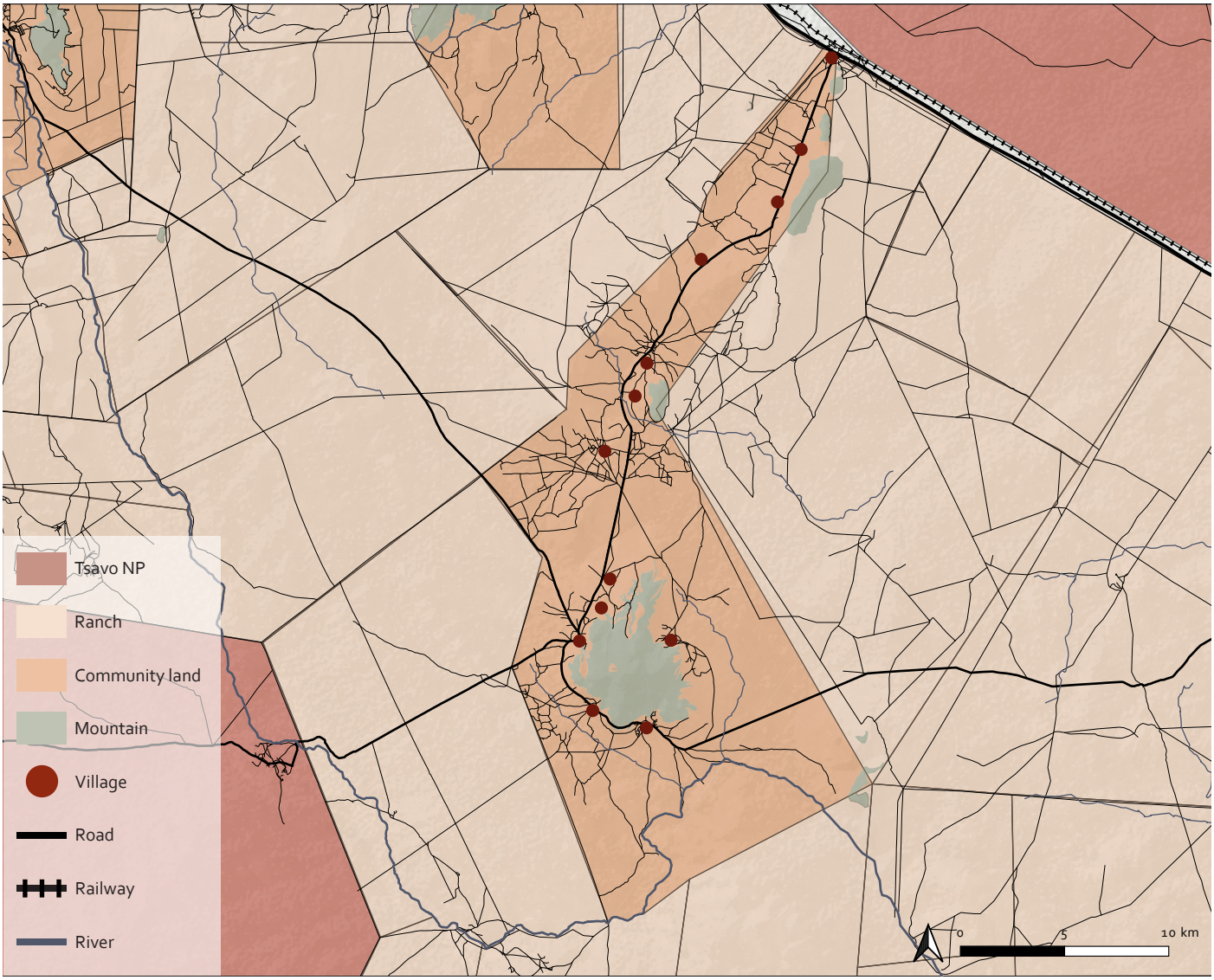


Figure 21: Land use and infrastructure, made by author with information from Wildlife Works (2022)

3.2 Habitat

The habitat level focuses on the spatial structure of the landscape and the habitats it provides for humans and wildlife. By analysing vegetation, land cover, habitat distribution, and connectivity, it becomes possible to understand how elephants move through the landscape and where their habitats overlap with human settlements and agricultural land. This provides a basis for identifying opportunities to strengthen habitat connectivity and reduce human–elephant conflict.

3.2.1 Elephant behaviour

Elephant population

Historically, Tsavo supported extremely large elephant populations, but severe droughts and intensive ivory poaching caused major mortality events during the 1970s and 1980s. Since then, elephant numbers in Kenya have gradually recovered due to improved conservation measures, anti-poaching efforts, and habitat protection. Today, the Tsavo ecosystem remains one of the most important strongholds for African elephants in East Africa (Ngene et al., 2013b).

Elephant distribution and movement

Elephants are unevenly distributed across Tsavo, mainly concentrating around permanent water sources such as the Galana, Tsavo and Athi Rivers. More than 11,000 elephants move between Tsavo East and Tsavo West, while approximately 2,000 reside more permanently in the Kasigau region.

Their movements are primarily driven by food and water availability. During the wet season, elephants spread across larger areas, while in the dry season they concentrate around permanent water sources, including rivers, springs and artificial water pools (Wato et al., 2018. Their movements also follow historical routes, supported by their long-term memory of migration paths and water sources (King et al., 2023).

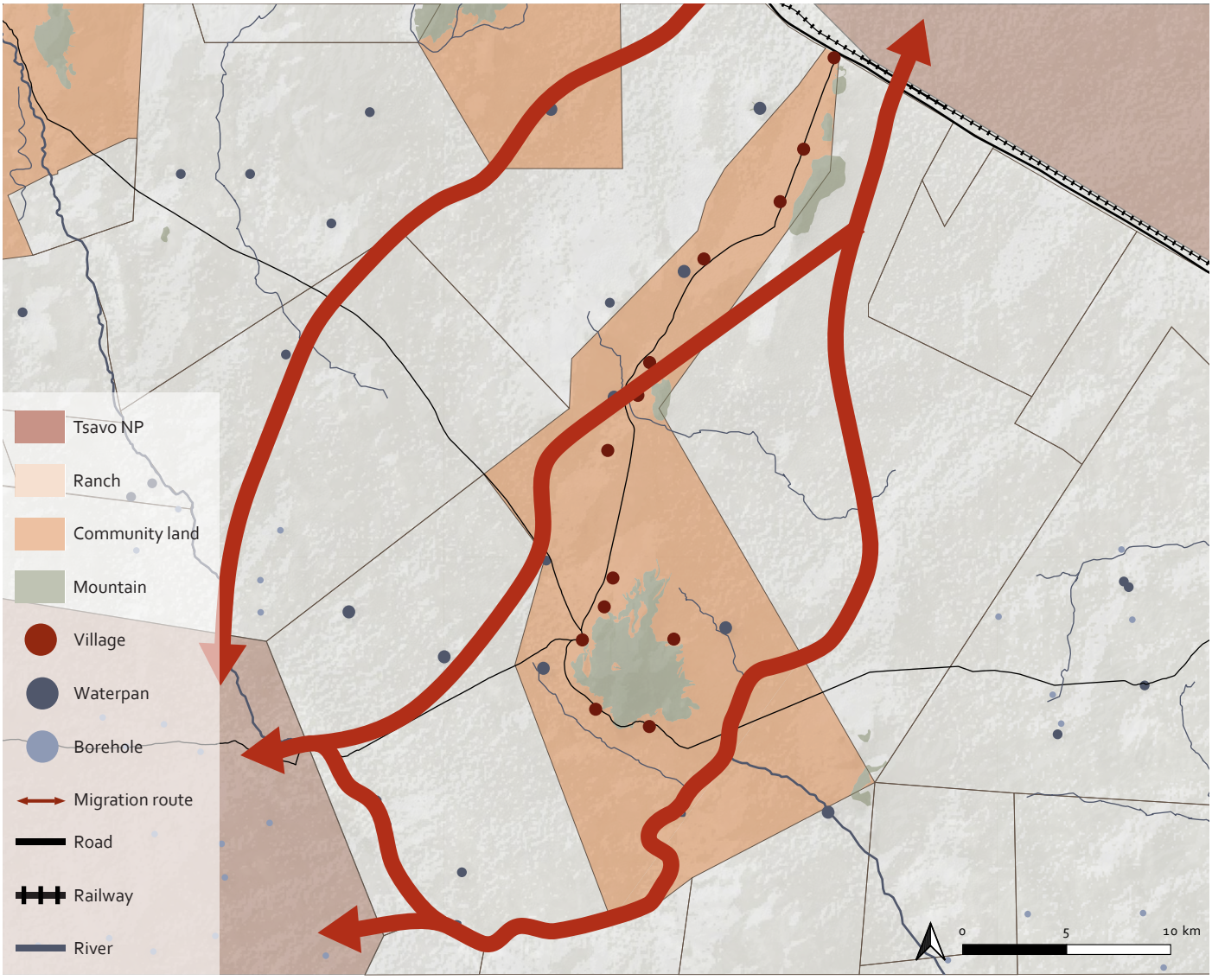


Figure 22: Historic migration routes, made by author

3.2.2 The inhabitants of the Kasigau region

Settlement in the Kasigau region

From the 1980s onward, the population in the Kasigau region increased due to migration, population growth and infrastructure development. Historically, most inhabitants belonged to the Taita community, concentrated in the cooler, wetter Taita Hills and around Kasigau Mountain. By the late 1980s, growing population pressure encouraged many Taita families to move into the hotter, drier lowlands, where they cleared dryland forests for subsistence farming, mainly maize cultivation.

At the same time, migration by the Duruma people from Kenya's Coast Province accelerated land conversion. In the early 1990s, a local politician encouraged Duruma settlement by promising land in exchange for political support. As newcomers moved into the area, forest clearing increased, contributing to widespread deforestation despite the unreliable rainfall.

Infrastructure further stimulated settlement growth. During the 1990s, poor road conditions along the Nairobi–Mombasa highway caused trucks to stop frequently between Voi and Mombasa. Roadside settlements such as Maungu expanded by providing services to the transport sector, while the unusually wet El Niño season of 1998 encouraged further migration and forest clearing by temporarily improving farming conditions.

Historically, the region remained sparsely populated due to limited water availability. Although the land was divided into ranches in the 1970s, many were initially used only lightly. Over time, ownership became fragmented as shares were sold to outsiders. Today, Taita and Duruma communities live intermixed and participate in agriculture, ranching and conservation activities (Wildlife Works, 2022).

Population growth

The population of the Kasigau region continues to grow, although more slowly than Kenya's overall population. This slower growth is partly linked to rural-to-urban migration, as many young adults leave areas such as Kasigau in search of higher education, employment and better living conditions. This contributes to a greater concentration of population growth in urban centres rather than remote rural areas (Kenya National Bureau of Statistics, 2019).

Year	Inhabitants	Density (people/km²)	Households
1999	246.671	14	57.635
2009	284.657	17	71.090
2019	340.671	20	96.429

Figure 23, Population trends of Taita Taveta, KNBS (1999;2009;2019)

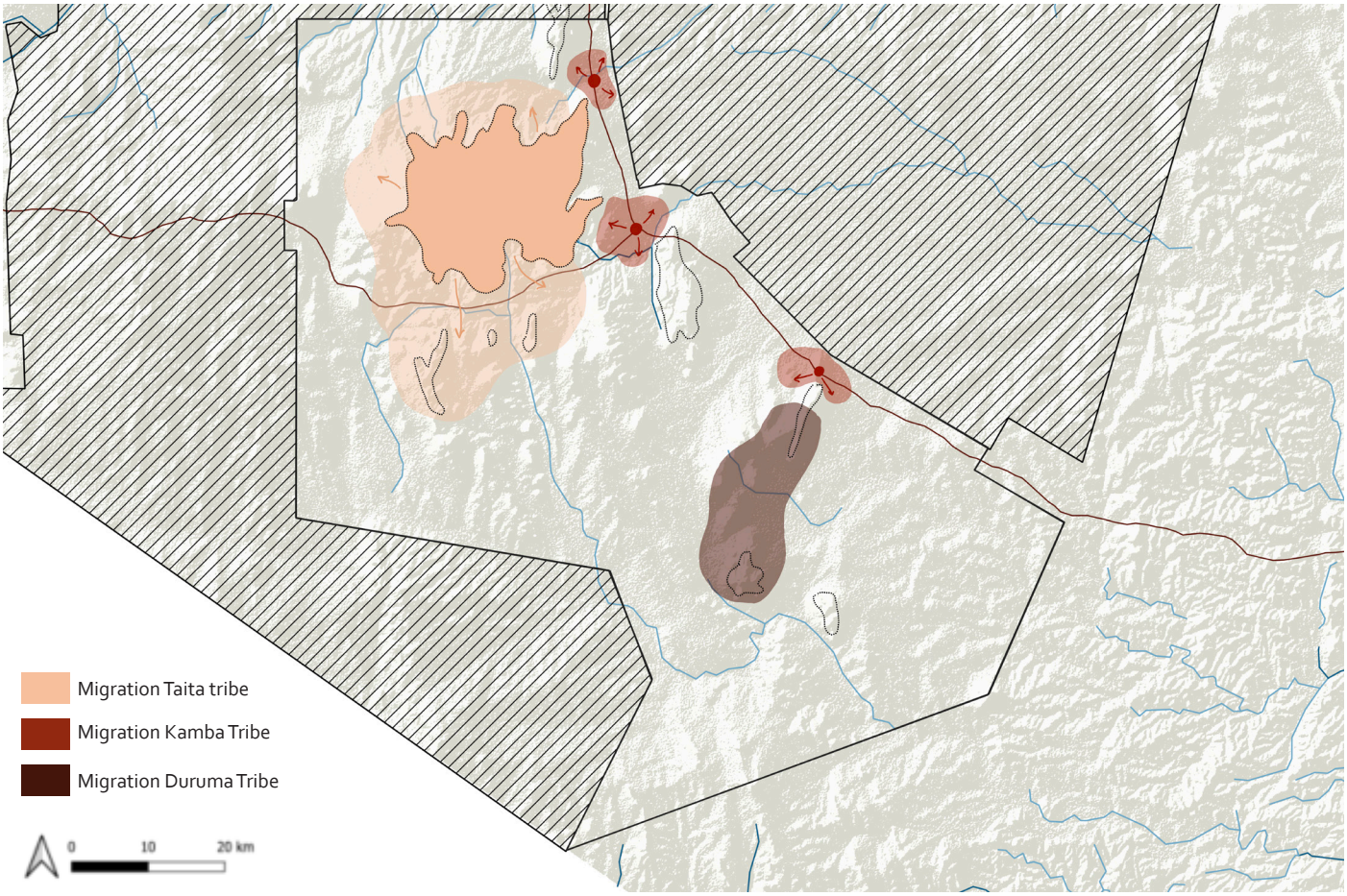


Figure 24: Settlement movement, made by author

3.2.3 Water availability











Figure 25: Collection of water sources, made by author

Water sources

In addition to natural water resources, such as rivers, springs and local streams, several systems are used in the Kasigau region to collect, store, and distribute water. These systems are particularly important in this semi-arid landscape, where rainfall is seasonal and water availability decreases during the dry season. They support different needs, including domestic use, agriculture, livestock grazing, and wildlife conservation. The systems differ in how they collect water, how long water can be stored, and how it can be accessed during periods of limited rainfall. Understanding these differences is important when exploring opportunities to improve water availability for both local communities and wildlife.

Mount Kasigau Community Water Project

This project makes use of the natural rock formations of Mount Kasigau to collect rainwater for local communities. Rainwater flows over the exposed rock surfaces of the mountain and is directed towards a collection point or reservoir. These rock surfaces function as a natural catchment, allowing rainfall to be collected before it infiltrates into the ground. The collected water is stored and distributed through a pipeline network to supply surrounding communities (African Wildlife Foundation, 2026).

Springs from Mount Kasigau

Ancient springs are located within the dense indigenous forest on Mount Kasigau. Local inhabitants call them the Lalambela springs (Kenya News Agency, 2023). The springs are fed by the horizontal precipitation that happens because of the mountain's cloud forest. Cloud forests are frequently enveloped in low-lying mist, allowing vegetation to capture tiny water droplets from passing fog. Mosses, ferns, and epiphytes on the forest canopy and branches intercept these droplets, which can subsequently drip onto the ground and infiltrate the soil. This process support groundwater recharge, which is the source of the springs.

Water is collected near the spring and transported downhill through a supply system, using collection chambers, pipes, storage tanks, and distribution points. Because the pipes go downhill, gravity support the water transport and reduce the need for pumping. The springs supply Bungule and Jora, and during drought, parts of Rukanga can also receive water from these sources (Ataroff & Rada, 2000).

Boreholes

Boreholes provide access to groundwater stored beneath the land surface. Rainfall infiltrates into the soil and underlying geological formations, where water accumulates within pores, cracks, and spaces in soil, sediment, or rock. These groundwater-bearing formations are known as aquifers. Before drilling, a hydrogeological survey is generally conducted to identify suitable locations and estimate the expected groundwater depth and yield. This is particularly important in Kasigau, where groundwater availability can vary considerably over short distances. Borehole depths depend on local geology, with some Kenyan projects drilling to approximately 230 m, although other boreholes are shallower (Ministry of Water, Sanitation and Irrigation, n.d.).

Once developed, groundwater can be pumped to the surface for domestic use, livestock, agriculture, or wildlife. Solar-powered pumps offer a potential solution in locations with limited access to electricity. However, the long-term effectiveness of a borehole depends on groundwater recharge and the maintenance of pumps and associated infrastructure. Sustainable groundwater management is therefore important in semi-arid landscapes, where recharge may be limited during prolonged droughts (African Wildlife Foundation, 2025; Sheldrick Wildlife Trust, n.d.).

Water pans

A water pan is a small, excavated reservoir designed to collect and store rainwater runoff for use during the dry season. It captures water flowing over the land surface rather than directly collecting groundwater. Catchments can include surrounding rangelands, sloping terrain, roads, and rocky surfaces. Water pans are generally constructed at low points where runoff naturally accumulates. Their effectiveness depends on the size of the catchment, rainfall, reservoir capacity, and the amount of water lost through evaporation and seepage (Mati, 2018). A typical water pan includes an inlet or diversion channel that directs runoff into the reservoir. Roads can also function as part of the catchment by concentrating rainwater through their drainage systems (County Government of Taita Taveta, 2023).

Sand dams

Unlike conventional dams, which store water in an open reservoir, sand dams store water beneath the surface of the sand. A low concrete or masonry wall is built across a seasonal river to slow down the flow of water. During the rainy season, sand and other sediments are carried downstream and gradually accumulate behind the wall. Water then fills the spaces between the sand grains, creating an underground reservoir. To ensure the structure remains stable during heavy rainfall, spillways and bank protection are needed to safely direct excess water and prevent erosion (Mati, 2018).

During the dry season, water can be accessed through a shallow well, a protected collection point, or a pump. Because the water is stored beneath the surface, it is less exposed to direct evaporation than water in an open pan. However, the amount retained depends on the volume and composition of the sand, the characteristics of the

riverbed, and the movement of groundwater into the surrounding landscape (Hut et al., 2008).

Sand dams are not specifically located in the Kasigau region, but are placed along Mwatate river, which flows from the Taita hills into the Kasigau corridor.

Water usage calculation

To gain a better understanding of water demand in relation to water availability, a rough calculation was made for the Taita Teveta county.

The Tsavo ecosystem is home to approximately 13.000 elephants, of which an estimated 3.000 reside permanently in the area between Tsavo East and Tsavo West National Parks. The remaining elephants move seasonally between the two parks. It is estimated that these elephants spend approximately ten days per visit in the area, crossing it twice a year. This means they use the region's water resources for around 20 days annually. With an estimated daily water intake of 220 litres per elephant, this contributes to the overall water demand (Pontzer et al., 2020).

In addition to wildlife, the Taita Taveta's inhabitants and livestock also require substantial amounts of water. Assuming that inhabitants use 20 litres per person per day (Njoroge et al., 2024) and that approximately 170.000 livestock (Creemers et al., 2021) each require 35 litres per day (Food and Agriculture Organization of the United Nations, 1991), the combined annual water demand of inhabitants, livestock, and elephants is estimated at approximately 5,2 billion litres.

For comparison, annual precipitation in the area is estimated at approximately 6,29 billion litres. However, this figure does not represent the amount of water available for human and animal consumption. A substantial proportion is used by vegetation and crops, lost through evaporation and infiltration, or required by other wildlife. Industrial water use may also contribute to demand but is not included in this calculation.

The known water pans in the area have a combined storage capacity of approximately 1,9 billion litres. Assuming that all water pans are full and that 40% of the stored water is lost through evaporation, around 1,14 billion litres would remain available. This is equivalent to approximately 22% of the estimated annual water demand of inhabitants, livestock, and elephants. However, the actual contribution of water pans is likely to be lower. Rainfall is irregular and reportedly declining, meaning that water pans may not fill completely. Furthermore, some water pans are no longer fully functional due to sediment accumulation. Maintaining and desilting these water pans can also be expensive (Ministry of Water Resources Management and Development, 2003).

This calculation provides a rough indication of the water demand versus the water availability in the Kasigau region. It is not a complete calculation, as some water pans may not be documented and other sources have not been included. These include seasonal rivers, surface runoff collection, water collected from Mount Kasigau, and domestic rainwater harvesting from rooftops. This is why the calculation should be interpreted as an initial estimate rather than a complete assessment of the region's water resources.

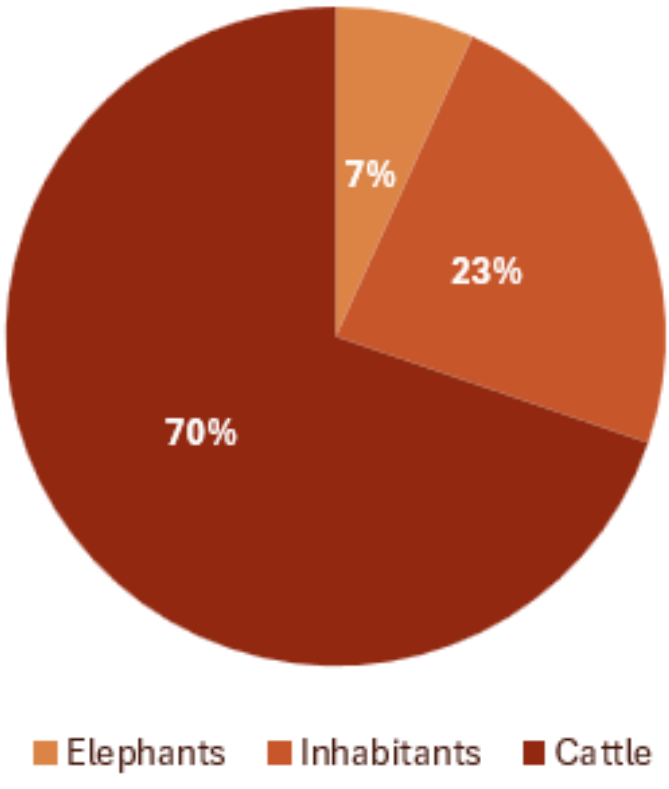


Figure 26: Water usage division, made by author

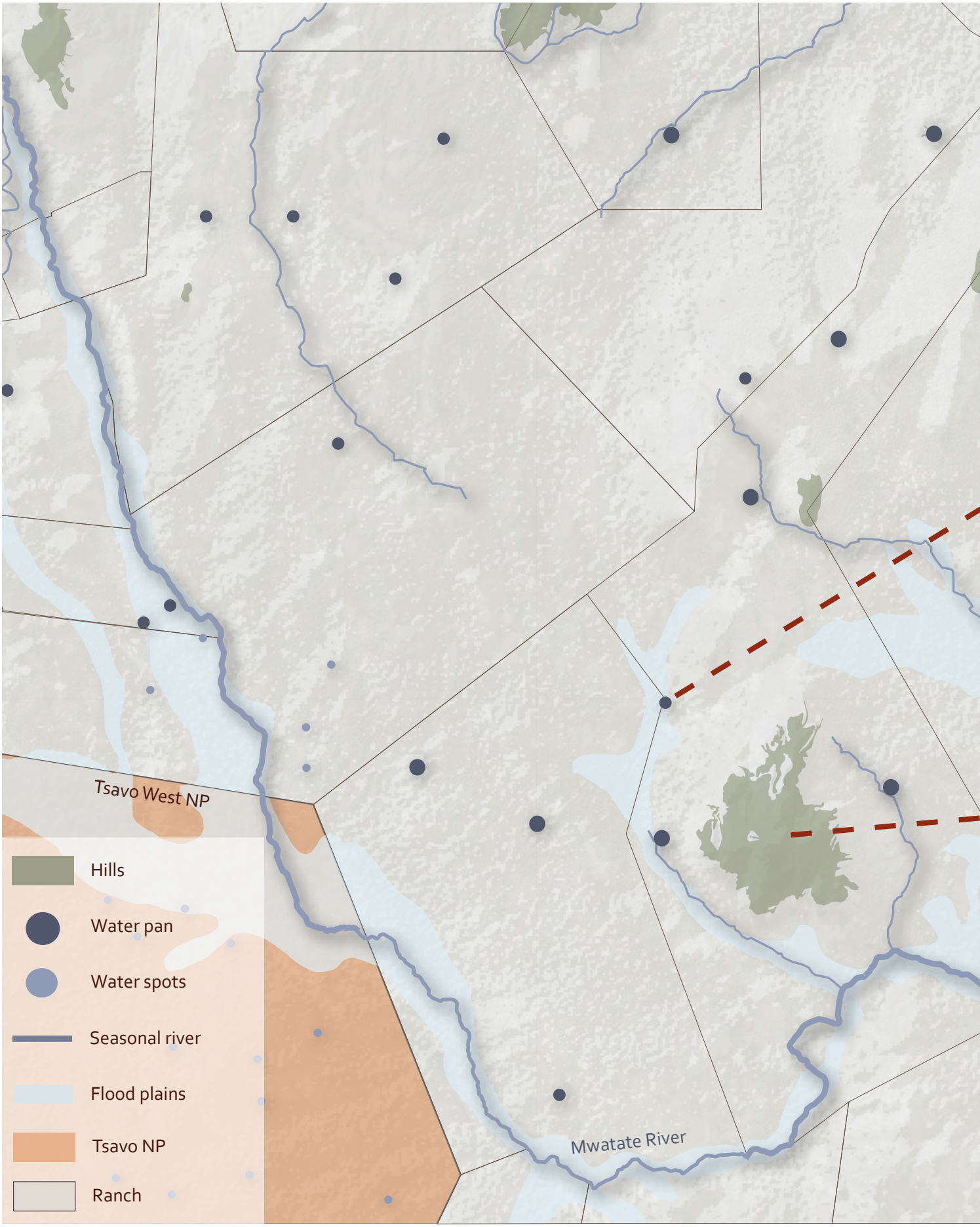
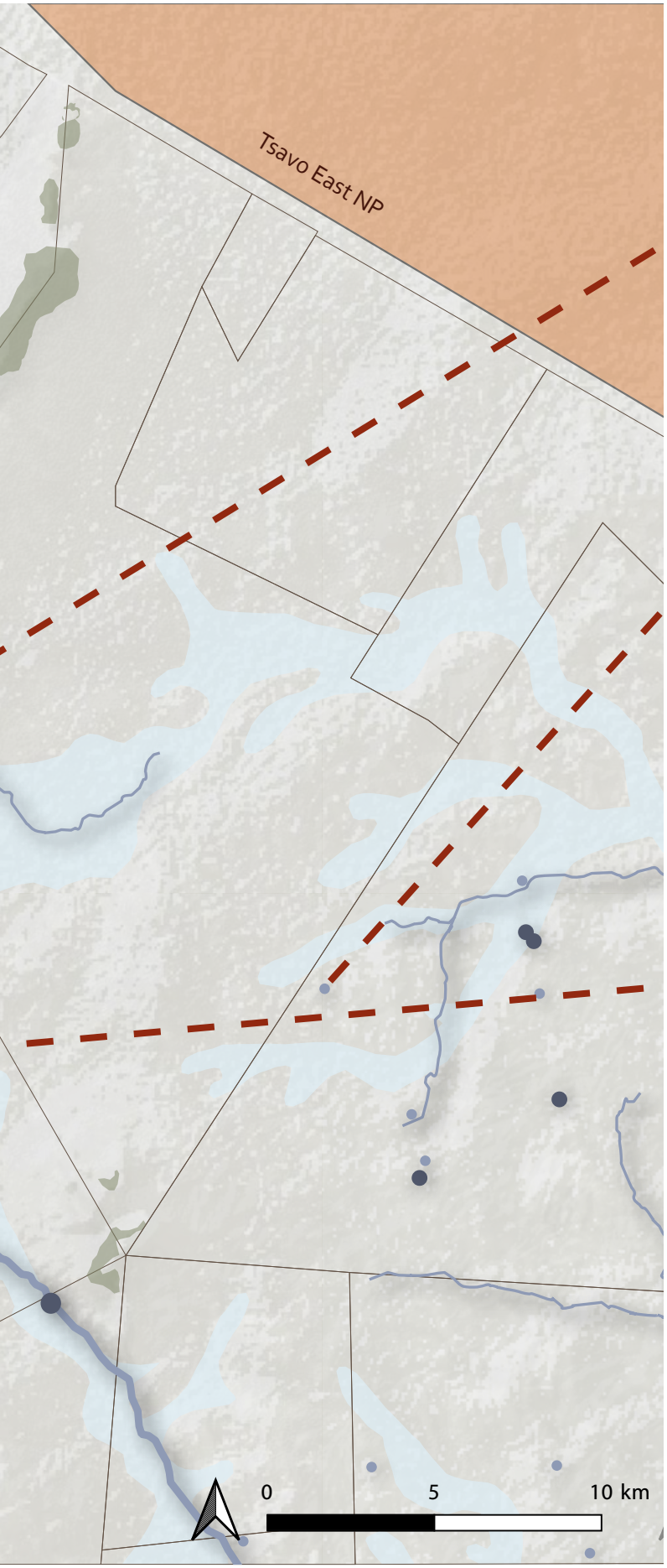


Figure 27: Water sources of the Kasigau region, made by author



Water pan



Borehole



Moist cloud forest



Tap point



3.3 Species

The species level focuses on the needs and behaviour of individual species, with particular attention to African elephants and the people living in the Kasigau region. By examining their requirements for food, water, shelter, safety, and movement, it becomes possible to understand how their needs interact and where conflicts arise. This knowledge helps identify targeted interventions that support coexistence between elephants and local communities.

3.3.1 Elephant needs

Elephant characteristics
Name: African Savanna Elephant
Latin name: Loxodonta africana
Appearance: Very large, fan-shaped ears; longer front legs; outward-curving tusks
Size: height: 3–4 meters at the shoulder; lenght: 6–7.5 meters;ears can be up to 2 meters wide
Weight: Males: 5,000–7,000 kg, females: 2,700–4,000 kg
Age: 60–70 years in the wild
Herd: Matriarchal herds of ~10 females/calves; can form clans of up to several hundred.
World population: About 415,000 in the wild, 37 countries Africa (WWF, 2002)

Food
African elephants are herbivores that feed on a wide variety of vegetation, including grasses, leaves, bark, roots, fruits, and shrubs. An adult elephant can consume between 100 and 150 kilograms of vegetation each day, requiring access to large and productive habitats with diverse plant species. Because of their enormous food requirements, elephants continuously move through the landscape in search of fresh vegetation, especially during dry seasons when food becomes scarce.

Water
Water is one of the most important resources for elephants. An adult elephant can drink up to 20 liters of water per day and also uses water for bathing, cooling, and protecting its skin from insects and heat. Elephants depend heavily on rivers, wetlands, springs, and waterholes, particularly during the dry season when permanent water sources become limited. In semi-arid ecosystems such as Tsavo, water availability strongly influences elephant movements and habitat use.

Safety
Adult elephants have few natural predators, and their greatest threats are poaching, habitat loss, and increasingly climate change. Calves are protected by the herd, especially by adult females that cooperate in guarding and caring for young animals. Elephants benefit from large, open landscapes where they can detect danger from a distance, while mixed savannahs with trees and shrubs provide shade, shelter, and additional food sources such as leaves, bark, and fruit.

Reproduction and shelter
Female elephants usually give birth to a single calf after a pregnancy lasting about 22 months. Calves depend on long-term care from their mothers and the herd for protection, feeding, and social learning. Safe habitats with limited human disturbance are therefore essential for successful reproduction. Open savannahs combined with wetlands and riverine areas are especially important during dry periods, while trees and shrubs provide shade and shelter that protect calves from heat and wind.

Connection
Elephants require connected habitats to migrate seasonally between feeding and watering areas. Wildlife corridors allow elephants to move between ecosystems during wet and dry seasons and are essential for maintaining genetic diversity within populations. Human infrastructure such as roads, fences, settlements, and farms can block traditional migration routes and increase conflict between humans and elephants. Maintaining habitat connectivity is therefore one of the most important aspects of elephant conservation.

Habitat
African elephants occupy a wide range of habitats, including tropical and subtropical forests, flooded grasslands, savannahs, miombo woodlands, and Acacia-dominated bushlands. In East Africa, elephants are particularly associated with savannah ecosystems where open grasslands, shrubs, and scattered trees provide both food and shelter. Their habitat requirements vary seasonally depending on water availability and vegetation growth.

Daily habits
Elephants spend most of their day feeding and can eat for 14–18 hours daily, mainly during the cooler morning, afternoon, and evening hours. They travel several kilometers each day in search of food and water and often follow the same migration routes over long periods of time. During the hottest part of the day, elephants usually rest in shaded areas and may bathe or cover themselves with mud to cool down and protect their skin.

Elephants are highly social animals that live in close family groups and communicate through touch, body language, and low-frequency sounds. They may also remain active at night, particularly in hot conditions or in areas with human disturbance.

Importance in the ecosystem
African elephants are often described as "ecosystem engineers" because they strongly influence the environments in which they live. By pushing over trees,

opening vegetation, and creating clearings, elephants shape the structure of savannahs and forests and create habitats for many other species. They also play an important role in seed dispersal, as seeds consumed in fruits are transported and deposited elsewhere through dung. Elephant dung additionally provides nutrients for plants and food for insects and other organisms.

During droughts, elephants may dig for underground water, creating water access for other wildlife species. Their footprints can also collect rainwater, forming small temporary pools used by amphibians and insects. Because elephants require very large and connected habitats, protecting elephant landscapes also indirectly protects many other plant and animal species within the same ecosystem, a concept often referred to as the "umbrella effect" (Wildlife works, n.d.).

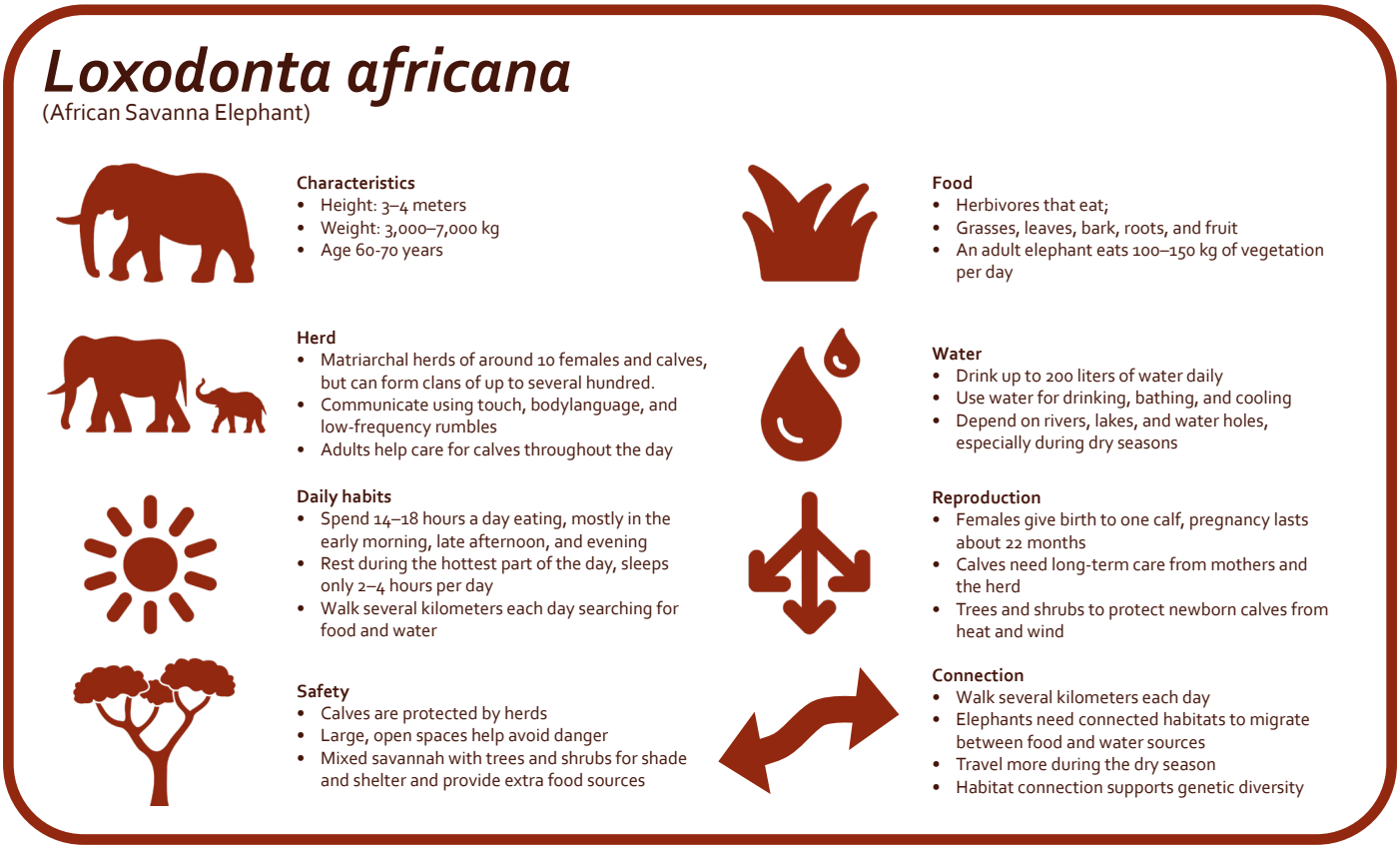


Figure 28: Elephant factsheet, made by author





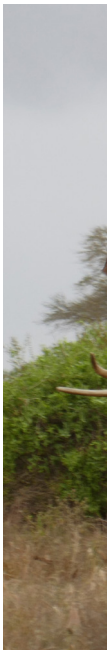



Figure 29: Collection of elephant encounters during fieldwork, images made by Jelmer Veenstra, Ann Lo and author













3.3.2 Inhabitants of Kasigau

The inhabitants of the Kasigau region in Taita-Taveta County, southeastern Kenya, depend on a combination of small-scale agriculture, livestock keeping, wage labour, and small businesses. The importance of each activity varies between households and is influenced by rainfall, access to land and water, and proximity to roads, markets, and employment opportunities (National Drought Management Authority, 2025).

Small-scale agriculture provides both food for household consumption and income from selling surplus produce. Farmers mainly grow crops such as maize, green grams, beans, cowpeas, and sorghum, which are cultivated largely for domestic consumption in the region's drier areas. Production is closely linked to seasonal rainfall, making farming vulnerable to drought and unreliable rainfall patterns (Motaroki et al., 2021).

Livestock keeping is another important livelihood, providing food, income, and financial security. Cattle, goats, and sheep can graze on natural grasslands and shrub vegetation, making livestock particularly valuable in areas where conditions limit crop farming. Households generate income by selling animals, meat, milk, and other livestock products. Animals also serve as a form of savings that can be sold when money is needed or harvests fail. Ranches contribute to the local economy through activities such as breeding and fattening livestock, selling beef and milk, and providing grazing opportunities for livestock owners (Kasigau Ranching, n.d.).

Many households supplement their agricultural income through temporary work, local shops, petty trading, construction, and other paid activities. Casual labour on ranches, farms, plantations, and mining sites is also an important source of income in Taita-Taveta County (National Drought Management Authority, 2025). Overall, livelihoods in Kasigau depend on a combination of activities, helping households meet their daily needs while coping with the challenges of an unpredictable climate.



Figure 30: collage of the current crops, made by author









Figure 31: Pictures life in research area, made by author

4

Defining the problems

4.1 Mapping human-elephant conflict
4.2 Water scarcity
4.3 Stakeholders

4.1 Mapping human-elephant conflict

Human–elephant conflict (HEC) occurs when elephants and people compete for space and resources, resulting in negative interactions. These include crop raiding, damage to property and water infrastructure, and threats to human safety. In turn, elephants may be injured or killed in retaliation. Conflict often increases when habitat loss, drought, and human activities bring elephants and communities into closer contact.

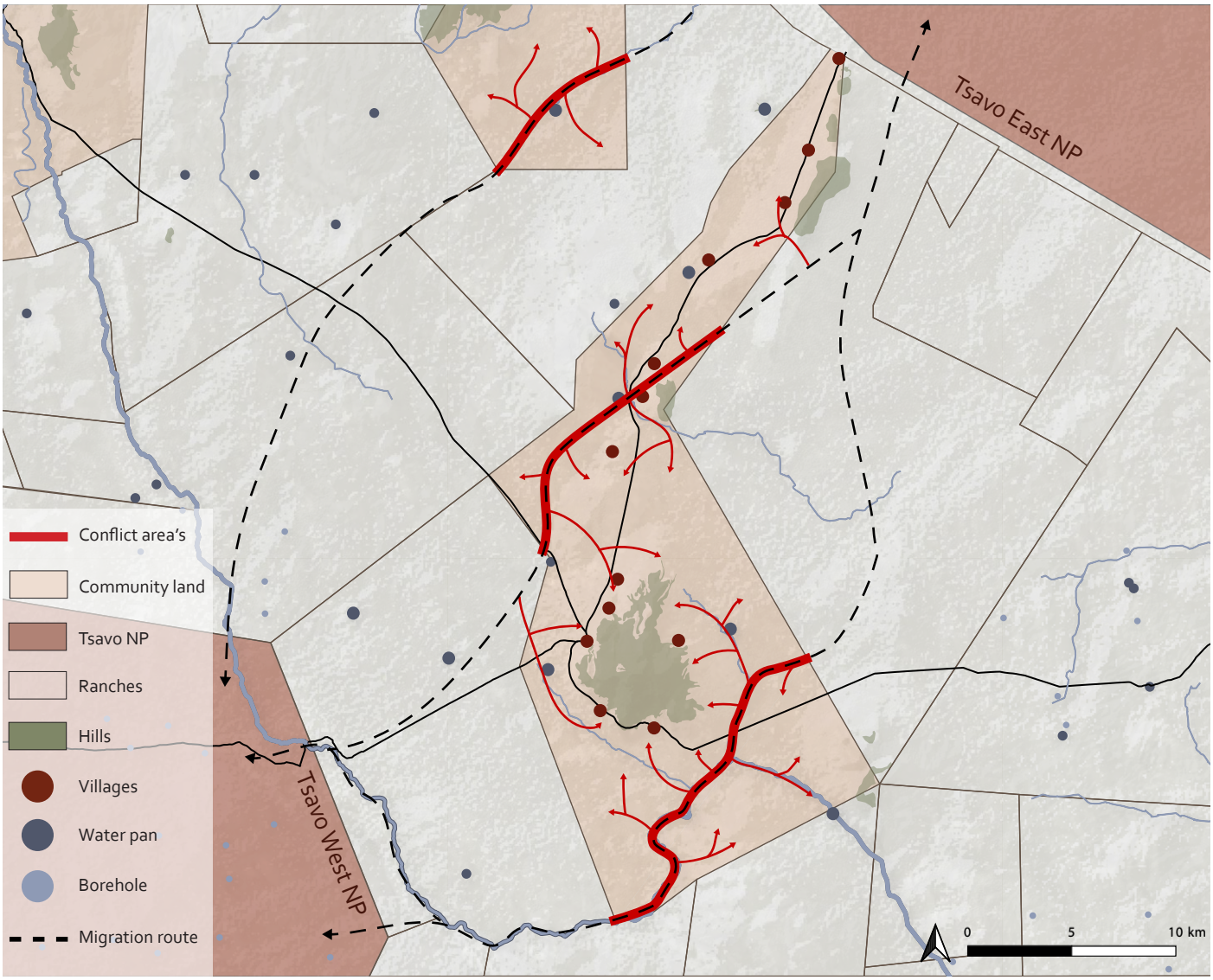
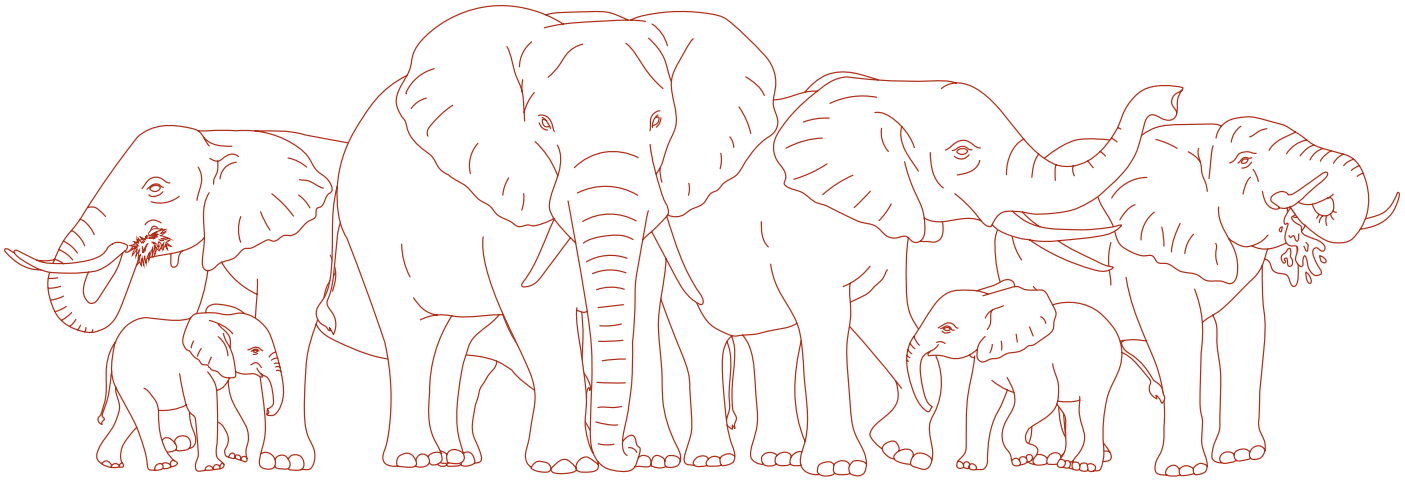


Figure 35: HEC map, made by author

"Poachers kill one of Africa's last remaining 'big tusker' elephants"
- The Guardian 2017

"Ancient elephant migration routes are being blocked off – can anything stop the rising death toll?"
- The Guardian 2025

"Elephant Poachers Kill Wildlife Works Conservation Ranger and Critically Injure Another"
- Wildlifeworks 2012



"The elephants are the enemy!"

"The elephants get mad when they encounter a fence, so they attack the first person they see."

"I sleep in the field every night to guard the crops from elephants, it is very scary"

"Almost every year I lose my crops to the elephants"

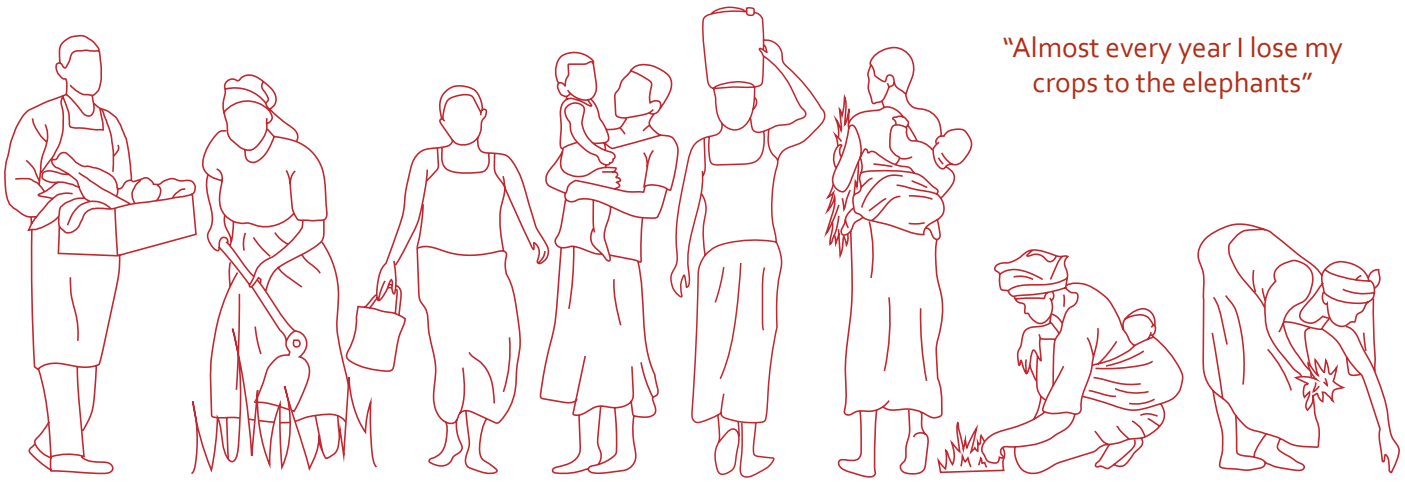


Figure 36: HEC from elephant and local inhabitant perspectives, made by author

4.1.1 Causes

Several interconnected threats contribute to the increase in HEC in the Kasigau region.

Habitat loss

Habitat loss can occur in several ways, reducing or degrading the natural areas elephants rely on for food, water, shelter, and movement. This can force them to move beyond protected areas into human-dominated landscapes, increasing competition for resources and the likelihood of human–elephant conflict. The main causes of habitat loss in the Kasigau region are:

- Livestock increase and overgrazing: elephants require extensive landscapes and sufficient food resources to survive. Increasing livestock numbers, including illegal grazing within wildlife areas, can reduce the grass available to both livestock and wildlife. Overgrazing also degrades the soil and increases erosion, making vegetation recovery more difficult. When grass becomes scarce, elephants may browse more on trees and shrubs or move beyond protected areas to find food, increasing their chances of encountering people. Livestock activity around water points may also influence wildlife use of these locations.
- Farmland: as the human population grows, agricultural land increasingly occupies areas used by elephants. When farms overlap with elephant movement routes or feeding grounds, crops become an attractive food source. Elephants can destroy a farmer's harvest in a single night, threatening food security and income.
- Deforestation: forests and woodland are cleared to create space for settlements and farmland, as well as to produce charcoal, often through illegal activities. Charcoal production can place considerable pressure on trees: approximately ten tonnes of wood is needed to produce one tonne of charcoal (Wildlife Works, 2021).

Habitat fragmentation and urbanisation

Growing populations require more infrastructure, including roads, railways, pipelines, fences, and settlements. These developments can form barriers to wildlife movement, fragmenting habitats into smaller areas. Without corridors connecting these areas, elephant herds have difficulty reaching food and water, especially during the migrating seasons. They also become separated from other elephant groups, reducing breeding opportunities and affecting the genetic diversity of the population.

Human settlements built on or near elephant corridors can force elephants to find alternative routes across rangelands. Farms and urban settlements that disrupt their natural movement also provide a rich source of food, attracting elephants into human-dominated areas. When elephants' usual routes are blocked or disturbed, they have to change their movement patterns and enter unfamiliar areas or approach other settlements. These encounters can increase stress and the likelihood of human–elephant conflict, particularly when elephants come into contact with people while searching for alternative routes or resources.

Poaching

Ivory poaching is driven by demand for ivory, with its high market value creating financial motivation for poachers despite international trade restrictions. Elephants with the largest tusks, often older bulls, are frequently targeted. Their removal can disrupt elephant social structures, as older bulls and experienced females play important roles in guiding and regulating the behaviour of other elephants. The older bull elephants help regulate the behaviour of younger bulls, including during musth. Removing older bulls can disrupt this social control, potentially leading to more unpredictable and aggressive behaviour among younger males, which can increase risks when they enter farms or settlements. Older female elephants provide valuable knowledge about safe routes, water sources, and how to navigate areas near human settlements. When experienced females are killed, their families may lose this knowledge, potentially increasing the likelihood of encounters with people.

Direct contact between inhabitants and elephants

Frequent encounters can increase the risk of conflict, particularly when elephants enter settlements, approach people, raid crops, or damage water infrastructure. Previous negative experiences with humans, including harassment or injury, influence how elephants respond to future encounters. Elephants will react defensively when they perceive people as a threat, especially when calves are present or escape routes are blocked.

Experiencing the death of a family member caused by human activities can also increase aggressiveness in elephants. Conflict therefore develops through a combination of human activities, environmental pressures, and individual elephant experiences.

Drought

Drought intensifies competition for food and water. When rainfall decreases, water pans, rivers, and other water sources may dry up, while vegetation becomes less abundant. Elephants must travel farther to find sufficient water and food, increasing the likelihood that they enter agricultural land or settlements.

During severe droughts, elephant family groups may change their movement patterns or temporarily separate as they respond to scarce resources. This can increase the number of elephants moving through areas close

to people. At the same time, communities may depend more heavily on the same remaining water sources, increasing competition between wildlife, livestock, and residents

Risk of intensifying HEC over time

HEC can become self-reinforcing. As habitat is lost and traditional movement routes are disrupted, elephants increasingly use farms and settlements to access food and water. If they repeatedly obtain food from crops or water from human infrastructure, these locations become familiar resources. At the same time, people respond by chasing, injuring or killing elephants. Elephants can recognise different human threats through scents and sounds, and older elephants can pass this knowledge on to younger generations. As a result, they may remember people associated with negative encounters and respond more defensively or aggressively towards them in the future, increasing the risk of further conflict (King et al., 2023).

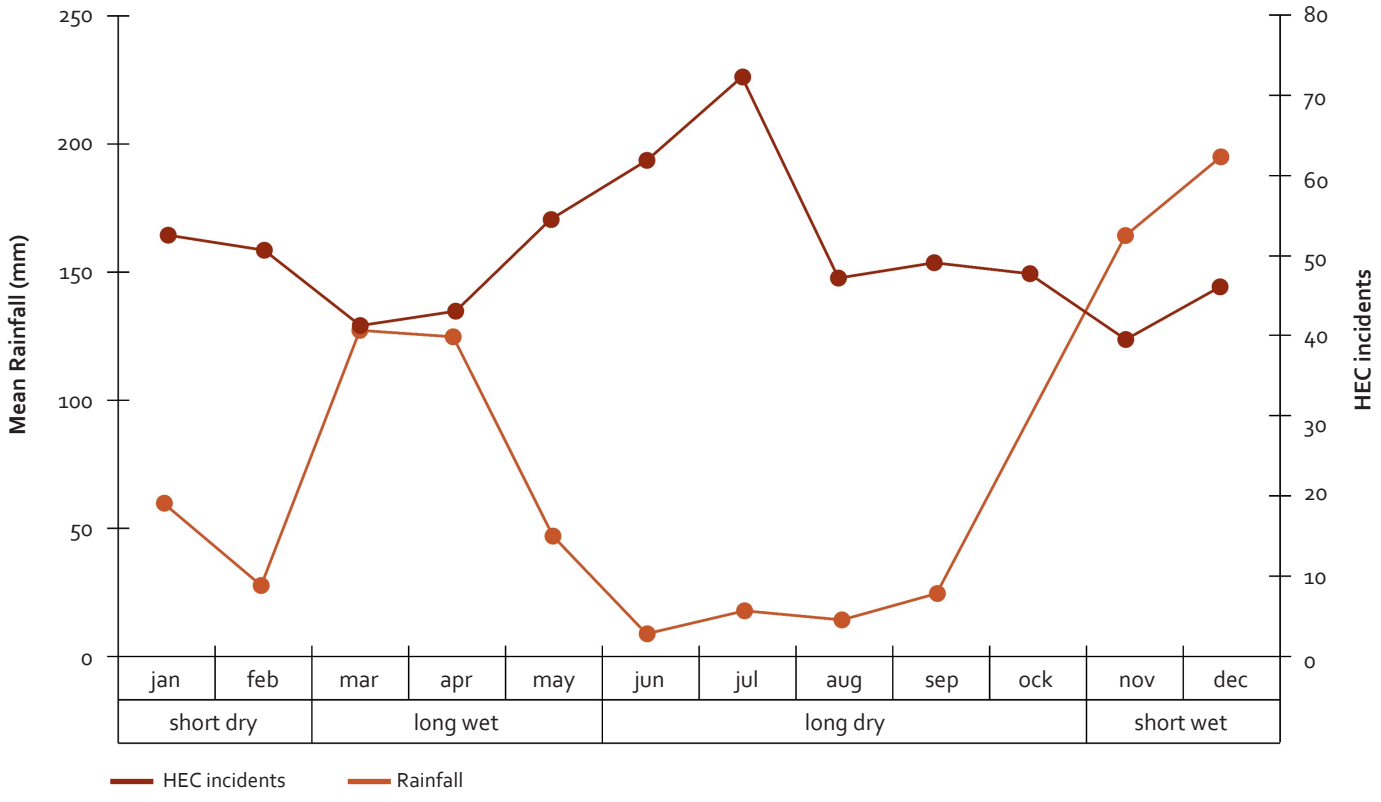


Figure 37: HEC incidents in relation to rainfall, made by author with information from Munyaoet al. (2020)

4.1.2 Forms of HEC

Munyao et al. (2020) distinguish eight forms of human–elephant conflict in Taita Taveta County, Kenya:

1. Elephant threat: Elephants enter or approach human settlements, creating fear and concerns for people's safety, even without causing physical harm.
2. Crop raiding: Elephants eat, trample or damage crops, threatening farmers' food security and income. Once elephants discover accessible crops, they may return to raid the fields again.
3. Property damage: Elephants damage human-made structures and infrastructure, such as houses, fences, water pipes and storage facilities.
4. Human injury: People are physically injured during encounters with elephants
5. Human death: A person dies as a result of an encounter with an elephant, with serious consequences for families and communities.
6. Elephant death: An elephant is killed in connection with human–elephant conflict, for example through retaliation or wildlife management actions.
7. Livestock death: Domestic animals, such as cattle, goats, donkeys or camels, die during incidents involving elephants, resulting in losses for livestock owners.
8. Elephant injury: Elephants sustain physical injuries during conflicts involving people, potentially affecting their movement, feeding and survival.

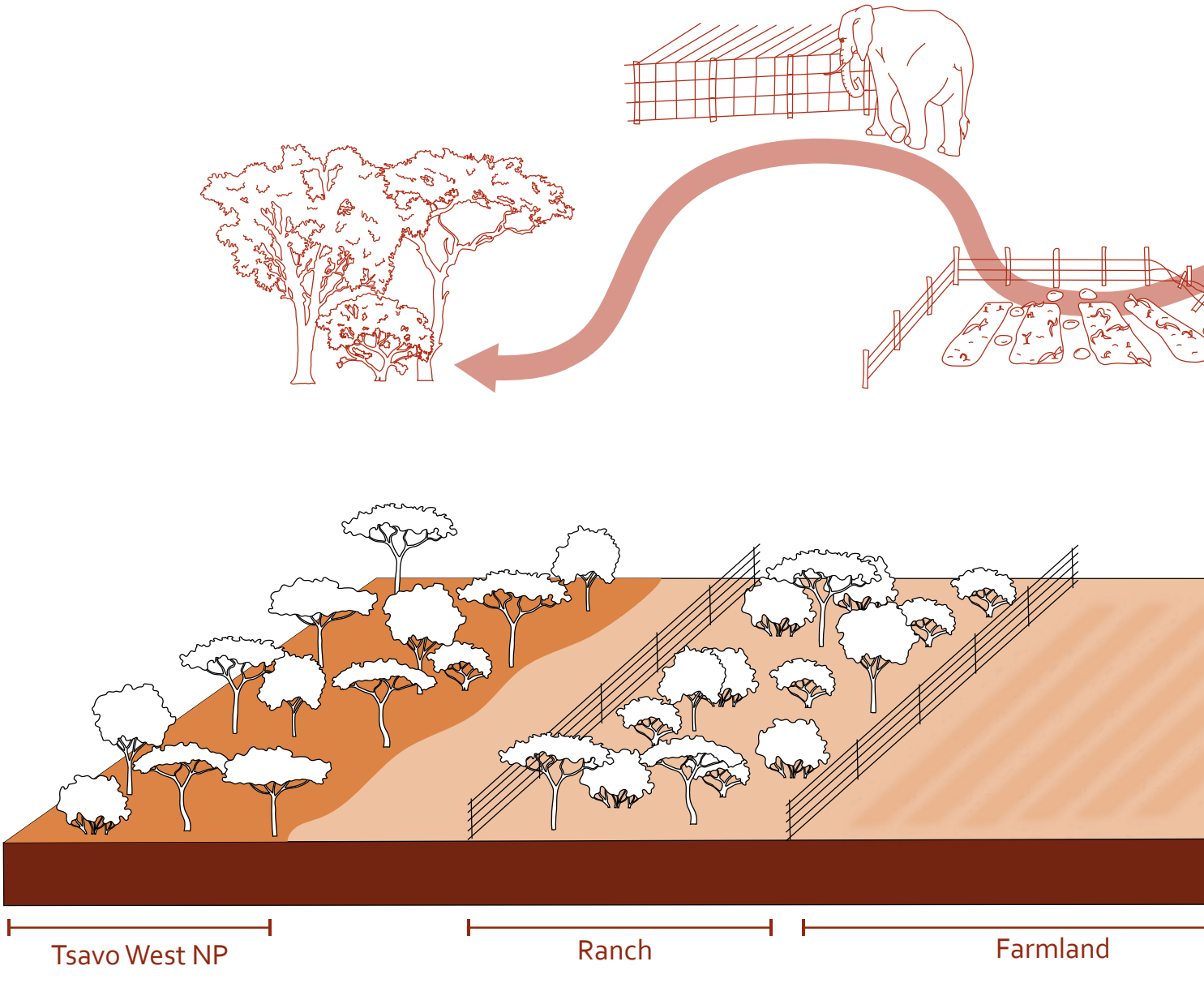
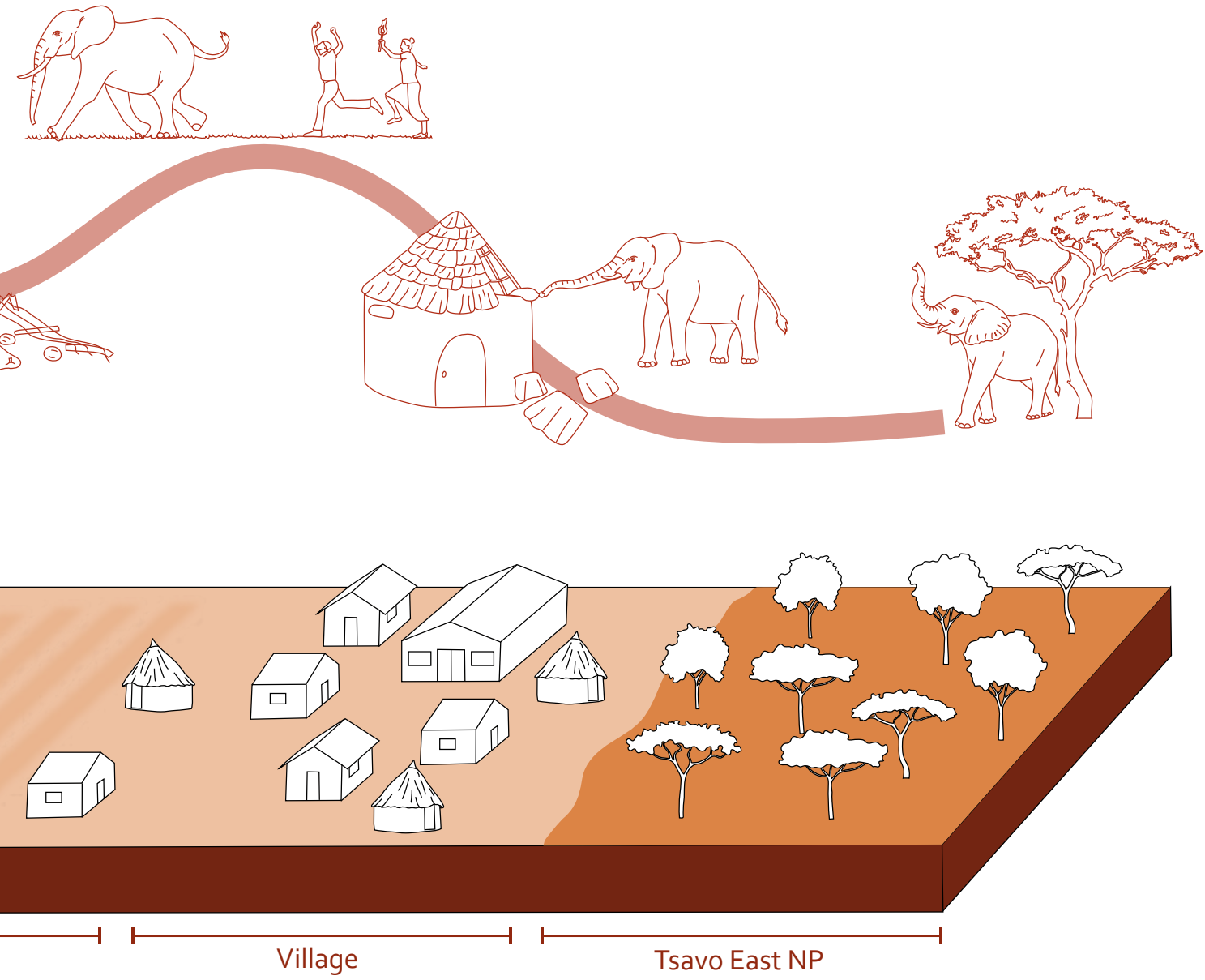


Figure 38: Types of HEC that occurs when elephants cross the Kasigau region, made by author

The study indicates that HEC is primarily characterised by elephants entering human-used spaces and damaging agricultural resources, rather than by direct physical harm to people or elephants. Nevertheless, the less frequent incidents involving human deaths, injuries and elephant deaths have serious consequences for both community safety and conservation. These conflicts occur where people and elephants share the landscape, highlighting the importance of maintaining elephant movement corridors while reducing encounters around farms and settlements.



4.2 Water scarcity

Water scarcity in the Kasigau region is caused by a combination of irregular rainfall, climate change, land degradation, population growth, and limitations in existing water infrastructure. Rainfall is becoming less predictable, while higher temperatures can increase evaporation and water demand. At the same time, human activities and growing pressure on natural resources make it more difficult to retain and distribute the available water.

Soil degradation and land-use changes
Human activities, including deforestation, overgrazing, and illegal livestock grazing within protected areas, can contribute to soil degradation. When livestock compact the soil or vegetation cover is removed, rainwater infiltrates less effectively and more water flows away as surface runoff. Exposed soil also loses moisture more rapidly through evaporation. These processes reduce the amount of water retained in the landscape and limit the availability of water for vegetation and agriculture. Although soil degradation does not directly cause a lack of rainfall, it intensifies the effects of dry periods and increases the region's vulnerability to agricultural and ecological drought (Mganga, 2022).

Failing of existing water infrastructure
Existing water structures, especially water pans, do not always provide a reliable supply throughout the dry season. Several processes contribute to this problem:

- Evaporation: High temperatures and prolonged dry periods increase water loss from exposed surfaces.
- Reduced rainfall: Water pans receive less water when rainfall decreases or becomes more irregular.
- Infiltration: Water can seep into the underlying soil, depending on its permeability and the condition of the reservoir.
- Increasing demand: Population growth, livestock needs, and wildlife dependence can place additional pressure on existing water sources.
- Sedimentation: Soil and other materials accumulate in water pans over time, reducing their storage capacity. Removing this sediment can be expensive, meaning that some water pans may become unusable when maintenance is not carried out.

The final stages of water storage are particularly critical. As the water level decreases, a larger proportion of the remaining water can be lost through evaporation, while water quality may deteriorate as sediments and pollutants become more concentrated. Consequently, water pans may become less effective precisely when water demand is highest (National Drought Management Authority, 2025).

Damage to water infrastructure by elephants
Water infrastructure can also be damaged by elephants. While searching for water, elephants destroy water tanks, pipes, and other installations to reach the water. Such damage can interrupt water supplies. Repairing the damage is often too expensive, which leaves the affected people without water resources.

Financial limitations
The construction, maintenance, and restoration of water infrastructure require financial resources. Boreholes, pumps, pipelines, storage tanks, and water pans can involve substantial initial investments, as well as ongoing maintenance costs. For households with limited and irregular incomes, these expenses can make reliable access to water difficult to achieve. Even where suitable solutions exist, their implementation may be limited by the availability of funding and the costs of operation and repair.

Climate change
Climate change can intensify water scarcity through rising temperatures, changing rainfall patterns, and longer or more severe droughts. When rainfall becomes less reliable and temperatures increase, both natural water sources and artificial storage systems face greater pressure.

4.2.1 Effects on elephants

During prolonged droughts, rivers, water pans, and other water sources may dry up, forcing elephants to travel further to find water. These longer journeys require additional energy and can increase exposure to human settlements and agricultural land. At the same time, vegetation becomes less available, reducing access to food and increasing the risk of malnutrition and dehydration. In severe cases, these conditions can lead to wildlife deaths.

The East African drought of 2022 illustrates the severity of these impacts. More than 200 elephants died from drought-related causes across Kenya, including over 100 in the Tsavo ecosystem. The deaths were primarily associated with dehydration and malnutrition as water sources and vegetation became increasingly scarce (Tsavo Trust, 2022).

4.2.2 Effects on local inhabitants

For local communities, water scarcity affects domestic activities, livestock keeping, and agricultural production. When nearby water sources dry up or become unreliable, residents may have to travel longer distances to collect water. Carrying heavy containers over long distances is physically demanding, particularly in high temperatures. To avoid overheating, some residents collect water during the cooler hours of darkness. However, this increases the risk of unexpected encounters with elephants and exposes them to other dangers associated with travelling at night. Limited access to safe water can also create health risks.

Agriculture and livestock production are particularly vulnerable to prolonged dry periods. Insufficient water reduces crop growth and harvests, while livestock may suffer from dehydration and a lack of pasture. These effects can reduce household income and food availability, increasing the risk of food insecurity. As water becomes more limited, competition between domestic use, agriculture, livestock, and wildlife can also intensify.



Figure 39: Elephants digging for water in a riverbed, from Buffalo (n.d.)



Figure 40: Watertank destroyed by elephants, from Bidan (2021)









Figure 41: Collection of the drought problems, made by author


NDOVU TANK







4.3 Stakeholders

Human–elephant conflict in the Kasigau region is not caused by a single factor, but by the interaction between land use, wildlife movement, water availability, and human livelihoods.

The stakeholders operate at different geographical scales, and their roles are closely connected. National institutions establish the policies and legal frameworks governing wildlife, land and conservation, while county and ward administrations influence local planning and community engagement. At the wider Tsavo landscape scale, conservation organisations, researchers and conservancy networks can contribute ecological knowledge, coordinate habitat protection and support wildlife management. Within Kasigau itself, farmers, households, ranch owners and community-based organisations have a more direct relationship with the land and its resources. Their decisions about farming, grazing, fencing and water use can influence whether elephants can move safely through the landscape.

The distinction between stakeholders who contribute to the problem and those who contribute to solutions is not always clear-cut. Some activities, such as illegal grazing, poaching and unsustainable charcoal production, can directly threaten habitat quality and wildlife. Other pressures, such as fencing, intensive livestock grazing and the expansion of farmland, may result from legitimate livelihood needs but can nevertheless restrict elephant movement. These pressures should therefore be understood in their local context rather than treating all land users as having the same responsibility. In particular, ranch owners and conservancy managers can be both part of the challenge, where land management obstructs movement, and important partners in creating connected habitat.

Funding organisations and conservation partners can help turn the corridor concept into a practical intervention. Potential funders may support relevant activities such as habitat restoration, community

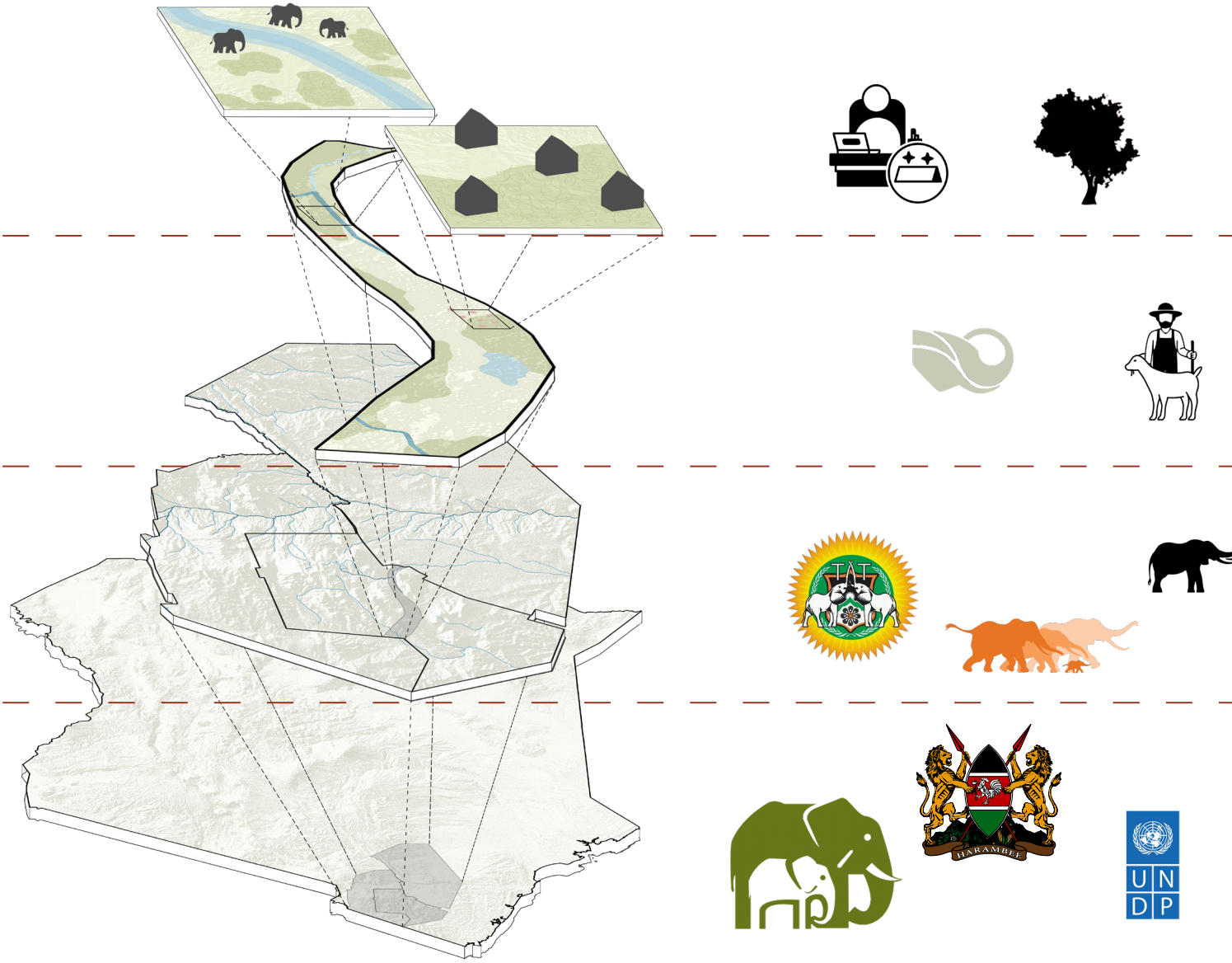


Figure 42: Stakeholder mapping, made by author

livelihoods, water provision or tourism development. Conservation organisations can contribute existing experience, research, local networks and conservation capacity. Their involvement is particularly important because the project would need to build on existing initiatives in Kasigau rather than operate separately from them. Research institutions could further support evidence-based decisions about elephant movement, vegetation, agriculture and water management.

Local inhabitants are both directly affected by HEC and essential to the corridor's long-term success. Farmers face crop losses, while households may experience safety concerns and increased pressure on water and other natural resources during dry periods. At the same time, these communities possess valuable knowledge of seasonal changes, elephant movements and local resource use. Their participation can help identify suitable routes, determine where mitigation measures are needed and ensure that the transformed land provides meaningful benefits. If the corridor restricts access to farmland, grazing or water without offering viable alternatives, it risks creating new conflicts rather than resolving existing ones.

Finally, elephants are the primary ecological beneficiaries of the project, but their needs cannot be considered separately from the surrounding landscape. The corridor must provide sufficiently connected habitat, food, shelter and access to water while accounting for existing settlements, agricultural land and livestock use. Its success will therefore depend on cooperation between stakeholders at all four scales: Kenya, the wider Tsavo landscape, the Kasigau region and individual communities.






Community scale

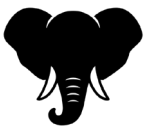




Kasigau scale





Tsavo scale








Kenya scale

Contributors to solutions (Conservation organisations and NGO's)

East African Wildlife Society (EAWLS)		Regional conservation NGO involved in environmental advocacy and conservation initiatives.	Partner for conservation advocacy and environmental awareness.
African Wildlife Foundation (AWF)		Works on wildlife conservation, landscape planning, habitat protection and community coexistence.	Relevant expertise in connecting habitats and supporting conservancies.
Wildlife Works — Kasigau REDD+ Project		Protects dryland forest through carbon finance, community governance, conservation employment and forest protection.	An established conservation actor in the Kasigau region; essential to coordinate with and understand existing corridor management.
Save the Elephants		Conducts elephant research and develops approaches to reduce conflict between people and elephants.	Important partner for research and solutions about elephant behaviour, movement data and coexistence measures.
Tsavo Trust		Supports wildlife monitoring, anti-poaching operations, KWS and community conservancies in the greater Tsavo ecosystem.	Strong potential for field coordination, wildlife data and landscape-level partnerships.
Taita Taveta Wildlife Conservancies Association (TTWCA)		Represents conservancies and ranches, supporting collaboration, governance, rangeland management and community livelihoods.	A key route to identifying land managers and coordinating connectivity across properties.
Sheldrick Wildlife Trust		Supports wildlife protection, elephant rescue, veterinary interventions and conservation outreach.	Wildlife-management and conservation partner.
Kenya Wildlife Conservancies Association (KWCA)		National umbrella body supporting conservancies through advocacy, networking and capacity-building.	Can connect the project with conservancies, relevant policy discussions and management expertise.
Wildlife Research and Training Institute (WRTI)		A Kenyan state corporation conducting and coordinating wildlife research and training, with a research centre focused on savannah, arid and semi-arid ecosystems in Tsavo.	Source of ecological data, mapping, elephant research and corridor-monitoring methods.
Kenya Agricultural and Livestock Research Organization (KALRO)		Conducts agricultural and livestock research, including work relevant to farming systems and resilience.	Could help develop farming practices and crops that support local livelihoods alongside elephant conservation.
Taita Taveta University (TTU)		Public university that	Can contribute with academic research about ecology, agriculture and community, student projects and surveys.
CBO's		Represent local groups and organise community activities related to conservation, livelihoods, water, farming or natural-resource management.	Organise participation, communicate local priorities and support implementation.

Contributors to the problem

Illegal grazers		People letting their livestock graze illegally on ranches, conservancies or protected land.	Illegal grazing creates competition between livestock and wildlife for pasture and water. It can also cause overgrazing, degrading vegetation and reducing the resources available to elephants.
Poachers		Poachers kill elephants to obtain their ivory, which has a high market value.	Poaching directly threatens elephant populations through illegal killing and can disrupt their social structures and movement patterns.
Charcoal burners		People cut down trees and burn the wood to produce charcoal, which is commonly used as cooking fuel. This activity is sometimes driven by a lack of affordable alternatives.	Illegal or unsustainable charcoal production causes woodland degradation and habitat fragmentation. This reduces the food and shelter available to elephants and puts additional pressure on already stressed vegetation.
Ranch owners		Ranches are used for livestock grazing.	Especially fenced ranches and extensive presence of cattle contribute to habitat fragmentation and disturbance of migration routes

Figure 43: Stakeholder overview, made by author

Affected

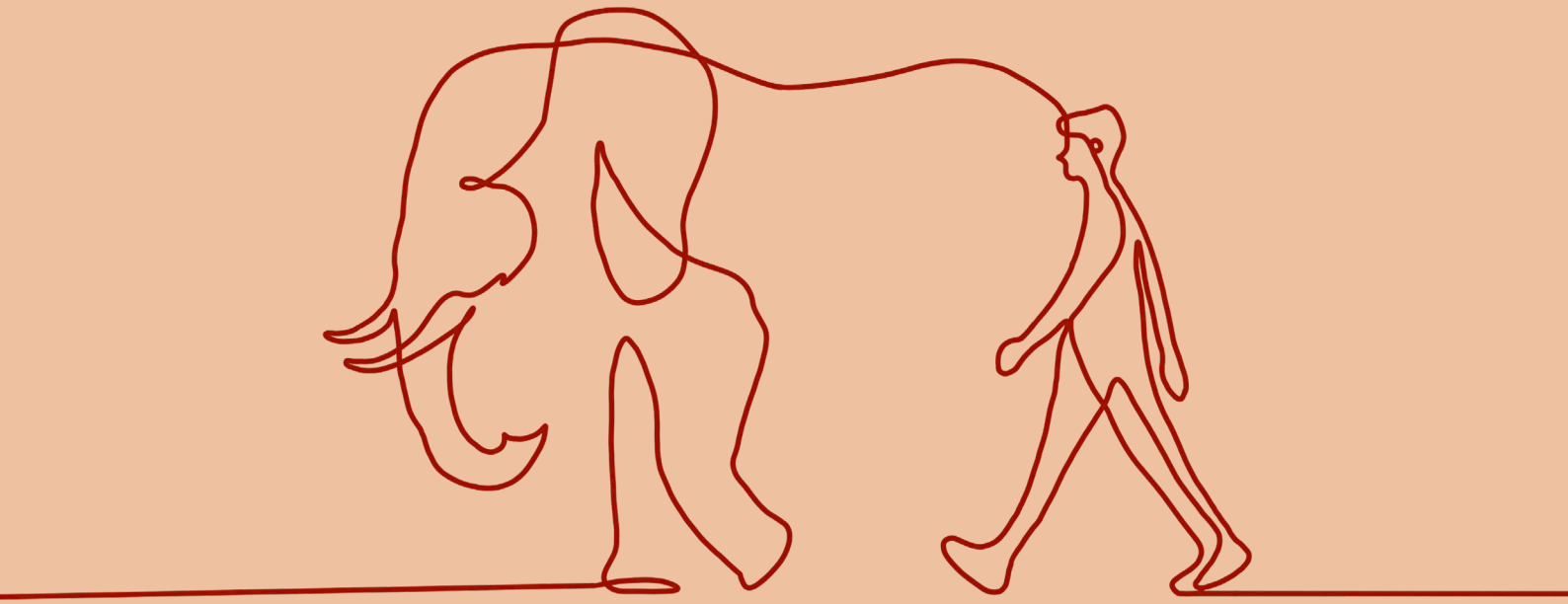
Farmers		Farmers depend on crop production as a primary source of income. Their livelihoods are vulnerable to drought, crop damage caused by elephants, and other forms of HEC.	Their land-use decisions, crop choices and willingness to participate is key in reducing HEC.
Villagers and local households		Live in settlements throughout the Kasigau region and depend on local land, water, infrastructure and livelihoods. They experience elephant encounters, safety risks and competition over resources.	Community acceptance is essential for implementing effective HEC mitigation measures. Local residents can contribute valuable knowledge about elephant movements, water points and seasonal changes.
Conservancy ranch owners		They manage large areas of land that combine livestock ranching with wildlife conservation, providing habitat for wildlife while supporting managed livestock grazing.	They can negotiate land access, maintain habitat connectivity, and coordinate wildlife-friendly grazing and water management practices.
Elephants		The primary ecological beneficiaries of the project and are therefore key ecological stakeholders.	Elephants' habitat requirements, seasonal movements and responses to human activity should guide the corridor's location, width, vegetation and water infrastructure.

Policy makers

Kenya Wildlife Service (KWS)		An government organization that manages wildlife and protected areas, enforces wildlife laws and works on wildlife security and human–wildlife conflict.	Important for elephant movement data, protected-area connections, wildlife management and conflict mitigation.
National government of Kenya		Establishes national wildlife, environmental and land policies through the relevant ministries and agencies.	Important for legal frameworks, public land, national infrastructure and wildlife policy.
County Government of Taita Taveta		Oversees county planning, local development and relevant county services.	Can help integrate the project into land-use planning and coordinate county departments.
Kasigau ward administration		Supports local planning, services and development within its jurisdiction. Chiefs and assistant chiefs provide links to national administration, while ward representatives connect residents with county politics.	Can support local consultation and planning and verifes which authorities cover the project area.

Funding

United Nations Development Programme (UNDP)		Supports sustainable development, environmental programmes and community initiatives through national and international partnerships.	Can provide funding for conservation and community livelihoods.
Kasigau Foundation		A Dutch initiative that specifically supports community projects around Mount Kasigau, including education and water-related initiatives	Could support community engagement and complementary water or livelihood projects.
TUI Care Foundation		Supports projects that use tourism to benefit communities and the environment	Can fund parts of the ecotourism, local employment or tourism-linked conservation parts of the project.
International Fund for Animal Welfare (IFAW)		International wildlife conservation organisation working through conservation programmes and partnerships.	Can provide funding for landscape conservation and human–wildlife coexistence.



PART III

FINDING SOLUTIONS

5

Existing solutions

5.1 Local solutions
5.2 Working with the drought
5.3 Case studies

5.1 Local Solution

5.1.1 Organisational solutions

Two major conservation organisations work in the Kasigau region to address human–elephant conflict and improve coexistence between local communities and wildlife: Save the Elephants and Wildlife Works. Their approaches differ, with Save the Elephants focusing primarily on elephant research and conflict mitigation, while Wildlife Works combines conservation with community development and sustainable livelihoods.

Save the Elephants
Save the Elephants is an elephant research and conservation organisation founded in 1993. It works across Africa to protect elephants and their habitats, with a strong focus on scientific research into elephant behaviour, migration, intelligence and human–elephant coexistence. The organisation is active in the Kasigau region and the wider Tsavo ecosystem, where its research and conservation initiatives contribute to improving coexistence between elephants and local communities.

One of its main activities is tracking elephant movements using GPS collars. This enables researchers to understand migration routes, habitat use and how elephants respond to drought, infrastructure and human activity. The resulting data can help identify important wildlife corridors and inform conservation planning, including in the Tsavo ecosystem.

Save the Elephants also develops and promotes strategies to reduce HEC. These include beehive fences, alternative crops, educational programmes and other coexistence measures designed to protect farms while allowing elephants to remain in their natural habitats. Its research and community-based initiatives contribute to developing practical solutions for people living alongside elephants.

In addition, the organisation supports wider elephant conservation efforts, including research and initiatives to combat ivory poaching and protect elephant populations and their habitats (Save the Elephants, n.d.).



Figure 44: STE office, made by author

Wildlife Works' REDD+ Kasigau Corridor Project
The Kasigau Corridor REDD+ project, developed by Wildlife Works, is described by the organisation as the world's first and longest-running certified REDD+ project. REDD+ stands for Reducing Emissions from Deforestation and Forest Degradation. The project aims to protect forests, reduce carbon emissions and support local communities through sustainable economic development.

The project addresses threats such as deforestation and poaching by creating employment opportunities that provide alternatives to unsustainable activities, including illegal tree harvesting and some forms of livelihood-based resource use. Its activities include wildlife protection, the production of environmentally friendly products, support for education and the development of conservation agriculture practices with local farmers.

A central principle of the project is to place local communities at the heart of conservation. Through a community-focused governance model, carbon-credit revenue supports locally identified priorities, including scholarships, school infrastructure, access to clean water and other initiatives intended to improve livelihoods and well-being.

By linking forest protection with employment and community investment, Wildlife Works aims to reduce pressure on the ecosystem while creating economic incentives for conservation. This approach provides an alternative to conservation models that rely primarily on restricting human access to protected areas, recognising that the long-term protection of wildlife depends partly on the well-being and participation of the people living alongside it (Wildlife Works, n.d.).



Figure 45: Water project initiative by WW, made by author

5.1.2 Community based organisations

A Community-Based Organisation (CBO) is an organisation established by people from a particular community to address shared needs and improve local living conditions. It provides a structure through which community members can identify problems, set priorities, organise activities, manage resources and work together towards common goals. Unlike an organisation that primarily designs projects for a community from the outside, a CBO is intended to involve local people in the decisions and activities that affect them. However, the degree of community participation depends on how the organisation is governed in practice. CBOs are not necessarily funded by the government, and they do not automatically receive funding simply because they exist. Their resources can come from different sources, depending on their activities and agreements.

Alternative livelihoods

A CBO can help generate alternative livelihoods by turning local skills and natural resources into income-generating activities. These activities can provide additional income while supporting conservation and reducing dependence on farming or other activities vulnerable to drought and human–elephant conflict.

A CBO does not necessarily produce the goods itself. Instead, it can act as a facilitator, helping community members develop skills, organise into groups, access funding and reach buyers. With support from a CBO:

- Groups can approach larger buyers collectively.
- The CBO can coordinate training and seek funding.
- Products can be collected, processed and sold collectively.
- Shared records can improve financial transparency.

A CBO can therefore act as an intermediary between residents, conservation organisations, funders and commercial buyers. It can help turn a livelihood idea into a functioning local enterprise while ensuring that community members participate in decisions about production and income (Wildlife Works, n.d.).

Alternative income-generating activities can reduce residents' dependence on traditional farming and livestock keeping, providing greater economic stability and reducing pressure on the landscape. With less dependence on livestock keeping, grazing pressure and overgrazing can decrease, allowing natural vegetation to recover and creating more space for ecological areas. Similarly, additional income sources can reduce the need to expand farmland, potentially lowering irrigation demand and helping to alleviate water scarcity. Diversifying livelihoods also provides a financial safety net when harvests are poor due to drought or crop raiding by elephants. Furthermore, areas under less pressure from farming and grazing can be used for tree planting and habitat restoration. This can help reconnect fragmented landscapes, improve ecological conditions and potentially reduce human–elephant conflict. Finally, conservation activities can provide direct economic benefits: beehive fences can generate income through honey production while helping protect crops, and ecotourism can create jobs and support local businesses while encouraging elephant and habitat conservation.

Several income-generating activities already exist in the Kasigau region.

Community bandas and homestays

In the Kasigau region, there are two ecotourism initiatives that allow visitors to experience local life while staying in a banda, a simple, traditionally styled accommodation.

- Kasigau Community Bandas: are a community-based ecotourism initiative around Mount Kasigau in Taita-Taveta County, Kenya. The initiative began around 2000 with the aim was to create economic opportunities for communities around Mount Kasigau while encouraging forest conservation. Each participating village had its own banda, allowing visitors to stay locally and experience the surrounding landscape and culture. Activities included guided nature walks, birdwatching, forest visits, traditional dances, basket weaving and visits to historical sites. These activities created potential employment opportunities for local guides, cooks, craftspeople and other service providers. However, the project proved difficult to maintain over time. (Okech, n.d.; Kenyan Camper, 2015)
- Kasigau Homestay: is a community-based tourism initiative at the foothills of Mount Kasigau. It allows visitors to stay with local host family and experience everyday life in the Taita community rather than staying exclusively in conventional hotels or safari lodges. Activities have included local meals, village tours, traditional activities, tree planting and guided hikes on Mount Kasigau. These experiences create opportunities for visitors to spend money on locally provided services and products. Payments support host-family livelihoods, while part of the income has been channelled towards environmental protection (Kenya Community Based Tourism Network, 2014).

Cotton clothing

Wildlife Works established its factory in Kasigau in 2001 as part of its mission to combine wildlife conservation with sustainable economic development for rural communities. The factory produces clothing from organic cotton using environmentally friendly dyes for sustainable brands worldwide. Some of the cotton is sourced from local farms. Employees receive living wages and full health benefits, helping them support their families without relying on activities such as poaching or slash-and-burn agriculture. The factory has grown over the years to employ around 70 full-time workers across three buildings (Wildlife Works Factory, n.d.).

Sisal baskets

Basket weaving is a traditional Taita craft. The CBO Hadithi helps generate income from this tradition by connecting local basket weavers with markets. It works with more than 500 weavers in rural villages between Tsavo East and Tsavo West National Parks. The baskets are made from sisal grown on the weavers' farms or purchased from other sisal estates in Kenya's Coast region. The leaves are processed to extract fibres, which are rolled into twine and woven into baskets. Members of the Kasigau Weavers Group dye the fibres themselves, creating their own colours, patterns and designs. Hadithi Crafts adds leather details to locally made baskets. This aims to increase the value of the products and create additional job opportunities (Hadithi Crafts, n.d.).

Soap production

Wildlife Works established a small soap-making operation to create employment and support local producers. The initiative produces soaps with different ingredients for Kenyan consumers and international tourists. It also provides income opportunities for small-scale producers who supply oranges, limes, honey and other ingredients used in the soap. The products are generally packaged in elephant-dung paper produced in Rukinga or in sisal baskets made by local women. This example shows how an individual's initiative, combined with organisational support, can develop into a new income-generating activity that benefits the wider community (Wildlife Works, 2011).

Sustainable charcoal

Wildlife Works has developed a sustainable charcoal alternative using pruned branches from indigenous trees. This approach aims to reduce tree destruction associated with conventional charcoal production while providing an alternative source of fuel. The branches are harvested through pruning practices designed to preserve the trees and maintain habitat for small animals. The resulting charcoal is mixed with a binder made from inedible cassava flour, pressed into briquettes and packaged for sale. The briquettes provide an alternative fuel source intended to reduce pressure on local forests (Wildlife Works, 2021).

Leather production

The Neema Leather Products Manufacturing Group in Kasigau is a local enterprise involved in leather manufacturing. The initiative was established with support from the Kasigau Foundation and aims to add value to livestock products by transforming hides and skins into finished goods rather than selling them as raw materials. This creates opportunities for employment and additional income throughout the production chain. Hides and skins are collected from local butchers, providing them with a additional source of income. The materials are then prepared and processed before being cut, dyed, stitched and assembled into finished products. The enterprise currently produces items mainly for local use, including schoolchildren's shoes, belts and colourful beaded sandals. Over time, the enterprise could expand its production and reach markets beyond the local area, including national markets and tourists.

Honey from beehive fences

Beehive fences consist of beehives hung at intervals around farms and connected by wires, where the bees help deter elephants. In addition to protecting crops and support pollination of nearby crops, the hives produce honey, a valuable product that farmers can harvest, process and sell for additional income. CBOs can support this activity by coordinating beekeeping training, hive maintenance, honey harvesting and marketing, helping households benefit from both crop protection and a potentially high-value source of income (Mwongeli, 2019).

Products made from elephant dung

Elephant dung is abundant in areas inhabited by elephants and can be used to produce several value-added products. Although these practices are not currently established in the Kasigau region, examples from elsewhere in Africa demonstrate their potential.

- Paper products: CBO's in Kenya and Uganda have developed methods of turning elephant dung into paper. The resulting material can be used to make handcrafted products such as photo frames, visitor books, postcards, shopping bags and event cards. This approach creates opportunities for craft production and income generation. Because the paper incorporates processed plant fibres recovered from dung, it also reduce the demand for conventional paper materials, which contributes to less deforestation. Examples include the Kataara Women's Poverty Alleviation Group and Nampath Paper (Kataara Women's Poverty Alleviation Group, n.d.; Design Indaba, n.d.).
- Fertiliser: elephant dung contains partially digested plant material and nutrients, including nitrogen, phosphorus and potassium. When appropriately handled and applied, it can be used as an organic soil amendment to support soil fertility and plant growth. Collecting and processing dung for fertiliser

can provide another potential livelihood opportunity in the Kasigau region, particularly where it can be used in local agriculture or sold to farmers.

- Traditional medicinal uses: traditionally, elephant dung has been used in some communities as a folk remedy, with the smoke inhaled to relieve headaches, toothaches and sinus problems. Some traditional healers have also used it to treat skin conditions such as eczema. Further research could explore whether elephant dung contains compounds with potential applications in medicinal or skincare products. Combining traditional knowledge with scientific research may offer opportunities to develop new products, including those that could be marketed to tourists (Inverdoorn Private Game Reserve, 2025).



Homestays



Cotton clothes



Basket weaving from sisal fibers



Leather shoes



Soap



Honey from the beehive fences



Sustainable charcoal



Community banda's



Elephant dung products

Figure 46: Collection of alternative livelihoods, made by author

5.1.3 Creating protection

Local communities and residents already use various methods to protect themselves and their crops from elephants. The different approaches are outlined below.

Elephant-deterrent fences
To protect their crops, farmers install fences around their fields. However, elephants are strong and intelligent animals that can break through conventional fences or learn to overcome deterrents. Save the Elephants (STE) has helped introduce alternative fencing methods designed to discourage elephants from entering farmland. These methods vary in cost, effectiveness, maintenance requirements and impact on elephants.

Organic, smelly elephant repellent fence
This repellent uses inexpensive ingredients to create a strong odour intended to deter approaching elephants. The mixture consists of freshly ground chilli, elephant dung, eggs and water. It is placed in bottles that are hung around the farm. The repellent needs to be reapplied approximately every two months and is reported to be particularly effective during the dry season.

Chilli fences
Chilli contains capsaicin, a compound that irritates the eyes and sensitive tissues of elephants. Farmers can use chilli to create a low-cost deterrent fence by soaking cloth strips in a mixture of freshly ground dried chilli and used engine oil, then hanging them between fence posts. The strong smell is intended to discourage elephants from approaching the farm. This method is reported to be particularly effective during the dry season. However, used engine oil can contaminate soil and water, so it is not really an environmental friendly solution..

Metal-strip (Kasaine) fences
A Kasaine fence consists of lightweight strips cut from creased metal sheets and attached to fencing wire. When the wind blows, the strips produce irregular clanging noises and reflect sunlight or torchlight. This initially discourage approaching elephants. The downside is that elephants become accustomed to the disturbance over time and learn that it poses no real threat, reducing the fence's long-term effectiveness.

Bottle fences
Empty bottles are hung on strings along a fence to create movement, reflections and noise. This is an inexpensive method that can serve as an initial deterrent. However, it is generally considered less effective than other methods because elephants may quickly learn that the bottles are not a threat. Its low cost makes it accessible to farmers and functions as a first deterrent.

Beehive fences
Elephants tend to avoid African honeybees because stings around sensitive areas, such as the eyes, trunk and mouth, can be painful. Even the sound of disturbed bees may discourage elephants from approaching. Beehive fences consist of hives suspended from posts and connected by wires around the farm. When an elephant pushes against the fence, the wires cause the hives to swing, disturbing the bees and creating a deterrent. Dummy hives can be installed between occupied hives. These imitations of real beehives help discourage approaching elephants while reducing the number of active colonies required. This can lower installation and maintenance costs and help spacing the beehives.

Electric fences
Electric fences deter elephants by delivering a short, sharp electric shock when they touch an electrified wire. The shock is intended to discourage further contact without killing the animal. Because elephants can learn from negative experiences, they may develop an association between the fence and the unpleasant shock and avoid it in the future. Electric fences can be powered by solar panels, which charge batteries during the day to supply electricity at night. When properly installed and maintained, they can provide an effective barrier against crop raiding. However, they are relatively expensive and require regular maintenance. They can also restrict wildlife movement and create a physical barrier between habitats. There are several electric-fence designs:

- Hedgehog wiring: this design uses electrified wire strands approximately 1.2 metres long, spaced around 60 centimetres apart and angled upwards at approximately 45 degrees. The arrangement makes it more difficult for elephants to use their tusks to break the wires or knock down fence posts.
- Vertically hanging electric fences: this design uses two horizontal wires installed at an elevated height, reportedly above 4.5 metres, with vertical electrified wires hanging down at intervals of approximately one metre. The hanging wires are arranged in two staggered rows and stop around 1.2 metres above the ground. When an elephant makes contact, the vertical wires can affect a larger area of its body than a conventional horizontal fence. The open space beneath the wires allow people and livestock to pass.
- Single-, double- or triple-high-strand fences: these fences consist of one, two or three electrified horizontal wires installed approximately 1.5–2 metres above the ground and supported by posts or trees. The additional strands provide more opportunities for contact and can make it harder for elephants to pass through (King et al., 2023).

Elephant chasing youth group

When elephants enter settlements, rangers from Tsavo National Park should be alerted to guide them back towards conservancy areas. However, if often takes a long time for them to respond, and sometimes they do not arrive at all. To address this issue, a group of local youths has been formed and trained to help drive elephants away from settlements. They mainly use traditional methods based on indigenous knowledge, such as torches and loud noises, to deter the animals. Although this work is dangerous, the youths provide an important service to the community, which is very grateful for their efforts. They do not receive a formal wage but are rewarded with food and other products from local farmers in appreciation of their work.



Figure 47: Metal strip fence, made by author



Figure 48: Bottle fence , made by author



Figure 49: Beehive fence , image made by author



Figure 50: Vertically hanging electric fence , made by author

5.1.4 From ranch to conservancy

More and more ranches in the Kasigau region are transitioning into wildlife conservancies or mixed-use conservation areas. These conservancies help maintain habitat connectivity, allowing elephants and other wildlife to move between protected areas in search of food, water, breeding grounds and seasonal resources.

Conservancies can reduce habitat fragmentation by limiting fencing, intensive agriculture and settlement expansion. They may also support anti-poaching patrols, habitat restoration, water management and wildlife monitoring, helping to improve elephant survival and ecosystem health. In addition, ecotourism and conservation projects can generate income and create economic incentives for communities to protect wildlife rather than convert land entirely to agriculture or intensive livestock production.

To maintain income from livestock, grazing is often still permitted in mixed-use conservancies. However, it is desired to be restricted to designated areas, with limits on the number of livestock allowed per day. This helps prevent overgrazing and can reduce encounters between livestock and elephants.

There are three main ownership models for conservancies in the Kasigau region

Organisation-owned conservancies
Some organisations acquire or manage land for conservation. Rukinga Conservancy, for example, was developed for conservation in partnership with Wildlife Works from 1998, following a period when the former livestock-ranch landscape had experienced overgrazing, deforestation and poaching. Conservation efforts have included habitat restoration, ranger patrols and local employment. Today, the conservancy protects dryland Acacia–Commiphora woodland and provides habitat for elephants and other wildlife. Tourism and community livelihood programmes also form part of its approach (Rukinga Conservancy, n.d.)
.

Community-owned conservancies
The Kasigau Wildlife Conservancy is a community-based conservation established in 1971 as a community agricultural company. Kasigau Ranch has more than 3,000 members and aims to combine wildlife conservation with livestock ranching, tourism and community benefits. A designated area of the ranch is managed for wildlife, including elephants, giraffes and buffalo. Conservation activities include habitat protection, wildlife monitoring and employing local guardians to improve security and cooperation with surrounding communities. The conservancy works closely with the Rukinga Consercancy (Kasigau Ranching, n.d.).

Privately owned conservancies
Privately owned ranches can also integrate wildlife conservation into their land management. The Taita Taveta Wildlife Conservancies Association (TTWCA) supports conservancies in the region through coordination and conservation initiatives. Amaka Ranch & Wildlife Conservancy, is an example of a privately associated ranch and wildlife conservation area covering approximately 15,000 acres. It combines livestock ranching with wildlife conservation, helping protect savannah habitat in a landscape of ranches, community land and national parks (Taita Taveta Wildlife Conservancies Association, 2026; Kenya Wildlife Conservancies Association, n.d.).



Figure 51: Rukinga Wildlife Sanctuary, made by author

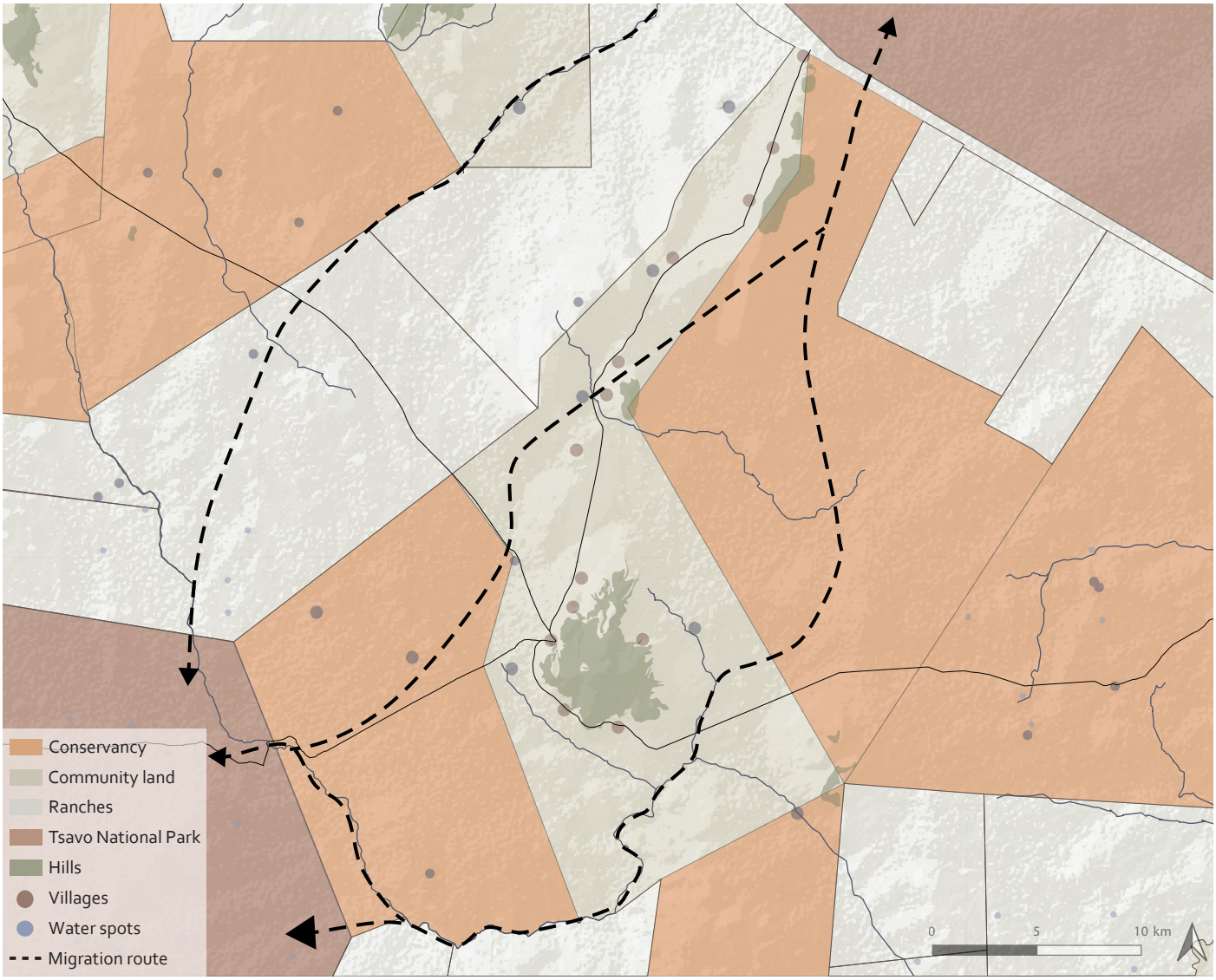


Figure 52: Map showing the ranches that turned into a conservancy , made by author



Figure 53: Traces of elephants in Kasigau Wildlife Conservancy, made by author

5.2 Working with the drought

Solutions to reduce water stress in the Kasigau region can be divided into three main approaches. First, improving the availability of water for elephants can help reduce the distances they need to travel in search of water, which will limit their movement into human settlements and agricultural areas.

Second, improving access to reliable water sources for local communities can reduce water stress for residents and livestock. Finally, protecting community water infrastructure from elephant damage can help maintain a stable water supply and prevent disruptions.

5.2.1 Water for inhabitants

There are several ways to improve existing water sources for human and livestock use by reducing evaporation and infiltration. Alternative methods for constructing new water pans are also explored.

Existing water pan adaptation 1
One way to improve existing water pans is to add a separate, covered water reserve. The water pan remains the main landscape catchment and ecological water body, while the reserve stores excess water and protects it from evaporation.

During the wet season, the water pan functions as usual. When it approaches full capacity, excess water is diverted into the covered reserve. During the dry season, a solar-powered pump transfers the stored water back into the pan when needed. This creates a seasonal water bank, preserving part of the collected water for later use without having to cover the entire water pan (Critchley & Siegert, 1991).

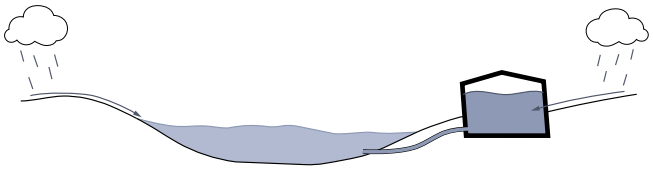
Existing water pan adaptation 2
Another option is to reshape an existing water pan into two storage zones: a large, shallow basin and a smaller, deeper basin. Rather than keeping the entire pan shallow, the deeper basin acts as a reserve, with a smaller surface-area-to-volume ratio, reducing evaporation relative to the amount of water stored. Once the shallow basin is empty, water from the deeper reserve can be pumped to a tap point and drinking trough, providing easier access to the remaining water (Ministry of Water and Irrigation, Government of Kenya, 2015).

The Somali Berkad system
The berkad is a traditional water-storage system used in Somalia to collect and store wet-season runoff for use during the dry season. It typically consists of a large, rectangular reservoir lined with masonry and cement to reduce infiltration and water loss into the surrounding soil. By retaining rainwater in a constructed basin, the system provides a more reliable water supply when rainfall is scarce (SamSamWater, 2012).

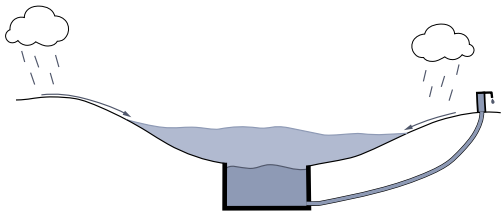
This approach could be adapted to create new, smaller water pans in the Kasigau region. Runoff could be directed into the reservoirs from surrounding terrain, while a sealed lining would help retain the collected water. Compared with conventional, unlined water pans, this design could reduce water loss through infiltration. However, evaporation from the exposed water surface would remain a challenge.

Covering water sources
Covering smaller water sources or part of a water pan can help reduce evaporation. Two innovative approaches are particularly interesting.

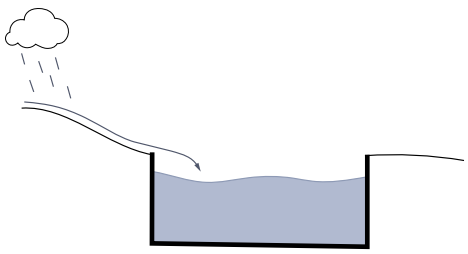
- Floating covers: a membrane or floating material can be placed over the water surface to reduce direct exposure to sunlight and wind. Research on small reservoirs in semi-arid regions found that floating covers reduced evaporation by approximately 65–80% under field conditions (Mady et al., 2021).
- Solar panels: can be installed above part of a water pan. In addition to generating electricity for water pumping, the panels provide shade and can reduce evaporation (Ferrer-Gisbert et al., 2013).



Water pan adaptation 1



Water pan adaptation 2



Somali Berkad system

Figure 54: Adapted water sources sections, made by author

5.2.2 Water for elephants

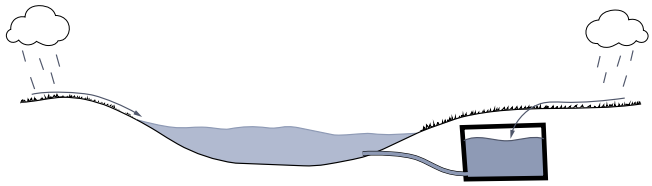
These solutions focus specifically on creating new or improving existing wildlife drinking sources to provide water for elephants.

Elephant water pan adaptation

The elephant-friendly water pan is an adapted water pan designed to reduce evaporation while providing wildlife with access to water. It uses the same principle as the 'existing water pan adaption 1', where instead of storing water in an open basin, runoff is collected in a reservoir. The difference is that reservoir should be underground and the water pan is a naural-looking drinking pool. This helps preserve water during the dry season while allowing the drinking area to blend naturally into the landscape (Critchley & Siegert, 1991).

Using seasonal rivers

When seasonal rivers dry up, water can remain stored beneath the sand in the riverbed. This subsurface water is protected from direct sunlight, reducing evaporation compared with open water storage. A subsurface storage system can help retain this water for use during the dry season. A solar-powered pump can then extract the stored water and transport it through a pipe to a nearby wildlife drinking pool.



Elephant water pan adaptation

Figure 55: Adapted water source section, made by author



Figure 56: Water collection from the dry Tiva river, made by author

5.2.3 Protecting water tanks

Different physical barriers and structural adaptations can help protect water points from elephant damage.

Water towers

Water tanks can be elevated on a sturdy metal, concrete, or wooden structure, ideally at least three metres high. Strong foundations and a stable construction are essential to support the weight of a full tank. Elevating the tank makes it less accessible to elephants, although the level of protection depends on the design and surrounding conditions. A ladder or other safe access system is needed for maintenance. Multiple tanks can also be installed at different heights, making efficient use of the structure (King et al., 2023).

Concrete water tanks

Concrete tanks can provide a more robust alternative to plastic tanks. Elephants cannot break through them. Concrete tanks are generally more expensive to construct, making this option only viable for larger water installations.



Figure 57: Water tower, made by author



Figure 58: Water tank in concrete casting, made by author

5.2.4 New developments

Mzima Springs is a major natural spring system located in Tsavo West National Park. The springs are largely fed by groundwater originating from rainfall that infiltrates the volcanic soils and rocks of the Chyulu Hills. The springs form clear pools that support a distinctive aquatic ecosystem within the dry Tsavo landscape.

The existing Mzima Pipeline I transports water from the springs towards the coast, including Mombasa, where it provides an important water supply for residents and economic activities. To increase water availability in water-stressed areas, Mzima Pipeline II has been proposed as an expansion of this regional water-supply system. Following the distribution route from Mzima Springs through Bughuta, Kisimenyi, Kiteghe, Rukanga, Jora, Ngambenyi, Bungule, and Rukinga. The plan includes storage facilities with a capacity of 200 m^3, transmission mains, and a local distribution network. This infrastructure is intended to improve access to water in communities along the proposed route.

If implemented, the pipeline could provide a more reliable water supply for residents and livestock in the Kasigau region, reducing dependence on local water sources during dry periods and shortening the distances people need to travel to collect water. The network could include community storage tanks and public taps, helping to reduce water stress. The planned pipeline could also be connected to existing boreholes and other water sources within the elephant corridor. This could help replenish local water points and wildlife drinking pools during the dry season, improving water availability for elephants while reducing pressure on existing sources (Muoki & Lala, 2026).



Figure 59: Mzima springs, made by author

5.3 Case studies

5.3.1 Agroforestry

Agroforestry combines trees and shrubs with crops and/or livestock on the same piece of land. It is particularly valuable in semi-arid regions like Kasigau, where irregular rainfall, prolonged dry seasons and declining soil fertility challenge agricultural production. By integrating trees into farms, agroforestry can provide food, fodder, timber and other products while improving soil health, water conservation, biodiversity and farmers' livelihoods (Food and Agriculture Organization of the United Nations, n.d.).

Africa Wood Grow – Kitui, Kenya

Africa Wood Grow (AWG) is a reforestation initiative restoring degraded land in Kitui, Kenya, through community-led agroforestry. Since 2010, it has planted tens of thousands of trees to reduce soil erosion, increase vegetation cover and biodiversity, and improve soil fertility and food security. Its work focuses on the Tiva River catchment, where climate change, deforestation and overgrazing contribute to land degradation and water scarcity. By integrating trees into conventional farming systems, AWG aims to improve soil conditions, retain water and support more gradual water flow into the Tiva River, which supplies Tsavo National Park downstream.

AWG follows a bottom-up approach in which local farmers lead the restoration process and choose to adopt agroforestry on their own land. Farmers collectively choose to plant trees on their farms, with an emphasis on a variety of indigenous tree species. This diversity can support biodiversity and contribute to the long-term sustainability and productivity of agroforestry systems.

The first step is to establish a demonstration farm, developed and managed by Africa Wood Grow Limited. These farms provide a place to test and demonstrate promising agroforestry techniques, allowing farmers to see how the methods work in practice. AWG also operates a tree nursery that supplies seedlings to participating farmers. Farmers who wish to join the initiative receive training, knowledge and the necessary materials to help them establish and maintain their agroforestry systems. Once the demonstration farm has shown promising results, other farmers can adopt and adapt the techniques on their own land.

When a farmer officially joins, the process of converting their farm to agroforestry begins.
The process includes fencing fields to protect young trees from livestock, creating sowing pits and contour trenches to capture rainwater and prevent erosion, and planting trees before the rainy season. Trees are monitored and replaced when necessary. Once established, they can be pruned to maintain tree health and allow sufficient light for crops. Pruned branches provide firewood, reducing pressure on surrounding trees. Mature trees can also be harvested gradually for timber income, while regrowth helps maintain tree cover (Africa Wood Grow, 2026).

The AWG approach could also benefit Kasigau, where deforestation, charcoal production, overgrazing and agricultural expansion contribute to landscape degradation. AWG also demonstrates the value of a bottom-up approach in which local communities actively participate in decision-making and implementation. Its demonstration-farm model is particularly relevant to Kasigau because farmers can see the practical benefits before deciding to change their own farming practices. Instead of converting the entire landscape at once, the project could begin with a small number of willing farmers who establish demonstration farms. If these farms show improvements in productivity, soil conditions and income, other farmers may be more willing to adopt the approach.



Figure 60: An AWG farmer practising agroforesty , made by author

5.3.2 Elephant corridors

Wildlife corridors are areas of habitat that animals, including elephants, use to move between larger habitat areas that may otherwise be fragmented or disconnected.

Securing wildlife corridors is a long-term strategy for reducing human–elephant conflict (HEC), facilitating elephant movement and maintaining genetic connectivity between populations. Corridors allow elephants to reach food, water and breeding areas, and to access alternative habitats during droughts. By enabling elephants to move between areas, corridors can also reduce prolonged pressure on vegetation in particular locations, allowing forage to recover for other species. A corridor does not necessarily need to provide permanent habitat for elephants. Its primary function may instead be to facilitate movement between protected areas and other important habitats. Maintaining corridors free from intensive development can also benefit local communities by preserving access to resources such as firewood, medicinal plants, honey and wild fruits and berries (King et al., 2023).

Ecoexist Elephant Corridor, Botswana

Ecoexist is an organisation working to improve coexistence between people and elephants around Botswana's Okavango Delta. Its work focuses on understanding elephant movement, reducing conflict and protecting migration routes while supporting local livelihoods.

Like residents of Kasigau, many communities in the Okavango region depend on farming and livestock for their livelihoods. Irregular rainfall and poor crop yields make it difficult for some households to produce enough food throughout the year. Low yields and poor soils can encourage farmers to clear additional land or abandon existing fields and establish new ones. When new farmland is created close to elephant pathways, the risk of crop raiding and trampling increases. This can further undermine farmers' livelihoods and resilience to drought.

Ecoexist aims to reduce these conflicts by combining scientific research with practical, community-based solutions. Its approach recognises the importance of maintaining elephant movement routes between water sources and feeding areas while reducing the likelihood of elephants entering farmland. In the project area, communities have participated in identifying and maintaining a network of 14 elephant corridors between water and bush habitats. These routes have been marked with signs to improve awareness of elephant movement. Farms between the corridors are protected using measures such as clustered solar-powered electric fences and beehive fences, which help reduce the likelihood of elephants leaving established routes and entering agricultural areas.

The project also seeks to create economic opportunities linked to the presence of elephants. These include local enterprises producing crafts and products from elephant dung, honey production, arts and cultural activities, and tourism opportunities connected to elephant conservation. Such activities can help communities benefit economically from wildlife rather than experiencing elephants only as a source of crop damage and risk.

Ecoexist has also supported market-based incentives for conservation. For example, farmers can receive a premium price for millet when they commit to protecting elephants. The millet is used by brewery to produce beer for the tourism market. These initiatives form part of what is described as an elephant-aware economy: an approach in which local people can earn income from activities connected to elephants and conservation. By creating economic opportunities, the approach aims to improve attitudes towards elephants and make coexistence more viable for communities (Ecoexist Trust, n.d.).

The Ecoexist case is particularly relevant to Kasigau, as both landscapes face challenges related to crop raiding, drought, low agricultural yields and maintaining elephant movement routes. It demonstrates how clearly identified corridors can be combined with farm protection measures, such as beehive and electric fences, to reduce crop damage without blocking elephant movement. It also highlights the potential of elephant-related enterprises, local crafts and cultural activities to generate income, while tourism businesses can connect local products to wider markets. Incentives such as premium prices can further encourage farmers to support conservation. For Kasigau, these approaches could help maintain habitat connectivity, reduce human–elephant conflict and strengthen community resilience by diversifying livelihoods and creating tangible economic benefits from conservation.



Figure 61: Ecoexist elephant corridors, from Murphy (2023)

Right of Passage Project, India

Many of India's elephant habitats are unprotected and vulnerable to encroachment or are already shared with human activities. As forests become fragmented, relatively narrow strips of vegetation can provide vital connections between larger forest areas. These corridors allow elephants to move between habitats to access resources, find mates and maintain contact between populations.

Through its Right of Passage project, the Wildlife Trust of India (WTI) works to secure elephant corridors while addressing the needs of communities affected by conservation measures and human–elephant conflict. Its approach recognises that corridor protection must consider both ecological connectivity and local livelihoods. WTI has developed four main approaches to securing elephant corridors:

- Private purchase model: WTI and its implementation partners purchase strategically important land, support the resettlement of affected residents where necessary, and transfer the land to the relevant state forest department for legal protection.
- Community securement model: community-owned land is secured for corridor use through arrangements such as easements or agreements that share benefits between stakeholders.
- Government acquisition model: WTI supports policy development and provides technical assistance to national and state governments to help secure important corridor land.
- Public securement model: local stakeholders, are encouraged to monitor and protect corridors over the long term. Public campaigns and targeted interventions help maintain awareness and community involvement.

Of the 101 elephant corridors identified by WTI, six had been secured through the project at the time of the cited source. One example is the Thirunelli–Kudrakote corridor in Kerala.

The Thirunelli–Kudrakote corridor connects forests in the Brahmagiri Wildlife Sanctuary in Karnataka with Wayanad Wildlife Sanctuary and the Wayanad North Forest Division in Kerala. It helps elephants move between larger forest habitats in the Western Ghats, within a wider connected landscape that extends towards Nagarahole and Bandipur. The corridor is approximately 6 kilometres long and 1–1.8 kilometres wide. Its vegetation includes natural forest, teak plantations and regenerating woodland. Seven villages were located within the corridor, and four were strategically positioned in ways that considerably narrowed its effective width.

Beginning in 2005–2006, WTI worked with the Kerala Forest Department and local communities to secure strategically important land and support the voluntary relocation of families living in critical sections of the corridor. Resettlement support included land for housing and agriculture, new houses, water facilities and other basic amenities. This approach sought to restore elephant movement while providing affected families with alternative living conditions and livelihood opportunities (Menon et al., 2017; Wildlife Trust of India, n.d.).

The Thirunelli–Kudrakote case demonstrates how a corridor can be secured by identifying critical bottlenecks and protecting strategically important parcels of land rather than acquiring an entire landscape. Its reported width of approximately 1–1.8 kilometres also provides a useful reference for considering corridor dimensions. For Kasigau, this approach highlights the importance of identifying narrow sections where settlements, farms or infrastructure restrict elephant movement and protecting strategically located land to maintain or restore connectivity. It also demonstrates the need to involve affected communities in planning and decision-making and to provide viable alternatives and appropriate support when land use or relocation needs to change. The project further illustrates how corridors can be secured through different arrangements, including private land purchase, community agreements, government action and local monitoring. Although the Indian context differs from Kasigau, these approaches offer useful models for combining habitat protection with community participation.



Figure 62: Asian elephants next to corridor sign, from Wildlife Trust of India (n.d.)

5.3.3 Ecotourism as a way to fund conservation

Eco-tourism already exists in the Kasigau region, although current initiatives are relatively small-scale. Studying larger ecotourism models can provide insight into how eco- tourism can generate reliable income while supporting wildlife conservation, habitat restoration and local livelihoods on a larger scale. The following case studies illustrate different approaches, from gradually transforming agricultural land into a wildlife refuge to developing high-end safari tourism that helps finance long-term conservation.

Singita – high-end ecotourism in Africa

Singita is an African ecotourism company that combines high-end safari tourism with the protection and restoration of large natural landscapes. It opened its first property, Singita Ebony Lodge in South Africa, in 1993 and has since expanded into conservation landscapes in several African countries, including Zimbabwe, Tanzania, Rwanda and Botswana. Its business model is based on the idea that tourism can generate income, employment and international support for the long-term protection of wildlife and natural habitats.

Rather than simply providing accommodation near a wildlife area, Singita builds the visitor experience around the surrounding landscape. Guests stay in carefully designed lodges, explore wildlife habitats with trained guides, enjoy locally inspired food and learn about the ecosystem. The high prices reflect the quality of service, privacy, facilities and guided experiences. This allows the company to target visitors willing to pay more for an exclusive nature-based experience. Singita's approach connects three main priorities:

Biodiversity: protecting wildlife, restoring habitats and maintaining functioning ecosystems.

Community: creating local employment and supporting education, livelihoods and partnerships with surrounding communities.

Sustainability: reducing the environmental impact of lodges and tourism operations through measures such as renewable energy, water-saving systems, wastewater treatment, recycling and more sustainable purchasing.

Conservation extends beyond the immediate tourism properties. Singita works with not-for-profit conservation partners and supports community initiatives involving education, scholarships, vocational training and local enterprise development. Examples of economic links with surrounding communities include smallholder agricultural cooperatives supplying lodges, honey production, and local arts and crafts. These initiatives allow local people to benefit from tourism through employment, supply chains and business opportunities, even if they do not work directly in wildlife tourism.

Despite its sustainability measures, high-end tourism also presents environmental challenges. Luxury lodges require water, energy, food and infrastructure, often in remote areas where resources are limited. Singita acknowledges that water consumption remains a challenge and that its absolute carbon footprint has not yet declined substantially. This highlights an important limitation: sustainability measures can reduce environmental impacts but do not automatically eliminate them.

Singita demonstrates how high-end ecotourism can connect conservation with employment, local supply chains and investment in surrounding communities. For Kasigau, this could eventually provide a way to generate greater income from wildlife and landscape protection. Local farmers and businesses could supply lodges with food, honey, crafts and other products, while local residents could benefit from guiding, hospitality and conservation-related employment. However, this model would be difficult to implement fully at the beginning of a project in Kasigau, particularly where water scarcity and limited infrastructure remain significant challenges. High-end tourism requires reliable water supplies, suitable accommodation, trained staff and sufficient wildlife to attract visitors. It is therefore more realistic to consider it a potential long-term strategy, once water management, habitat connectivity and wildlife protection have improved. The Singita example also shows that tourism income does not automatically benefit all local residents. Community partnerships, local employment and accessible supply chains need to be deliberately developed so that economic benefits reach surrounding communities. For Kasigau, this would mean designing tourism around both conservation goals and local livelihood opportunities, while ensuring that water and other resources are managed responsibly (Singita, 2018; Singita, n.d.).



Figure 63: View from a Singita lodge, from (Dorsia Travel, 2024)

Agro-ecotourism – Costa Rica

In Costa Rica, some farmers have diversified their traditional agricultural activities by combining food production with nature conservation and tourism. Rather than abandoning farming entirely, they gradually adapt their land so that visitors can experience tropical forests, wildlife, local food production and rural life. This approach is commonly known as agrotourism or agro-ecotourism.

Several factors have encouraged this transition. Traditional agricultural activities, including coffee and banana production and livestock farming, have faced economic pressures due to fluctuating global prices, rising production costs and competition. For some farmers, relying on agriculture alone has become increasingly difficult. At the same time, Costa Rica's exceptional biodiversity, including rainforests, volcanoes, beaches and diverse wildlife, provides opportunities to generate income from nature-based tourism. Farmers can earn money by offering accommodation, guided tours, wildlife-watching experiences and farm visits.

Government policy has also contributed to the development of ecotourism. Since the 1970s and 1980s, Costa Rica has promoted conservation through the establishment of protected areas. These initiatives have encouraged landowners to preserve forests rather than convert all their land to agriculture. Growing international demand for sustainable travel has further increased the economic potential of ecotourism. In some cases, it also offers an alternative to agricultural practices that contribute to deforestation and soil degradation.

By diversifying their activities, farmers can reduce their dependence on unpredictable crop prices and weather conditions. Tourism does not necessarily replace agriculture; instead, it can provide an additional source of income while creating an economic incentive to maintain natural habitats (Little & Blau, 2020).

Curú Wildlife Refuge, located on the southeastern tip of the Nicoya Peninsula in Costa Rica, illustrates how a working farm can gradually transition towards conservation and ecotourism while retaining some agricultural activities. The property was originally established as a farm in 1933. Its activities included timber harvesting, growing crops and raising livestock.

Over time, the owners increasingly prioritised the protection of the area's forests and mangroves. In 1981, the government granted protection status to the area, and in 1983 it became Costa Rica's first privately owned wildlife refuge. The property gradually developed into a destination for visitors, students and researchers. Instead of relying primarily on agricultural production, it began generating income through nature experiences, accommodation, guided activities, education and scientific research. Conservation became central to land management, while some agricultural production continued.

The approximately 1,500-hectare property is divided between different uses:

- 1100 hectares: Ecotourism, scientific research, conservation projects and environmental education. Activities include wildlife rehabilitation and habitat restoration, including work involving coral reefs and marine environments.
- 310 hectares: Agricultural activities, including subsistence livestock farming and crop production, which support the farm's operations, provide livelihoods and generate income.
- 90 hectares: Biological forest conservation, where visitor access is restricted to protect natural habitats.

This division demonstrates how different land uses can coexist within one property. Areas dedicated to tourism and research can generate income and support conservation, agricultural land can continue to provide food and livelihoods, and strictly protected areas can offer habitats with limited human disturbance (Curú Wildlife Refuge, n.d.).

Curú demonstrates how ecotourism can support habitat protection and research while diversifying income without requiring the complete abandonment of agriculture or livestock keeping. Instead, land can be managed according to its ecological sensitivity and economic potential, allowing conservation, tourism and existing livelihoods to coexist. This approach is relevant to Kasigau, where not all landowners or farmers may be willing to change their current activities. By identifying areas with high wildlife or landscape value for conservation and carefully managed tourism, while maintaining agriculture and livestock keeping in suitable areas, Kasigau could gradually develop a mixed-use landscape. The transition could begin with a small number of willing landowners or communities and expand as the economic and ecological benefits become clear. This would make conservation more feasible by offering different participation opportunities without requiring everyone to change their livelihoods.



Figure 64: Cúru Wildlife Refuge, from Wikiloc (n.d.)

6

Designed solutions

6.1 Design concept
6.2 Design strategy
6.3 Elephant corridor
6.4 Buffer
6.5 Community lands
6.6 Proposed design

6.1 Design concept

The goal of this project is to develop a spatial framework that reconnects Tsavo East and Tsavo West National Parks through an elephant corridor in the Kasigau region, while integrating the needs and activities of surrounding communities. The framework aims to improve local resilience through alternative farming practices, landscape restoration and additional income-generating opportunities.

The corridor should provide elephants with safe passage between the two national parks, with sufficient food, shelter and water to support their movement. At the same time, the surrounding communities should benefit from the transformed landscape through more resilient agricultural systems, improved access to resources and diversified livelihoods.

By combining wildlife conservation with community development, the framework aims to reduce negative interactions between people and elephants, restore and protect historical elephant migration routes, strengthen livelihood security, improve ecological conditions and address the impacts of drought. Rather than treating conservation and human activities as separate functions, the design seeks to create a landscape in which they can coexist.

To achieve these goals, the project is based on the concept **Prevent Contact** and **Reduce Impact**. This approach addresses human–elephant conflict in two complementary ways: reducing the likelihood of unwanted encounters between elephants and people, and limiting the damage when these encounters do occur.

Prevent Contact
This principle focuses on preventing unwanted encounters between elephants and local communities. It does so by addressing elephants' habitat needs and providing sufficient space for them to move, migrate and access food and water. By restoring connected habitats and ensuring that essential resources are available along the corridor, elephants should have less reason to enter agricultural areas and settlements in search of food or water. The surrounding landscape is also designed to discourage elephants from leaving the designated corridor by introducing crops and vegetation that are less attractive to them. The objective is not to prevent elephants from moving freely through their natural habitat, but to guide their movement towards safer routes while reducing the overlap between elephant movement and human activities.

Reduce Impact
Because it is not possible to prevent every encounter, the second principle focuses on minimising the damage and risks when elephants enter areas used by people. This includes cultivating crops that elephants are less likely to eat, protecting agricultural fields and community water sources, and introducing measures to reduce crop raiding. At the same time, alternative income-generating activities, such as ecotourism and processing locally grown products, can reduce communities' dependence on agriculture. This reduces the need to expand farmland or intensify cultivation to generate sufficient income, helping to limit pressure on elephant habitats and reducing additional demand for water. This approach aims to make communities more resilient while allowing people and elephants to coexist in the wider landscape.

6.2 Design strategy

To translate the concept into a spatial framework, the landscape is divided into three zones. Each zone has a specific function within the two design principles: Prevent Contact and Reduce Impact. Together, they create a gradual transition from an area primarily dedicated to elephant movement and habitat, through a protective buffer, to community land where agriculture and other livelihood activities can continue.

Zone 1: Elephant corridor
The first zone, which goals is to prevent contact, is a designated elephant corridor that follows the historical migration route between Tsavo East and Tsavo West National Parks. Its primary function is to provide safe, continuous passage for elephants while meeting their essential habitat needs. The corridor incorporates suitable vegetation for food and shelter, as well as strategically located water sources. By ensuring these resources are available along the route, the design aims to reduce the need for elephants to leave the corridor in search of food and water.

To maintain the corridor's functionality, human activities that obstruct elephant movement must be limited. In areas where settlements or agricultural land prevent safe passage, the design proposes relocating affected households from the designated corridor. This would require careful planning, community participation and appropriate support to ensure that relocation is socially feasible and that affected residents have viable alternatives. The resulting space would be managed primarily for wildlife movement, habitat restoration and access to essential resources.

Zone 2: Buffer zone
The second zone also prevent contact by forming a protective transition between the elephant corridor and the surrounding community land. Its purpose is to discourage elephants from leaving the corridor and entering agricultural areas. This is achieved by planting crops and vegetation that elephants generally find less attractive, creating a landscape that is less rewarding for them to move through than the corridor itself.

The buffer zone could combine elephant-deterrent crops with suitable vegetation and carefully planned land uses. In addition to discouraging elephants from crossing into farmland, it can help define the corridor spatially and create a gradual transition between wildlife habitat and areas used by people. The buffer should complement the corridor rather than become a barrier that obstructs elephant movement. Its effectiveness therefore depends on the selection and arrangement of plant species, as well as ongoing management.

Zone 3: Community land
The third zone consists of land used by surrounding communities for agriculture, settlements and other livelihood activities. Its focus is on reducing impact of damage and risks when elephants enter human-used areas.

Farmers are encouraged to cultivate non-edible crops or crops that elephants generally dislike.
Crop selection should also consider drought resistance, local growing conditions, food security and potential market value.

In addition to adapting agricultural practices, this zone focuses on strengthening community resilience through alternative income-generating activities. These opportunities can also create economic links between communities and conservation, allowing residents to benefit from the protection and restoration of the landscape.

Water management is another important component of this zone. Protecting community water sources and improving water retention can help reduce the effects of drought on households and agriculture. By combining crop protection, more resilient farming systems, water management and livelihood diversification, community land can remain productive while becoming less vulnerable to elephant damage and environmental pressures.

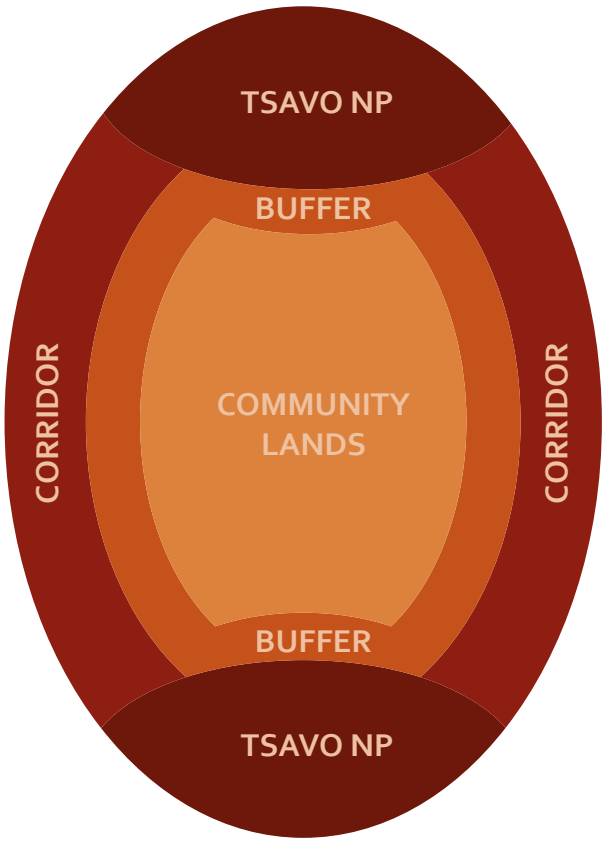


Figure 65: conceptual visualisation of the design strategy, made by author

6.2 Design strategy

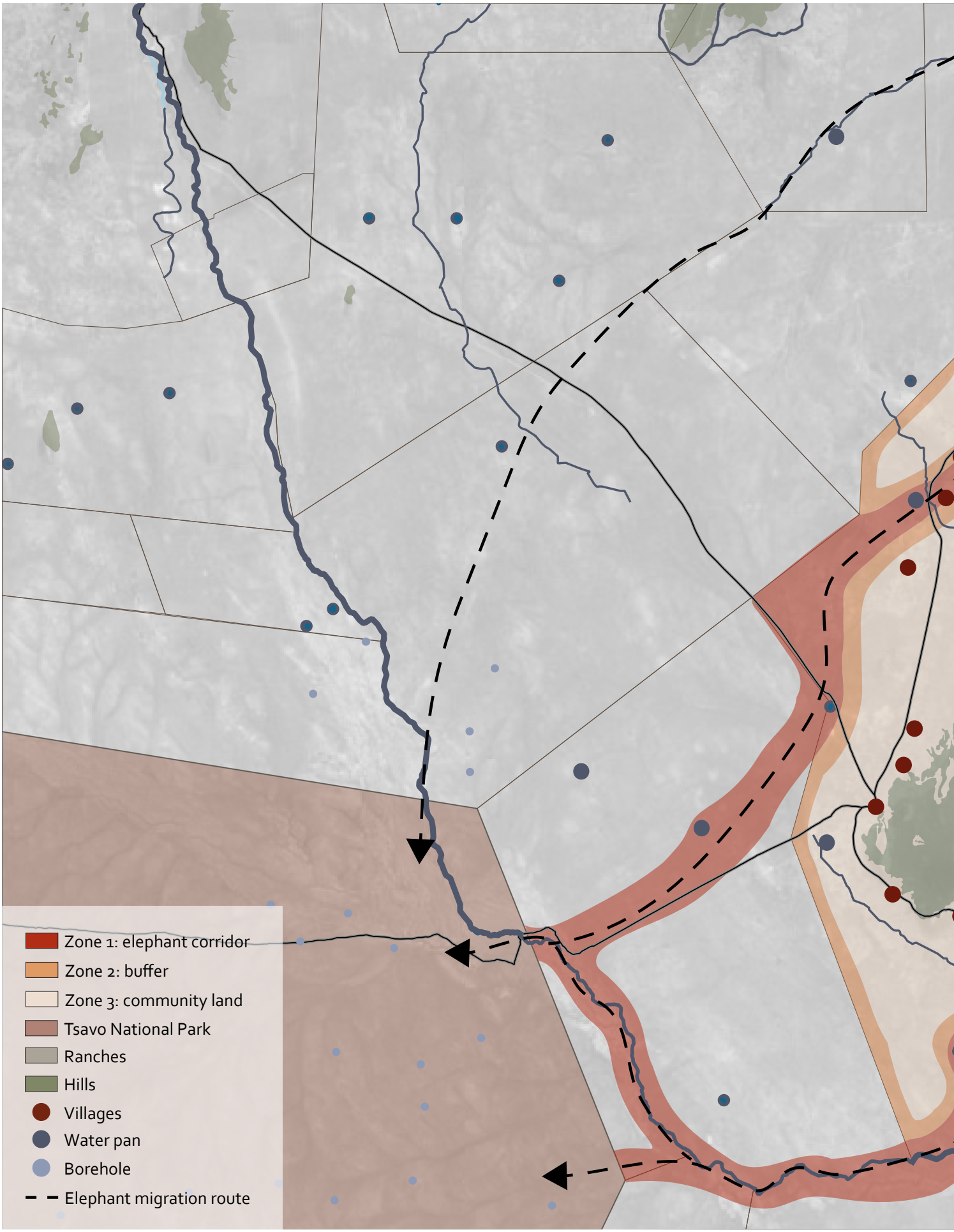
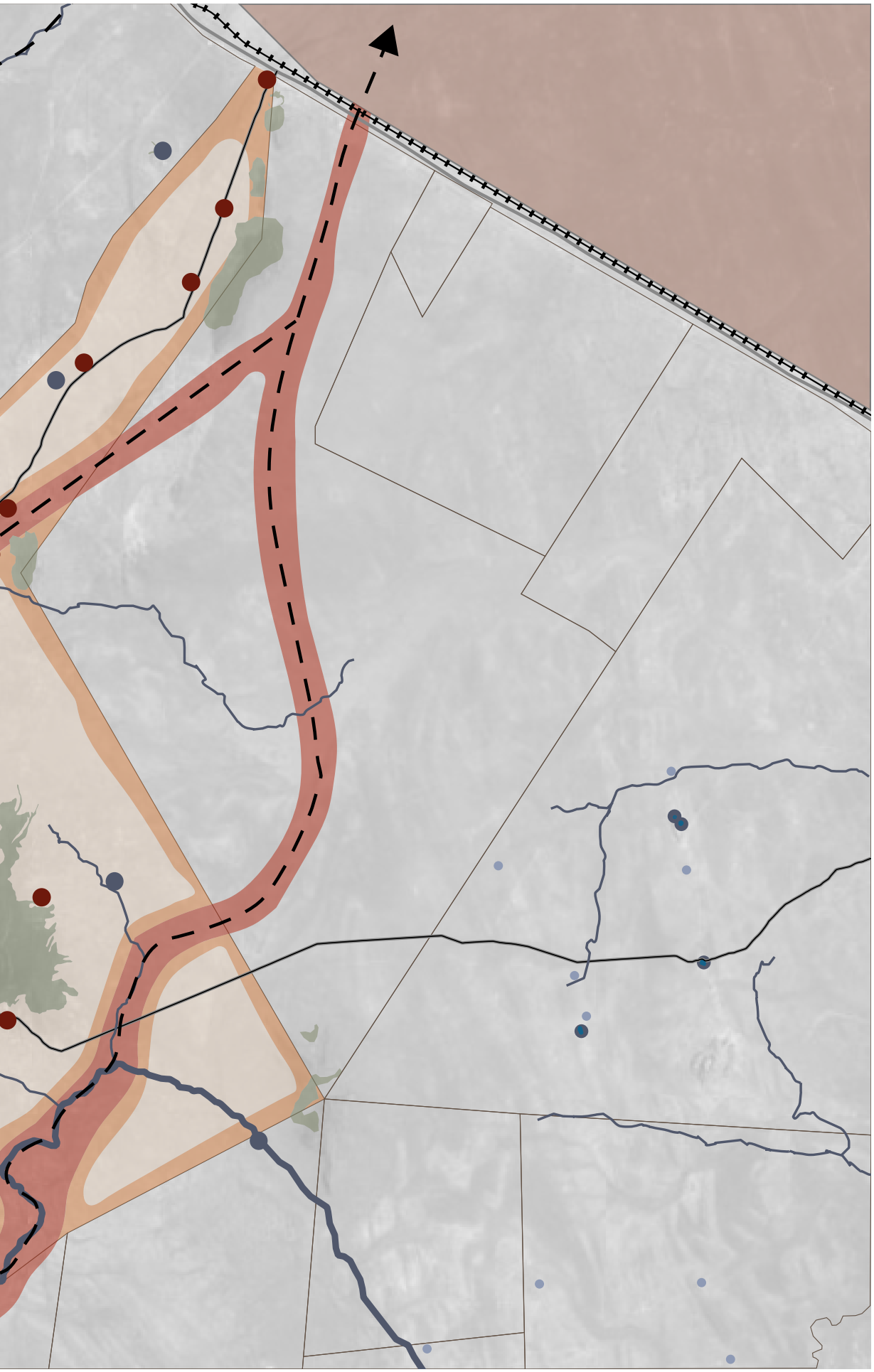


Figure 66: Design location divided into the three zones of the design strategy, made by author



6.3 Elephant corridor

The landscape along the historical elephant migration routes will be transformed into an elephant corridor. The design follows a funnel principle, guiding elephants from the national parks into designated corridors where they can migrate with limited contact with local inhabitants. This is achieved by creating an attractive corridor that provides everything elephants need, including food, shelter and water. To ensure sufficient space for habitat creation and elephant movement, the corridor should be approximately 2 km wide.

6.3.1 Design principles

To translate the strategy into a spatial design, several design principles have been established. These focus on the elements needed to create a suitable habitat for elephants.

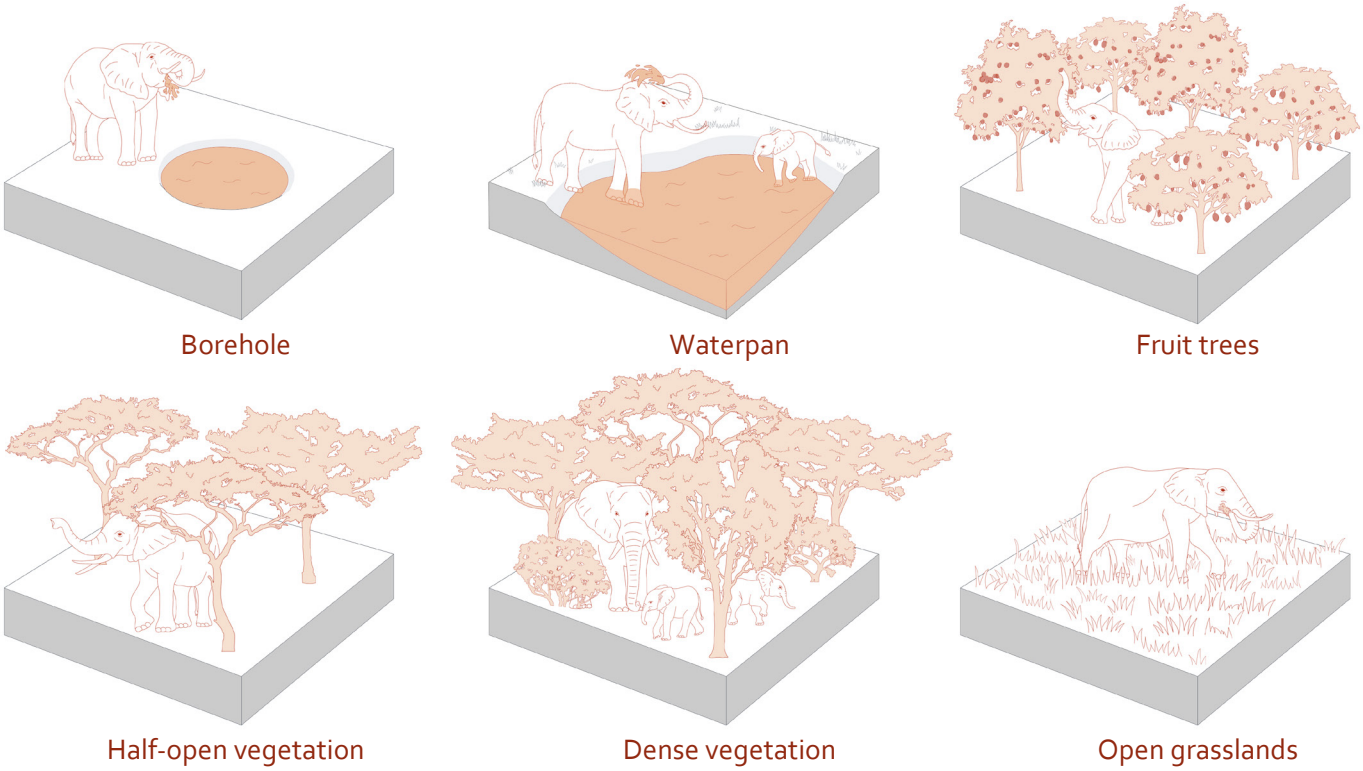


Figure 67: Design principles for the elephant corridor, made by author

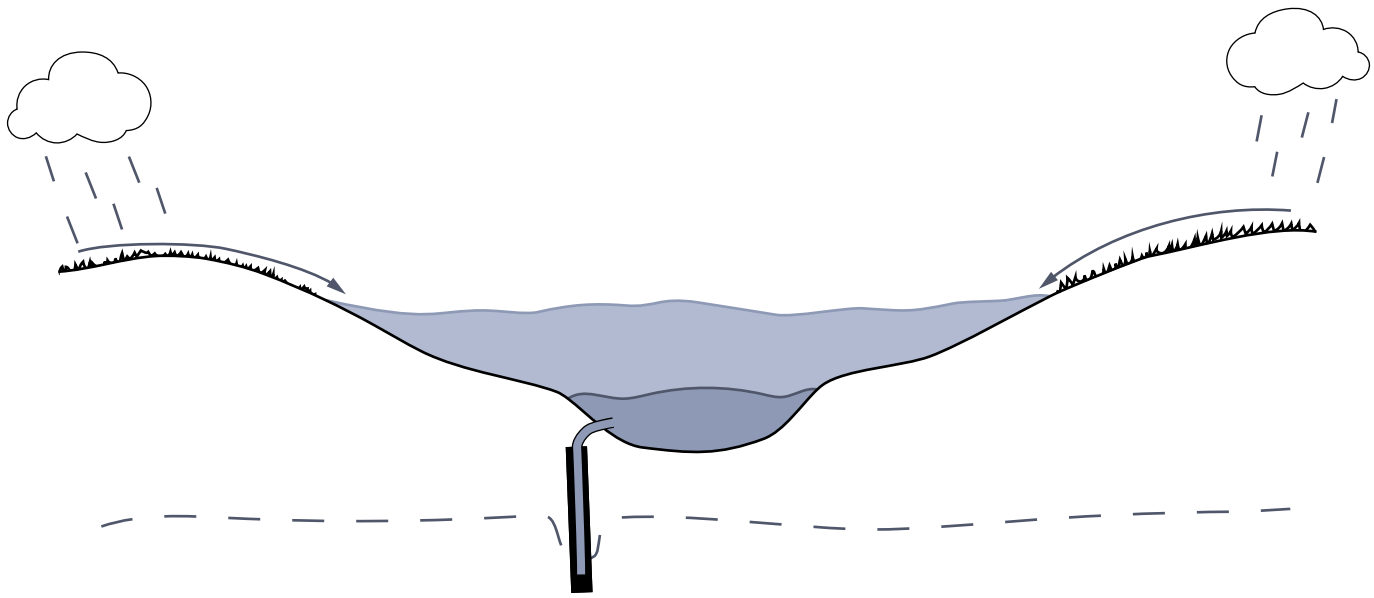
6.3.2 Water sources

Water availability has been shown to strongly influence elephant behaviour during the dry season. During this period, elephants move more purposefully towards water and may travel greater distances to reach it. To prevent elephants from wandering into settlements in search of water, sources within the corridor should be sufficiently close together and remain available throughout the dry season.

This can be achieved by ensuring that existing water pans function properly and do not dry up during the dry months. Additional water sources can be introduced where water pans are too far apart. A general guideline for the distance between water sources is 5–8 km.

When space is limited, as is the case along the elephant corridor that crosses the community lands, installing a borehole is the preferred solution. Where sufficient space is available, the proposed solution is a drinking pool that combines elements of a borehole and a conventional water pan. It is smaller than a typical water pan and does not rely entirely on groundwater, as it can also collect and store rainwater runoff. This provides a potential solution for supplying elephants with a more reliable water source in the Kasigau corridor while reducing pressure on groundwater resources.

To create the drinking pool, runoff from a small natural drainage valley or seasonal stream is directed towards the pool by shaping the surrounding terrain. Rainwater can then be collected and stored, allowing the pool to function similarly to a conventional water pan during the rainy season. If the collected rainwater is insufficient to meet demand throughout the dry season, a solar-powered pump can supplement the supply by pumping groundwater into the pool. A water-level sensor or float can regulate the pumping system, ensuring that water is replenished only when necessary.



Drinking pool

Figure 68: Drinking pool design proposal, made by author

6.3.3 Vegetation specifics

Foraging is one of the main activities in an elephant's daily routine, as elephants need to consume large quantities of vegetation. The corridor must therefore contain abundant food sources that remain available throughout the year, requiring careful selection of plant species. To make the corridor more attractive, preferred food sources, such as fruit-bearing trees, can also be planted.

In addition to providing food, trees and other vegetation are important for shelter. Elephants use both relatively open and denser vegetation to find shade and protection from the sun. The corridor should therefore contain a varied vegetation structure that provides both sufficient food and suitable shelter.



Sclerocarya birrea



Commiphora kua



Mangifera Indica



Carica papaya



Grewia bicolor



Opuntia ficus-indica



Vachellia nilotica



Senegalia mellifera



Portulacaria afra

Figure 69: Vegetation functioning as elephant food overview, made by author

Fruit Pods Twig

Foliage Bark Stem Grass



Balanites aegyptian



Syzygium cordatum



Tamarindus indica



Passiflora edulis



Vachellia abyssinica



Vachellia tortilis



Cenchrus ciliaris



Panicum maximum



Brachiaria brizantha

6.3.3 Vegetation specifics - fruiting calender

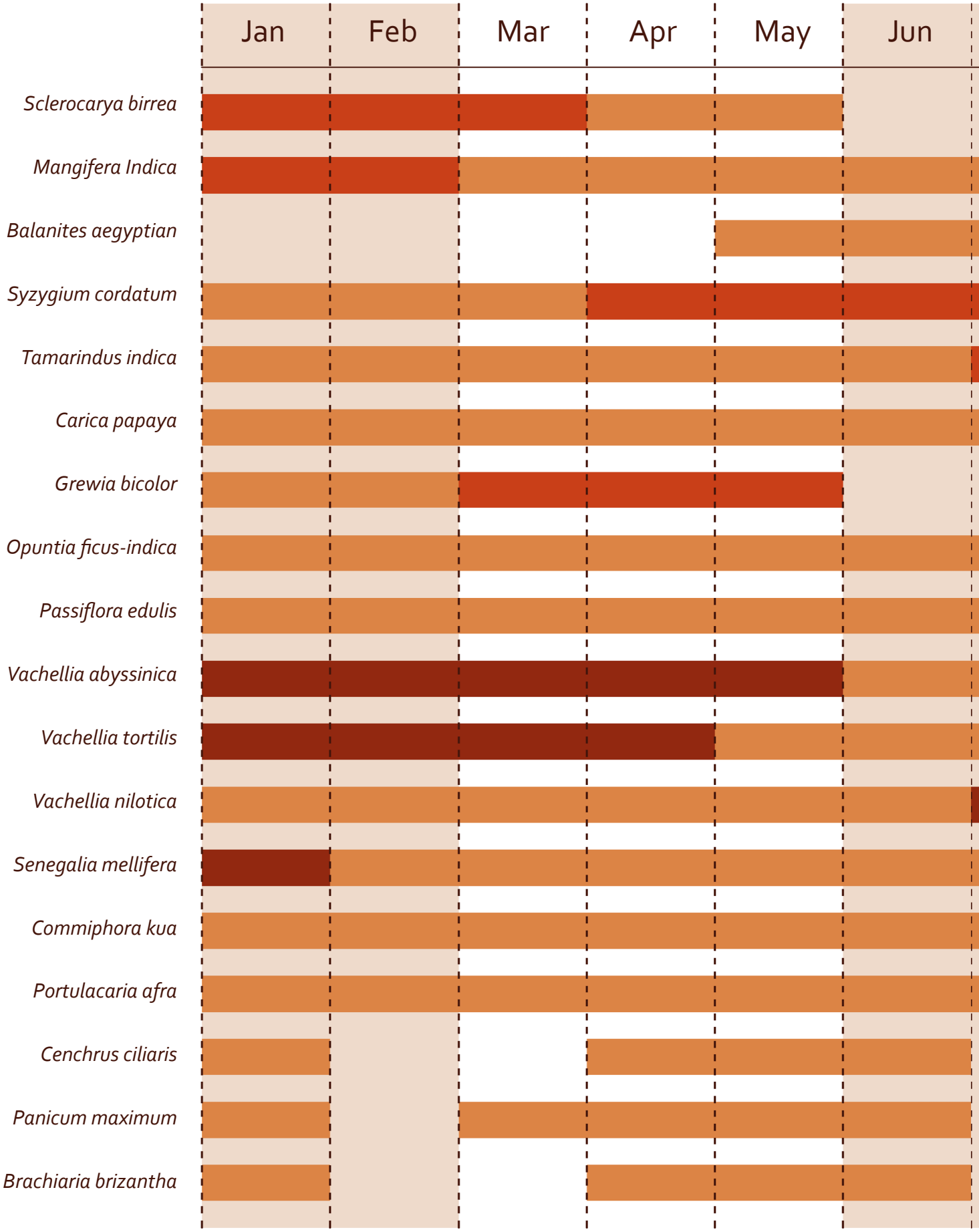
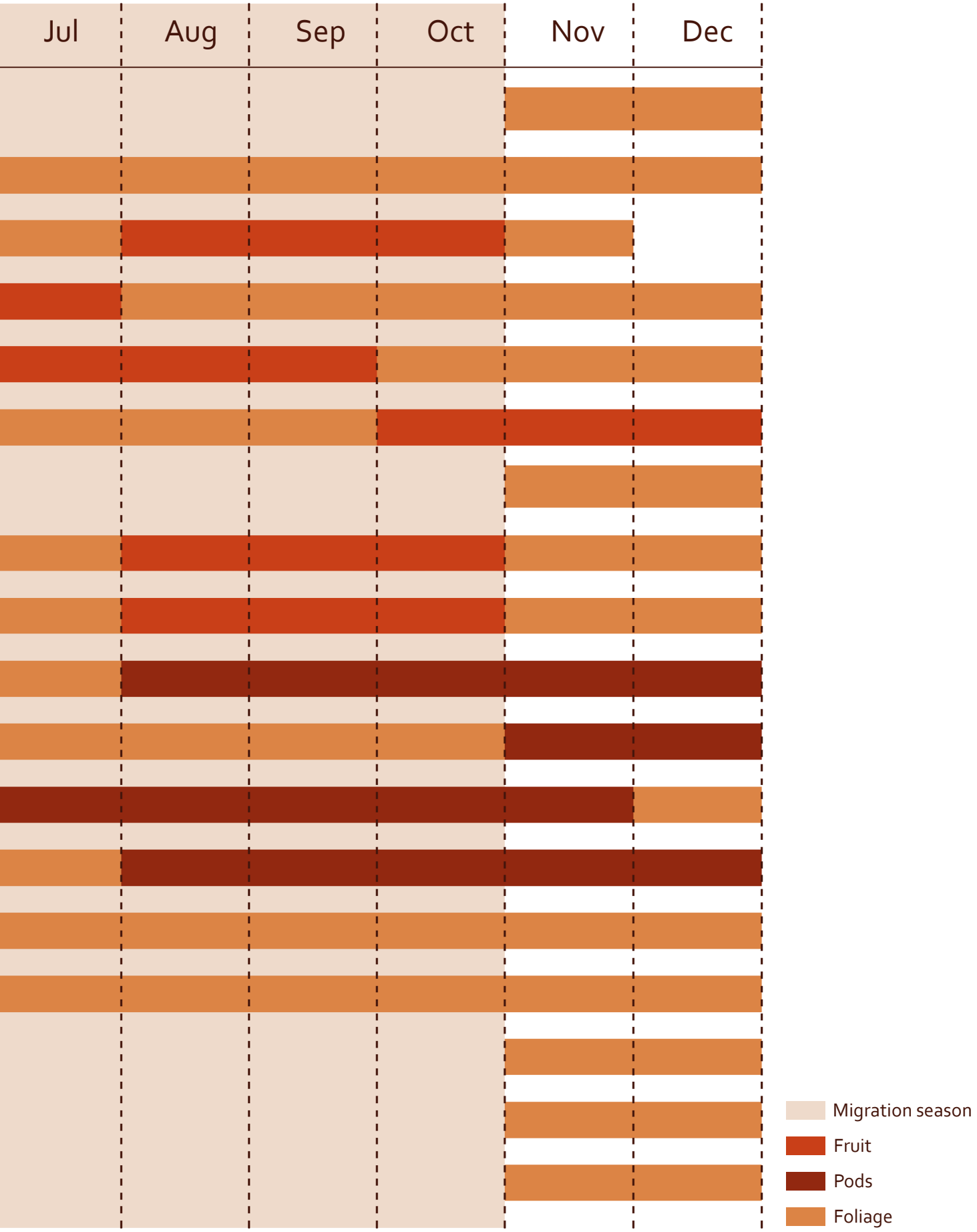


Figure 70: Fruiting calender, made by author


Jul
Aug
Sep
Oct
Nov
Dec
Migration season
Fruit
Pods
Foliage

6.3.4 Version 1 - Farmland transformed into an elephant corridor

Where historical migration routes cross farmland, it is particularly important to create an attractive corridor. Water sources should be placed closer together, and the corridor should contain an abundance of preferred vegetation to encourage elephants to remain within the designated route.

To generate an extra source of income, eco-tourism can be established.

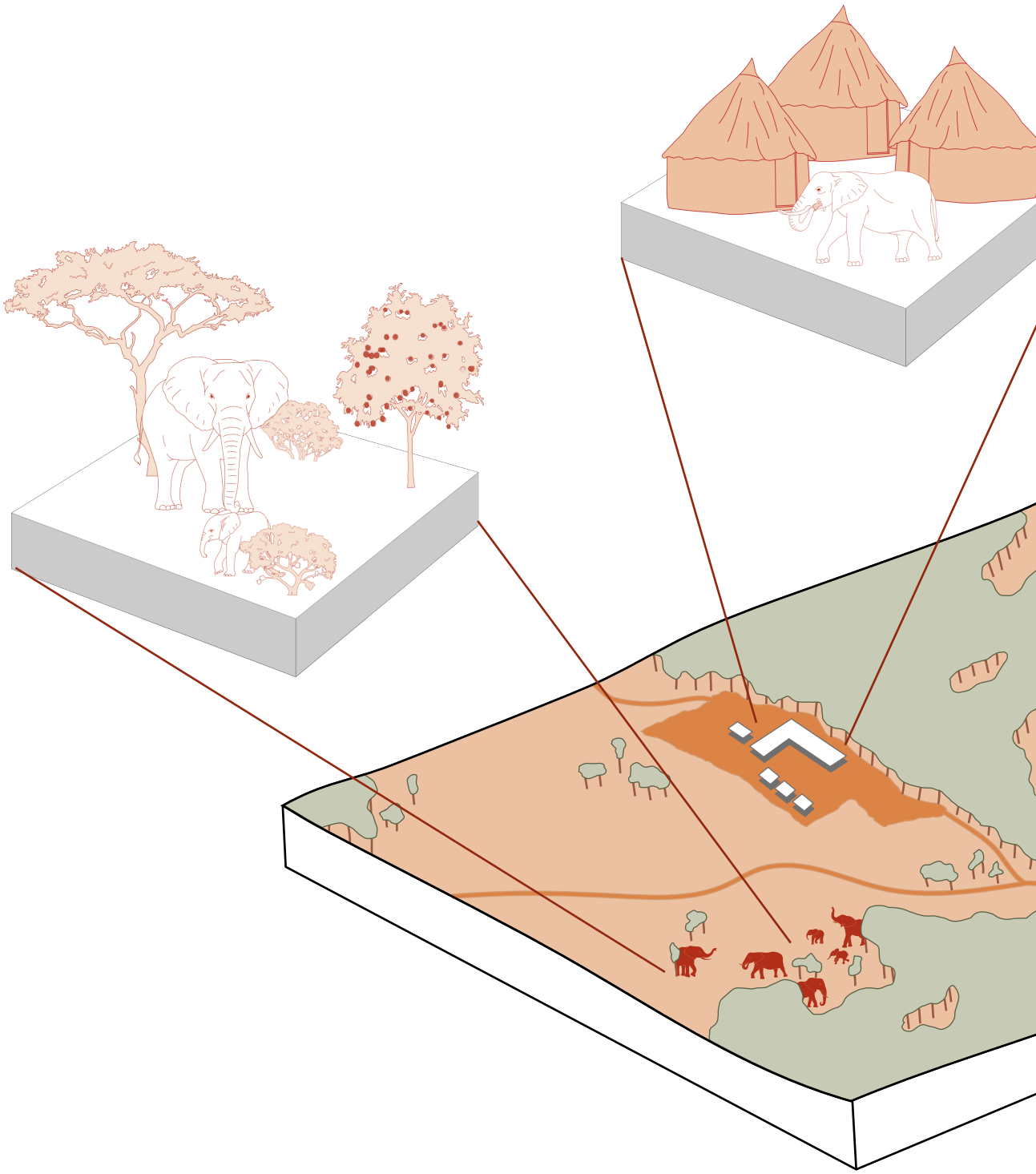
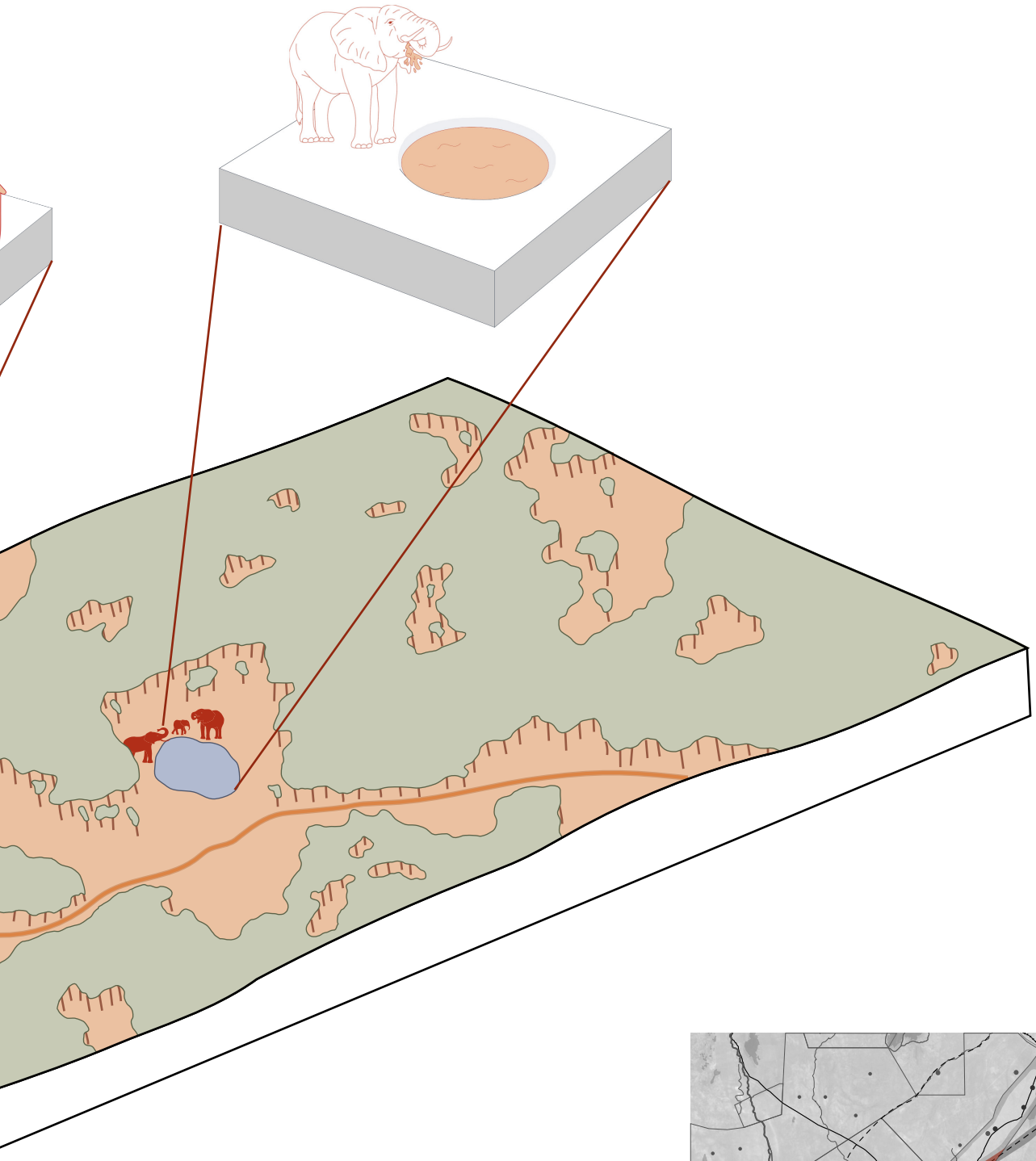
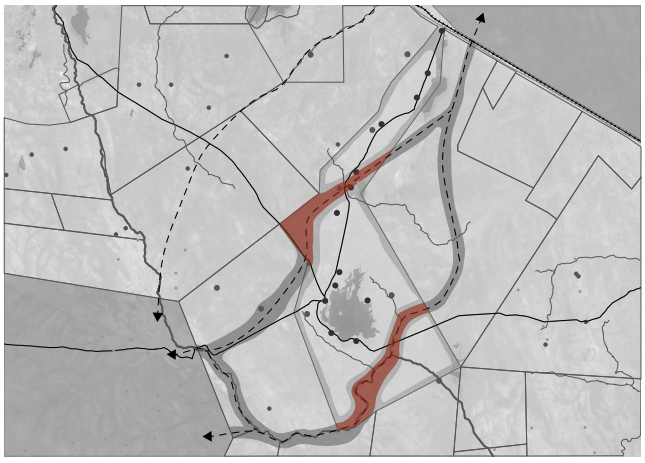


Figure 71: Design for elephant corridor that crosses the community lands, made by author





Options for farmers

To establish the corridor, farms located within the designated zone would need to undergo significant changes. It is understandable that not every farmer will want to relocate or change their livelihood. Therefore, several options are proposed to accommodate different preferences and circumstances.

1. Moving to a community hub

Farmers can relocate to a small plot of land within the surrounding community areas. Their income-generating activities would shift towards alternative livelihoods, supported by joining a CBO. These opportunities are described in Chapter 5.1.2 'Community based organisations', Alternative Livelihoods. This is the preferred option because it allows farmers to move away from farming within the corridor while remaining part of the local community and developing alternative sources of income.

2. Exchanging land

Farmers who do not want to give up farming can participate in a land-exchange scheme. They would relocate their farms to a ranch that has agreed to participate in the project, with funding provided to support the transition. The new location would be carefully selected based on soil suitability for agriculture, a lower risk of human–elephant conflict, connectivity to settlements and water availability. Farmers would be encouraged to cultivate drought-tolerant and elephant-compatible crops. These are discussed in Chapter 6.5 'Community Land'.

This option is particularly relevant because communities in Kasigau are already concerned about the limited amount of community land remaining. Some residents fear that giving up additional land could reduce their influence and control over the area. A land-exchange scheme could help address these concerns by allowing farmers to continue agricultural production elsewhere.

3. Ecotourism

Farmers who are willing to give up farming but do not want to relocate could participate in ecotourism. One possibility is to host tourists through homestays, allowing residents to generate income while remaining in their homes. A dedicated CBO would be established to coordinate and promote ecotourism activities. The organisation could also arrange activities such as safaris, although individual farmers could choose to host activities themselves.

4. Grazing

Farmers who do not want to relocate or give up their land could convert their plots into areas of denser vegetation for livestock grazing. Although livestock are less compatible with the intended corridor than a landscape managed primarily for wildlife, additional vegetation could contribute to ecological restoration and help address drought-related challenges.

Farmers would be strongly encouraged to use elephant-friendly fencing, as explained in Chapter 5.1.3 'Creating protection', to avoid creating barriers to elephant movement and further fragmenting the landscape. They could apply for a small fund to purchase seedlings and construct suitable fences.

5. Continued farming

The final and least-preferred option is to allow farmers to continue farming within the designated corridor. For their own safety and to reduce crop losses, they would be encouraged to cultivate crops that deter elephants or are compatible with elephant presence. Support would be limited to elephant-friendly measures, and farmers could apply for a small fund to purchase seeds and construct suitable fences.

Regardless of which option farmers choose, they can decide whether to sell or lease the parts of their farmland that will be converted into the corridor. Leasing would preferably involve a long-term contract of approximately ten years. At the end of this period, farmers could choose whether to sell their land or continue leasing it. This arrangement would provide a more stable source of income and give farmers greater security and motivation to participate in the project. They could also choose to lease or sell additional land during the contract period.

Farmers would not be responsible for converting their land themselves. Instead, a dedicated organisation would oversee the establishment and development of the corridor. This should be a new organisation that would need to be established as part of the project.

It is expected that only a small number of farmers may initially be willing to relocate or change their livelihoods. However, participation could increase over time if the available alternatives are properly supported and demonstrate clear benefits. Farmers living along historical migration routes currently experience repeated crop-raiding incidents, which can undermine their livelihood security. This may make alternative arrangements more attractive if they offer a realistic opportunity to reduce these losses.

Participation in the project would always be voluntary. Farmers would only make changes if they chose an option that suited their circumstances. Providing sufficient information and education is therefore essential. Residents need to understand the project's purpose, its intended outcomes and the process of implementation. Transparency about the different options, their implications and the importance of community participation is equally important.

It is inevitable that some farmers will choose not to participate. However, the project could still proceed and reduce human–elephant conflict in the areas where the corridor is established. The organisation cannot control the risks faced by farmers who choose to remain outside the project and continue farming along elephant migration routes. Over time, however, successful implementation and positive experiences among participating farmers may encourage others to reconsider their decisions.



Figure 72: Options for farmers living in the corridor zone, made by author

6.3.5 Version 2 - Ranch transformed into an elephant corridor

Where the corridor passes through ranches, more space is generally available for elephants to move freely. Consequently, water sources and preferred vegetation do not need to be as concentrated as in sections passing through farmland. The main priority in these areas is to remove barriers to movement, particularly fences that divide the landscape, and minimise disturbance caused by livestock.

The long-term vision is to transform all ranches within the designated area into wildlife conservancies. This would be an important step towards restoring a healthy savannah ecosystem and maintaining connectivity between the national parks. Grazing could still take place within these conservancies, but it would be restricted to designated areas where livestock numbers are carefully managed. This would allow livestock keeping and wildlife conservation to coexist while reducing disturbance and pressure on natural vegetation.

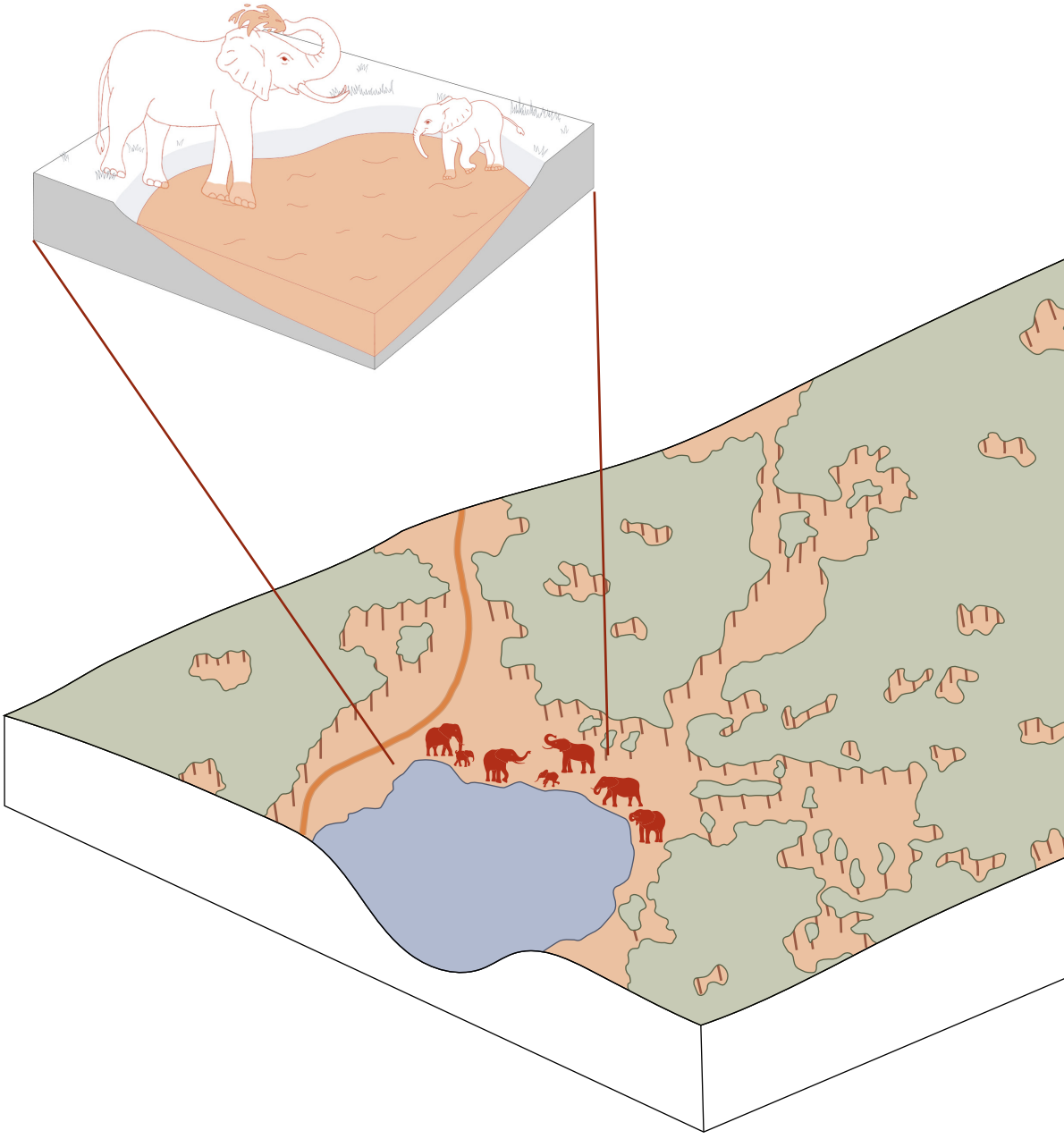
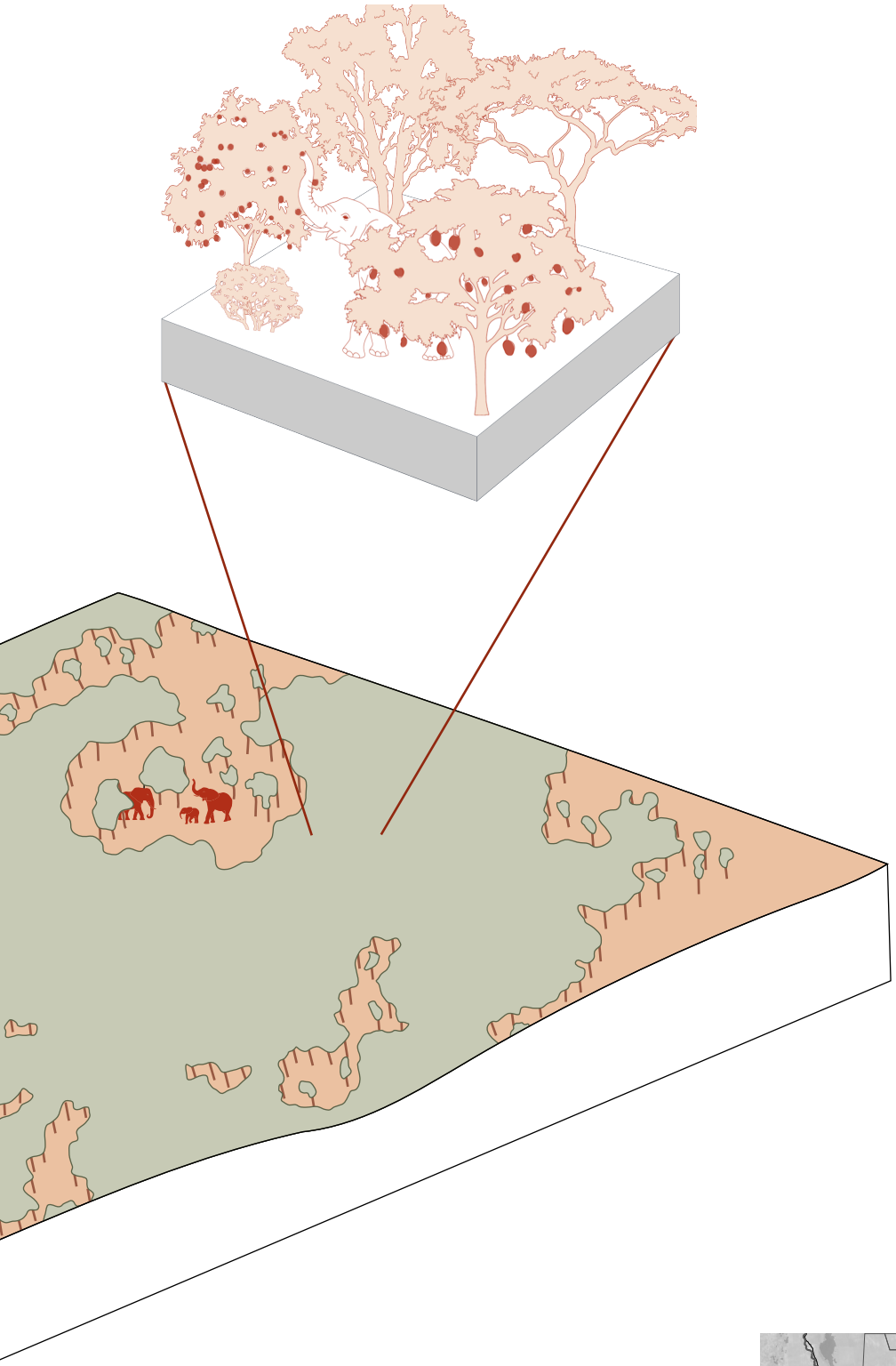
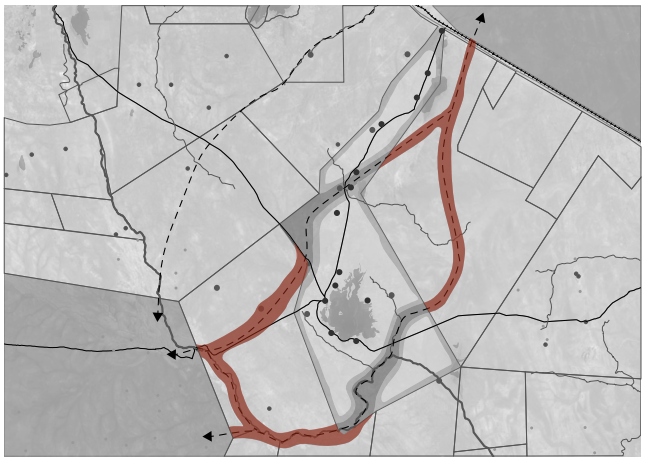


Figure 73: Design for elephant corridor that crosses ranches, made by author





6.4 Buffer

Another way to prevent elephants from entering human settlements is to create a boundary that strongly discourages them from moving through it. This can be achieved by growing crops that deter elephants. The buffer zone should be approximately 1–1.5 km wide and run along the boundaries between the elephant corridor and community land. Its width depends on the proximity of human settlements: the closer the settlements are, the wider the buffer zone should be. The zone does not use fences to block elephant movement, but instead relies on natural barriers created by vegetation.

6.4.1 Design principles

There are three main reasons why elephants may avoid certain plants:

- Touch: Plants with large, stiff, or sharp leaves can cause discomfort or injury to elephants. To make this barrier as effective as possible, these plants should be planted densely with as few gaps as possible.
- Smell: Elephants have a highly developed sense of smell and may avoid plants whose scent they find unpleasant.
- Taste: Some plant species are unpalatable or toxic to elephants. Elephants can often recognise and avoid these plants through their senses of smell and sight while foraging.

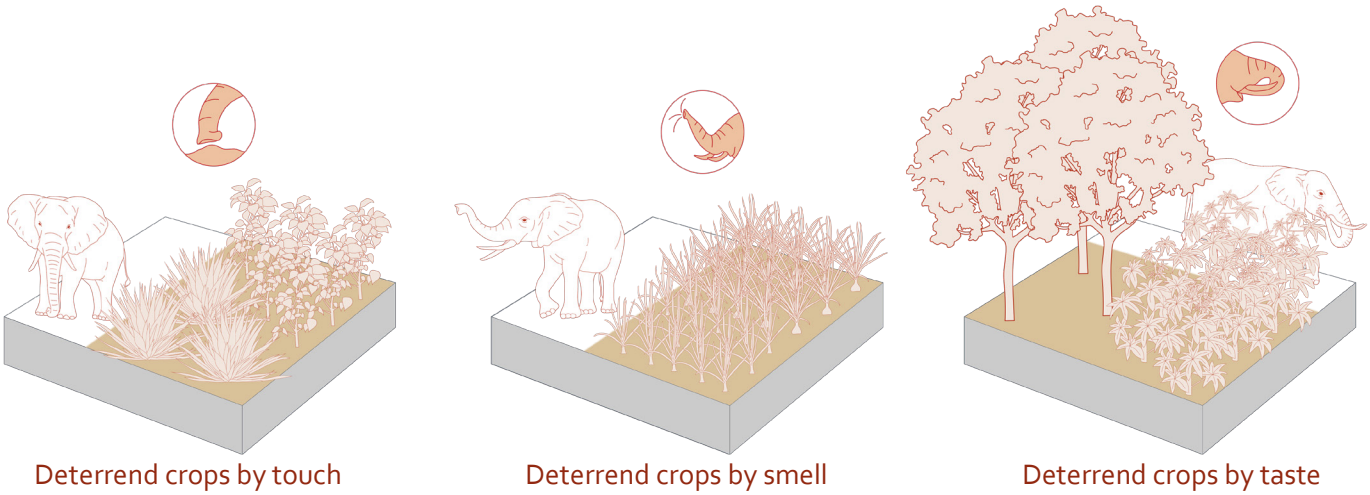


Figure 74: Design principles for the buffer zone, made by author

Three natural barriers

To maximise the effectiveness of the deterrent boundary, the buffer zone is divided into three natural barriers, arranged in the following sequence. Closest to the elephant corridor, unpalatable crops are planted. Further out, rows of crops that deter elephants through physical discomfort are established. Closest to the community lands, crops with an unpleasant smell are planted.

This sequence is intended to discourage elephants from entering the farmland at different stages. First, elephants encounter plants they dislike eating while foraging near the corridor boundary. This discourages them from moving further into the farmland. They are discouraged even more by the smell of unpleasant crops planted further away, as this signals that there is nothing attractive for them ahead. Ideally, the elephants will decide to turn back towards the corridor, where more tasty vegetation grows. If elephants do pass through the first natural barrier, the physical discomfort caused by the next layer of plants may discourage them from proceeding further. The effect is strengthened by the unpleasant-smelling crops ahead, making it less worthwhile for elephants to continue through the buffer zone and risk discomfort.

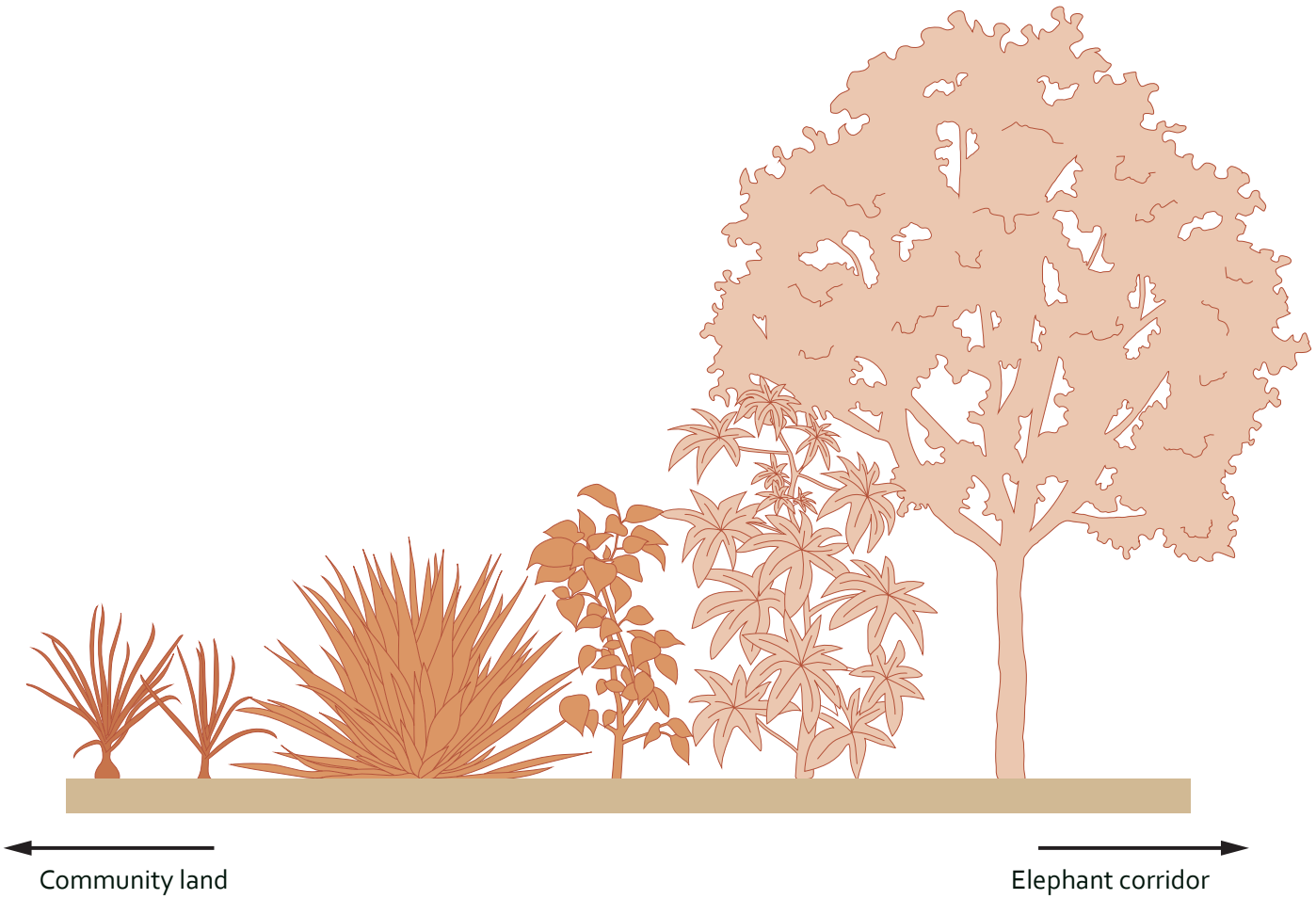


Figure 75: The three natural barriers, made by author

6.4.2 Crop specifications

The selected crops can also provide an additional source of income for farmers. Edible crops can be sold at local markets, while non-edible crops can serve as raw materials for products made by local CBOs. Establishing reliable markets for these products could provide farmers with a more secure and stable income while helping to reduce HEC.

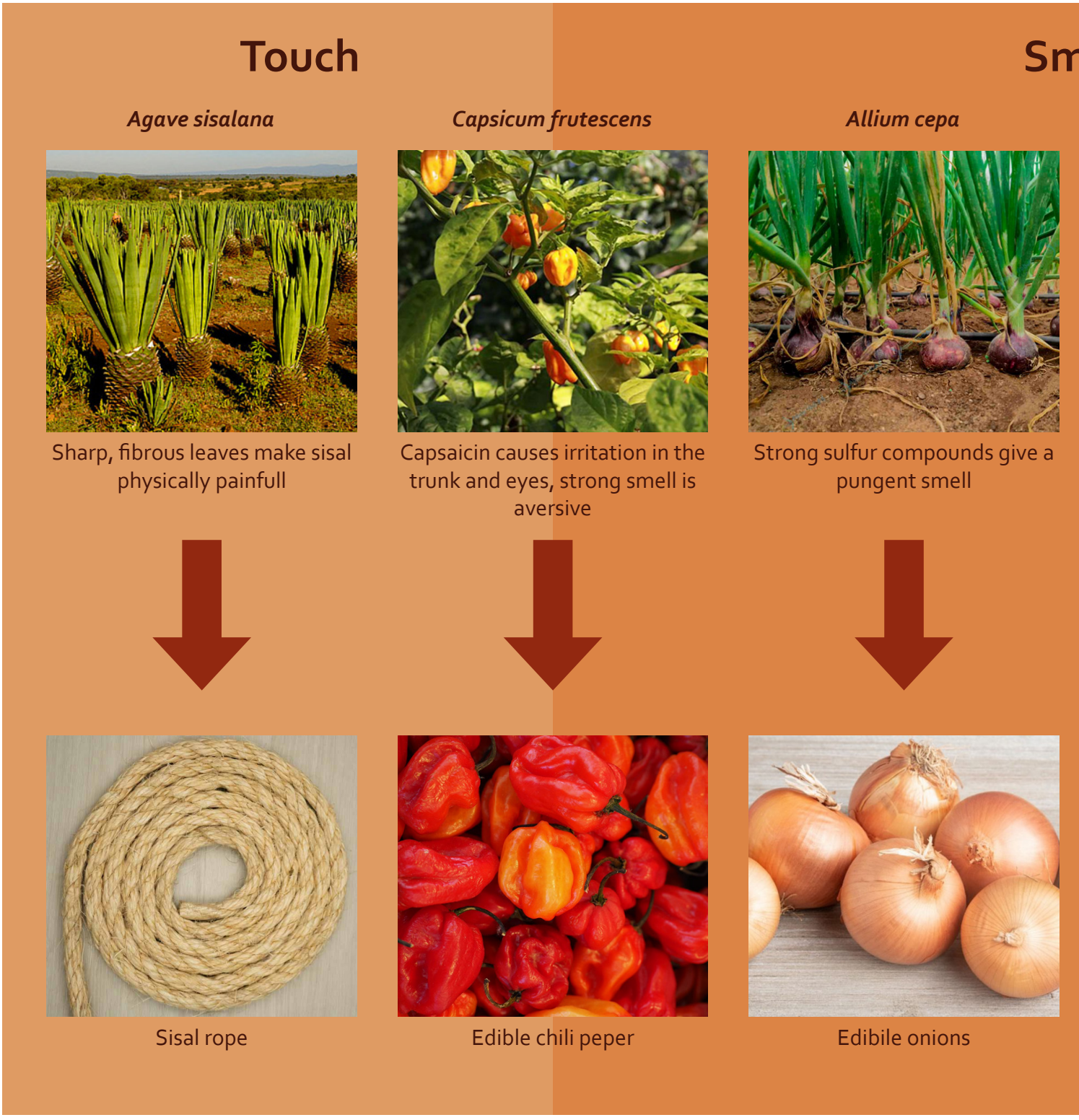


Figure 76: Elephant deterrent crops and its products, image by author

nell

Allium sativum



Strong sulfur compounds give a pungent smell



Edible garlic

Taste

Azadirachta indica



Bitter, aromatic leaves



Medicinal leaves, oil and bark

Ricinus communis



Leaves have an upleasant taste and seeds are toxic



Castor oil

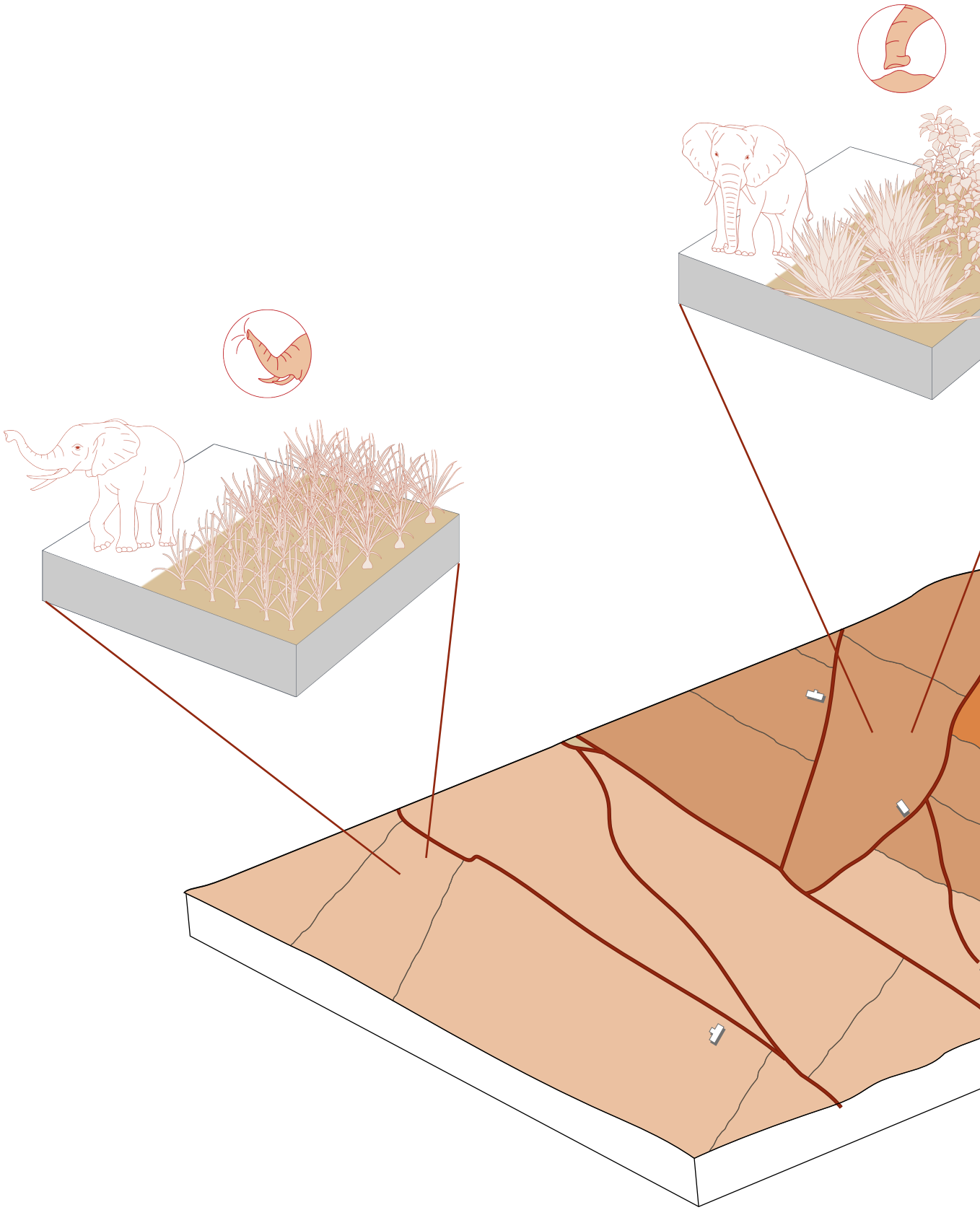
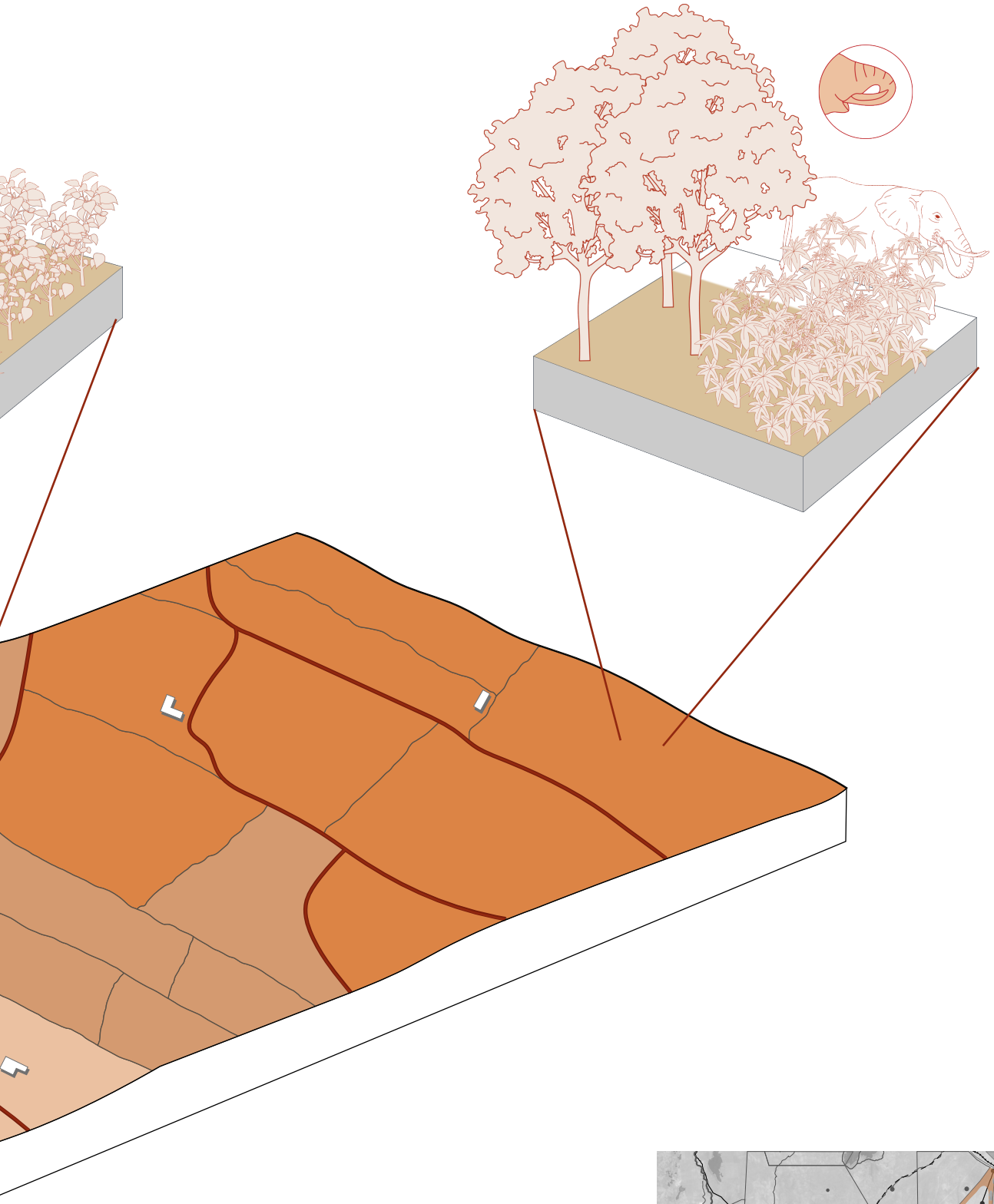


Figure 77: Design for the buffer zone, made by author





6.5 Community land

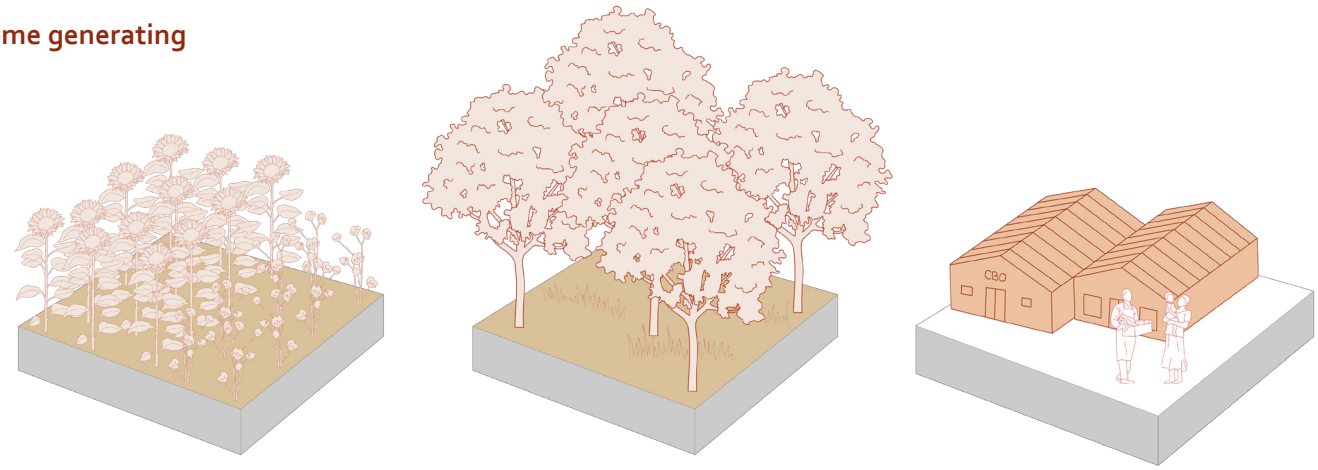
This area focuses entirely on reducing the impact of elephants when they enter community land. The community lands consist mainly of farmland, with multiple villages spread throughout the area

The design principles can be divided into two categories: income generating and inhabitants' needs. Income-generating crops and initiatives can be widespread throughout the area, while the production of resources needed for local livelihoods will be reduced to the minimum required to sustain the Kasigau region.

6.5.1 Design principles

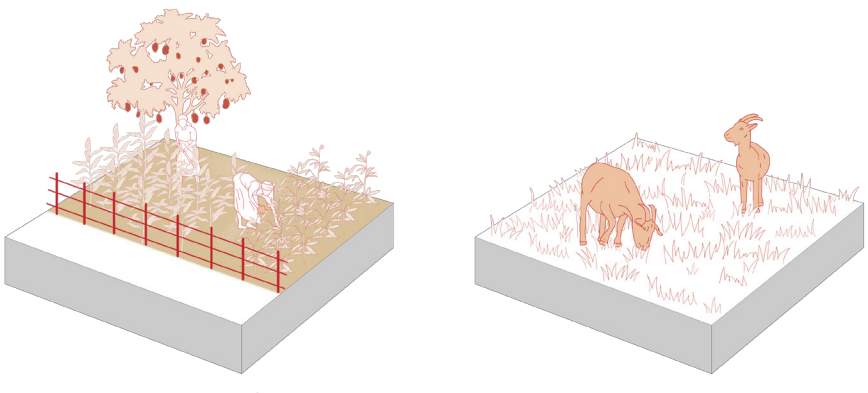
The goal in this area is to maintain the existing structure as much as possible. Farming is the main source of income for the inhabitants. However, to reduce conflict with elephants, farmers will be encouraged to switch to elephant-compatible farming practices. This means that most cultivated crops will be species that elephants dislike. Another important criteria is that the crops should be drought-resistant. CBOs can establish enterprises that create additional income opportunities and use the products from these new cash crops. To prevent inhabitants from becoming dependent on food brought in from elsewhere, existing edible crops and livestock can still be raised, but their production will be limited to the amount needed to feed the communities and ecotourists. Strict measures will be taken to prevent elephants from raiding crops.

Income generating



Non-palatable crops | Agroforestry | CBO building

Inhabitants needs



Community farm | Livestock

Figure 78: Design principles for the community lands, made by author

6.5.2 Water sources

To reduce water stress in community areas, several measures will be taken. First, existing water pans will be restored and improved to ensure that they remain functional and retain water throughout the dry season. How this can be achieved is explained in Chapter 5.2.1 'Water for inhabitants'.

Existing water tanks will be made elephant-proof, as explained in 5.1.3 'Creating protection'. This will prevent elephants from accessing and damaging the tanks, while reducing the likelihood of elephants being attracted to water sources near human settlements.

Rainwater harvesting at individual households will also be strongly encouraged. The collected rainwater will make households less dependent on other water sources. Funding and increased income will be key factors in making this possible.

Finally, drought-resistant crops require less water, reducing water stress when these crops are cultivated on a large scale.

6.5.3 Version 1 - Cash crops farming

Farmers will be provided with seeds to grow new types of crops. They can choose which crops they want to cultivate, but site-specific recommendations will be made based on factors such as soil type and condition. For example, deep-rooted crops can help access water and nutrients deeper in the soil, particularly in areas with poor soils. The crops cultivated by surrounding farmers will also be taken into account.

To improve harvests, farmers will receive education on how to cultivate and manage their new crops. Crop rotation will also be encouraged, as rotating crops can help maintain soil fertility for future harvests. In addition, farmers will be advised to avoid planting crops from the same family in the same field to reduce the risk of spreading diseases.



Helianthus annuus



Simmondsia chinens



Sunflower oil and seeds



Jojoba oil



Sesamum indicum L.



Citrus limon



Sesame seeds



Lemons

Figure 79: Elephant compatible crops and its products, made



Gossypium hirsutum



Panicum miliaceum



Moringa oleifera



Melia volkensii



Cotton



Craft beer



Medicinal leaves and bark



Timber



Punica granatum



Manihot esculenta



Cajanus cajan



Adansonia digitata



Pomgrenate fruit



Cassava



Pigeon peas



Boabab fruit

e by author

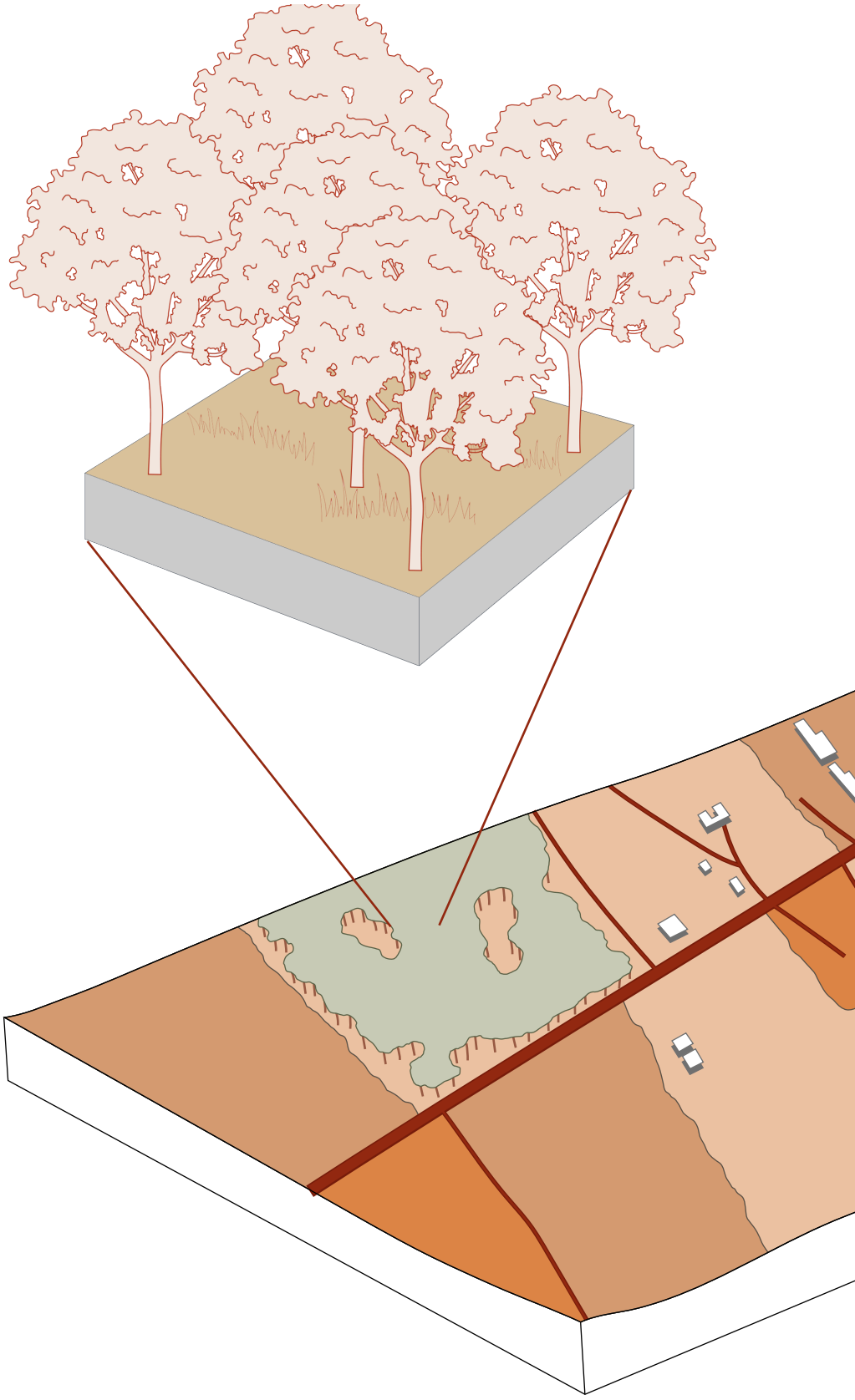
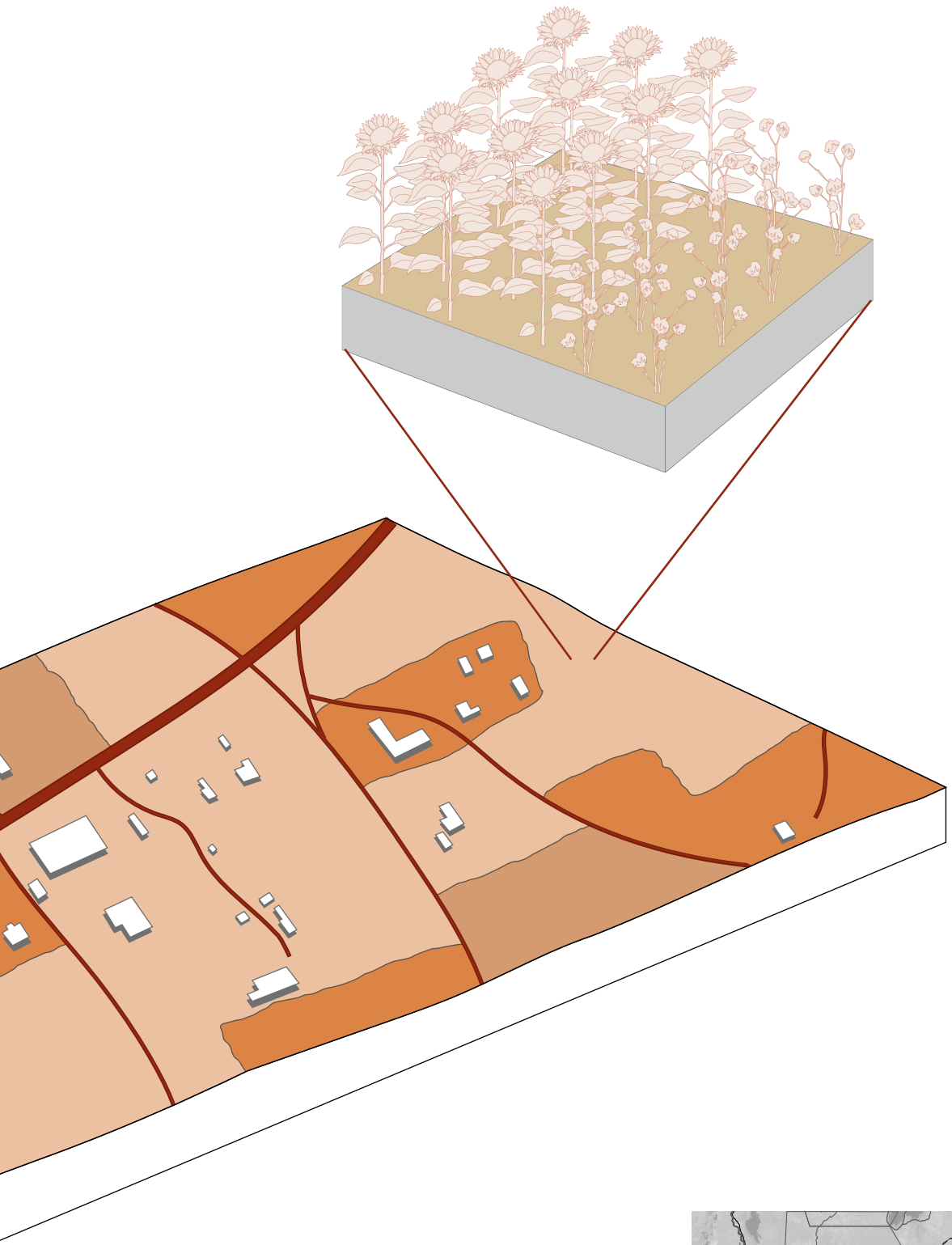
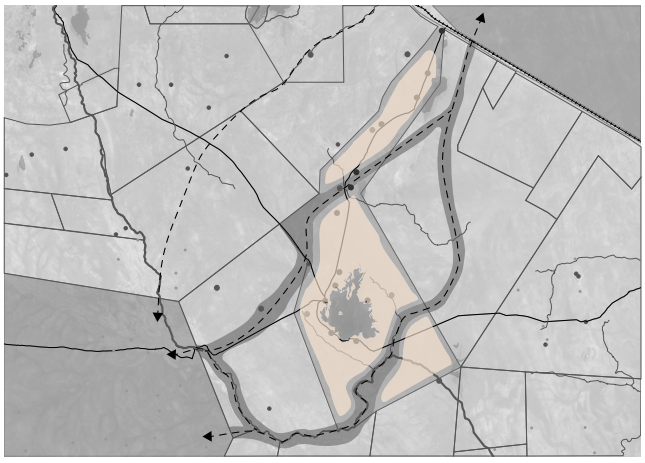


Figure 80: Design for farms with elephant compatible crops, made by author





6.5.4 Version 2 - Community farms

There are 12 villages in the Kasigau region. Each village will have its own community farm, where crops will be grown to ensure that every household has access to sufficient food. These crops will be cultivated in a concentrated area close to the village. A CBO will oversee the farms to ensure that the harvest is distributed equally among the community members. The farms will grow crops traditionally cultivated in the region, with a particular focus on drought-resistant species. Livestock can also be kept in limited numbers. Small grazing areas will remain throughout the region, but livestock will mainly be fed using other resources, such as sunflower stalks.

To protect the high risk crops, fences will be installed. Initially, these will be solar-powered electric fences. Although electric fences are not particularly elephant-friendly, they are considered the most effective way to keep elephants out of cultivated areas. Firm boundaries are important during the initial stages, when elephants are still likely to roam through the area. Changing their behaviour will take time. After a few years, when elephant sightings in the settlements have decreased, the electric fences can gradually be replaced with softer, more elephant-friendly alternatives.

The villages and community farms will also be preferred locations for CBOs to produce their products, as these locations are accessible to most inhabitants.

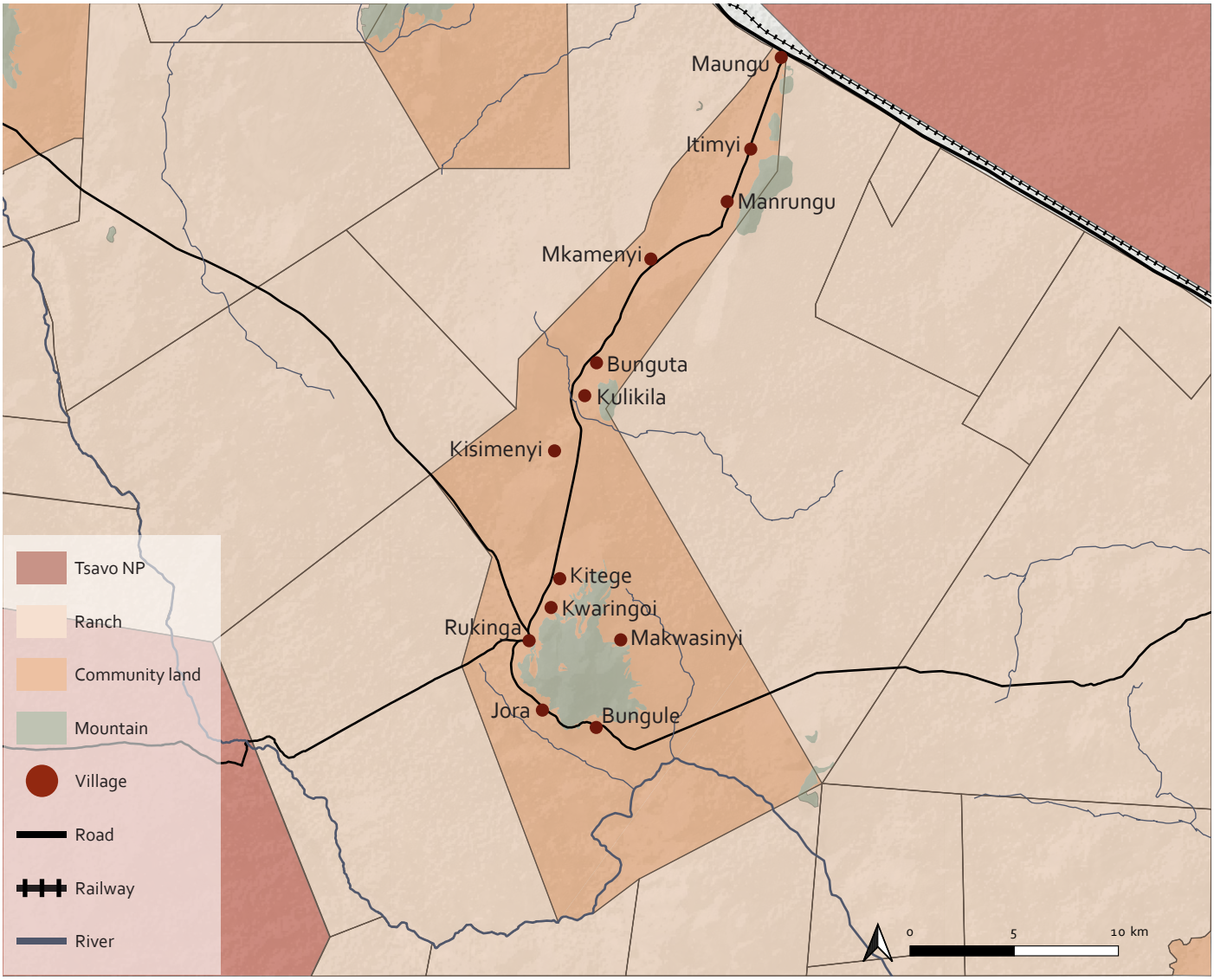


Figure 81: Villages and communities of the Kasigau region, made by author



Sclerocarya birrea



Vigna radiata



Mangifera Indica



Carica papaya



Annona reticulata



Sorghum bicolor



Eleusine coracana

Figure 82: Drought-resistant crops suitable for the community farms, made by author

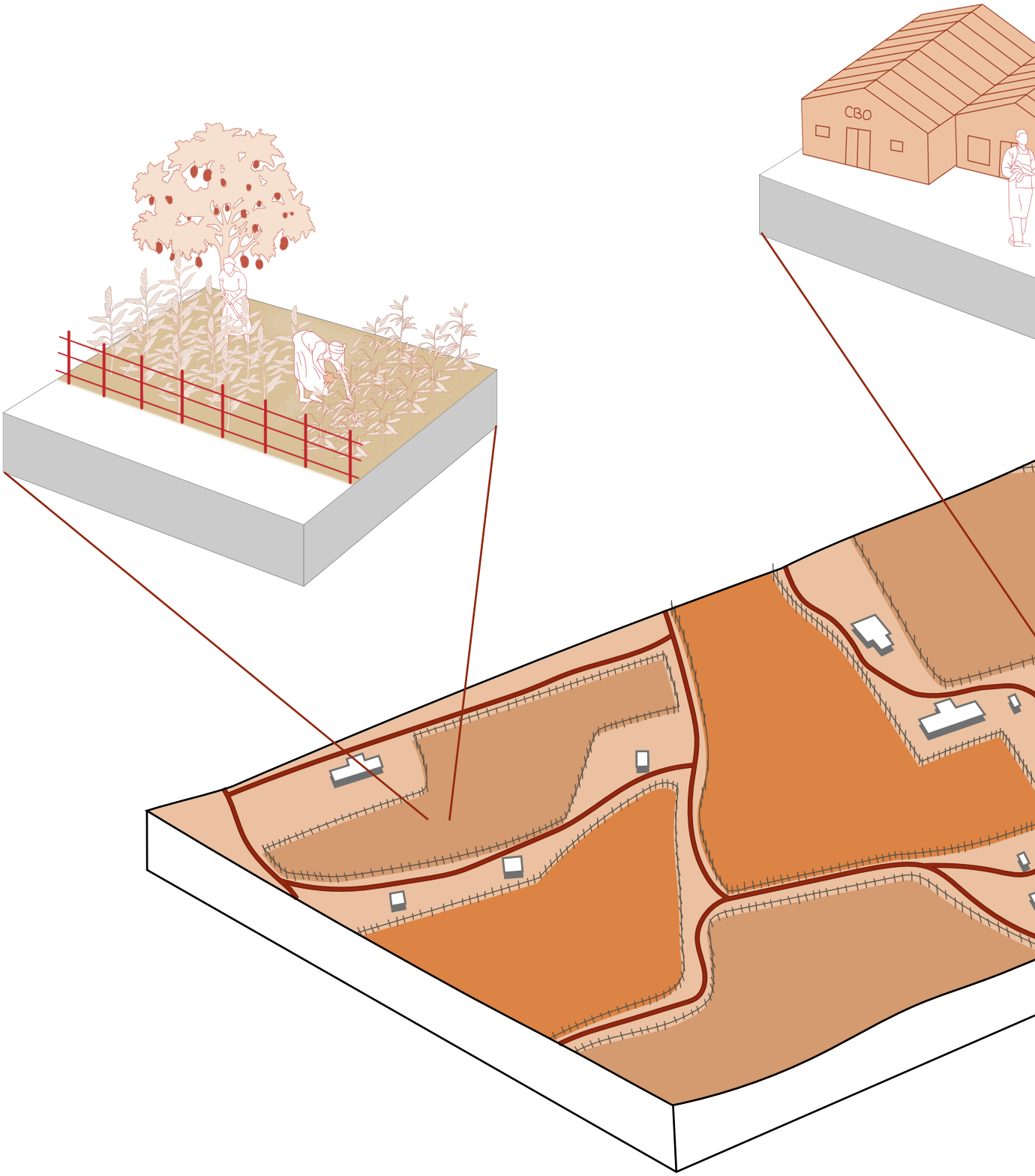
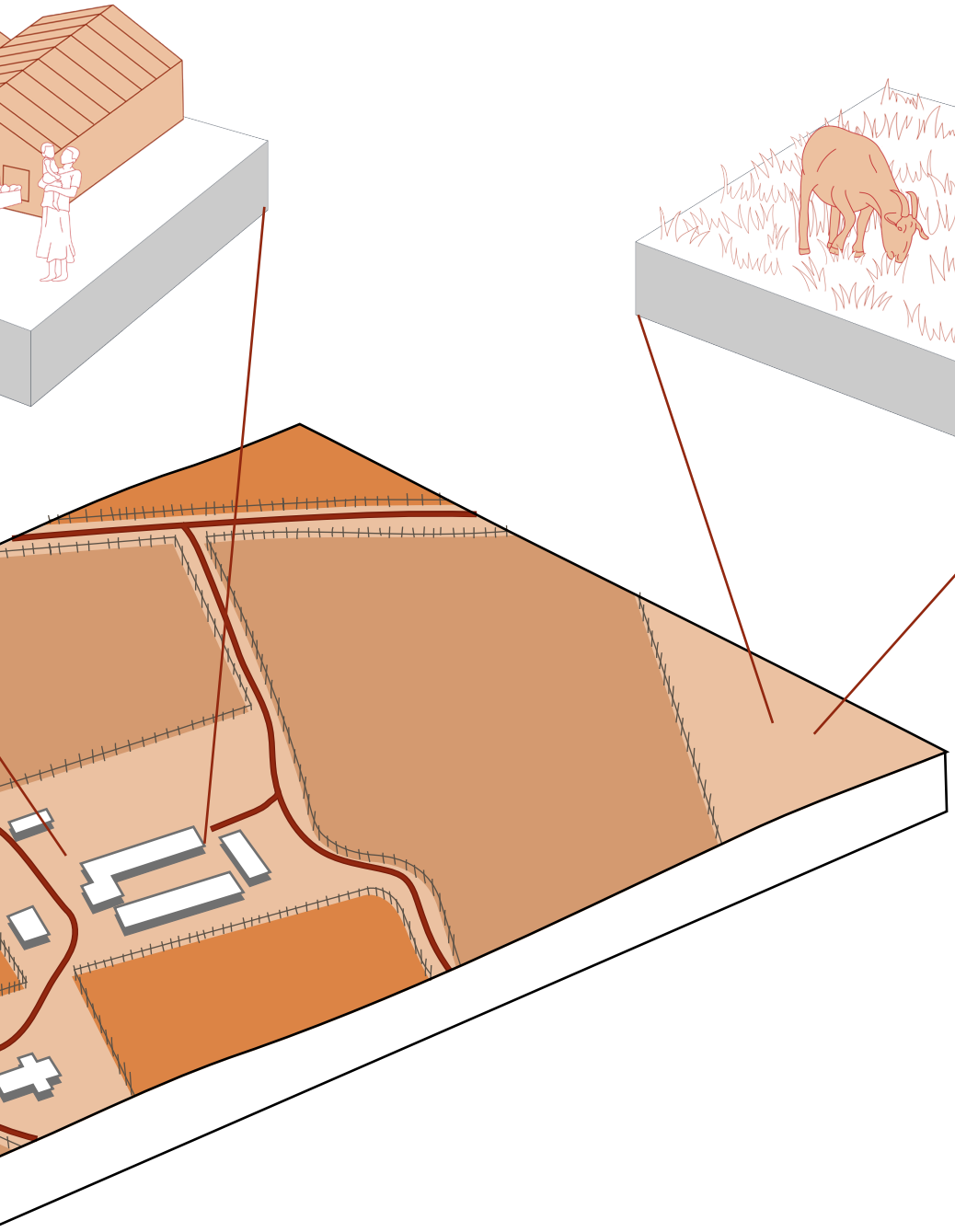
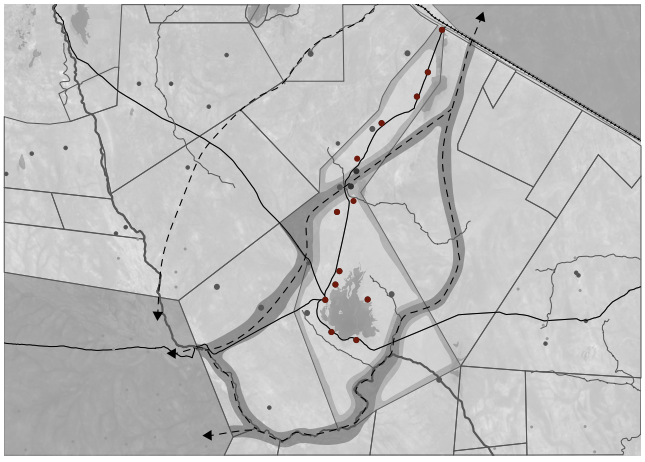


Figure 83: Design for the community farm, made by author



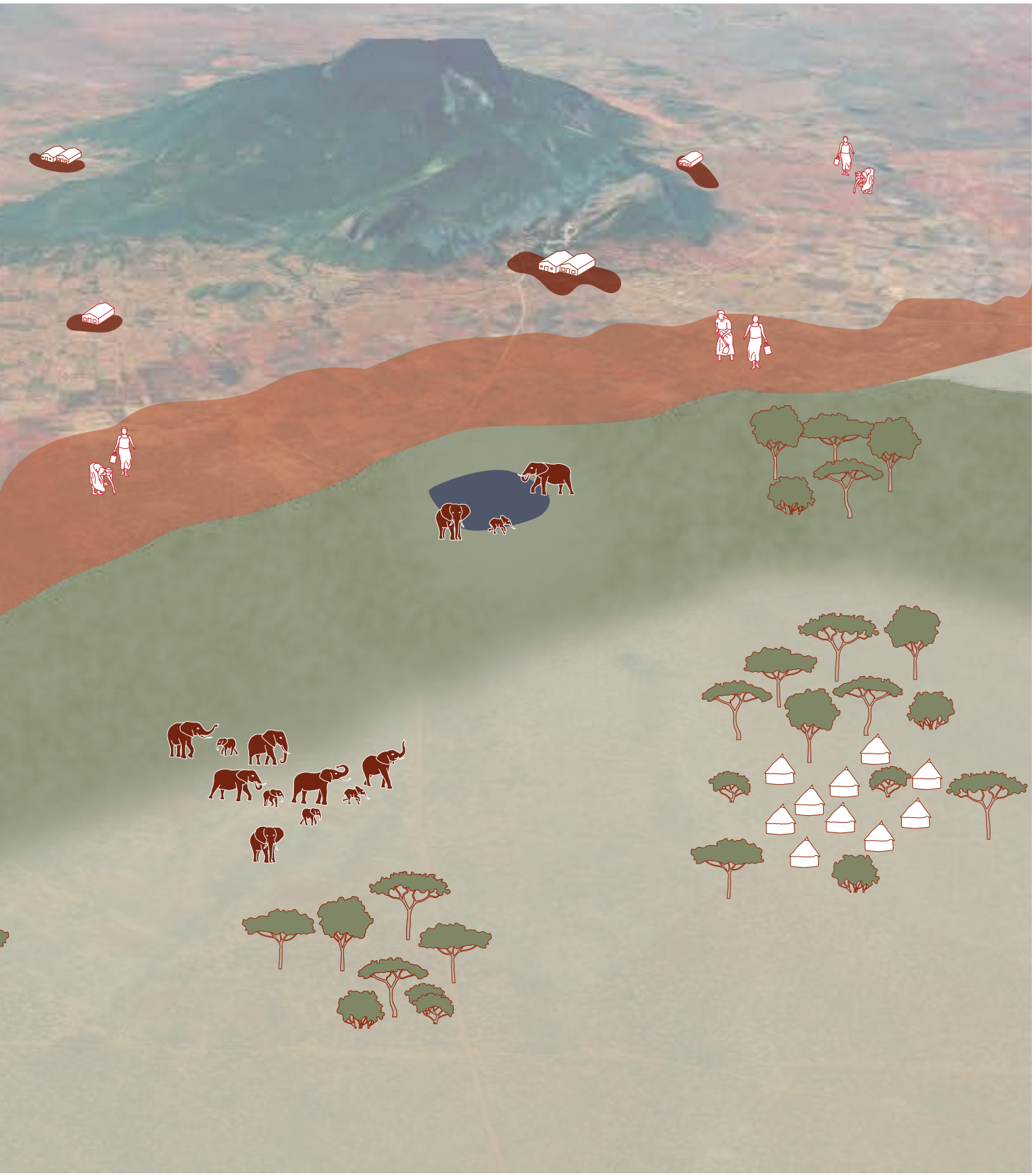


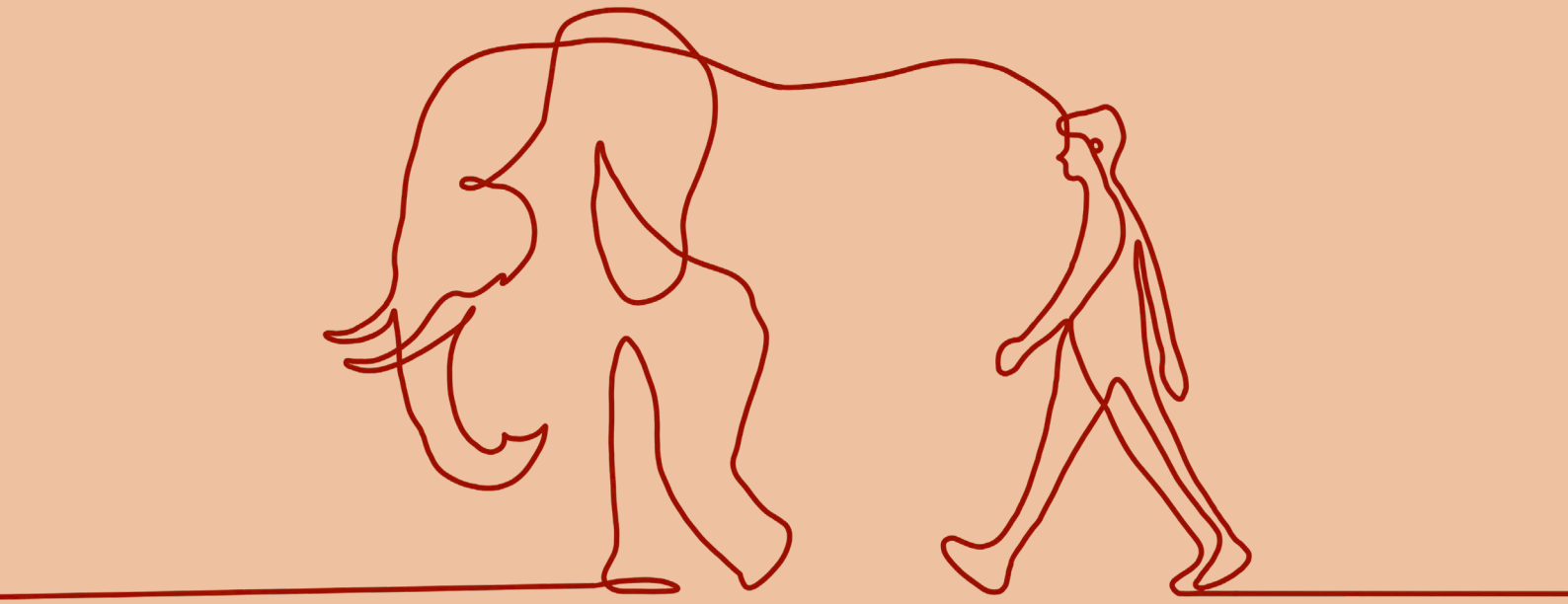
6.6 Proposed design

By combining the three zones the area will transform where not only an elephant corridor that simply protects land for elephants, but the whole area is a framework where the interventions supports a more resilient landscape, in which local livelihood and wildlife conservation can co-exist.



Figure 84: Concept master plan of the design area, made by author





PART IV
IMPLEMENTATIONS

7

Design implementations

7.1 Design site 1: Elephant corridor
7.2 Design site 1: Community farm
7.3 Co-exist

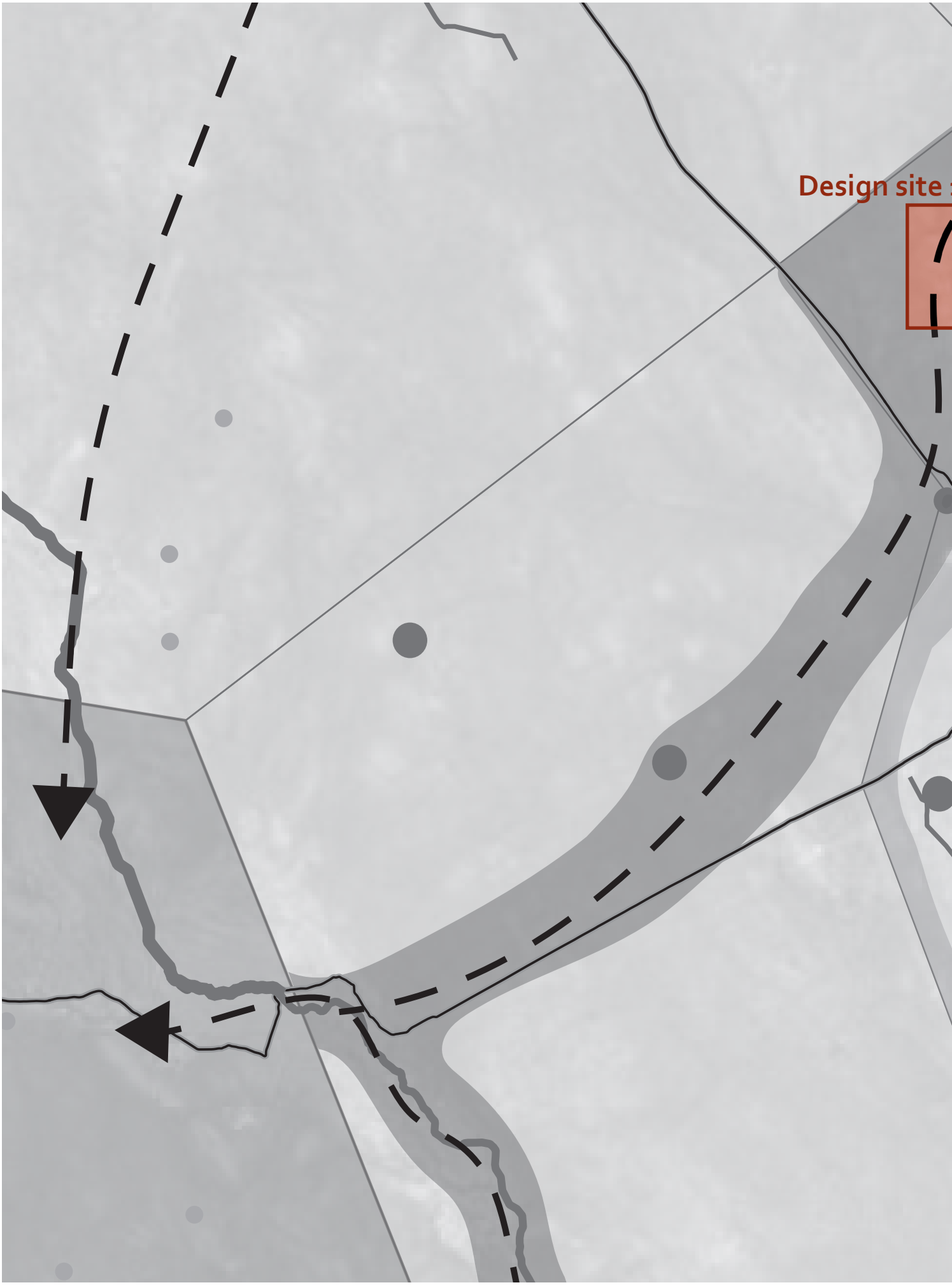


Figure 85: Location design sites, made by author


1
Design site 2

7.1 Design Site 1: Elephant corridor

7.1.1 Current situation

The first design intervention is located on community land where a historical elephant migration route crosses agricultural fields. As a result, farmers in this area regularly experience human–elephant conflict. Elephants move through their fields, eating and trampling crops. This leads to significant crop losses and makes it harder for households to earn a living from farming.

During a conversation with one of the farmers, he explained that he loses crops to elephants almost every year. After experiencing these losses repeatedly, he started to feel helpless, especially when they have few ways to protect their fields. He does not take preventive measures because he experienced that they do not work or are too expensive. The seriousness of the situation became clear when the farmer explained that his son sleeps in the field every night during the harvest season to guard the crops against elephants, which is really dangerous.

Interestingly, the farms are not surrounded by fences. Instead, farmers mark their boundaries with piles of branches from thorny shrubs, a common practice in the region.

Six households currently farm within the selected area, and agricultural land covers approximately 40% of the site. The remaining area consists mainly of Acacia–Commiphora bushland, which is used for livestock grazing. This dryland vegetation includes drought-resistant trees, thorny shrubs and grasses. It provides food and shade for livestock.





Figure 85: Pictures of the design site, made by author

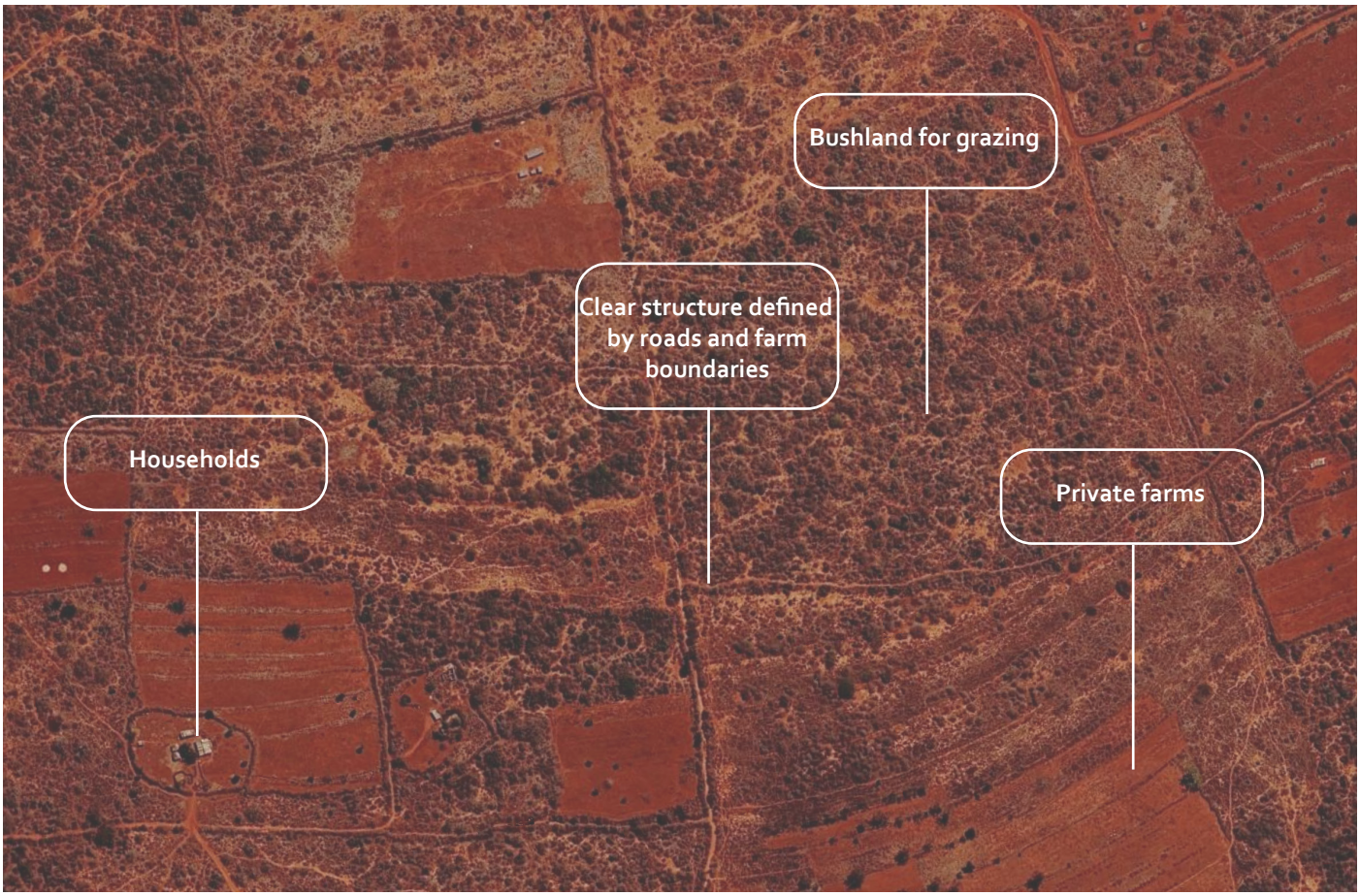


Figure 86: Current situation, image from google earth


Figure 87: Farmer living in the elephant corridor with his family, made by author

7.1.2 Creating room for elephants

In this design, scenarios 1 and 2 from the farmer options described in Chapter 6.3.4 'Version 1 – Farmland transformed into an elephant corridor', are applied. Both scenarios involve relocating farms away from the historical migration route to create a more continuous elephant corridor. This completely removes the overlap between agricultural activities and elephant movement within the selected area, providing elephants with a safe and unobstructed route through the community lands.

The nearest existing water pans are approximately 5.5 and 6 km from the selected area. To make water more accessible within the corridor, reducing the chance that elephants roam into the community lands to search for water, a borehole is installed. A solar-powered pump supplies water throughout the year, reducing dependence on seasonal rainfall and surface water. The water infrastructure is integrated into the landscape as discreetly as possible to minimise disturbance to wildlife. Where technically feasible, the pump infrastructure is placed underground, while the solar panels are positioned farther from the drinking point and hidden by existing vegetation. The drinking point has a gentle approach and shallow banks, allowing elephants and other wildlife to reach the water easily.

Within the corridor, dense vegetation is combined with more open spaces. Dense vegetation provides food, shade and shelter, while open areas allow elephants to see their surroundings more clearly. Clear sightlines are

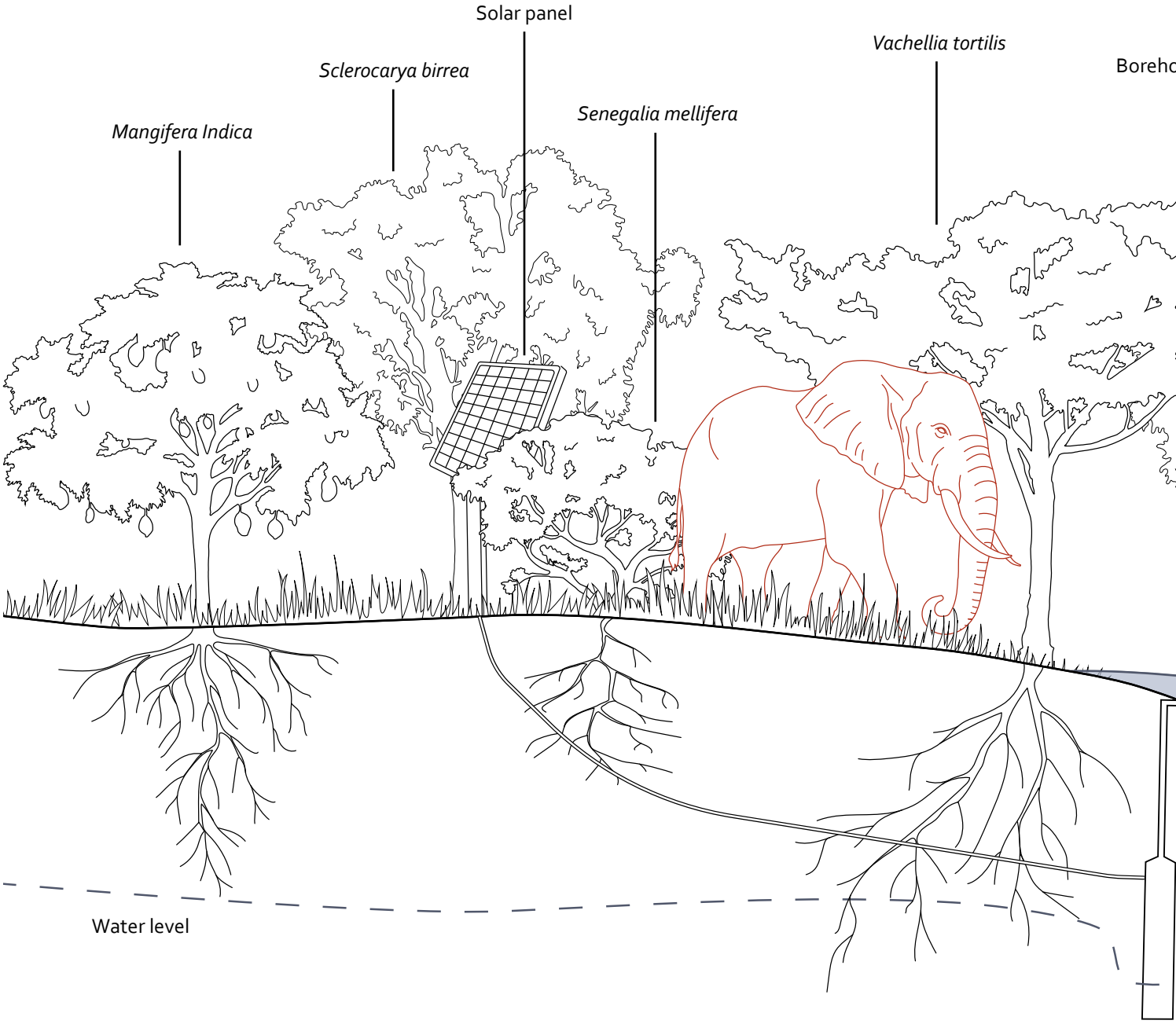
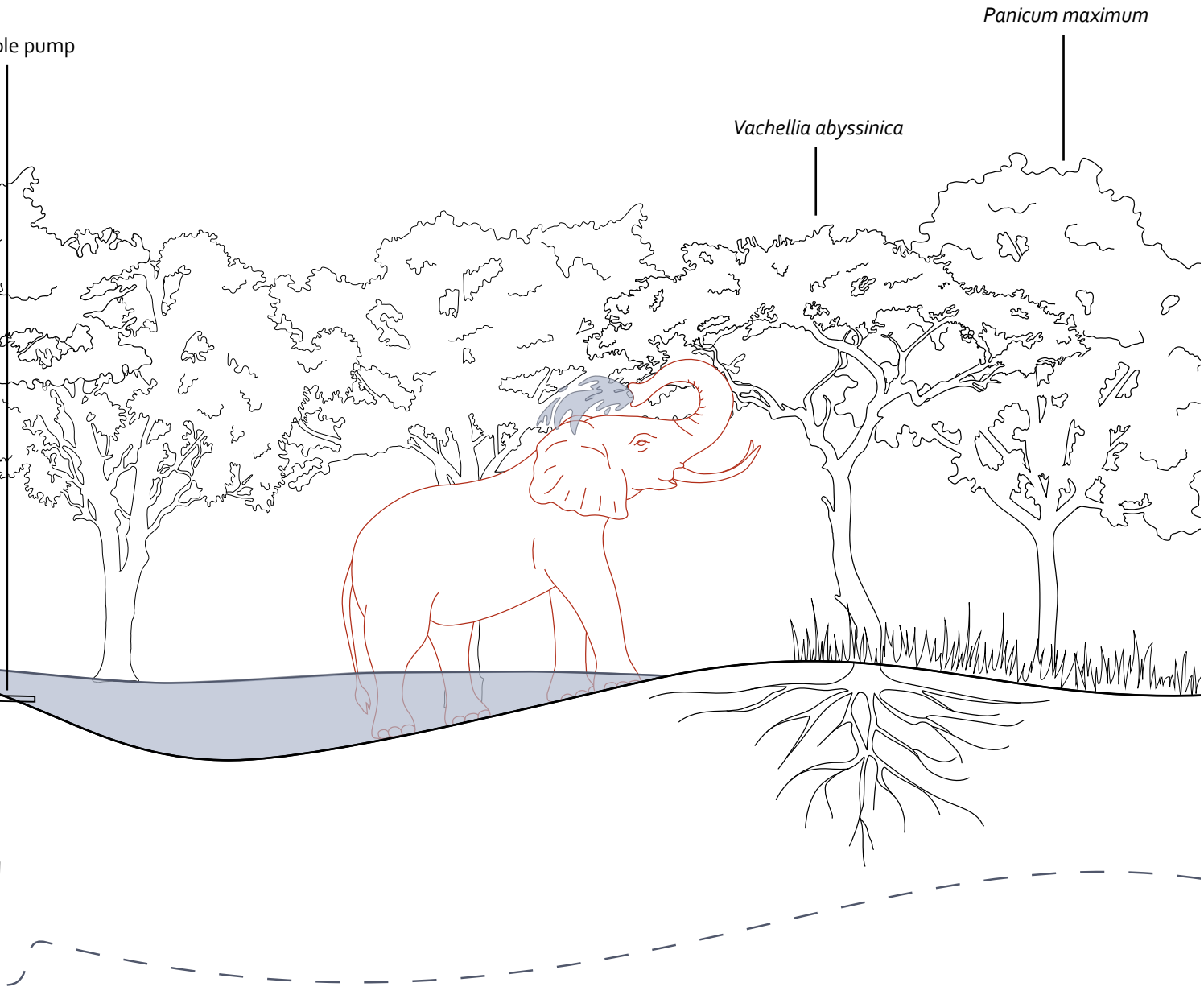


Figure 88: Section of a waterhole located in the elephant corridor, made by author

particularly important around water sources, where elephants may be more vulnerable to predators. The existing Acacia–Commiphora bushland provides a starting point for habitat development. Once livestock grazing is removed from the selected area, the existing vegetation can provide food and shelter for wildlife and support natural regeneration. The existing vegetation is assessed to determine where natural regeneration is sufficient and where additional planting is needed. Native trees and shrubs, including Umbrella thorn (*Vachellia tortilis)*, Blackthorn (*Senegalia mellifera)* and Elephant bush (*Portulacaria afra)*, are planted where necessary to improve the vegetation structure and habitat quality. Because the corridor passes through community land, it is important to make it an attractive area for elephants to use rather than allowing them to seek food in neighbouring fields. Additional food sources are therefore introduced by planting fruit-bearing trees and plants that elephants feed on, such as Sclerocarya birrea and Mangifera indica. The scent of ripe fruit can help attract elephants to these areas.

Although most of the existing spatial structure is changed in the new design, one existing road is retained to provide access for maintenance and ecotourism activities. It allows the borehole and surrounding vegetation to be maintained and can also support visitor access. The route is managed carefully to minimise disturbance to elephants and prevent it from becoming a barrier to their movement.



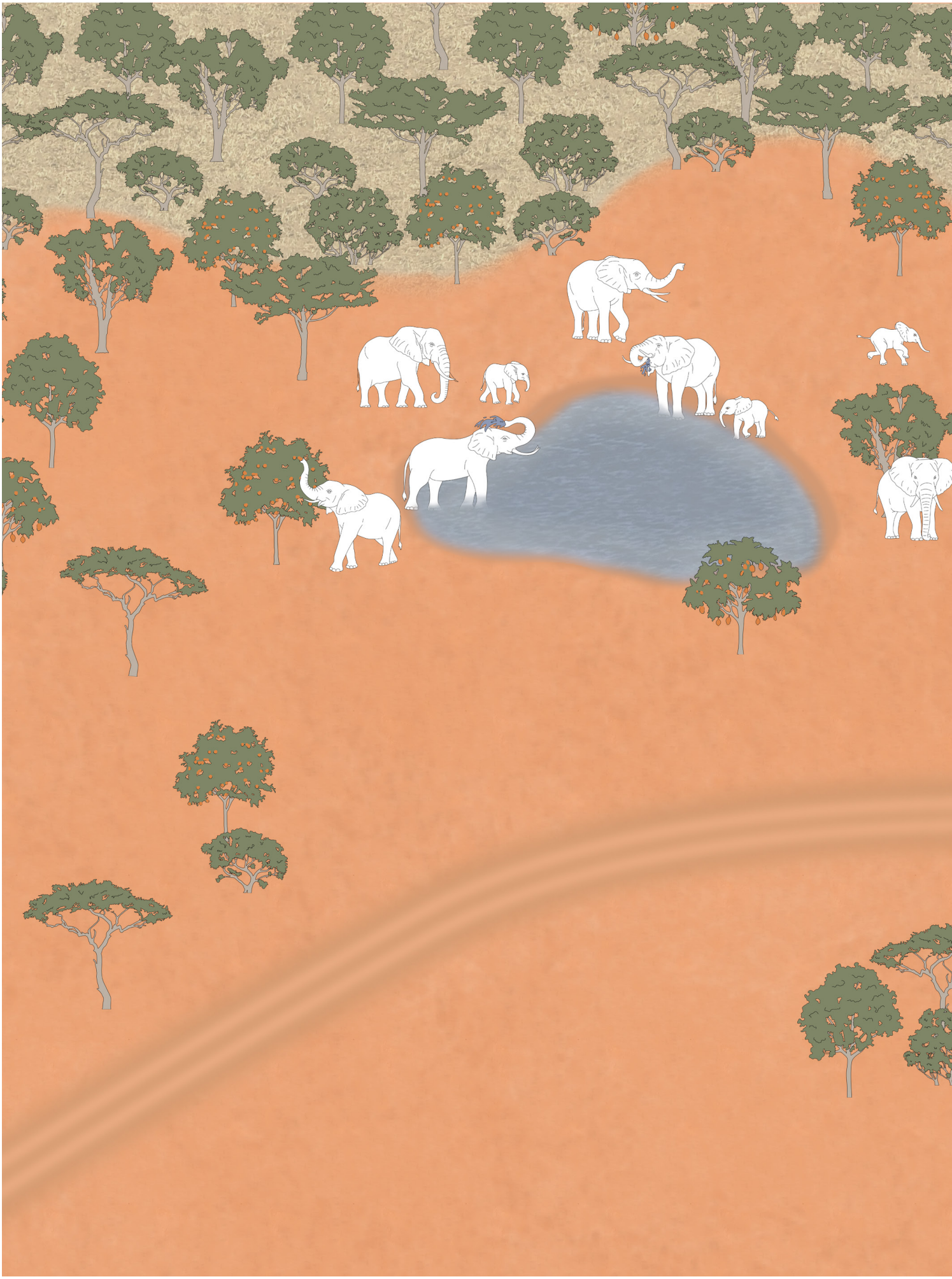


Figure 89 Design of the elephant corridor, made by author



7.2 Design site 2: Community farm

7.2.1 Current situation

The second design area is located next to Bungule village, south of Mount Kasigau. The proximity to the mountain provides slightly better water availability, making the area more suitable for agriculture than some of the surrounding drylands. The selected area contains six farming households, each surrounded by small agricultural plots.

Within the area, there is also a plot of Acacia–Commiphora bushland used for livestock grazing. Following the design principle described in Chapter 6.5.4 'Version 2 – Community Farms', livestock keeping is reduced to household needs rather than relying on large herds as a primary source of income. This creates an opportunity to use part of the land for other purposes that better support local food security and provide alternative sources of income.

During a conversation with one of the farmers, he explained that he grows a variety of crops, including cow peas (*Vigna unguiculata*) and maize (*Zea mays*), as well as fruit such as papaya (*Carica papaya*). He identified both HEC and drought as major threats to his livelihood. He was therefore interested in agroforestry, especially after seeing the benefits on his cousin's farm. He expressed a willingness to adopt similar practices if given the opportunity and support. This shows that farmers are open to changing their farming methods when practical alternatives are available, especially when there are already success stories in the area.





Figure 90: Pictures of the design site, made by author



Figure 91: Current situation, image from google earth

7.2.2 Strengthening farming and local livelihoods

The design aims to retain the existing settlement and farm structure as much as possible, allowing farmers to continue using their land. Instead of relocating farms, the focus is on helping households adapt their farming practices to reduce crop losses and improve resilience to drought.

Farmers are supported in introducing agroforestry and non-palatable crops. These include Mukau (*Melia volkensii)*, millet (*Panicum miliaceum*) and sunflower (*Helianthus annuus*). Other crops that are edible, but elephants generally dislike, such as lemon (*Citrus limon*) and cassava (*Manihot esculenta*), can also be grown.

Farmers can choose which crops best suit their needs, whether that is growing a mix of crops for household consumption or as cash crops. Growing a wider variety of crops reduces dependence on a single harvest and reduces the risk of having crops with diseases.

The existing bushland grazing plot is transformed into a community farm that produces food for local inhabitants. The farm focuses on drought-resistant crops such as green grams (*Vigna* radiata), sorghum (S*orghum bicolor*) and pigeon peas (*Cajanus cajan*). This creates an additional source of food while making productive use of land that is currently used for grazing.

To reduce crop losses, elephant-friendly deterrent fences are installed around the community farm. This is a combination of either beehive fences or chilli fences.
An newly established community-based organisation (CBO) manages the farm, coordinates cultivation and organises the distribution of the harvest among local households. A dedicated building provides space for the CBO to organise its activities, store equipment and coordinate production. Honey harvested from the beehive fences can be processed and sold, providing revenue for the CBO and supporting the maintenance of the farm.

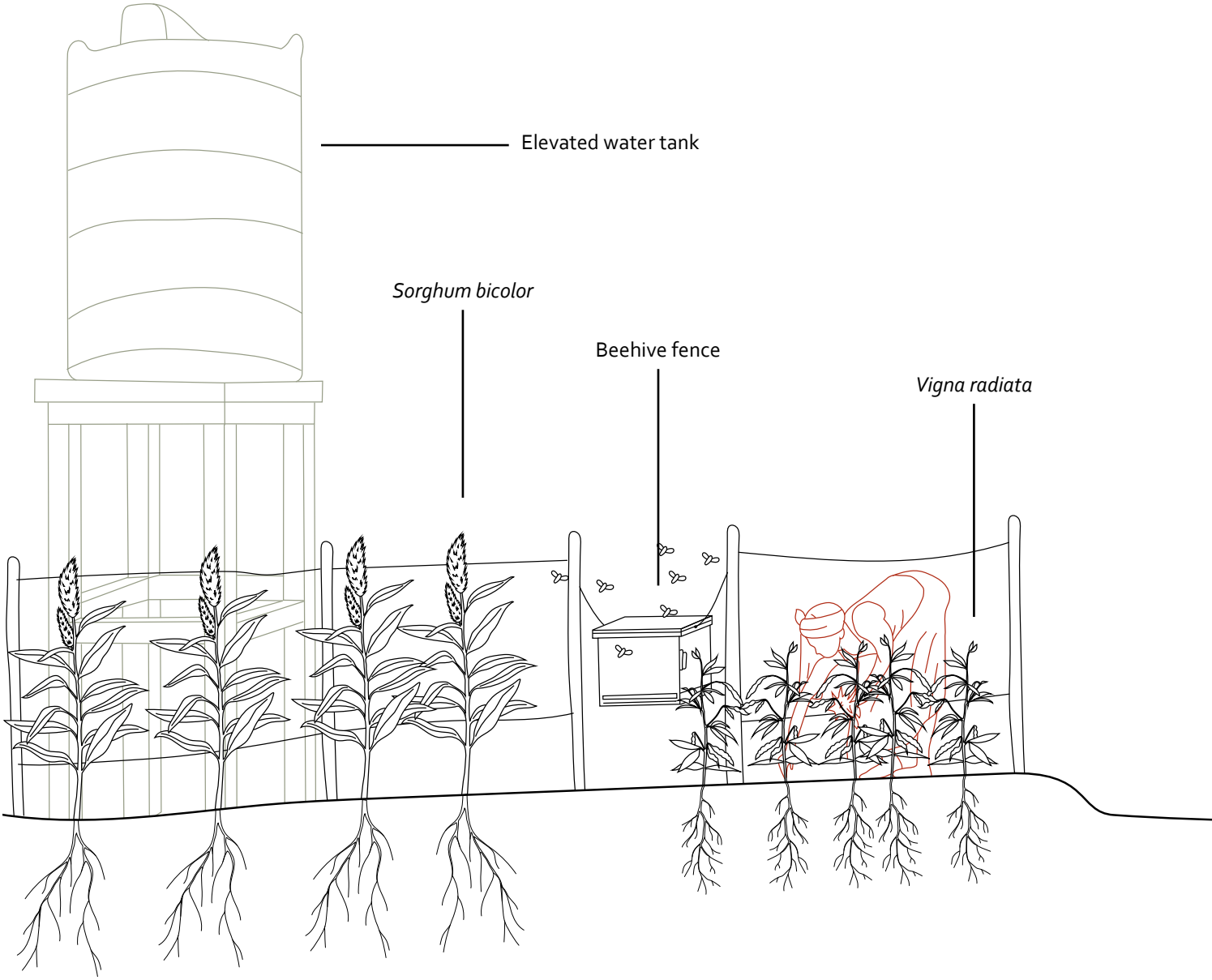
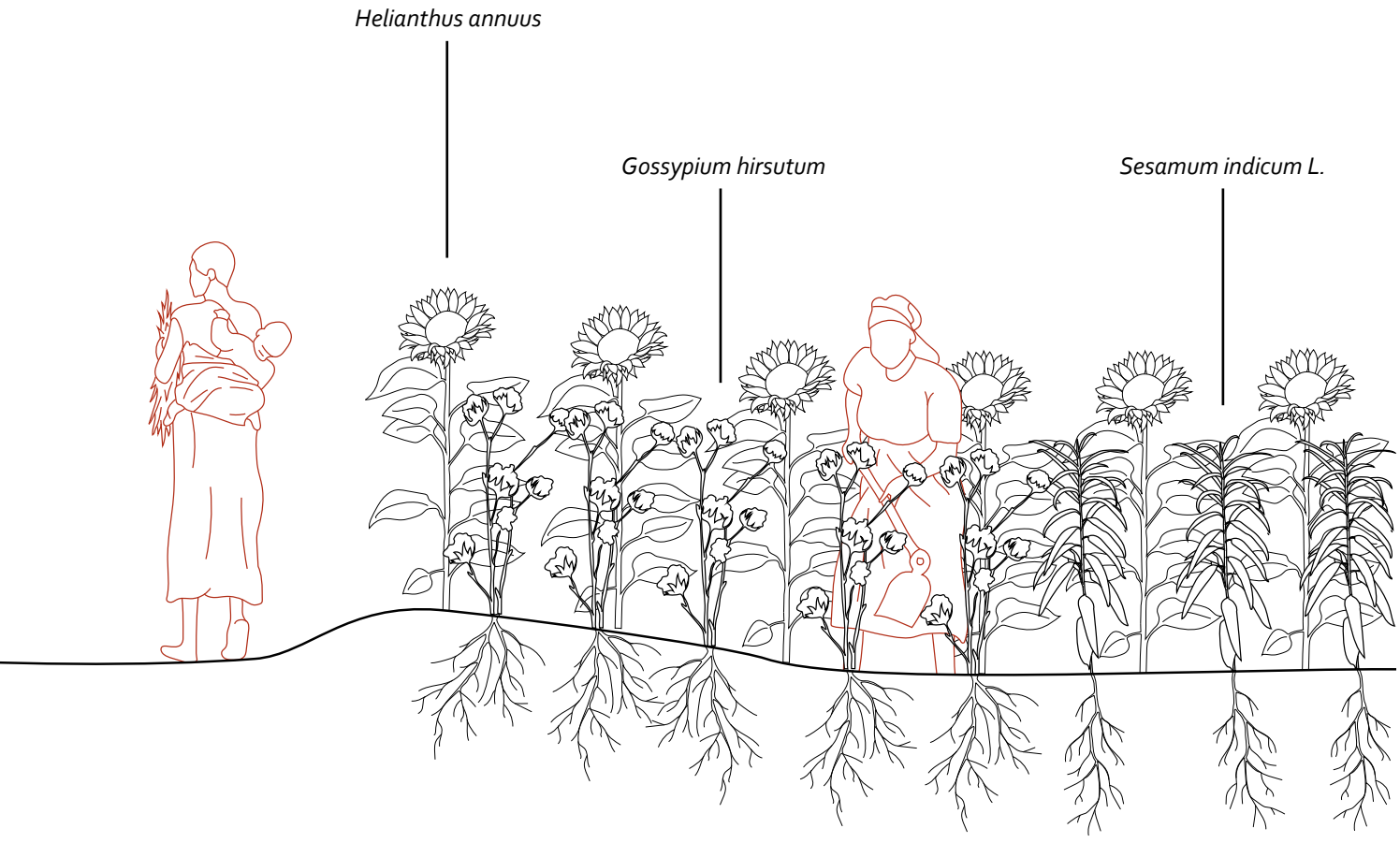


Figure 92: Section of a waterhole located in the elephant corridor, made by author

Additional CBOs can be established on the same plot to process neighbouring farmers into products with a higher market value. For example, millet can be used to develop locally produced food or beverages. This allows the entire process, from growing crops to processing and selling the final products, to take place within the community. As a result, more income stays local, creating opportunities for employment and helping the community become more self-sufficient.



7.3 Co-exist

By implementing the proposed design strategies, the Kasigau region can gradually transform into a landscape where elephants and local communities not only coexist peacefully but also benefit from one another. Through the integration of the three zones, the area develops beyond a conventional elephant corridor that primarily protects land for wildlife. Instead, it becomes a connected and multifunctional landscape in which each zone contributes to a more resilient ecosystem. By combining wildlife conservation, sustainable land use and improved living conditions, the interventions create opportunities for local livelihoods while supporting wildlife movement and habitat protection. In this way, the landscape becomes a framework in which people and elephants can share the same environment, with their needs complementing rather than conflicting with one another.



Figure 93: Visual showing that elephants and local inhabitants can co-e



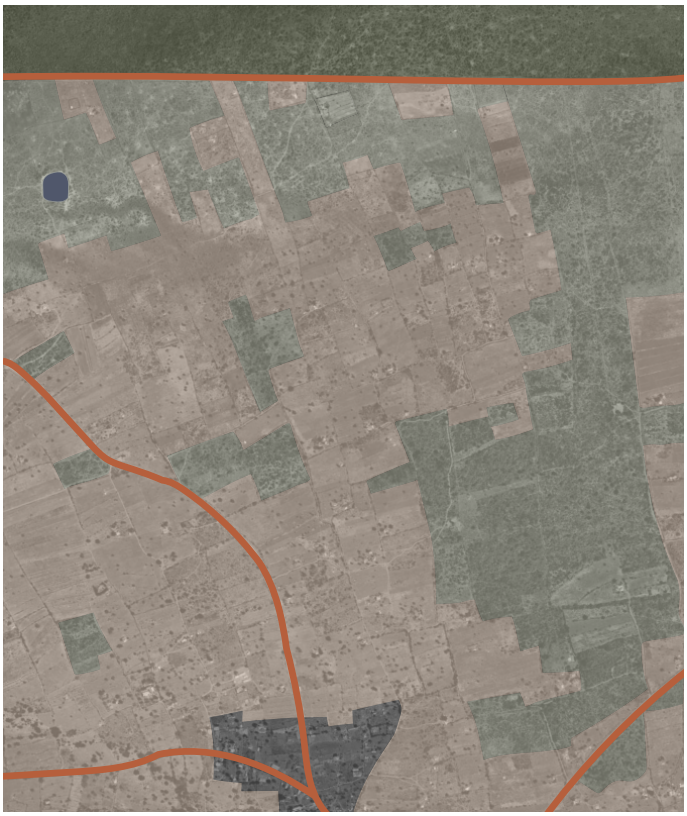
xist, made by author

8

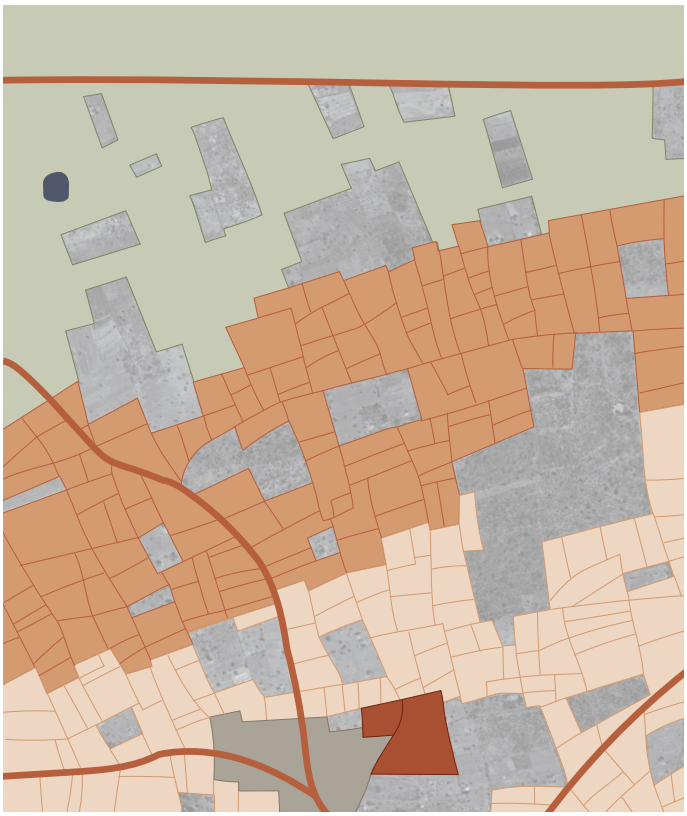
Feasibility

8.1 Phasing
8.2 Financial planning

8.1 Phasing



Existing situation



2 years : phase 1

- Water scarcity is addressed by repairing and renovating existing water structures.
- Boundaries between ranches are softened where possible.
- Around half of the farmers in the corridor zone are expected to participate, with higher participation in the buffer zone and community lands due to less drastic changes.
- Vegetation is planted in spaces freed by relocating farmers, gradually expanding elephant habitat.
- Participating farmers in the buffer zone and community lands switch to recommended crops.
- The first CBOs are established, and a community farm is created and protected by electric fencing.
- The first homestays are established by farmers that live in the corridor zone.

Community land
Buffer zone
Elephant corridor
CBO + Community farm
Village
Water spots
Roads

Figure 94: Phasing, made by author

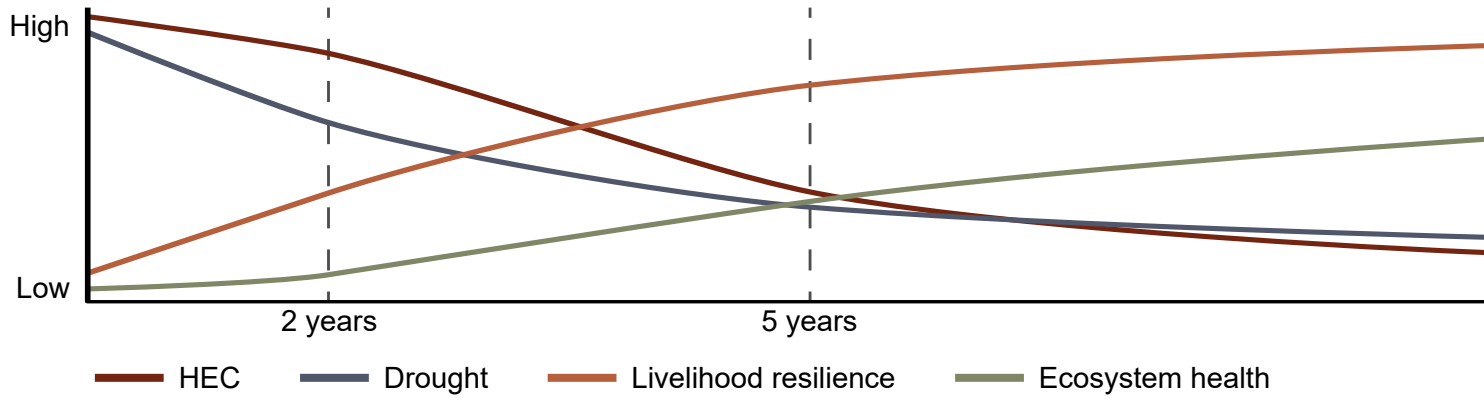
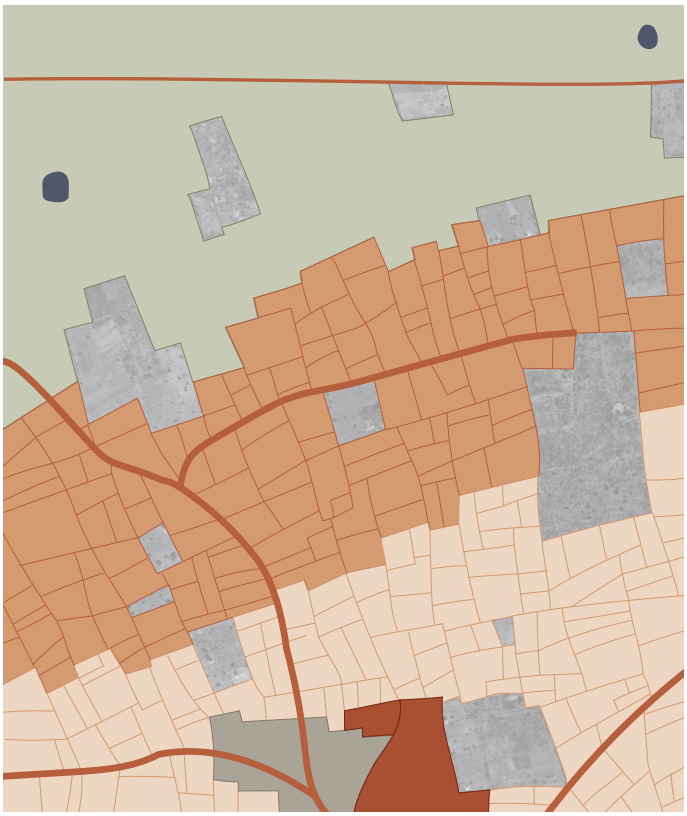
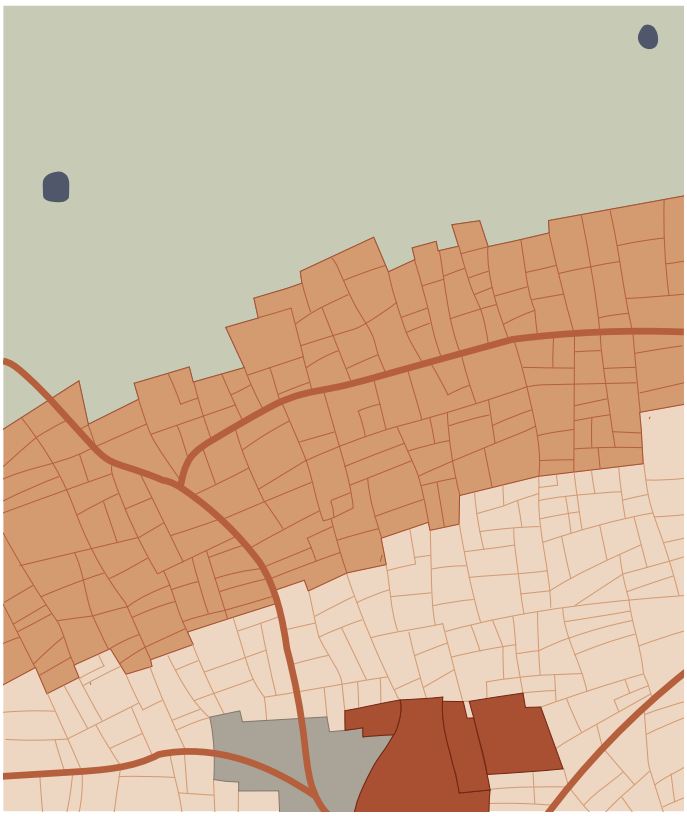


Figure 95: Graph of expected impact per phase, made by author



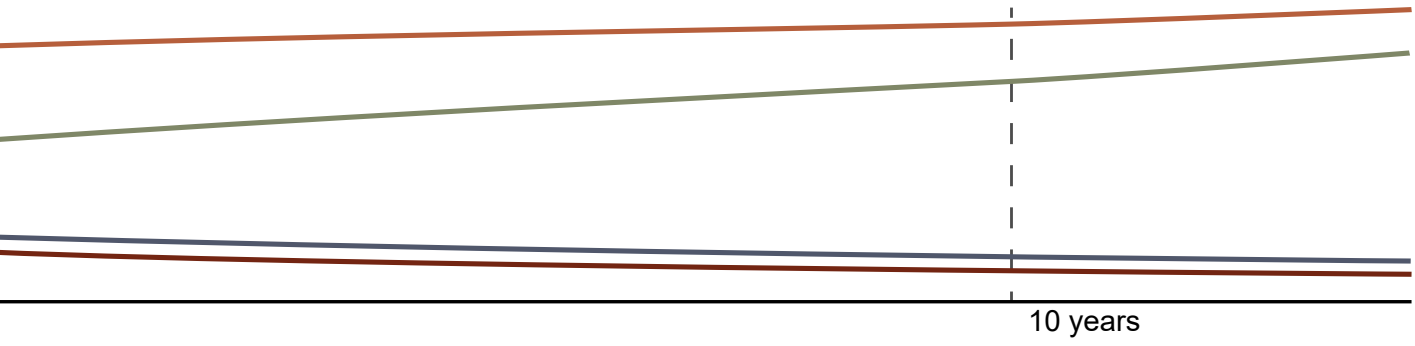


5 years : phase 2

- Additional drinking pools and boreholes are created where necessary.
- Boundaries between ranches and the corridor are removed. The main road is used less intensively, and a new connecting road is created within the buffer zone.
- As neighbouring farmers see the benefits, more are expected to join, expanding the corridor and strengthening the buffer zone.
- Corridor vegetation is maintained and improved to support elephant habitat.
- More participating farmers increase local production, allowing additional CBOs to develop and the community farm to expand.

10 years: phase 3

- Water sources are maintained, and new projects address any remaining shortages.
- With almost all farmers participating, a continuous and functional elephant corridor without a boundary between ranches and community lands is established.
- Farmers benefit from more stable harvests, while CBOs provide alternative income through processing and selling local products.
- A functional buffer zone reduces elephant movement into community lands, allowing the electric fences to be replaced with elephant-friendly fences.
- As wildlife increases, ecotourism expands and creates more benefits for local communities.



8.2 Financial timeline

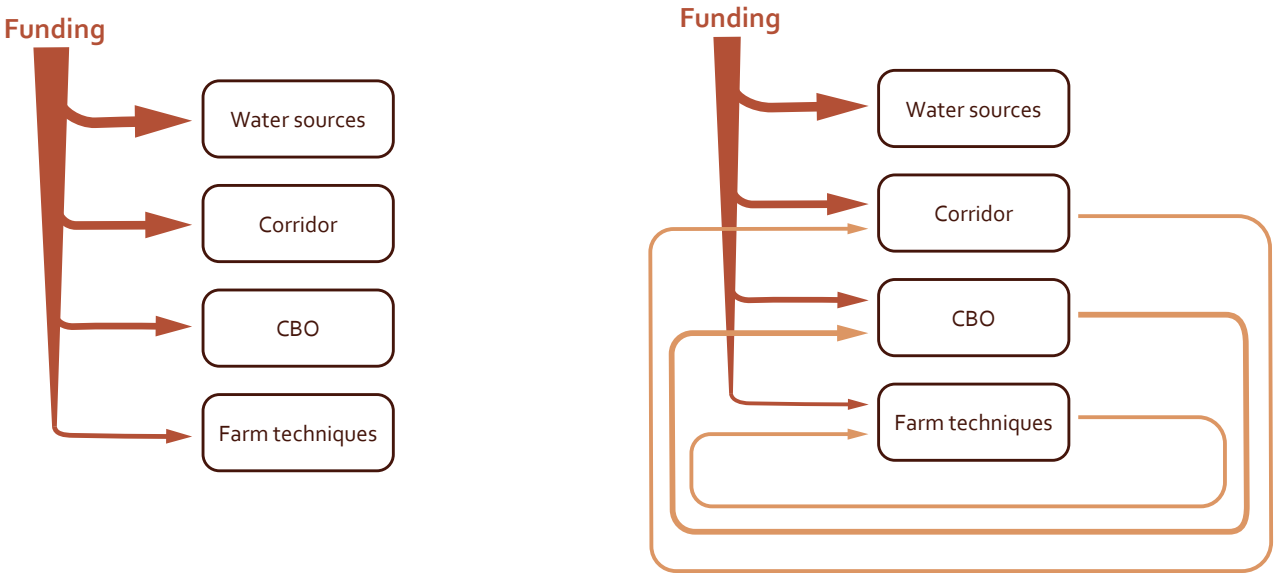
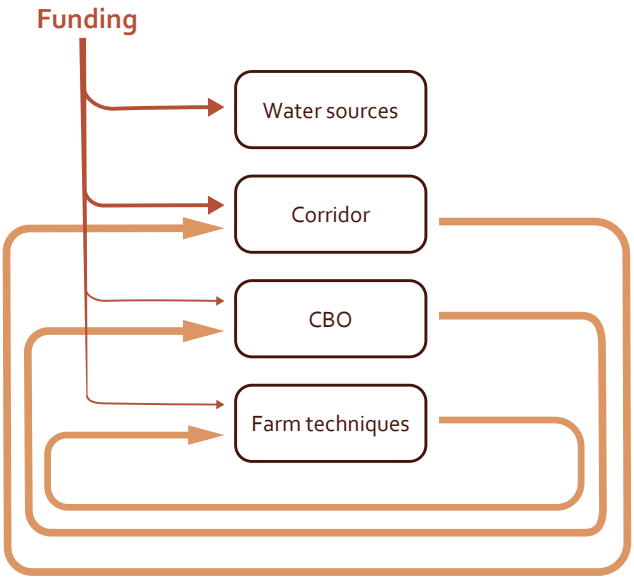
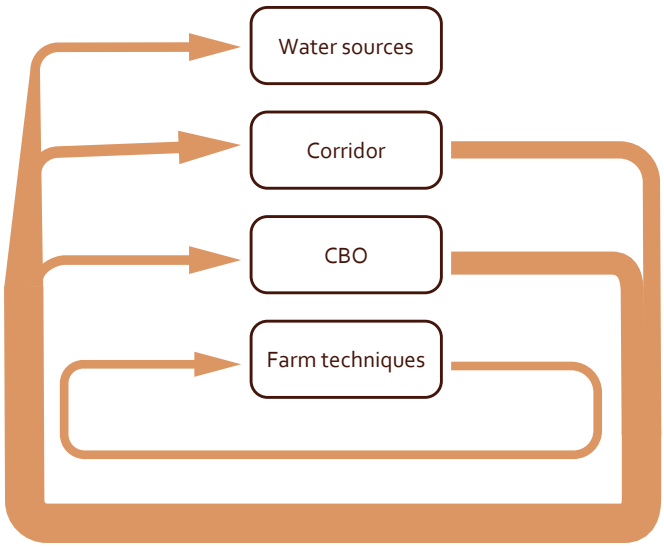


Figure 96: Financial timeline, made by author

2 years: phase 1
The project is largely dependent on external funding. The main expenses are addressing water scarcity through large-scale renovations of existing water sources and establishing the elephant corridor, including vegetation planting and compensating farmers who relocate. Funding also supports the establishment of CBOs and helps farmers transition to alternative farming practices.

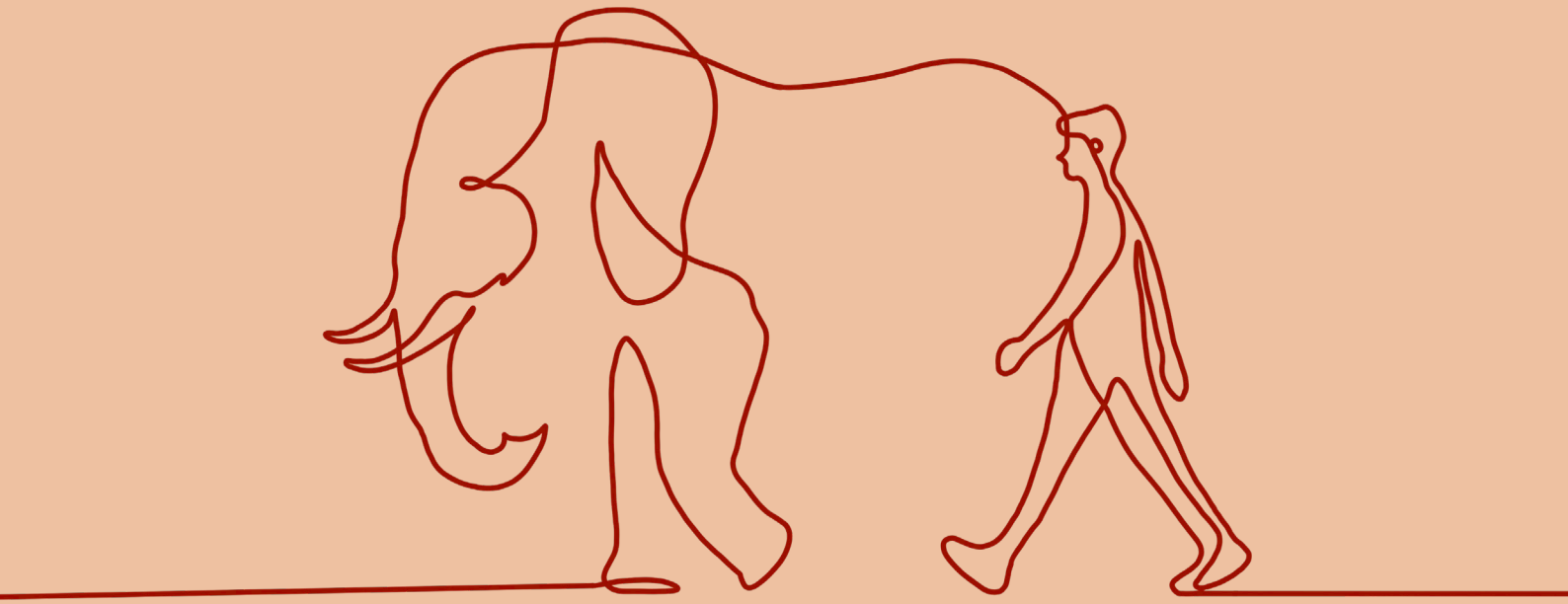
5 years: phase 2
External funding remains essential as new water sources are developed, existing ones are maintained, and more farmers relocate to expand the elephant corridor. Supporting farmers in adopting alternative practices remains a significant expense. Meanwhile, more CBOs are established, and income from local products, farming and ecotourism begins to grow. This revenue can gradually be reinvested in the project.





10 years: phase 3
The need for external funding decreases significantly as farmers and CBOs generate increasing revenue and ecotourism expands. Income from these activities supports local livelihoods and contributes to corridor development and maintenance. Funding is still required for the final stages of corridor implementation and the construction of remaining water sources, which involve substantial costs. Smaller amounts are also allocated to support farmers and CBOs as they become more self-sufficient.

30 years: phase 4
The project is expected to become financially self-sufficient, with little or no external funding required. Farmers have more stable incomes, while CBOs generate revenue that can be reinvested in the community and local economic development. Ecotourism provides additional income to support corridor maintenance and water sources are maintained through revenue generated by the project. This allows the landscape and its associated livelihoods to be sustained in the long term.



PART V

LESSONS LEARNED

9

Conclusion & discussion

9.1 Conclusion
9.2 Discussion

9.1 Conclusion

This research explored how a regenerative spatial landscape framework can be developed across the Kasigau region to reduce Human-elephant conflict (HEC) between Tsavo East and Tsavo West National Parks while strengthening local livelihoods and supporting elephant movement. The findings demonstrate that a wildlife corridor has the potential to function as a connecting framework between ecological restoration and human land use by integrating landscape-scale connectivity with targeted spatial interventions that support coexistence between elephants and local communities. By combining habitat restoration, water management, agricultural adaptation and livelihood diversification, the proposed framework aims to address the underlying causes of HEC while creating co-benefits for both people and wildlife.

The problem analysis revealed that HEC in the Kasigau region is closely connected to habitat loss, fragmentation, drought, water scarcity and human activities. The expansion of farmland and settlements, deforestation, overgrazing and infrastructure development reduce natural resources and restrict elephant movement between Tsavo East and Tsavo West National Parks. As a result, elephants increasingly enter agricultural areas and settlements in search of food and water, increasing the risk of crop raiding, property damage and dangerous encounters. Water scarcity intensifies these pressures, as irregular rainfall, high evaporation and insufficient water infrastructure limit availability for both communities and wildlife. These findings demonstrate that HEC is not caused by individual encounters alone, but by the wider competition for land and natural resources within a shared landscape. Addressing the problem therefore requires a spatial approach that restores ecological connectivity while considering the existing land uses and resource needs of local inhabitants.

The impact assessment demonstrated that growing HEC has significant social and environmental consequences for both communities and elephants. For inhabitants, crop raiding and property damage threaten household income and food security, particularly because agriculture and livestock keeping are important livelihood activities. Damage to water infrastructure can further disrupt access to essential resources, while water scarcity forces inhabitants to travel greater distances to collect water, increasing their physical workload and the risk of encountering elephants. For elephants, habitat degradation and restricted movement reduce access to food, water and suitable habitat. During droughts, elephants must travel further to find resources, increasing their exposure to agricultural areas and settlements. Prolonged shortages of water and vegetation can cause dehydration, malnutrition and death, while encounters with people can also result in elephant injuries and fatalities. These impacts reveal a cycle in which environmental pressures increase competition for resources, and the resulting encounters further threaten community livelihoods, human safety and elephant welfare. Consequently, interventions should not only reduce the frequency of encounters but also minimise the damage when elephants enter areas used by people.

The design exploration identified several regenerative principles that can address these challenges while creating benefits for both stakeholders. Restoring ecological connectivity through wildlife corridors, habitat restoration and agroforestry can improve access to food and water while reducing habitat fragmentation. Conservancies and mixed-use landscapes can support wildlife conservation alongside carefully managed livestock grazing. Improving water availability through restored water pans, covered storage and rainwater harvesting can help retain water during dry periods and reduce competition between communities and elephants. Furthermore, livelihood diversification through community-based enterprises, honey production, crafts, sustainable charcoal and ecotourism can reduce dependence on climate-sensitive agriculture and livestock. The research also highlighted the role of targeted conflict-mitigation measures, including elephant-friendly fencing, elephant-deterrent crops and community-based initiatives, in protecting agricultural land and settlements. However, these measures should complement connected wildlife habitats rather than create additional barriers to elephant movement. Together, these principles demonstrate that regenerative design should integrate habitat restoration, water management, conflict prevention and livelihood development instead of treating ecological conservation and community well-being as separate objectives.

The development of the spatial design framework translated these principles into a landscape structure consisting of three interconnected zones: an elephant corridor, a buffer zone and community land. The framework is guided by the concepts of Prevent Contact and Reduce Impact, addressing both the prevention of unwanted encounters and the reduction of damage when encounters occur.

The elephant corridor follows historical migration routes between Tsavo East and Tsavo West National Parks, providing safe passage, suitable vegetation for food and shelter, and reliable water sources. Where the corridor crosses farmland, different voluntary options are proposed for affected farmers, including relocation to community areas, land exchange, ecotourism and alternative land uses. Within ranches, removing obstructive fences, restoring vegetation and managing livestock grazing can improve habitat connectivity while allowing compatible land uses to continue.

The buffer zone creates a gradual transition between the corridor and community land. By combining elephant-deterrent crops and vegetation, it aims to discourage elephants from entering agricultural areas without physically blocking their movement. The selected crops may also provide additional income through local markets and community-based enterprises.

Community land remains focused on agriculture, settlements and other livelihood activities, but farming practices are adapted to reduce vulnerability to HEC and drought. Drought-resistant and elephant-compatible crops can reduce crop losses and water demand, while individual cash-crop farming and community farms provide alternative approaches to agricultural production and food security. Restoring existing water pans, protecting water tanks from elephant damage and encouraging household rainwater harvesting can improve water availability. In addition, community-based organisations and alternative income-generating activities, including ecotourism, can diversify livelihoods and reduce dependence on vulnerable agricultural activities.

By combining these interventions across the three zones, the proposed framework seeks to reconnect elephant habitats while maintaining productive landscapes for local communities. Elephants can benefit from improved access to food, water, shelter and migration routes, while inhabitants can benefit from reduced crop damage, improved water security, more resilient agricultural systems and additional economic opportunities. The framework therefore moves beyond treating wildlife conservation and human activities as competing land uses. Instead, it coordinates them spatially to reduce pressure on shared resources and strengthen the relationship between ecological restoration and livelihood resilience. Its success depends on effective management, community participation and viable alternatives for inhabitants affected by changes in land use. Overall, the design provides a basis for a multifunctional landscape in which the needs of elephants and local communities are addressed together, contributing to the long-term reduction of HEC in the Kasigau region. The interconnection of the solutions are shown on the next page.

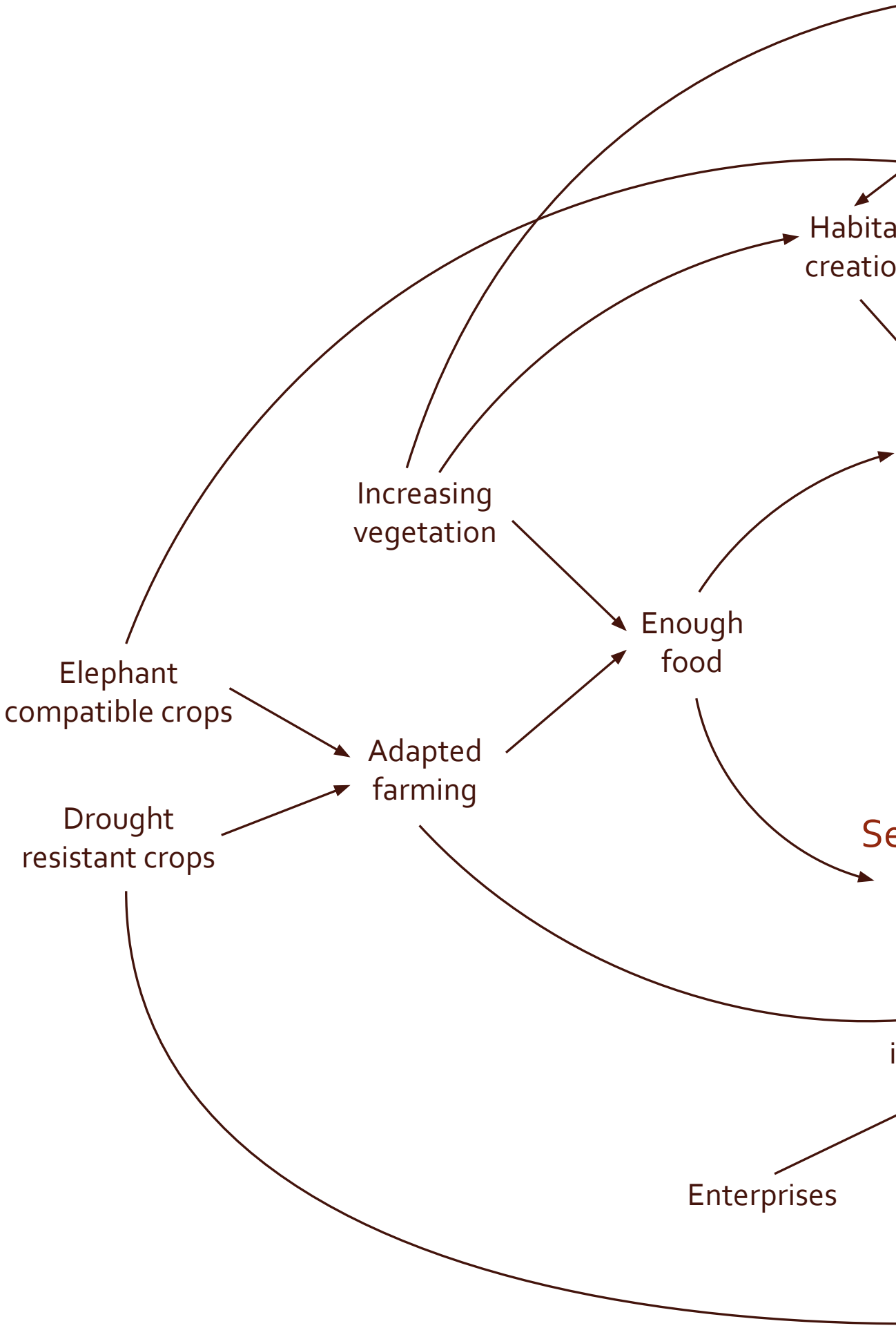
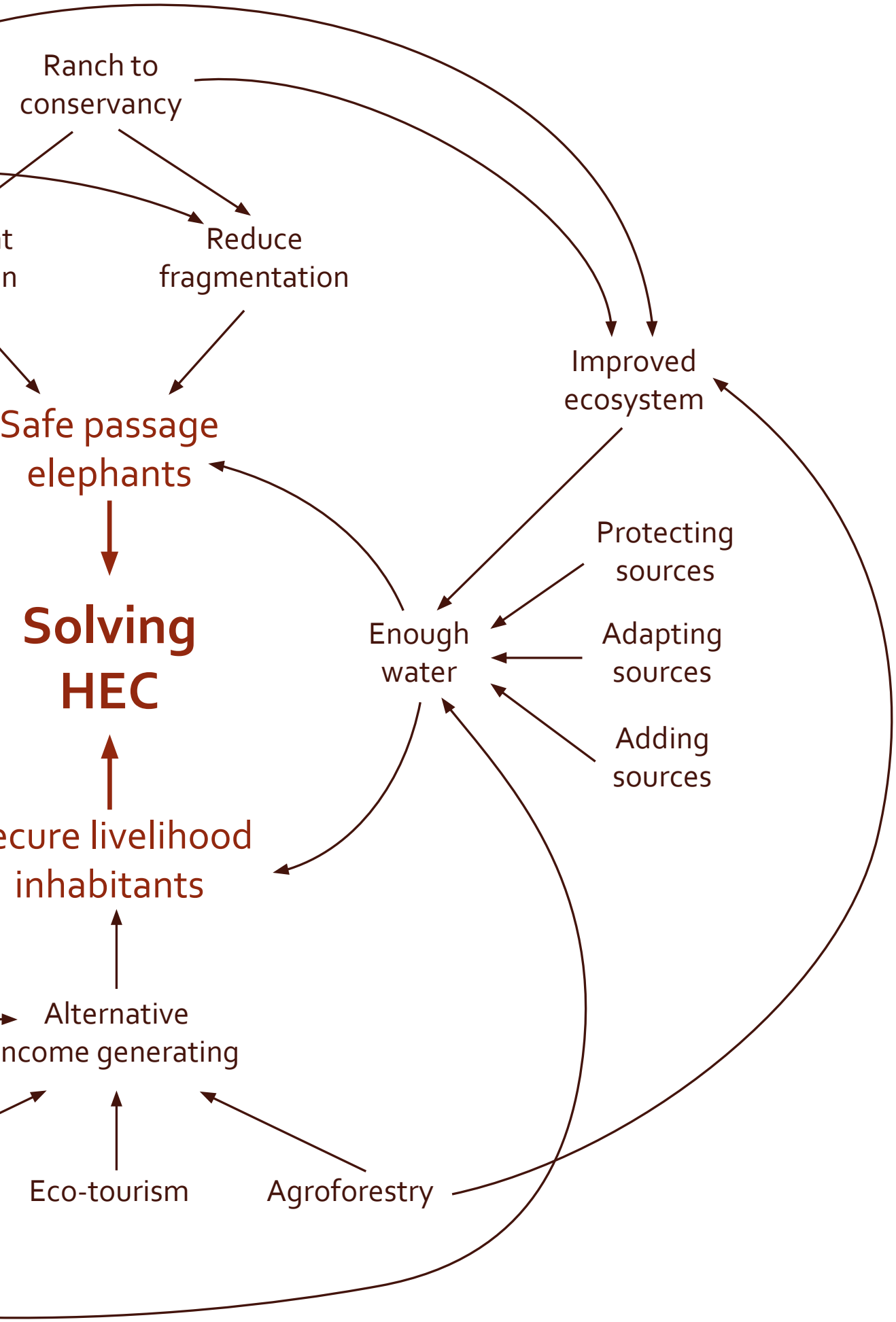


Figure 97: Model of the solutions and their interconnections, made by author


Ranch to conservancy
Reduce fragmentation
Improved ecosystem
Safe passage elephants
Solving HEC
Protecting sources
Enough water
Adapting sources
Adding sources
ecure livelihood inhabitants
Alternative ncome generating
Eco-tourism
Agroforestry

9.2 Discussion

9.2.1 Design limitations

This research developed a landscape framework for an elephant corridor between Tsavo East and Tsavo West National Parks. The framework is based on literature, spatial analysis, site analysis, stakeholder conversations, and design exploration. This approach made it possible to explore ways to reduce human–elephant conflict (HEC) by combining elephant habitat improvement, increased livelihood resilience for local inhabitants, and ecological restoration. However, several limitations should be acknowledged.

Availability of data
For the Tsavo landscape and Kenya in general, some data was limited, outdated or not specific to the Kasigau region. Therefore, parts of the analysis are based on a combination of existing studies, spatial analysis, and estimates. This provided a basis for the design, but some aspects remain uncertain.

It was for example difficult to determine how much community land is used for farming, how much is available for grazing, and how much is unsuitable for either purpose. The locations and capacities of existing water sources are also not fully known and are currently based on estimates. Additionally, there is limited information on the frequency and flow of seasonal rivers and local runoff streams. Finally, the exact routes used by elephants when migrating between Tsavo East and Tsavo West National Parks remain uncertain.

Stakeholder engagement
During my research in Kenya, I spoke to many people, particularly local inhabitants, organisations, and community-based organisations (CBOs). They provided valuable insights into the nature of the problem and its consequences, traditional knowledge and solutions, current mitigation measures, and their perspectives on how the problem could be addressed. They also showed me how they live, which helped me better understand the inhabitants and their needs.

This information contributed significantly to defining the problem and exploring design solutions. However, the time available in Kenya was limited, meaning that only a relatively small number of people could be interviewed. A larger number of interviews would have provided a broader understanding of the problem. There are also many more organisations and CBOs in the area that provide funding and services. Mapping these stakeholders would help to understand the extent of the changes already taking place in the Kasigau region.
Furthermore, broader stakeholder engagement would have created more opportunities for stakeholders to participate throughout the different stages of the project. Rather than contributing only to the research, they could also have been actively involved in designing the landscape framework. It should also be noted that I had limited contact with governmental organisations, as they were generally not very open to interviews.

9.2.2 Challenges within the project

Although the design aims to be as feasible as possible, several challenges could arise if the project is implemented.

Political challenges
Gaining government support for the project may be difficult. According to local inhabitants, the government often makes promises without delivering visible changes. Corruption within the political system was named as the main reason for this.

As a result, local inhabitants have limited trust in the government. For example, farmers who experience damage to their property or crops caused by elephants are entitled to compensation, but according to local accounts, this compensation is rarely paid. This lack of trust could make inhabitants less willing to participate in larger projects involving the government. This highlights the importance of involving CBOs in the project.

A similar issue concerns the Kenya Wildlife Service (KWS), which is responsible for responding to human–elephant conflict. Local inhabitants feel that KWS should provide more benefits to the community. While KWS generates income from elephants through tourism, inhabitants experience many of the negative consequences of living alongside large numbers of elephants. KWS receive funding from the government, but none of it goes to supporting for communities affected by HEC. These concerns contribute to negative perceptions of KWS and may make inhabitants less willing to cooperate with the organisation.

Funding
A substantial amount of funding will be needed to make the project successful, particularly during the first years. Securing this funding will be difficult and may take considerable time, potentially delaying implementation.

To make the project as successful as possible with limited funding, it is important to identify the interventions that are most essential for reducing HEC. These include improving water availability, increasing vegetation to restore habitats and improve ecological conditions, and providing funding for CBOs to help inhabitants become self-sufficient more quickly.

Engaging farmers
Encouraging farmers to participate in the project may be challenging. Because their livelihoods are vulnerable, they may be reluctant to change their farming practices or adopt new approaches. They cannot easily afford to take risk, as they often lack alternative sources of income. However, it is expected that addressing water scarcity first could reduce livelihood stress and increase farmers' willingness to participate. Extensive education about the goals of the project and the demonstration of successful local examples will be important for gaining their trust and encouraging them to become involved.

Time required to achieve results
The design will take time to produce results because it requires changes in both elephant behaviour and community practices. This long implementation period could cause people to lose faith in the project if they do not see improvements quickly
.
Continued education about the purpose and importance of each step in the project will therefore be crucial for helping stakeholders understand that the design is a long-term process, rather than a solution that will deliver immediate results. To mitigate this problem it is also important to ensure that inhabitants experience more direct benefits from the project.

Furthermore, vegetation takes time to establish and grow, particularly under drought conditions, which can make the restoration process more vulnerable to failure. This further emphasises the need for long-term commitment and continued support throughout implementation.

10

Reflection

10.1 Further research
10.2 Personal reflection

10.1 Further research

To address the limitations and challenges described above, further research from different perspectives is necessary. This will allow for a more in-depth investigation of the topics addressed in the design, as well as aspects that fell outside the scope of this project.

10.1.1 Learning from other experts

The design was developed from a landscape architectural perspective. However, input from the following experts is essential to the success of the project. They can provide further insights into different aspects of the design.

Local expert
Extensive local research is needed, preferably conducted by a local inhabitant. Further research into the local culture is also important to better understand the needs of the inhabitants. Working with someone who understands the problem and the local context would help identify and explain the challenges more accurately. It could also make it easier to reach inhabitants and improve their willingness to participate, as they would feel better understood.

Sociologist
Social research is needed to understand how CBOs operate and what makes them successful. It is also important to study how inhabitants perceive and respond to elephants, particularly when livelihood resilience is low and resources are limited. Understanding this behaviour could help determine how it might affect the project, either positively or negatively.

Elephant expert
An elephant expert could provide further insight into elephant behaviour and assess how likely elephants are to change their behaviour over time, as well as how much human intervention may be needed to influence this change. Further research is also needed to determine the maximum number of elephants the area can support and how this capacity could be managed.

Policy expert
A policy expert could investigate how to work with the government, how to apply for funding, which policies must be followed, and how to report projects or apply for the necessary permits. This expert would also play an important role in gaining government support for the project.

Biologist
Further research is needed to determine which types of vegetation are required to create a flourishing ecosystem, taking local soil conditions into account. It is also important to investigate how new vegetation can be established despite its vulnerability to drought and the possibility that elephants will eat or damage a significant amount of it.

Water infrastructure expert
A water infrastructure expert could investigate how water stress can be reduced in the area. This includes identifying suitable locations for new water sources, such as water pans and boreholes, and assessing how effective these sources would be over the long term.

Agricultural specialist
Further research is needed to identify crops that deter elephants, confirm which crops are drought-resistant and suitable for the Kasigau region, and determine which could be cultivated as cash crops. An agricultural specialist could also recommend additional suitable crops. Furthermore, this expert could advise on the most efficient ways to cultivate edible crops for local consumption.

Food expert
Calculations are needed to determine how much food must be grown on the community farms to ensure that inhabitants have sufficient food. These calculations should also account for possible crop failures, providing a margin of safety and minimising the risk of food scarcity.

10.1.2 Expanding the scope

Due to the limited time available for research, some aspects were not included in the design. If further research is conducted, it is recommended that the following three topics be explored.

The Mombasa–Nairobi highway crossing
The crossing of the elephant corridor over the Mombasa–Nairobi highway, north of the design area, was not included in this project. The highway borders Tsavo East National Park, and considerable research has already been conducted on this topic. Nevertheless, it should be addressed in future research because it plays an important role in creating a safe elephant corridor. Elephants currently experience stress when crossing this dangerous highway.

Expanding the research area
It is recommended that the research be extended to cover the entire area between Tsavo East and Tsavo West National Parks. This would include addressing human–elephant conflict in urban areas such as Voi. Expanding the scope would allow the landscape framework to cover a larger area and make it more applicable to other locations experiencing similar human–elephant conflict.

The role of ranches
Further research into the ranches is also recommended. The current project focuses mainly on community land, but ranches can play an important role in connecting elephant habitats. Investigating their potential in greater detail could help the design contribute more extensively to improving the ecosystem.

Other wildlife
The current project focuses primarily on elephants and their interaction with local inhabitants, but the landscape also supports a wide variety of other wildlife species. Further research is needed to understand their habitat requirements and how the proposed interventions could benefit them. This knowledge is essential for developing a healthy and functioning ecosystem that supports a variety of species. It is also important to investigate how changes in wildlife presence may affect local communities and whether they could introduce additional challenges, such as leopards entering farmland or settlements. This would help ensure that future interventions support the wider ecosystem while taking the needs and safety of local communities into account.

10.2 Personal reflection

10.2.1 Reflecting on the process

Throughout the project, I used various methods to collect and interpret information, including literature reviews, online research, GIS mapping, site visits, photography, interviews with local inhabitants, conversations with experts, and research into elephants and their habitats. Each method contributed something different to the project.

This thesis started with my fascination and a problem and ended with a final design proposal and conclusion. However, the process of developing the design was not linear. Throughout the graduation period, I moved back and forth between the two. Although the idea of creating an elephant corridor was clear from the beginning, my understanding of what it should look like changed considerably over time.

In particular, my understanding of what designing a landscape in which elephants and inhabitants can coexist actually entails changed. I eventually concluded that the objective was not simply to create a corridor that protects elephants while benefiting inhabitants through ecotourism. Instead, it involved transforming the wider landscape structure. Gradually, I came to understand the benefits of genuinely reducing human–elephant conflict (HEC) and how closely this is connected to drought and the wider ecosystem. The site visit played a major role in reaching this conclusion.

The site visit was also the most remarkable part of the research. Travelling all the way to Kenya and being welcomed into local households was a very special experience. It allowed me to learn about the local culture and ways of life. Experiencing the welcoming attitude of the inhabitants and their willingness to help was particularly meaningful.

However, conducting research on site also presented challenges. I gathered a large amount of information in a short period, and it took a while to understand which information was most important to collect. The process was not without its shortcomings. Looking back, there are many things I would have liked to photograph, asked about, and documented.

I also had to accept that the limited time available in Kenya made it impossible to see and learn everything. Establishing priorities was therefore essential, while remaining open to changes in the itinerary based on new insights and opportunities to speak with people.

Another new experience was taking the lead on a project for the first time. This meant that I had to decide what was important to investigate and learn. Conducting interviews was challenging, especially since I had not practised this extensively beforehand. Fortunately, my research assistant, Faith, helped me considerably throughout the fieldwork.

Another challenge of choosing a project on a different continent was that I could not visit the site beforehand or return multiple times to experience the area during different seasons. Nevertheless, the site visit remained an extremely valuable part of the research.

One recurring challenge was keeping the project within its intended scope. As the research progressed, I continued to discover new problems, opportunities, and potential directions to explore. This was also influenced by the fact that the design itself changed over time, which continually opened up new possibilities to investigate.

Finally, I struggled to translate my proposed solutions into actual drawings. With the help of my mentors, fellow students, and friends and family, who helped me look at the project from different perspectives, I eventually managed to develop a design in which elephants and inhabitants can coexist in the Kasigau region.

10.2.2 Kenyan words of wisdom

These are the lessons I learned during my site visit to Kenya that changed my way of thinking as a landscape architect.

The power of communities
While working on this project, I came to realise how important CBOs are in creating meaningful impact. This made me appreciate the importance of communities, not only in the success of projects but also in everyday life.

Maji ni Uhai (Water is Life)

> "Water is life. When there is no water, nothing, no matter what you do, will move or progress."

This quote from Grace Mwachuga, a Rukanga CBO member representative (Wildlife works, 2024), beautifully expresses the importance of water. Being in a region where water is scarce made me realise how fragile access to this essential resource can be. This is an important lesson to keep in mind, especially as drought-related challenges are also becoming more common in the Netherlands due to climate change. It shows that water scarcity affects us all. As a landscape architect, it is therefore essential to approach water management thoughtfully and responsibly in every project.

The value of indigenous knowledge
Learning about indigenous knowledge showed me that our ancestors likely have faced problems similar to those we face today. They may have developed valuable solutions that have since been lost over time. This made me realise how important it is to explore the history of a place and speak with local people when working on a project. Their knowledge and experiences can provide valuable insights that might otherwise be overlooked.

Less is sometimes more
The difference between the Dutch way of life and that of the inhabitants of Kasigau is striking. However, the people I met showed me that that a project do not necessarily has to have expensive solutions involving large interventions to make a difference. Sometimes, the smallest interventions are enough. My time in Kenya also taught me that you do not need much to be content, as long as your livelihood is secure.

Time is fluid
And lastly, as my host, Newton, liked to say to me, "There is no hurry in Africa." Almost every day, we were unable to complete everything we had planned because other activities took longer than expected. At first, I saw this as a negative thing. However, I gradually realised that it often created space to focus on what we were doing in the moment and gain a deeper understanding of it, without feeling stressed about everything else we had planned. This experience taught me that it sometimes can be more valuable to slow down and take the time to explore one subject in depth than to rush through everything simply to meet predetermined goals.

References

Africa Wood Grow. (2026). Africa Wood Grow. Retrieved September 6, 2026, from https://africawoodgrow.org

Africa Wood Grow. (2026). How we work. Retrieved September 6, 2026, from https://africawoodgrow.org/how-we-work

African Wildlife Foundation. (2025, February 12). AWF, Elephant Cooperation partner to provide water for climate resilience in Kenya. Retrieved October 7, 2026, from https://www.awf.org/pressroom/awf-elephant-cooperation-partner-provide-water-climate-resilience-kenya

African Wildlife Foundation. (2026, June 11). Rukanga Community Water Project restored to improve water access for communities and wildlife in Kasigau, Kenya. Retrieved October 7, 2026, from https://www.awf.org/news/rukanga-community-water-project-restored-improve-water-access-communities-and-wildlife-kasigau

Anthony, L., & Spencer. (2017). The Elephant Whisperer. Pan Books. (Original work published 2009)

Ataroff, M., & Rada, F. (2000). Deforestation impact on water dynamics in a Venezuelan Andean cloud forest.

Ambio, 29(7), 440–444. Royal Swedish Academy of Sciences. https://doi.org/10.1579/0044-7447-29.7.440

Baker, C., Dudley, N., Chatterton, P., Ferwerda, W. H., Gutierrez, V., & Madgwick, J. (2021). The 4 returns framework for landscape restoration. Commonland.

Bidan, B. (2021, October 21). Elephants destroy water tank in Taita Taveta County. Facebook. Retrieved October 15, 2026, from https://www.facebook.com/groups/taitatavetacountycitizenryforum/posts/6815261021832382/

Buffalo, B. B. (n.d.). The Rescue of Maisha. Sheldrick Wildlife Trust. Retrieved October 15, 2026, from https://www.sheldrickwildlifetrust.org/news/updates/the-rescue-of-maisha

Bytebier, B. (2001). Taita Hills Biodiversity Project Report. National Museums of Kenya.

County Government of Taita Taveta. (2023). Environmental impact assessment project report for the proposed Ufunguo Water Pan, Taita Taveta County. Kenya Climate Smart Agriculture Project.

Creemers, J., Maina, D., Opinya, F., & Maosa, S. (2021, August). Forage value chain analysis for the counties of Taita Taveta, Kajiado and Narok: Final report for Taita Taveta County. Integrated & Climate Smart Innovations for Agro-Pastoralist Economies and Landscapes.

Critchley, W., & Siegert, K. (1991). Water harvesting: A manual for the design and construction of water harvesting schemes for plant production. Food and Agriculture Organization of the United Nations.

Curú Wildlife Refuge. (n.d.). About us. Retrieved September 14, 2026, from https://curuwildliferefuge.com/about

Design Indaba. (n.d.). Nampath Paper. Retrieved September 14, 2026, from https://www.designindaba.com/tags/nampath-paper

Dorsia Travel. (2024, July 18). Review: Singita Ebony, South Africa. https://dorsiatravel.com/review-singita-ebony-south-africa

Douglas-Hamilton, I., Krink, T., & Vollrath, F. (2005). Movements and corridors of African elephants in relation to protected areas. Naturwissenschaften, 92(4), 158–163. https://doi.org/10.1007/s00114-004-0606-9

Ecoexist Trust. (n.d.). The area. Retrieved September 14, 2026, from https://www.ecoexisttrust.org/challenge/area/

Ferrer-Gisbert, C. M., Ferrán-Gozálvez, J. J., Redón-Santafé, M., Ferrer-Gisbert, P., Sánchez-Romero, F. J., & Torregrosa-Soler, J. B. (2013). A new photovoltaic floating cover system for water reservoirs. Renewable Energy, 60, 63–70. https://doi.org/10.1016/j.renene.2013.04.007

Ferwerda, W. (2015). 4 returns, 3 zones, 20 years: A holistic framework for ecological restoration by people and business for next generations. Rotterdam School of Management, Erasmus University. http://hdl.handle.net/1765/101679

Food and Agriculture Organization of the United Nations. (n.d.). Agroforestry overview. Retrieved October 14, 2026, from https://www.fao.org/agroforestry/about-agroforestry/overview/en

Food and Agriculture Organization of the United Nations. (1991). Guidelines: Land evaluation for extensive grazing (FAO Soils Bulletin No. 58).

GeoPortal. (n.d.). Retrieved December 10, 2025, from https://kenya.africageoportal.com/

Government of the Republic of Kenya. (2007). Kenya Vision 2030: The popular version. https://nairobi.aics.gov.it/wp-content/uploads/2019/01/Kenya-Vision-2030.pdf

Hadithi Crafts. (n.d.). Products. Retrieved March 12, 2026, from https://www.hadithikenya.com/product

Hut, R., Ertsen, M. W., Joeman, N., Vergeer, N., Winsemius, H. C., & van de Giesen, N. C. (2008). Effects of sand storage dams on groundwater levels with examples from Kenya. Physics and Chemistry of the Earth, Parts A/B/C, 33(1–2), 56–66. https://doi.org/10.1016/j.pce.2007.04.006

Inverdoorn Private Game Reserve. (2025, February 21). Why elephant dung is essential to Africa's ecosystem. Retrieved September 14, 2026, from https://inverdoorn.com/elephant-dung-is-essential-to-africas-ecosystem

Kasigau Ranching. (n.d.). Kasigau Ranch. Retrieved September 14, 2026, from https://kasigauranching.com
Kasigau Ranching. (n.d.). Operations. Retrieved September 14, 2026, from https://www.kasigauranching.com/operations

Kataara Women's Poverty Alleviation Group. (n.d.). Kataara Women's Poverty Alleviation Group. Retrieved September 14, 2026, from https://kwpag.wordpress.com

Kenya Community Based Tourism Network. (2014, August 22). Taita homestay: If you want to live the real Kenyan way, then come, stay and experience!. https://kecobat.blogspot.com/2014/08/taita-homestay-if-you-want-to-live-real.html

Kenya GIS data. (n.d.). World Resources Institute. Retrieved December 10, 2025, from https://www.wri.org/data/kenya-gis-data

Kenya National Bureau of Statistics [KNBS]. (2019). 2019 Kenya Population and Housing Census, Volume I: Population by County and Sub-county.

Kenya News Agency. (2023, October 24). County changes community water projects to rural water providers. Retrieved September 21, 2026, from https://www.kenyanews.go.ke/county-changes-community-water-projects-to-rural-water-providers

Kenya Wildlife Conservancies Association. (n.d.). Conservancy members. Retrieved September 21, 2026, from https://kwcakenya.com/our-members

Kenyan Camper. (2015, June 23). Mount Kasigau—Behind the scenes. Retrieved September 21, 2026, from https://kenyancamper.com/2015/06/23/mount-kasigau-people-kenya

Kindt, R., van Breugel, P., Lillesø, J.-P. B., Gachathi, F., Omondi, W. O., Jamnadass, R., & Graudal, L. (2013). Potential natural vegetation of Eastern Africa (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia). Volume 8: Atlas and tree species composition for Kenya. Forest & Landscape Denmark, University of Copenhagen.

King, L., Raja, N., Kumar, M., & Heath, N. (2023). Human–elephant coexistence toolbox: Advice, actions and tools to reduce conflict with elephants: A technical manual for trainers and community leaders. Save the Elephants.

KWS. (n.d.). Our story. Retrieved December 9, 2025, from https://www.kws.go.ke/our-story#:~:text=Kenya%20wildlife%20Service%2C%20Kenya%20a,field%20stations%20outside%20protected%20areas

KWS. (n.d.). Tsavo East National Park. Retrieved December 2, 2025, from https://www.kws.go.ke/tsavo-east-national-park

LeatherWorld News. (2026, September 19). Kenya pushes leather manufacturing and value addition. Retrieved October 14, 2026, from https://leatherworldnews.com/article/news/kenya-pushes-leather-manufacturing-and-value-addition-5993

Little, M. E., & Blau, E. (2020). Social adaptation and climate mitigation through agrotourism: A case study of tourism in Mastatal, Costa Rica. Journal of Ecotourism, 19(2), 97–112. Routledge. https://doi.org/10.1080/14724049.2019.1652305

Mady, B., Lehmann, P., & Or, D. (2021). Evaporation suppression from small reservoirs using floating covers—Field study and modeling. Water Resources Research, 57(4), e2020WR028753. https://doi.org/10.1029/2020WR028753

Makueni County Government. (2026). Twin FLLoCA projects to transform water access and agriculture in Muvau Kikumini and Kikumbulyu South. Makueni County Government.

Marula Horizon Safaris. (n.d.). Tsavo West National Park. Retrieved October 7, 2026, from https://marulahorizonsafaris.com/destinations/kenya-safaris/tsavo-west-national-park
Mati, B. M. (2018). Water harvesting in practice: Towards building resilient livelihoods in semi-arid zones (Field Practitioners Guide No. 2). World Food Programme.

McHarg, I. L. (1969). Design with nature. Natural History Press.

Menon, V., Tiwari, S. K., Ramkumar, K., Kyarong, S., Ganguly, U., & Sukumar, R. (2017). Right of passage: Elephant corridors of India (2nd ed.). Wildlife Trust of India.

Mganga, K. Z. (2022). Agricultural land degradation in Kenya. In Impact of agriculture on soil degradation I (pp. 273–300). Springer International Publishing. https://doi.org/10.1007/698_2022_929

Ministry of Water and Irrigation, Government of Kenya. (2015). Practice manual for small dams, pans and other water conservation structures in Kenya (2nd ed.).

Ministry of Water Resources Management and Development. (2003). Inventory of dams and water pans in Kenya. Republic of Kenya.

Ministry of Water, Sanitation and Irrigation. (n.d.). Consultancy services for the national groundwater development and management strategy, regulations and guidelines: Terms of reference.

Motaroki, L., Ouma, G., & Kalele, D. (2021). "Conservation agriculture," possible climate change adaptation option in Taita Hills, Kenya. In African handbook of climate change adaptation. Springer Nature. https://doi.org/10.1007/978-3-030-42091-8_184-1

Muoki, K., & Lala, F. (2026). Payment for ecosystem services as a preventive water-security instrument: The Chyulu Hills–Mzima Springs catchment, Kenya. SSRN Electronic Journal. Elsevier.

Munyao, M., Siljander, M., Johansson, T., Makokha, G., & Pellikka, P. (2020). Assessment of human–elephant conflicts in multifunctional landscapes of Taita Taveta County, Kenya. Global Ecology and Conservation, 24, e01382. Elsevier B.V. https://doi.org/10.1016/j.gecco.2020.e01382

Murphy, J. (2023, August 6). Elephant corridors: The busy trunk routes where locals take care to cross. BBC News. https://www.bbc.co.uk/news/science-environment-66317706

Mwongeli, P. (2019, May 8). How beehive fences help reduce human–elephant conflict in Sagalla. Save the Elephants. https://savetheelephants.org/news/how-beehive-fences-help-reduce-human-elephant-conflict-in-sagalla

National Drought Management Authority. (2025, September). National drought early warning bulletin.
National Drought Management Authority. (2025, March). Taita Taveta county drought early warning bulletin for March 2025.

Newbold, T., Hudson, L. N., Arnell, A. P., Contu, S., De Palma, A., Ferrier, S., Hill, S. L. L., Hoskins, A. J., Lysenko, I., Phillips, H. R. P., Burton, V. J., Chng, C. W. T., Emerson, S., Gao, D., Pask-Hale, G., Hutton, J., Jung, M., Sanchez-Ortiz, K., Simmons, B. I., . . . Purvis, A. (2016). Has land use pushed terrestrial biodiversity beyond the planetary boundary? A global assessment. Science, 353, 288–291. https://doi.org/10.1126/science.aaf2201

Ngene, S., Lala, F., Nzisa, M., Kimitei, K., Mukeka, J., Kiambi, S., Davidson, Z., Bakari, S., Lyimo, E., Khayale, C., Ihwagi, F., & Douglas-Hamilton, I. (2017). Aerial total count of elephants, buffalo and giraffe in the Tsavo–Mkomazi ecosystem (February 2017). Kenya Wildlife Service & Tanzania Wildlife Research Institute. https://www.awf.org/sites/default/files/2024-09/Tsavo_Mkomazi_AerialTotalCountofElephants_20_06_2017.pdf

Ngene, S., Njumbi, S., Nzisa, M., Kimitei, K., Mukeka, J., Muya, S., Ihwagi, F., & Omondi, P. (2013). Status and trends of the elephant population in the Tsavo–Mkomazi ecosystem. Pachyderm, 53, 38–50. https://doi.org/10.69649/pachyderm.v53i.322

Nijhuis, S., & de Vries, J. (2020). Design as research in landscape architecture. Landscape Journal, 38(1–2), 87–103. University of Wisconsin Press. https://doi.org/10.3368/lj.38.1-2.87

Njoroge, C., Smith, A., & von Fintel, M. (2024). Inequalities in water insecurity in Kenya: A multidimensional approach. Social Indicators Research, 175(1), 171–193. Springer Nature. https://doi.org/10.1007/s11205-024-03435-3

Okech, R. (n.d.). Ecotourism Kenya newsletter (Issue 22). Ecotourism Kenya. https://ecotourismkenya.org/wp-content/uploads/ekdownloads/ek_newsletters_archive/ISSUE22.pdf

Okita-Ouma, B., Lala, F., Koskei, M., Mwazo, A., Kibara, D., King, L., Kanga, E., & Douglas-Hamilton, I. (2016). Movements of satellite-linked collared elephants and other wildlife in relation to the Standard Gauge Railway (SGR) and highways in Tsavo Ecosystem, Kenya (March–September 2016). Save the Elephants and Kenya Wildlife Service.

Polechová, J., & Storch, D. (2008). Ecological niche. In Encyclopedia of ecology (Vol. 2, pp. 1088–1097). Elsevier. https://doi.org/10.1016/B978-008045405-4.00811-9

Pontzer, H., Rimbach, R., Paltan, J., Ivory, E. L., & Kendall, C. J. (2020). Air temperature and diet influence body composition and water turnover in zoo-living African elephants (Loxodonta africana). Royal Society Open Science, 7(11), 201155. The Royal Society. https://doi.org/10.1098/rsos.201155

Price, J., Forstenhäusler, N., Graham, E., Osborn, T. J., & Warren, R. (2024). Report on the observed climate, projected climate, and projected biodiversity changes for Kasigau under differing levels of warming.

Roggema, R. (2013). Swarming landscapes: New pathways for resilient cities. AST Management. https://doi.org/10.1007/978-94-007-7152-9_6

Rukinga Conservancy. (n.d.). Rukinga Conservancy. Retrieved September 28, 2026, from https://www.rukingaconservancy.com

SamSamWater. (2012, August 27). Construction of berkad in Bundunbuto. Retrieved October 8, 2026, from https://www.samsamwater.com/news/?tag=berkad

Save the Elephants. (n.d.). Save the Elephants. Retrieved March 18, 2026, from https://savetheelephants.org

Save the Elephants. (n.d.). Threats to elephants. Retrieved October 7, 2026, from https://savetheelephants.org/about-elephants/threats-to-elephants

Scharmer, C. O., & Kaufer, K. (2013). Leading from the emerging future: From ego-system to eco-system economies. Berrett-Koehler Publishers.

Schengenga, P., Kupers, P., Kreulen, M., Luiten, E. A. J., Hooimeijer, F. L., Brand, A. D., Kuzniecow Bacchin, T., & Bijlsma, E. (2023). De lagenbenadering, het lagenmodel en het Casco concept: Reflecties op drie instrumenten in het herontwerpen van de Nederlandse delta. H+N+S Landschapsarchitecten, TU Delft. https://repository.tudelft.nl/record/uuid:c83a108c-a3c0-4b40-8522-eb54a7dd2c51

Sheldrick Wildlife Trust. (n.d.). Water initiatives. Retrieved October 7, 2026, from https://www.sheldrickwildlifetrust.org/news/updates/water-initiatives

Singita. (n.d.). About Singita. Retrieved October 7, 2026, from https://singita.com/about

Singita. (2018). Power of Purpose – Collaboration for conservation in Africa.

Taita Taveta Wildlife Conservancies Association. (2026). Terms of reference: Development and review of conservancy management plans.

Thouless, C. R., Dublin, H. T., Blanc, J. J., Skinner, D. P., Daniel, T. E., Taylor, R. D., Maisels, F., Frederick, H. L., & Bouché, P. (2016). African elephant status report 2016: An update from the African Elephant Database (Occasional Paper of the IUCN Species Survival Commission No. 60). IUCN. https://portals.iucn.org/library/node/46878

Tillie, N. (2025). The urban ecosystem as a basis for planning for synergies [Journal-article; Presentation slides]. Plantscapes Course, Section Of Landscape Architecture, Urban Ecology Design Lab, Delft University Of Technology, Delft, Zuid Holland, Nederland.

Timmermans, G., & de Zwarte, N. (2024, April 15). De natuurinclusieve stad. Biowetenschappen & Maatschappij. https://www.biomaatschappij.nl/artikel/de-natuurinclusieve-stad/

Tjallingii, S. (1995). Ecopolis: Strategies for ecologically sound urban development. Backhuys Publishers. https://www.researchgate.net/publication/281207281

Tourism Research Institute. (2025). Annual Tourism Sector Performance Report 2024. https://www.tri.go.ke/wp-content/uploads/2025/02/TRI-Tourism-Sector-Performance-Report-2024.pdf

Tsavo Climate. (n.d.). Climate Data. Retrieved December 10, 2025, from https://en.climate-data.org/africa/kenya/makueni/tsavo-103115/#climate-graph

Tsavo Trust. (2022). 109 elephants killed by drought in Tsavo this year: The initialising slide down a slippery slope. Tsavo Trust. Retrieved October 5, 2026, from https://tsavotrust.org/109-elephant-killed-by-drought-in-tsavo-this-year-the-initialising-slide-down-a-slippery-slope

Vagus, E. (n.d.). Tsavo East and Tsavo West national parks - Kenya. Retrieved October 5, 2026, from https://ermakvagus.com/Africa/Kenya/Tsavo/Tsavo.htm

Van Wijngaarden, W. (1985). Elephants, trees, grass, grazers: relationships between climate soils, vegetation and large herbivores in a semi-arid savanna ecosysteem (Tsavo, Kenya). https://doi.org/10.18174/211799

Wato, Y. A., Prins, H. H. T., Heitkönig, I. M. A., Wahungu, G. M., Ngene, S. M., Njumbi, S., & Van Langevelde, F. (2018). Movement Patterns of African Elephants (Loxodonta africana) in a Semi-arid Savanna Suggest That They Have Information on the Location of Dispersed Water Sources. Frontiers in Ecology and Evolution, 6. https://doi.org/10.3389/fevo.2018.00167

Wikiloc. (n.d.). Refugio Nacional de Vida Silvestre Mixto Curú. Retrieved October 5, 2026, from https://nl.wikiloc.com/routes-wandelen/refugio-nacional-de-vida-silvestre-mixto-curu-185471804

Wildlife Trust of India. (n.d.). Right of passage. Retrieved May 5, 2026, from https://www.wti.org.in/right-of-passage

Wildlife Trust of India. (n.d.). Right of passage: National elephant corridors project. Retrieved May 5, 2026, from https://www.wti.org.in/projects/right-of-passage-national-elephant-corridors-project

Wildlife Works. (n.d.). Kasigau Corridor REDD+ project, Kenya. Retrieved December 10, 2025, from https://www.wildlifeworks.com/redd-projects/kasigau-kenya

Wildlife Works. (2011, November 12). Meet Betty, Wildlife Works' enterprising soap maker. https://www.wildlifeworks.com/post/meet-betty-wildlife-works-enterprising-soap-maker

Wildlife Works. (2021, May 18). Constance Mademu teaches women in her community how to make sustainable charcoal. Wildlife Works. https://www.wildlifeworks.com/post/constance-mademu-of-wildlife-works-teaches-women-in-her-community-how-to-make-sustainable-charcoal

Wildlife Works. (2022). The Kasigau Corridor REDD+ Project Phase I – Rukinga Sanctuary. SD VISta.

Wildlife Works. (2024, June 17). Short Film: Water is Life - Kasigau Community Uses Carbon Credit Revenue to Increase Access to Water. Wildlife Works. Retrieved January 18, 2026, from https://www.wildlifeworks.com/post/kasigau-community-uses-carbon-credit-revenue-to-increase-access-to-water

Wildlife Works Factory. (n.d.). Wildlife Works Factory. Retrieved May 5, 2026, from https://www.factory.wildlifeworks.com

World Wide Fund for Nature. (2002). African elephants [Fact sheet].

WWF. (2024). WWF LIVING PLANET REPORT 2024 - A System in Peril. WWF, Gland, Switzerland.

Ylhäisi, J. (2004). Indigenous forest fragmentation and the significance of ethnic forests for conservation in the North Pare, the Eastern Arc Mountains, Tanzania. Fennia, 182(2), 109–132. https://fennia.journal.fi/article/view/3741

The colour palette of this report is inspired by the colours of the Kasigau landscape, particularly its distinctive red soil. It also reflects the famous "red elephants of Tsavo", whose reddish appearance comes from coating their skin with the iron-rich red soil.



Figure 98: Red soil in Kasigau, made by author



Figure 99: Elephant covering itself in red soil, made by Jelmer Veenstra

Asante sana





Image made by Ann Lo

Appendix A

Flora specification



Image made by author

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1. Introduction

This appendix provides additional information on the crops, plants and trees considered in the design research. Their characteristics, uses, and relationship with elephants are described to help evaluate the suitability of existing crops and identify potential alternatives for the Kasigau region.

In addition to the literature research, I spoke with several local farmers and conservation practitioners to gain a better understanding of farming practices, human–elephant conflict (HEC), and elephant feeding behaviour. I also spoke with representatives from Wildlife Works (WW) and Save the Elephants, who helped direct me towards relevant research and information they had already collected. Furthermore, a fieldwork case study by Africa Wood Grow provided information about agroforestry trees.

Farmer 1 – Jora

I first spoke with a farmer in Jora, near Kasigau Ranch. He experiences frequent HEC because elephants move around the area and encounter the ranch's electric fence, which can agitate them. To protect his farmland from elephants, he uses metal fencing.

Farmer 2 – Teacher and farmer in Kithege

During my visit to the Elemetry School in Kithege, I spoke with a teacher who also farms. He grows crops for his own use and as an additional source of income. His situation is an example of how farming supplements other sources of income when a single livelihood is insufficient.

Farmer 3 – Bungule

I spoke with a farmer in Bungule, a village that experiences high levels of HEC, because it is close to the historic elephant migration route brings elephants close to farmland. The relatively green vegetation and more productive agricultural land around Mount Kasigau can also attract elephants to cultivated areas.

Farmer 4 – Elephant corridor

I also spoke with a farmer living along the historic elephant migration route within the corridor. Because elephants regularly move through this area, his farmland is frequently exposed to HEC and he was even attacked by an elephant in 2011.

Farmer 5 – My host in Kasigau

My host in Kasigau also has farmland where he grows crops for his household and people he hosts. This illustrated how common it is for people in the area to cultivate their own food, even when they have other sources of income.

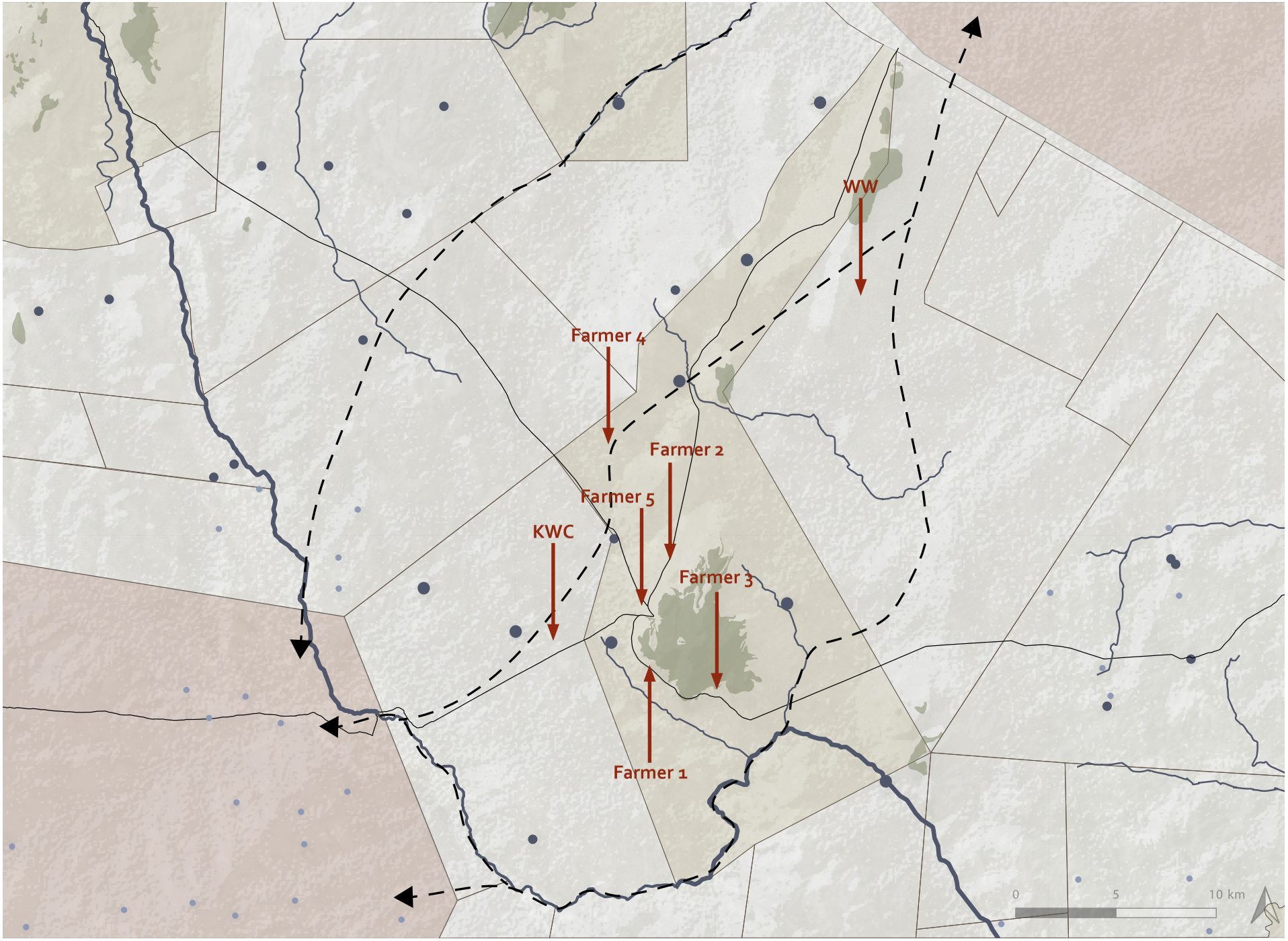
Manager of Kasigau Wildlife Conservancy (KWC)

I spoke with an employee of Kasigau Wildlife Conservancy, a community-owned ranch in the process of transitioning into a conservancy. Since elephants move through the area, the manager has practical knowledge of their presence and feeding behaviour. This provided a useful local perspective on which plants and crops elephants eat.

Head ranger at Wildlife Works (WW)

I also spoke with the head ranger at Wildlife Works. As part of his work, he helps protect elephants and other wildlife. His experience and knowledge of elephant behaviour and feeding preferences provided another perspective for evaluating which plants are suitable for the design.

The interviews complemented the literature research by providing practical insights into local farming practices, sources of income, crop choices, and experiences with HEC. The farmers helped me understand how conflict differs between locations, while the conservation practitioners provided additional knowledge of elephant behaviour and feeding preferences. Together with the literature and the Africa Wood Grow case study, these insights helped inform the evaluation of existing crops and potential alternatives for the Kasigau region.


WW
Farmer 4
Farmer 2
Farmer 5
KWC
Farmer 3
Farmer 1
0
5
10 km

2. Current crops

Farming and livestock keeping are important sources of income and food for inhabitants of the Kasigau region. Farmers typically grow a mix of crops for both household consumption and sale. Crops such as maize, beans and green grams provide food for their families, while surplus harvests and cash crops generate income. However, these livelihoods are vulnerable to drought, which reduces crop yields and water availability, and to crop losses caused by elephants, making both major challenges for local farmers.

Mangifera Indica

Mango - Embe





Made by author

Native: No
Drought resistant: Yes
Harvest season: Januari-Februari
Preferred by elephants: Yes, they eat the fruit and foliage
Mentioned by: farmer 1, farmer 2, farmer 5 and manager KWC
Explanation:
A fruit tree producing sweet, fleshy mangoes that are harvested when ripe. The fruits are eaten fresh or processed into juice, dried fruit and other products.

Vigna unguiculata

Cow Peas - Kunde



Source: mydesiredhome.com



Source: pza.sanbi.org

Native: yes
Drought resistant: yes
Harvest season: March-May and October-December
Preferred by elephants: yes
Mentioned by: farmer 2, farmer 3, farmer 5
Explanation:
A protein-rich legume harvested for its dry beans, green pods and edible leaves. The beans can be cooked in meals, while the leaves can be used as vegetables or livestock fodder.

Vigna radiata

Green grams - Ndengu



Source: theoriginalgarden.com



Made by author

Native: no
Drought resistant: yes
Harvest season: March-May and October-December
Preferred by elephants: yes
Mentioned by: Farmer 2, farmer 3, farmer 4, farmer 5
Explanation:
A protein-rich legume producing small green seeds, also known as mung beans. The seeds can be cooked whole, sprouted, split or ground into flour.

Zea mays

Maize - Mahindi



Source: aventurabotanica.com



Source: sciencephoto.com

Native: no
Drought resistant: no
Harvest season: October-January and August-September
Preferred by elephants: yes
Mentioned by: Farmer 2, farmer 3, farmer 4, farmer 5
Explanation:
A cereal crop producing ears of maize that can be harvested fresh or dried for grain and flour. It is one of the most common crops in Kasigau, where people use maize flour to prepare ugali, a staple food. However, maize is also a major source of human–elephant conflict because elephants are attracted to it. It is vulnerable to drought, which can significantly reduce yields.
Because maize is not highly drought-resistant, it requires additional care during establishment, including sufficient watering and strategic planting in locations with better soil moisture availability.

Annona reticulata

Custard apples - Tomoko



Source: richardlyonsnursery.com



Source: inaturalist.org

Native: no.
Drought resistant: drought tolerant
Harvest season: May-September
Preferred by elephants: moderate
Mentioned by: farmer 2
Explanation:
A fruit tree producing sweet, soft, creamy flesh inside a bumpy or segmented fruit. The fruits are harvested when ripe and eaten fresh. Elephants initially did not eat these fruits but began consuming them during drought, when other food became scarce.

Adansonia digitata

Baobab



Source: wikipedia.org



Source: commons.wikimedia.org

Native: yes
Drought resistant: yes
Harvest season: May-October
Preferred by elephants: no
Mentioned by: farmer 5
Explanation:
A slow-growing African tree producing nutrient-rich fruits with an edible, tangy pulp. The leaves are also edible, and the seeds can be processed for food or oil. Although it is not ideal for generating quick income, planting baobabs provides long-term food and ecological value for future generations.
Because of their drought tolerance and low palatability to elephants, these crops are suitable options for cultivation on community land.

Cajanus cajan

Pigeon Peas



Source: greenlife.co.ke



Source: inaturalist.org

Native: no
Drought resistant: drought tolerant
Harvest season: January-February and August-September
Preferred by elephants: no
Mentioned by: farmer 3
Explanation:
A protein-rich legume producing pods containing edible seeds. The green peas can be harvested fresh, while mature, dried seeds can be stored and used in soups and stews. The plants can also provide livestock fodder.

Carica papaya

Papaya - Pawpaw



Source: britannica.com



Source: inaturalist.org

Native: no
Drought resistant: drought tolerant
Harvest season: year round, peak October-December
Preferred by elephants: yes
Mentioned by: farmer 3
Explanation:
A tropical fruit crop producing large, sweet fruits with orange or red flesh and small black seeds. Ripe fruits are eaten fresh or processed into juice, while unripe fruits can be cooked. The plant grows quickly but needs sufficient moisture for reliable fruit production.
The tree is a suitable option for planting within the elephant corridor, as its fruits provide an attractive food source for elephants.

Sorghum bicolor

Sorghum



Source: healthforeverng.com



Source: theseedvine.com.au

Native: yes
Drought resistant: yes
Harvest season: July-August and January-February
Preferred by elephants: moderate
Mentioned by: Wildlife Works (n.d.)
Explanation:
A drought-tolerant cereal crop producing grain that can be ground into flour for porridge, flatbreads and other foods. The grain and remaining plant material can also be used as livestock feed, making sorghum useful in semi-arid regions.

Eleusine coracana

Millet



Source: feedipedia.org



Source: nyspiceshop.com

Native: yes
Drought resistant: yes
Harvest season: June-August and October-January
Preferred by elephants: no
Mentioned by: Ecoexist Trust (n.d.) and Wildlife Works (n.d.)
Explanation:
A group of drought-tolerant cereal crops producing small grains that can be ground into flour for porridge and other staple foods. Millet is well suited to dry climates and can provide a more drought-resilient alternative to maize, making it good crops to grow in the community land.

Dioscorea alata L.

White yam



Source: nparks.gov.sg

Native: no
Drought resistant: drought tolerant, 2-3 month dry spell
Harvest season: August-October
Preferred by elephants: not verified
Mentioned by: Wildlife Works (n.d.)
Explanation:
A tuber crop producing starchy underground tubers that are harvested when mature. The tubers can be boiled, roasted, fried or mashed and used as a staple food.Yams generally require more moisture than drought-adapted cereals, making reliable water availability important in dry regions.

Cymbopogon citratus

Lemongrass



Source: inaturalist.org

Native: no
Drought resistant: moderate
Harvest season: March-April and October-November
Preferred by elephants: no
Mentioned by: farmer 5, King et al. (2023), Gross et al. (2016)
Explanation:
An aromatic perennial grass harvested for its fragrant leaves. The leaves are commonly used to make herbal tea and can also be used in cooking. It also can be distilled to produce essential oil. Repeated harvesting allows the plant to produce new leafy growth.

Punica granatum

Pomgrenate



Source: agrovet.farmerstrend.co.ke

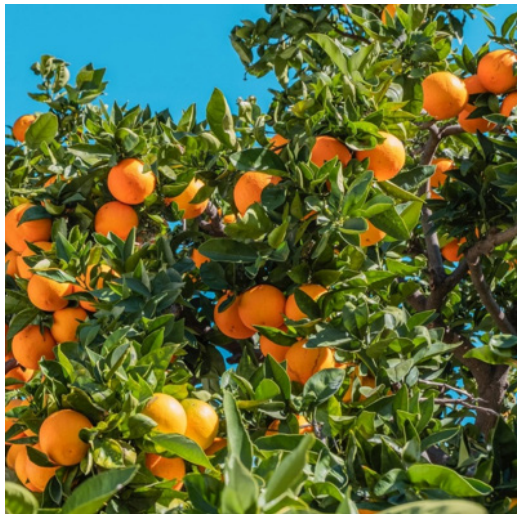


Source: inaturalist.org

Native: no
Drought resistant: yes, watering adequately for better harvest
Harvest season: November-January
Preferred by elephants: moderate
Mentioned by: farmer 2
Explanation:
A fruit tree producing round fruits filled with juicy, red edible seeds, known as arils. The fruit is harvested when ripe and sold fresh or processed into juice and other products. Pomegranate is relatively drought-tolerant once established, although irrigation can improve fruit size and commercial yields.

Citrus x sinensis

Oranges



Source: plantitude.co.ke



Source: thetutuguru.com.au

Native: no
Drought resistant: moderate
Harvest season: June-July and December-January
Preferred by elephants: no
Mentioned by: farmer 1, King et al. (2023)
Explanation:
An evergreen fruit tree that produces round fruits with a thick orange peel and juicy, sweet flesh. The fruits are harvested when ripe and eaten fresh or processed into juice, marmalade, jam and other food products. The peel is also used to produce essential oils, flavourings and pectin, while the flowers and leaves contain aromatic oils used in perfumes and cosmetics.

3. Elephant deterrent crops

Elephant deterrent crops are plants that discourage elephants from entering agricultural areas because of characteristics such as strong smells, pungent tastes or sharp leaves. Some plants are less attractive as food to elephants, while others can be used in physical barriers. However, their effectiveness has yet to be scientifically proven, with the exception of chillies . These crops can help reduce crop raiding and protect agricultural fields, while also providing additional benefits, such as food products or income for farmers.

Allium cepa

Garlic



Source: greenlife.co.ke



Source: gardenia.net

Native: no
Drought resistant: moderate
Harvest season: 3-4 months after planting
Deters elephants by: smell
Product: edible cash crop
Mentioned by: Gross et al. (2016)
Explanation:
A bulb crop consisting of multiple cloves enclosed in a papery skin. Garlic is harvested for its pungent bulbs, which are used as a seasoning and for medicinal purposes. Its strong sulfur compounds produce a distinctive smell that contribute to elephant deterrence.

Allium sativum

Onion



Source: aquahubkenya.co.ke



Source: gardenia.net

Native: no
Drought resistant: moderate
Harvest season: 4 months after planting
Deters elephants by: smell
Product: edible cash crop
Mentioned by: Gross et al. (2016)
Explanation: A bulb crop producing rounded bulbs with layered, fleshy leaves. Onions are harvested for cooking, seasoning and food processing. Their pungent smell comes from sulfur compounds, which may make them less attractive to elephants.

Ricinus communis

Castor oil plant



Source: mukuyu.wordpress.com



Source: globalresourcesdirect.com

Native: no
Drought resistant: yes
Harvest season: 4-6 months after planting
Deters elephants by: taste
Product: castor oil
Mentioned by: farmer 2
Explanation:
A fast-growing shrub that produces spiny seed capsules containing seeds rich in castor oil. The oil is used in industrial products, cosmetics and other applications. The seeds contain ricin, a highly toxic substance, while the leaves and other plant parts can also pose toxicity risks, making it unattractive for elephants.

Capsicum frutescens

African bird eye chillies



Source: b4fn.org



Source: balaccospeppers.com

Native: no
Drought resistant: moderate
Harvest season: January-April, or year round with irrigation
Deters elephants by: touch and smell
Product: edible cash crop
Mentioned by: farmer 2, King et al. (2023)
Explanation:
A chilli crop producing small, intensely hot fruits that can be harvested green or red. The fruits are used in cooking and can be processed into chilli products and deterrent mixtures. Capsaicin causes irritation to sensitive tissues, including the trunk and eyes. The strong, sharp smell also makes elephants stay away from the crops.

Agave sisalana

Sisal



Source: naturepl.com



Source: ropecentral.com.au

Native: no
Drought resistant: yes
Harvest season: all year round
Deters elephants by: touch
Product: rope
Mentioned by: farmer 5, manager KWC, King et al. (2023), Wildlife Works (2008)
Explanation:
A drought-tolerant succulent plant with long, stiff leaves containing strong fibres. The fibres are extracted and processed into rope that can be used as twine or be made into baskets and other woven products. Its sharp leaf tips and rigid structure can form a physical barrier that is painful for elephants to walk through.

Azadirachta indica

Neem - Mwarobaini



Source: plantitude.co.ke



Source:

Native: no
Drought resistant: yes
Harvest season: evergreen throughout the year
Deters elephants by: Taste and smell
Product: Medicinal leaves, oil and bark
Mentioned by: farmer 5, Wildlife Works (2008)
Explanation:
An evergreen tree that produces small, olive-like fruits and has bitter, aromatic leaves and bark, making it unappealing for elephants. Neem seeds are processed to produce oil used in traditional remedies, cosmetics and botanical pest-control products. Its leaves, bark and oil have medicinal and agricultural uses.

4. Elephant compatible crops

Elephant-compatible crops are crops that are less attractive to elephants and are therefore less likely to be eaten or damaged. These include non-palatable crops, which elephants tend to avoid, and agroforestry. By cultivating less attractive crops, farmers can reduce the risk of crop raiding while continuing to produce food and generate income. However, no crop is completely elephant-proof, as feeding preferences can change depending on food availability and drought conditions.

Melia volkensii

Mukau



Source: betterglobemedia.com



Source: indiamart.com

Native: yes
Drought resistant: yes
Product: timber
Mentioned by: farmer 1, farmer 3, farmer 5, AWG
Explanation:
A fast-growing, drought-tolerant tree, what makes them suitable for agroforestry, providing a long-term source of income for farmers. Its high-quality timber is used for furniture, doors, window frames and construction, making it a valuable commercial tree for dryland farming systems.

Citrus × limon

Lemons



Source: gardeningknowhow.com



Source: www.gardenia.net

Native: no
Drought resistant: moderate
Harvest season: March-May and October-December
Product: fruit
Mentioned by: farmer 2, King et al. (2023)
Explanation:
Lemon is a citrus tree that produces yellow, acidic fruits and can tolerate some drought once established, although sufficient water is needed for reliable fruit production. The fruits are used in cooking, drinks, food processing and the production of juice and essential oils. They can provide farmers with a valuable cash crop.

Sesamum indicum L.

Sesame - Simsim



Source: brookgreen.org



Source: exportersindia.com

Native: no
Drought resistant: yes
Harvest season: June-July and December
Product: oilseed
Mentioned by: farmer 5, King et al. (2023)
Explanation:
An annual oilseed crop that grows well in warm climates and is drought-tolerant once established. It produces small seeds that can be harvested when mature. The seeds are used in cooking and baking and to produce sesame oil for food products and cosmetics, making sesame a high-value cash crop.

Simmondsia chinensis

Jojoba



Source: baskinnature.in



Source: gaiagarden.com

Native: no
Drought resistant: yes
Harvest season: flowers late winter, nuts early summer
Product: jojoba oil
Mentioned by: Wildlife Works (2008)
Explanation:
A drought-tolerant shrub adapted to arid environments. It produces seeds containing a liquid wax commonly known as jojoba oil. The oil is widely used in soaps, skincare, haircare, cosmetics and some industrial products, making jojoba a good cash crop for dry regions.

Moringa oleifera

Moringa



Source: landinmalindi.com



Source: organictraditions.com

Native: no
Drought resistant: yes
Harvest season: most productive dry season
Product: foliage, pods, bark, timber
Mentioned by: Wildlife Works (2008)
Explanation:
A fast-growing, drought-tolerant tree that is suitable for agroforestry. The leaves are consumed as a nutritious food, while the seeds produce oil used in cosmetics and other products. Various parts of the tree are also used in traditional medicine, offering more food and income benefits for farmers.

Gossypium hirsutum

Cotton



Source: fadfay.com



Source: yesfabrics.eu

Native: no
Drought resistant: moderate tolerant
Harvest season: September-November
Product: cotton
Mentioned by: farmer 2, farmer 5
Explanation:
A warm-climate crop that produces fluffy fibres around its seeds. It requires adequate water during important growth stages, and prolonged drought can reduce yields. The fibres are processed into textiles, clothing and other fabric products, while the seeds are used to produce cottonseed oil and animal feed. Cotton can provide farmers with income where growing conditions, processing facilities and markets are suitable.

Manihot esculenta

Cassave



Source: shutterstock.com



Source: lifeandagri.com

Native: no
Drought resistant: yes
Harvest season: December-July and July-February (9-15 months after planting)
Product: edible tubers
Mentioned by: farmer 2
Explanation:
A tropical shrub cultivated for its thick, starchy roots. It grows well in warm climates and is relatively drought-resistant, allowing it to grow in areas where rainfall is limited. It can also tolerate soils with low fertility, although good growing conditions improve root yields. The roots are rich in carbohydrates and are an important staple food in many tropical regions. They can be boiled, roasted, dried or processed into flour and starch. The leaves are also edible when properly prepared

Helianthus annuus

Sunflower



Source: safiorganics.co.ke



Source: qpfoodsuk.com

Native: no
Drought resistant: yes
Harvest season: June-September and January-March
Product: seeds and oil
Mentioned by: farmer 2, manager KWC, King et al. (2023)
Explanation:
An annual crop that grows well in warm climates and can tolerate some dry conditions, although prolonged drought can reduce seed production. It produces large flower heads containing oil-rich seeds. These seeds are used to produce edible oil and snacks, while the remaining material can be processed into animal feed. Sunflower are therefore a good source of income.

5. Vegetation elephants like

Elephants spend a large part of their day browsing and feeding to meet their daily food requirements, consuming approximately 100–150 kg of vegetation. To reduce the likelihood of elephants entering agricultural areas, vegetation that provides a food source can be planted within the wildlife corridor. Elephants feed on a wide variety of plant parts, including fruits, pods, leaves, twigs, stems, bark and roots. Providing suitable food resources within the corridor may help meet their nutritional needs and reduce their incentive to search for food on farmland. However, this approach on its own cannot guarantee that elephants will remain within the corridor, particularly during droughts or when food availability is limited.

Brachiaria brizantha

Palisade grass



Source: sgmseeds.com.br

Native: yes
Drought resistant: yes
Fruiting season: year round (can resist 3-6 month dry spell, less foliage though)
Parts eaten: grass
Mentioned by: Manager KWC
Explanation:
A perennial tropical grass that grows in warm climates and produces substantial amounts of forage under suitable conditions. It is palatable to herbivores and can tolerate periods of dry weather once established. Elephants eat grasses because they provide digestible energy and nutrients, particularly when fresh, young shoots are available after rainfall. Palisade grass can contribute to the food supply within wildlife areas. Its main uses are livestock grazing, hay production and pasture improvement.

Cenchrus ciliaris

African foxtrail



Source: pza.sanbi.org

Native: yes
Drought resistant: yes
Fruiting season: grows during raining season
Parts eaten: grass
Mentioned by: Manager KWC
Explanation:
A perennial grass adapted to warm environments and seasonal dry periods. Its young leaves provide palatable forage for herbivores. Elephants consume grasses because they are a source of energy and are often easier to digest when young and green. Fresh growth after rainfall can be especially attractive when dry-season food is limited. The grass is mainly used for livestock grazing, hay production, pasture restoration and erosion control.

Panicum maximum

Guinea grass



Source: sgmseeds.com.br

Native: yes
Drought resistant: yes
Fruiting season: November-July
Parts eaten: grass
Mentioned by: Manager KWC
Explanation:
Guinea Grass, also known as buffalograss in some local contexts, is a perennial tropical grass that grows in warm environments and can produce abundant green foliage when sufficient moisture is available. It can tolerate dry periods once established. Elephants eat grasses as part of their varied diet, particularly young, green shoots that are easier to digest and provide nutrients. Guinea grass can therefore contribute to the food supply within the wildlife corridor, especially during the rainy season. It is also widely used for livestock grazing, cut-and-carry fodder and hay production.

Grewia bicolor

False brandy bush



Source: inaturalist.org



Source: pza.sanbi.org

Native: no
Drought resistant: yes
Fruiting season: fruit March-May, foliage growth October-November
Parts eaten: fruit, foliage, twigs
Mentioned by: Head Ranger WW
Explanation:
A drought-tolerant shrub or small tree found in dry African savannas and bushland. It produces edible fruits and leaves that can provide food for wildlife. Elephants browse its leaves and young shoots and eat its fruits, which provide nutrients and energy. The plant can therefore contribute to the natural food supply within the wildlife corridor, particularly where other vegetation is limited. Its fruits are also used as food by people in some regions, while its stems and branches can provide firewood.

Sclerocarya birrea

Marula



Source: pinterest.com

Native: yes
Drought resistant: yes
Fruiting season: January-March
Parts eaten: fruit, bark, foliage (elephants can get drunk on fermented fruit)
Mentioned by: farmer 4, Scogings et al. (2012)
Explanation:
A deciduous African tree that produces fleshy, yellowish fruits and can tolerate relatively dry conditions. Elephants eat its fruits and also browse its leaves, twigs and bark. The ripe fruits are attractive because their soft, fleshy pulp provides energy and moisture. The fruits can ferment naturally as they ripen and begin to rot, leading to the popular story that elephants become drunk after eating them. Marula fruits are used for fresh consumption, juice, jams and alcoholic beverages, while the kernels provide oil for food and cosmetics. Note: the research is about Asian elephants.

Vachellia abyssinica

Flat topped acacia



Source: inaturalist.org



Source: efloraofindia.com

Native: yes
Drought resistant: yes
Fruiting season: dry season
Parts eaten: foliage, pods, bark
Mentioned by: farmer 6, Manager KWC, Head Ranger WW
Explanation:
A tree native to eastern Africa, recognised by its spreading crown and thorny branches. It grows in woodland and savanna environments and provides foliage and other plant material for herbivores. Elephants browse its leaves, young branches and bark, obtaining nutrients from the woody vegetation. The tree provides shade and habitat for wildlife and can be used for firewood and other local wood products.

Tamarindus indica

Tamarind - Ukwaju



Source: inaturalist.org



Source: beyondforest.org

Native: no
Drought resistant: yes
Fruiting season: July-September
Parts eaten: pods, foliage
Mentioned by: farmer 5, Sukumar (1990)
Explanation:
A long-lived tree with a broad crown and brown pods containing tangy, edible pulp. It can tolerate dry conditions once established, although young trees need sufficient moisture. Elephants can eat its fruits and other plant parts. The fleshy pulp provides energy, while the leaves, shoots and other vegetation offer browse. Tamarind trees also provide shade and contribute to habitat diversity. Their fruits are used in cooking, sauces, drinks and preserves.

Portulacaria afra

Elephant bush



Source: inaturalist.org



Source: toptropicals.com

Native: yes
Drought resistant: yes
Fruiting season: dry season
Parts eaten: foliage, stem
Mentioned by: farmer 6, South African National Biodiversity Institute (n.d.)
Explanation:
A succulent shrub with fleshy leaves and reddish stems, adapted to dry conditions. Elephants are known to feed on its leaves and branches in parts of southern Africa. Its fleshy leaves contain moisture, which may be beneficial in dry environments, and provide browse when other vegetation is limited. Its main uses include ornamental planting, drought-tolerant landscaping and, in suitable regions, use as a food plant.

Vachellia tortilis

Umbrella Thorn



Source: inaturalist.org



Source: efloraofindia.com

Native: yes
Drought resistant: yes
Fruiting season: pods September-October, foliage year round
Parts eaten: foliage, pods, bark
Mentioned by: Ihwagi (2007), Waweru & Githaiga (2014)
Explanation:
A drought-tolerant African tree with a distinctive umbrella-shaped crown and paired thorns. It grows in dry savanna environments and produces leaves and pods eaten by elephants and other herbivores. Its foliage provides browse, while its pods can be a useful food source, particularly when grass availability decreases. Elephants can also break branches to reach vegetation higher in the canopy. The tree provides shade and shelter for wildlife and is used for livestock fodder, firewood, charcoal and ecological restoration.

Vachellia nilotica

Scented thorn



Source: inaturalist.org

Native: yes
Drought resistant: yes
Fruiting season: pods August-October, foliage year round
Parts eaten: foliage, pods
Mentioned by: Manager KWC, Head Ranger WW
Explanation:
A thorny tree adapted to dry and seasonally wet environments across Africa, including Kenya. It produces compound leaves and distinctive pods containing seeds. Elephants feed on its foliage, twigs and pods, which provide browse and additional nutrients when grass is scarce. The pods are also consumed by livestock, making the tree relevant to both wildlife and pastoral systems. Its other uses include livestock fodder, firewood, charcoal, traditional medicinal applications and, in some locations, tannin production from the bark and pods.

Senegalia mellifera

Black thorn



Source: inaturalist.org



Source: seedsandall.co.za

Native: yes
Drought resistant: yes
Fruiting season: pods September-October, foliage year round
Parts eaten: foliage, bark, twigs
Mentioned by: Waweru & Githaiga (2014)
Explanation:
A dense, thorny shrub or small tree native to dry regions of Africa, including Kenya. It is adapted to arid and semi-arid conditions and often forms dense thickets in bushland. Elephants may browse its leaves and young shoots, although its sharp thorns and dense growth can make feeding more difficult. The plant can contribute to the diversity of natural browse within the corridor. Its uses include livestock browse, firewood, charcoal, live fencing and traditional applications.

Opuntia ficus-indica

Prickly pear



Source: inaturalist.org



Source: ruthbancroftgarden.org

Native: yes
Drought resistant: yes
Fruiting season: August-October
Parts eaten: fruit, stem
Mentioned by: Wells et al. (2023)
Explanation:
A drought-tolerant cactus with fleshy pads that store water and fruits that can be eaten by people and wildlife. Elephants have been observed feeding on its pads in parts of Kenya. The water-rich pads provide moisture and plant material in dry environments, while the fruits offer sugars and other nutrients. Its fruits are used for fresh consumption, juice and preserves, while the pads are eaten as a vegetable in some regions.

Balanites aegyptian

Desert date



Source: inaturalist.org



Source: saharaconservation.org

Native: yes
Drought resistant: yes
Fruiting season: June-September and January-February
Parts eaten: fruit, bark, foliage
Mentioned by: Buss (1961)
Explanation:
A drought-resistant tree adapted to dry African environments. It produces oval fruits with a fleshy outer layer and a hard stone, that elephants like to feed on. The fleshy pulp provides food, while the fruits may also offer moisture in dry environments. The tree can provide shade and contribute to the resilience of dryland vegetation. Its fruits, seeds and other plant parts have traditional food, medicinal and agricultural uses, and its seeds can be processed for oil.

Commiphora kua

Abyssinian myrrh



Source: inaturalist.org



Source: inaturalist.org

Native: yes
Drought resistant: yes
Fruiting season: Foliage year round
Parts eaten: foliage
Mentioned by: Head Ranger WW
Explanation:
A drought-adapted shrub or small tree found in dry regions of East Africa, including Kenya. It produces aromatic resin when the bark or stems are damaged. It is well adapted to dryland conditions and elephants like to its foliage. The resin is traditionally used in incense, perfumes and medicinal preparations, while the plant contributes to natural dryland vegetation.

Syzygium cordatum

Waterberry tree



Source: zimbabweflora.co.zw



Source: inaturalist.org

Native: yes
Drought resistant: drought tolerant when mature
Fruiting season: April-July
Parts eaten: fruit, bark, foliage
Mentioned by: farmer 2
Explanation:
An evergreen tree generally associated with wetter habitats, including riverbanks, streams and areas with reliable moisture. It produces dark purple to almost black berries. Elephants may be attracted to its fleshy fruits because they provide energy and moisture, and they may also browse its leaves and branches. Its preference for wetter environments makes it more suitable for planting near rivers, springs or other dependable water sources in Kasigau than in exposed, dry areas. Its fruits are edible and can be used for fresh consumption and preserves, while its wood has uses as timber and firewood.

References

Buss, I. O. (1961). Some observations on food habits and behavior of the African elephant. The Journal of Wildlife Management, 25(2), 131–148. https://doi.org/10.2307/3798671

Ecoexist Trust. (n.d.). Ecoexist: Fostering coexistence between elephants and people. Retrieved October 5, 2026, from https://www.ecoexisttrust.org/

Gross, E. M., McRobb, R., & Gross, J. (2016). Cultivating alternative crops reduces crop losses due to African elephants. Journal of Pest Science, 89, 497–506. https://doi.org/10.1007/s10340-015-0699-2

Ihwagi, F. W. (2007). Forage quality and bark utilisation by the African elephant (Loxodonta africana) in Samburu and Buffalo Springs National Reserves, Kenya [Master's thesis, University of Nairobi]. https://savetheelephants.org/wp-content/uploads/2022/12/2007Foragequality.pdf

King, L., Raja, N., Kumar, M., & Heath, N. (2023). Human–elephant coexistence toolbox: Advice, actions and tools to reduce conflict with elephants: A technical manual for trainers and community leaders. Save the Elephants. https://ste-coexistence-toolbox.info/en/

South African National Biodiversity Institute. (n.d.). Portulacaria afra. PlantZAfrica. Retrieved October 5, 2026, from https://pza.sanbi.org/portulacaria-afra

Scogings, P. F., Taylor, R. W., & Ward, D. (2012). Inter- and intra-plant variations in nitrogen, tannins and shoot growth of Sclerocarya birrea browsed by elephants. Plant Ecology, 213(3), 483–491. https://doi.org/10.1007/s11258-011-9996-x

Sukumar, R. (1990). Ecology of the Asian elephant in southern India. II. Feeding habits and crop raiding patterns. Journal of Tropical Ecology, 6(1), 33–53. https://doi.org/10.1017/S0266467400004004

Waweru, F. K., & Githaiga, A. N. (2014). Resource partitioning by the black rhinoceros (Diceros bicornis), elephant (Loxodonta africana), and giraffe (Giraffa camelopardalis) in Tsavo West National Park, Kenya. International Journal of Engineering Research & Technology, 3(1), 2530–2544. https://doi.org/10.17577/IJERTV3IS10021

Wells, H. B. M., Crego, R. D., Alston, J. M., Ndung'u, S. K., Khasoha, L. M., Reed, C. G., Hassan, A. A., Kurukura, S., Ekadeli, J., Namoni, M., Stewart, P. S., Kimuyu, D. M., Wolf, A. A., Young, T. P., Kartzinel, T. R., Palmer, T. M., Goheen, J. R., & Pringle, R. M. (2023). Wild herbivores enhance resistance to invasion by exotic cacti in an African savanna. Journal of Ecology, 111, 33–44. https://doi.org/10.1111/1365-2745.14010

Wildlife Works. (2008). The Kasigau Corridor REDD project, phase I—Rukinga Sanctuary: CCB project design document. https://s3.amazonaws.com/CCBA/Projects/The_Kasigau_Corridor_REDD_Project/Rukinga_CCB_PDD_Ver_2_0.pdf

Wildlife Works. (n.d.). Kasigau Corridor REDD+ project. Retrieved October 5, 2026, from https://www.wildlifeworks.com/redd-projects/kasigau-kenya

Links

https://pixabay.com/photos/mango-mangifera-indica-about-ripe-321070
https://mydesiredhome.com/how-to-grow-vigna-unguiculata-or-cowpea-in-your-garden/
https://pza.sanbi.org/vigna-unguiculata
https://theoriginalgarden.com/p/seeds/vegetables/microgreens-babyleaf/vigna-radiata-mung-bean
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https://www.richardlyonsnursery.com/annona-reticulatared-custard-apple2-2/#page-content
https://www.inaturalist.org/taxa/284506-Annona-reticulata#map-tab
https://en.wikipedia.org/wiki/Adansonia_digitata
https://commons.wikimedia.org/wiki/File:Baobab_-_seeds_from_one_fruit,_Adansonia_digitata.jpg
https://www.greenlife.co.ke/pigeon-peas-production/
https://www.inaturalist.org/taxa/139444-Cajanus-cajan
https://www.healthforeverng.com/post/the-triumph-of-sorghum-bicolor-revolutionizing-the-world-of-natural-supplements
https://theseedvine.com.au/product/sorghum-bicolor/
https://www.feedipedia.org/node/721
https://nyspiceshop.com/products/finger-millet-ragi-eleusine-coracana?srsltid=AU7gw4VCu5gnrVVrEVkUFsTe6FftjIWCuoCVsNFU_gxTSFn2um2N4sA9
https://www.britannica.com/plant/papaya
https://www.inaturalist.org/taxa/62811-Carica-papaya
https://www.nparks.gov.sg/florafaunaweb/flora/6/0/6055
https://www.inaturalist.org/taxa/123728-Cymbopogon-citratus
https://agrovet.farmerstrend.co.ke/farming-guides/pomegranate-farming-in-kenya-complete-profitable-planting-guide-to-success/
https://www.inaturalist.org/taxa/58300-Punica-granatum
https://www.plantitude.co.ke/products/citrus-sinensis-local-grafted-orange?srsltid=AfmBOoqAkepEB1jpt13XhEayNGaQR7tKRJ33SDvt9ykMjiFQTqzUqAl8
https://www.thetutuguru.com.au/shop/citrus-orange-tree-blood-orange
https://www.greenlife.co.ke/garlic-farming-in-kenya/
https://www.aquahubkenya.co.ke/profitable-onion-farming-venture-in-kenya/
https://mukuyu.wordpress.com/2015/11/26/mbariki/
https://www.globalresourcesdirect.com/product/oils/castor-oil/
https://www.b4fn.org/resources/species-database/detail/capsicum-chinense-jacq/

https://balaccospeppers.com/en/blogs/notizie/capsicum-chinense?srsltid=AfmBOorlnFooPbsdTlJYta6-UUfwUPp6HNOWkqwK8bUSBV2C_AQtkZRi
https://www.naturepl.com/stock-photo-sisal-agave-sisalana-cultivation-kenya-october-2013-nature-image01469934.
html?srsltid=AfmBOopka3OiuDwe4w5UzvJv9uks678CoFsM08OYhIifMNSjfy0SRTU4
https://ropecentral.com.au/products/sisal-rope-natural-fibre?variant=49289579397441
https://www.plantitude.co.ke/products/azadirachta-indica-neem-tree?srsltid=AfmBOopSw_E-TuThBDrh6o1AWtYQyiyijIljxorDy1dmp7UBZWDYFR9x
https://www.betterglobemedia.com/public/blog/277/sharing-knowledge-on-management-of-melia-volkensii
https://farmerstrend.co.ke/fruits/citrus-farming/lemon-farming/lemon-farming-in-kenya-profits%20varieties-cost/
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https://landinmalindi.com/blog-post/moringa-farming-in-kenya-the-miracle-tree-for-nutrition-and-profit%20/
https://fadfay.com/blogs/blogs/ubiquitous-cotton-species?srsltid=AfmBOoofyW6xfIRcKat1tLdHImgGjlcpz96m-6oU7uua8E1mZOFNmPqr
https://www.shutterstock.com/nl/search/cassava-plants
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https://pza.sanbi.org/cenchrus-ciliaris
https://sgmseeds.com.br/en/sementes/panicum-maximum-cv-tanzania-1/
https://www.inaturalist.org/taxa/431074-Grewia-bicolor
https://pza.sanbi.org/grewia-bicolor
https://nl.pinterest.com/pin/african-marula-tree-seeds-sclerocarya-birrea-packet-of-2-seeds-palm-beach-seed-company-etsy--155303887410056639/
https://www.inaturalist.org/taxa/341054-Vachellia-abyssinica
https://efloraofindia.com/efi/vachellia-abyssinica/
https://www.inaturalist.org/taxa/62844-Tamarindus-indica
https://www.beyondforest.org/post/fruits-native-to-kenya
https://www.inaturalist.org/taxa/326086-Portulacaria-afra
https://toptropicals.com/catalog/uid/portulacaria_afra.htm
https://www.inaturalist.org/taxa/489563-Vachellia-tortilis
https://efloraofindia.com/efi/acacia-tortilis/
https://www.inaturalist.org/taxa/557826-Vachellia-nilotica
https://www.inaturalist.org/taxa/527007-Senegalia-mellifera
https://seedsandall.co.za/product/senegalia-mellifera-acacia-mellifera-black-thorn-swaarthaak-5-seed-pack/
https://www.inaturalist.org/taxa/64119-Opuntia-ficus-indica/browse_photos

https://www.ruthbancroftgarden.org/plants/opuntia-ficus-indica/
https://www.inaturalist.org/taxa/342713-Balanites-aegyptiaca
https://saharaconservation.org/news/profile-of-a-tree-the-desert-date-balanites-aegyptiaca/
https://www.inaturalist.org/taxa/1066418-Commiphora-kua/browse_photos
https://www.inaturalist.org/taxa/338719-Syzygium-cordatum
https://www.zimbabweflora.co.zw/cult/image-display.php?species_id=142310&image_id=29
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https://www.gardenia.net/plant/allium-cepa
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https://www.indiamart.com/proddetail/melia-dubia-wood-cutting-23592070162.html
https://www.exportersindia.com/product-detail/white-sesame-seeds-1479728931.htm
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https://organictraditions.com/products/moringa-leaf-powder?_pos=1&_psq=mor&_psid=ed25cdd4a&_ss=e
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Appendix B

Mapping the historical elephant migration routes



Image made by Jelmer Veenstra

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1. Introduction

This appendix documents the sources and methods used to estimate the location of historical elephant migration routes between Tsavo East and Tsavo West through the Kasigau region. To establish the most reliable estimation possible, literature research was combined with knowledge gathered from local experts and observations made during the site visit.

2. Literature research

Several studies have investigated elephant movements and migration routes within the Kasigau region and the wider Tsavo ecosystem. These studies provided valuable insights into elephant movement patterns and landscape connectivity. However, the routes presented in the different studies varied, making it difficult to determine the precise locations of the historical migration routes through the community lands.

1. Elephant movement tracking in the Tsavo ecosystem The first report presented a map of elephant movements through the Kasigau region based on satellite tracking data from ten elephants. The study investigated the effects of infrastructure developments, including the Standard Gauge Railway (SGR), the Mombasa–Nairobi highway and the Voi–Taveta highway, on elephant movements and ecosystem connectivity. It also examined the use of wildlife crossing structures, the influence of water distribution on elephant movements and the effects of fencing along the SGR. The study began in March 2016, when ten elephants were fitted with satellite collars to monitor their movements in relation to these infrastructure developments. The resulting maps provided insight into elephant movement patterns through the region (Okita-Ouma, 2016).

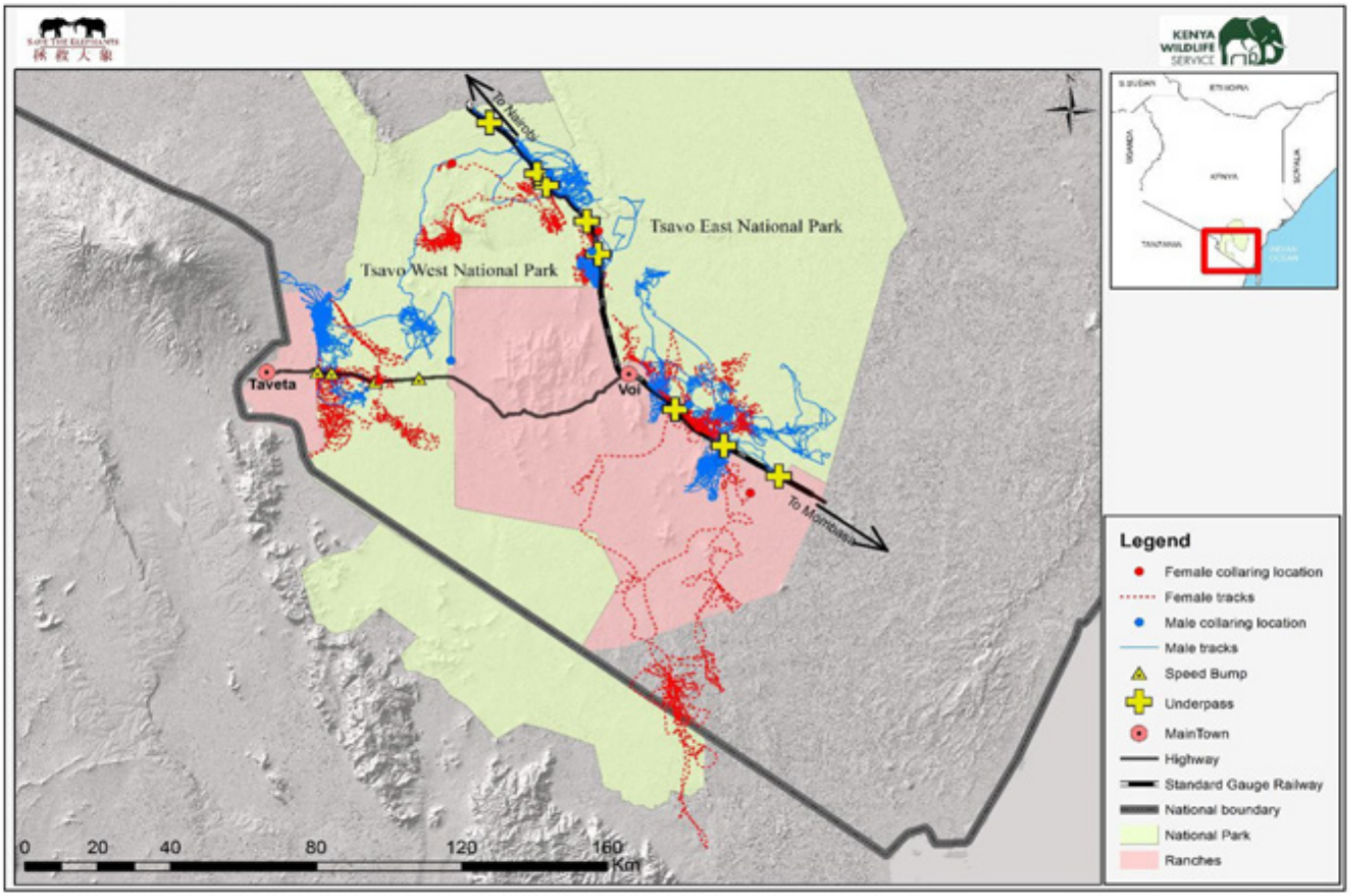


Figure 2: Movement tracks of 10 collared elephants in Tsavo ecosystem along the Standard Gauge Railway, the Mombasa - Nairobi and Voi - Taveta highways in March - September 2016.

2. Assessment of human–elephant conflict in Taita Taveta County

The second study analysed human–elephant conflict incidents recorded in Taita Taveta County between 2004 and 2018. The research identified eight forms of human–elephant conflict and mapped their occurrence across the county. As part of the analysis, the study also presented elephant migration routes, providing additional information about the relationship between elephant movements and human settlements and activities (Munyao et al., 2020).

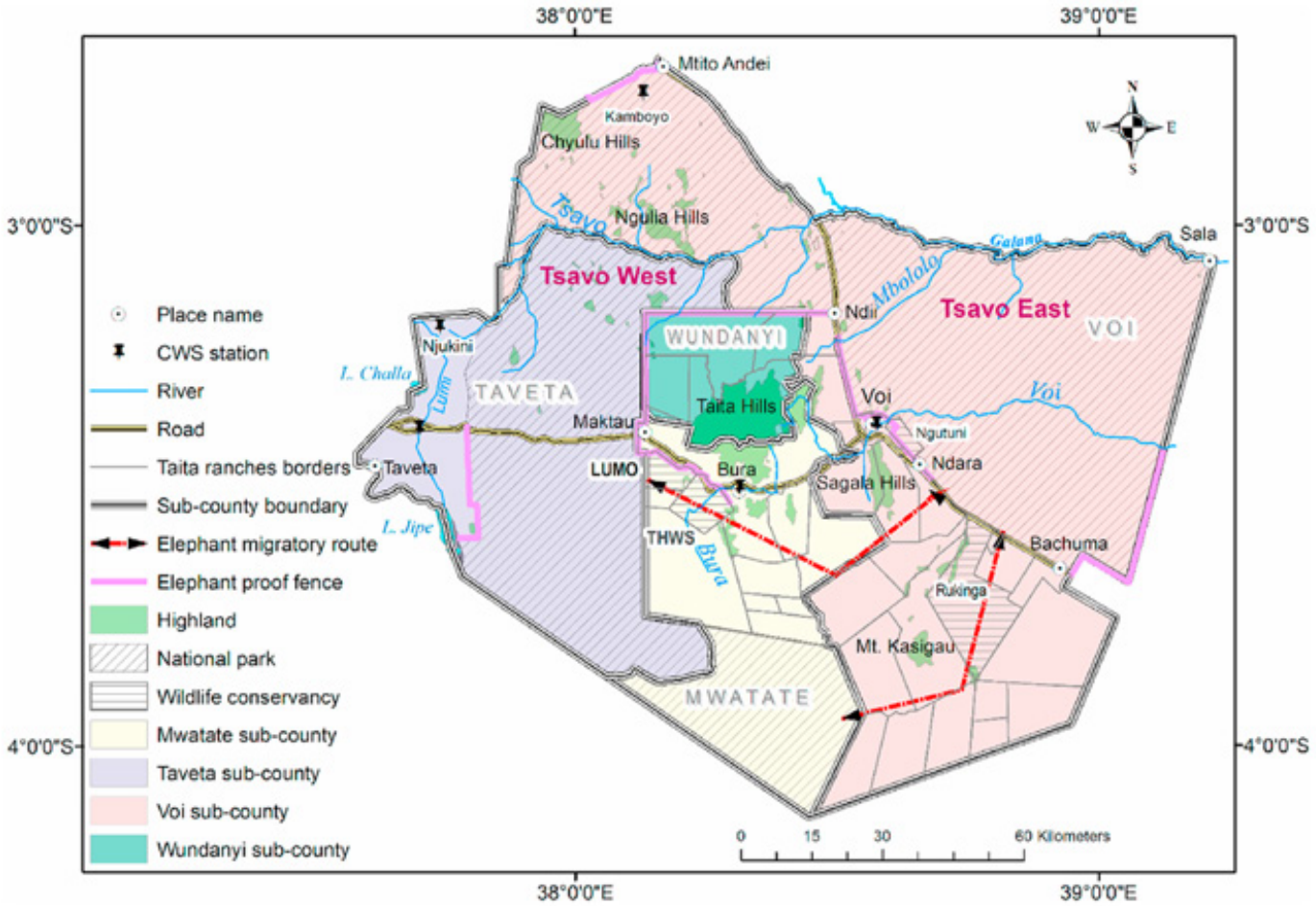
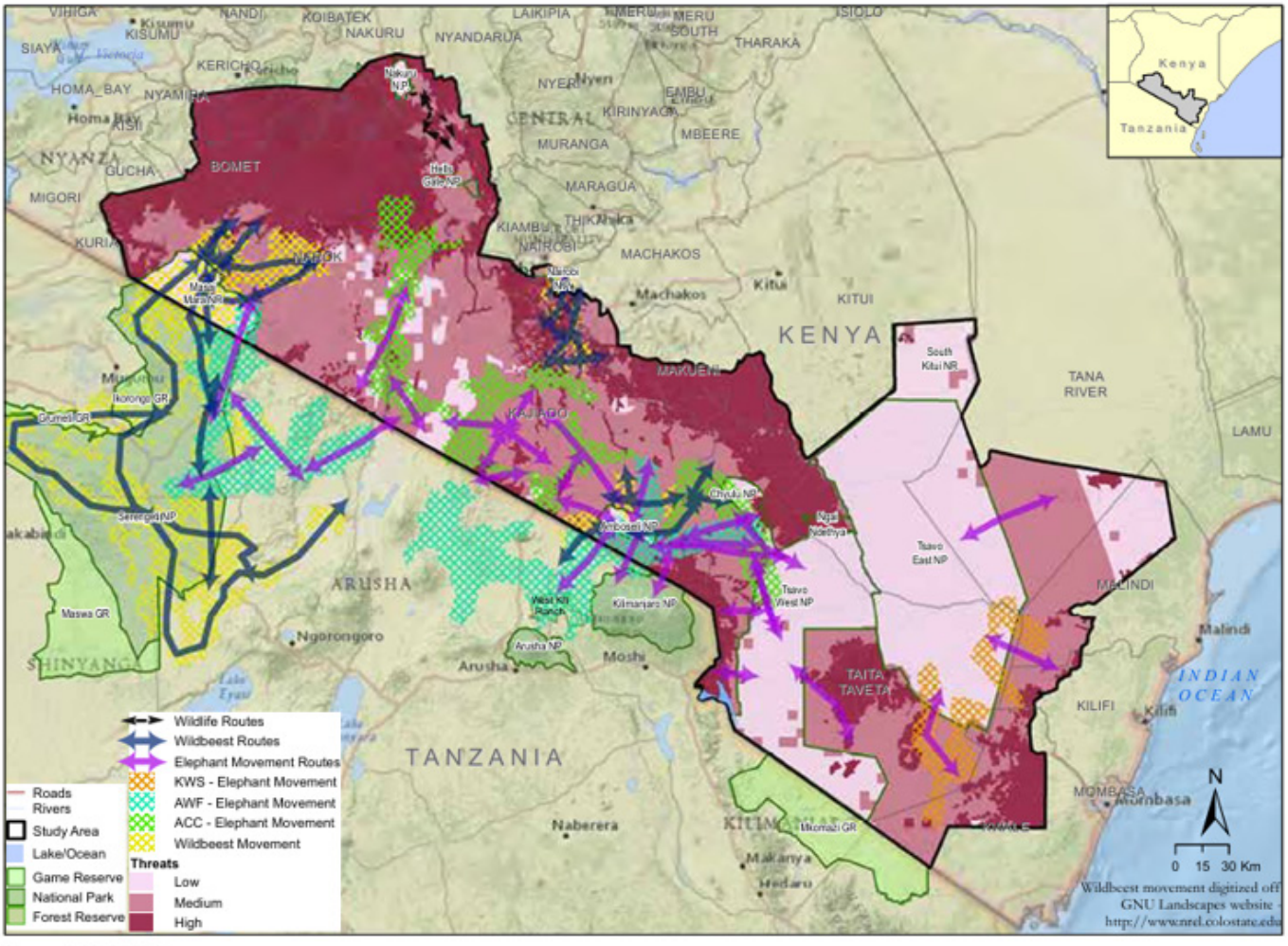


Fig. 2. Administrative division of Taita Taveta County into four sub-counties. Tsavo West and East National Parks also fall within the county administrative units. Elephant migratory routes were adapted and edited from Smith and Kasiki (2000) and Okita-Ouma et al. (2017).

3. National assessment of wildlife corridors and dispersal areas

The third source was a national report mapping wildlife dispersal areas and migration corridors across Kenya's rangelands and coastal terrestrial ecosystems. The report identified important areas for wildlife connectivity and highlighted conservation opportunities through integrated land-use planning, conservancies and the diversification of rural livelihoods. It also mapped elephant movement routes between Tsavo East and Tsavo West, providing a broader overview of the connections between the two protected areas.

Map 5.28: Spatial model of conservation threats to wildlife corridors (from agriculture, human population density, encroachment on protected areas and water bodies, and infrastructure development).



References

Munyao, M., Siljander, M., Johansson, T., Makokha, G., & Pellikka, P. (2020). Assessment of human–elephant conflicts in multifunctional landscapes of Taita Taveta County, Kenya. Global Ecology and Conservation, 24, e01382. https://doi.org/10.1016/j.gecco.2020.e01382

Ojwang G.O.,Wargute, P.W., Said, M.Y. , Worden, J.S., Davidson, Z., Muruthi ,P., Kanga, E., Ihwagi, F., and Okita-Ouma, B. (2017). Wildlife Migratory Corridors and Dispersal Areas: Kenya Rangelands and Coastal Terrestrial Ecosystem

Okita-Ouma B., Lala F., Koskei M., Mwazo A., Kibara D., King L., Kanga E. & Douglas-Hamilton I. (2016). Movements of satellite-linked collared elephants and other wildlife in relation to the Standard Gauge Railway (SGR) and highways in Tsavo Ecosystem, Kenya (March – September 2016). Pages 1-34. Save The Elephants and Kenya Wildlife Service, Nairobi.

3. Mapping by local experts

To supplement the literature research, local knowledge was collected from people with professional or practical experience of elephant movements in the Kasigau region. These individuals regularly encounter elephants or are involved in wildlife conservation and human–elephant conflict management. Their knowledge helped identify areas frequently used by elephants, locations where conflicts occur and landscape features relevant to their movements.
The mapping exercise was conducted by providing a base map of the region and asking participants to draw their understanding of the historical elephant migration routes. They were also asked to indicate relevant landscape features, including water pans and settlements. The resulting maps provided additional insights into the possible locations of the routes. Three local experts contributed to this process.

1. Head ranger at Wildlife Works
The head ranger at Wildlife Works has extensive knowledge of wildlife movements, particularly those of elephants in and around the Kasigau region. Rangers monitor wildlife and help manage situations in which elephants enter community lands. When elephants move into these areas, rangers may be called upon to guide them back towards the conservancies. Through this work, the head ranger has gained practical knowledge of elephant movement patterns and areas where human–elephant conflict occurs most frequently.



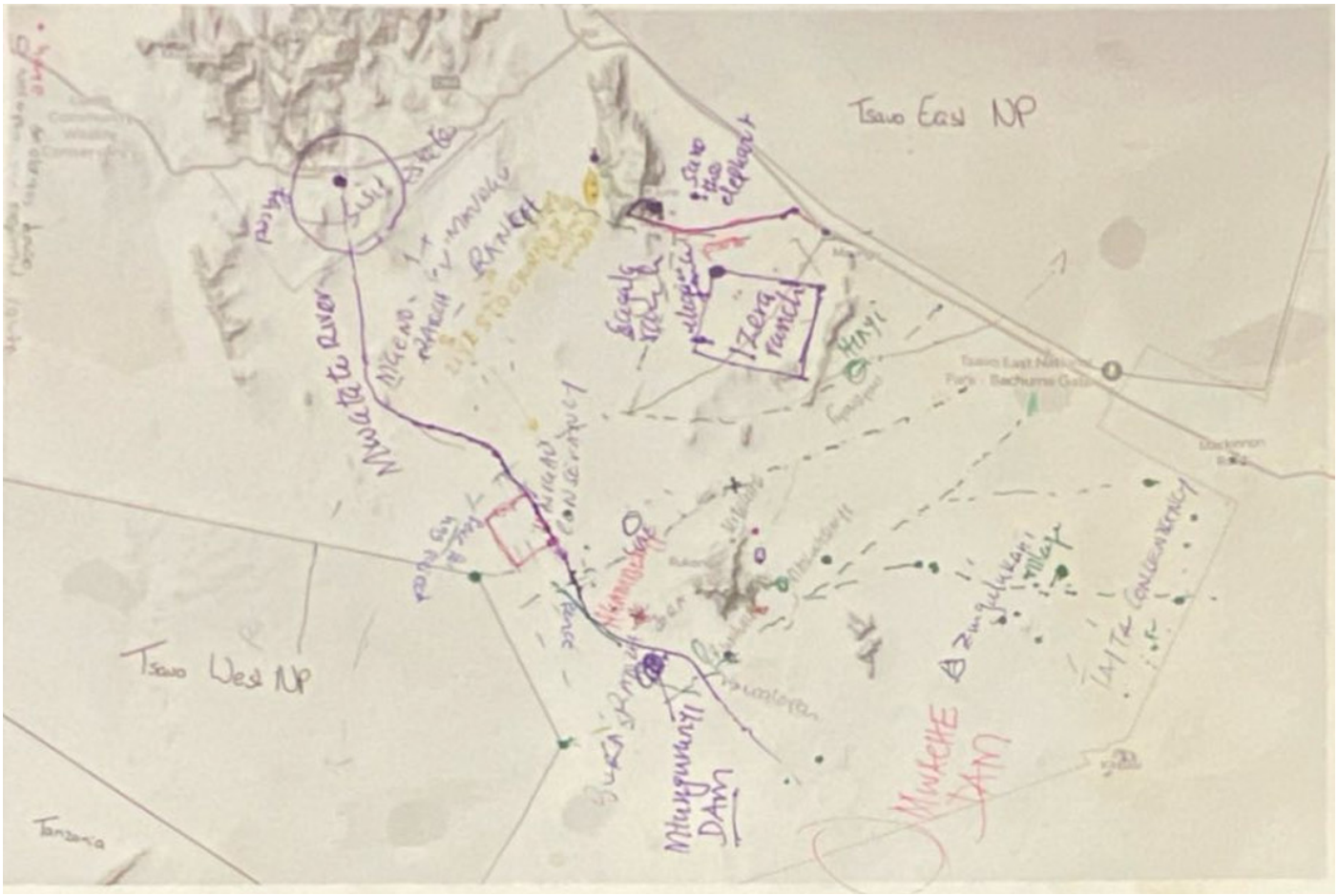
2. Manager of a community-based organisation (CBO) in Rukinga

The second participant manages a CBO in Rukinga that partners with Wildlife Works to protect the forest on Mount Kasigau. The organisation's scouts monitor activities such as charcoal production, illegal livestock grazing, poaching and other forms of illegal resource extraction. The scouts are also trained to respond to elephant-related situations. Their work provides the organisation with valuable knowledge of elephant movements around Mount Kasigau and the surrounding community lands.



3. Local host

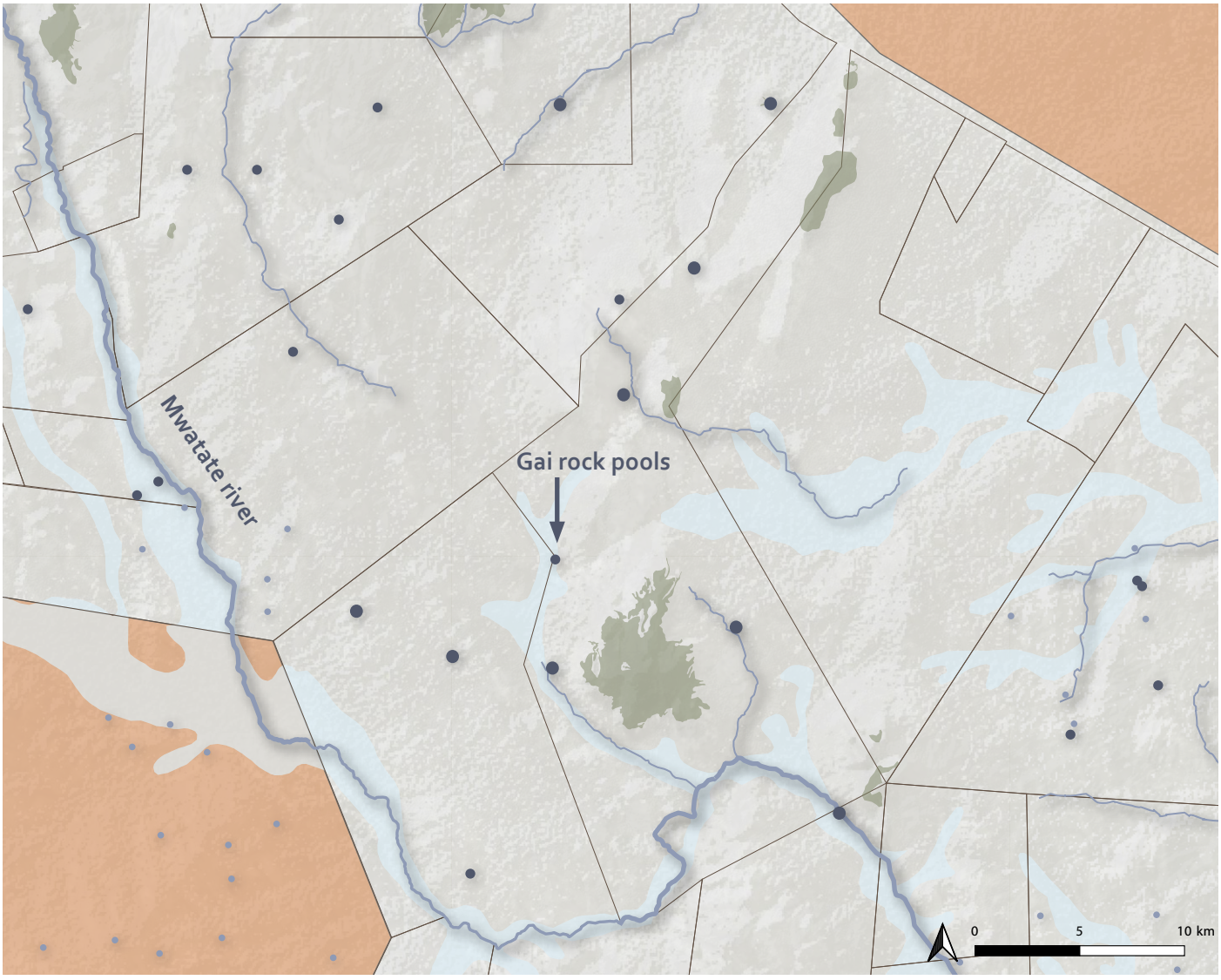
The third participant was my local host, Newton, who maintains contact with various people in the region and is actively involved in efforts to improve the situation surrounding human–elephant conflict. Through these contacts and his involvement in local initiatives, he has developed a good understanding of elephant movements and the areas where interactions between people and elephants occur.



4. Seasonal rivers and water sources

Despite combining the literature research and local knowledge, it remained difficult to determine the exact locations of the historical migration routes. Therefore water availability was also considered when estimating the routes. During dry periods, elephants move through the landscape in search of water and may obtain water by digging in the beds of dry seasonal rivers. These waterways can therefore provide important landscape features for understanding potential elephant movement patterns.

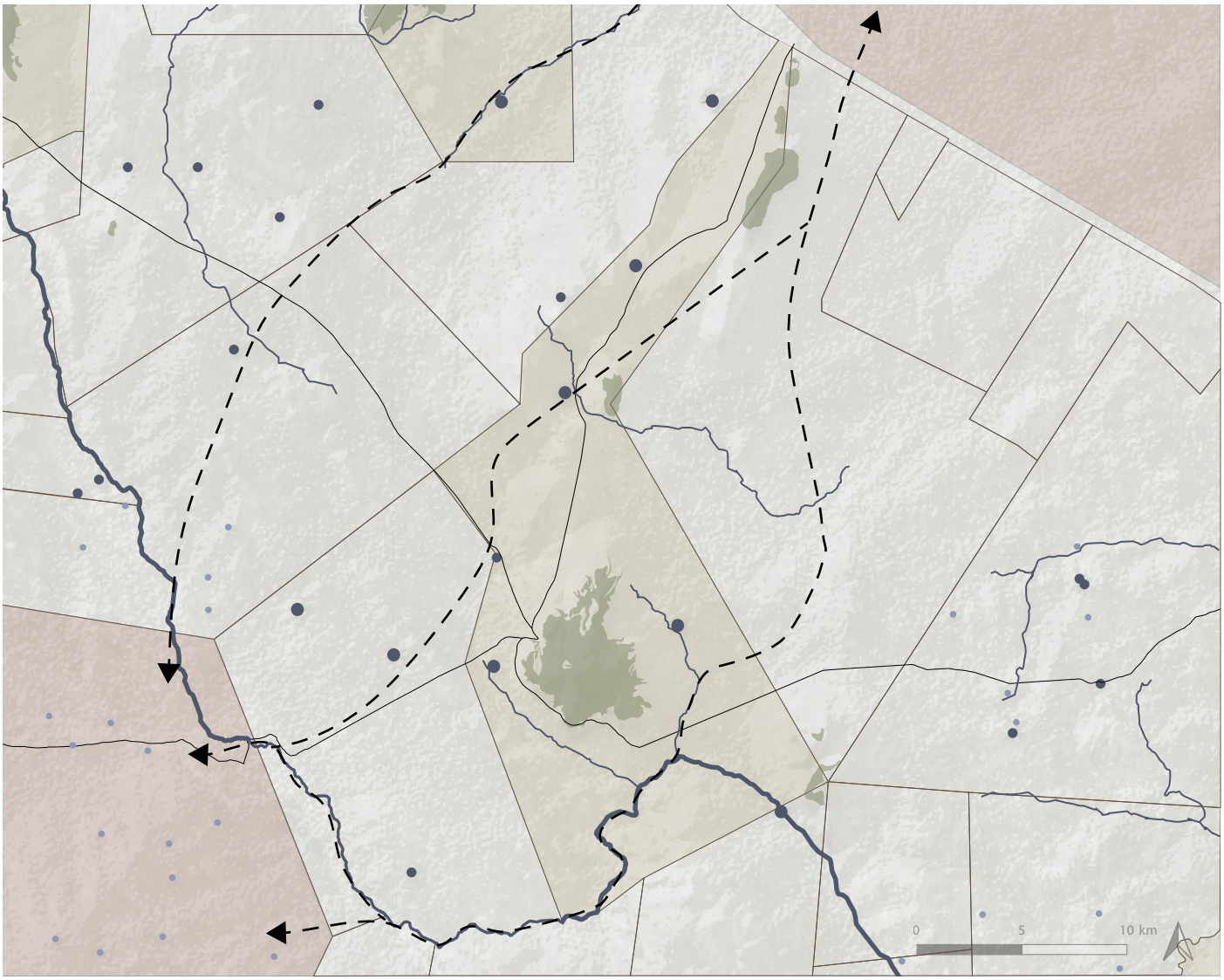
Based on this understanding, it was assumed that elephants travelling from Tsavo East towards Tsavo West enter the community lands from the southeast and follow the course of the seasonal Mwatate River. It was also assumed that their route passes the Gai rock pools on the western side of the community lands. These assumptions were used to help connect the information obtained from the literature and local mapping exercises.



Water sources map made by author

5. Selection of the migration routes

The final estimation of the historical elephant migration routes was developed by combining the findings from the literature review, the maps drawn by local experts and observations made during the site visit. Seasonal rivers and known water sources were also considered to help interpret the possible movement patterns through the landscape. Although the exact historical routes could not be established with certainty, combining these different sources of information provided a reasoned basis for estimating their locations. The resulting routes were used as the basis for the design interventions, with particular attention to areas where elephant movements intersect with community lands, settlements and agricultural activities.



Elephant migration routes map made by author