Integrating biodiversity conservation and agriculture in a landscape: a developing country perspective

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Declaration

I declare that this thesis was composed by myself and that the work contained herein is my own except where explicitly stated in the text. The work has not been submitted for any degree or professional qualification except as specified.

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Abstract

Balancing agricultural productivity and biodiversity conservation is a major global challenge. Addressing this dilemma requires a nuanced understanding of the social-ecological systems linking agriculture and conservation. This thesis investigates how both goals can be achieved within shared landscapes, using Kasungu, Malawi, as a case study. Like many African countries, Malawi's Agenda 2063 promotes agricultural expansion for poverty reduction and economic growth. However, this puts pressure on biodiversity, particularly around protected and conserved areas.

Using an interdisciplinary approach, this thesis explores the agriculture-biodiversity nexus by examining human-nature relationships, gendered land tenure systems, and local priorities for trade-offs and potential synergies. I first sought to understand the implications of human-nature relationships for livelihoods and conservation. I then assessed how gendered kinship systems of land tenure influence resource use. Next, I used hypothetical scenarios of change to investigate how communities prioritise agriculture and biodiversity conservation under different possible futures. Finally, I used a spatial modelling approach to predict biodiversity outcomes under the current and projected agricultural trends in the landscape.

Findings show that social and ecological factors shape people's perceptions and behaviours, which influence how trade-offs are experienced and managed. The research highlights that single approaches are unlikely to reconcile biodiversity conservation and agriculture, hence the need for integrated approaches that work simultaneously. I emphasise the importance of inclusive, context-sensitive strategies that reflect local realities and call for reframing the agriculture-biodiversity relationship as interconnected rather than conflicting.

This research provides a snapshot of broader agriculture-biodiversity debates by highlighting the importance of locally grounded, interdisciplinary approaches. Given that agriculture remains the dominant land use in sub-Saharan Africa, achieving global conservation targets will depend on integrating land tenure and food system considerations to ensure sustainable and equitable outcomes for both people and nature.

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I was also fortunate to work closely with colleagues from the Africa Oxford Initiative (AfOx), and Morally Contested Conservation (MCC) team- Darragh, Lovemore, Jess, Emily, Betty, Yolanda, Salum, and David. I learnt a great deal from everyone on both teams, and I am grateful for their insights and support.

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“Then Samuel took a stone and set it up between Mizpah and Shen. He named it Ebenezer, saying, ‘Thus far the LORD has helped us’.” 1 Samuel 7:12

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List of Acronyms and Abbreviations

AfOx	Africa Oxford Initiative
AIC	Akaike Information Criterion
AIP	Affordable Input subsidy Programme
CBD	Convention on Biological Diversity
CBNRM	Community Based Natural Resources Management
CI	Confidence Interval
CIFOR	The Centre for International Forestry Research
CLMM	Cumulative Link Mixed Models
CUREC	Central University Research Ethics Committee
DNPW	Department of National Parks and Wildlife
EPA	Extension Planning Area
ESA	European Space Agency
FAO	Food and Agriculture Organization
FGD	Focus Group Discussions
FIES	Food Insecurity Experience Scale
FISP	Farm Input Subsidy Program
FOLU	The Food and Land Use Coalition
FPE	Feminist Political Ecology
GBF	Global Biodiversity Framework
GDP	Gross Domestic Product
GLM	Generalised Linear Model
GoM	Government of Malawi

HWC	Human Wildlife Conflicts
IBA	International Bird Area
ICCS	Interdisciplinary Centre for Conservation Science
ICRAF	The World Agroforestry Centre
IFAW	International Fund for Animal Welfare
IUCN	International Union for Conservation of Nature
KII	Key Informant Interviews
KNP	Kasungu National Park
LUANAR	Lilongwe University of Agriculture and Natural Resources
LWT	Lilongwe Wildlife Trust
MEA	Millennium Ecosystem Assessment
MZTFCA	Malawi Zambia Transfrontier Conservation Areas
NBSAP	National Biodiversity Strategy and Action Plan
NCP	Nature Contribution to People
NGO	Non-governmental Organisation
NSO	National Statistical Office
NTFPs	Non-timber Forest Product
PCA	Principal Component Analysis
PCAs	Protected and Conserved Areas
PPF	Peace Parks Foundation
PPP	Public Private Partnerships
SES	Social-Ecological System
SI	Sustainable Intensification

SSA	Sub-Saharan Africa
TA	Traditional Authority
UNEP	United Nations Environment Programme
VIF	Variance Inflation Factors
WCMC	World Conservation Monitoring Centre

Chapter 1 : Introduction

Farms and households on the fenced side of Kasungu National Park

1.1 Background and research statement

Increasing agricultural productivity while also conserving biodiversity is a key global challenge (Balmford, 2021; Baudron & Giller, 2014; Herrero et al., 2020; Zabel et al., 2019). While agriculture is the primary driver of biodiversity loss (Laurance et al., 2014; Tilman et al., 2017), it remains crucial for food security and poverty alleviation, particularly in low and middle-income countries (Giller, 2020; Hossain et al., 2024). In sub-Saharan Africa (SSA), where economies are primarily agrarian, and biodiversity levels are high, the tension between agricultural expansion and conservation is especially pronounced (Baudron & Giller, 2014; Giller, 2020; Chapman et al., 2022; UNEP-WCMC, 2019). Projections suggest that agricultural land expansion could threaten over 80% of species globally by 2050, underscoring the urgency of sustainable land-use strategies (Tilman et al., 2017; Williams et al., 2021; Fisher et al., 2017; Grass et al., 2019; Phalan, 2018).

Sub-Saharan Africa is experiencing rapid population growth and shifting dietary demands, placing additional pressure on land and ecosystems (Conway et al., 2019; FAO, 2017; Ritchie et al., 2022). While efforts to meet food needs often involve expanding farmland or intensifying production, both approaches carry significant environmental costs (Baudron & Giller, 2014; Ceddia et al., 2013; Smith, 2013; Williams et al., 2021). For example, agricultural expansion leads to habitat loss, while intensification, can result in pollution and reduced habitat quality (Ball et al., 2024; Laurance et al., 2014; Williams et al., 2021). Despite technological advances and policy initiatives, such as sustainable intensification, the practical implementation of sustainable solutions remains constrained by socio-economic, political, and institutional barriers (Bunge et al., 2022; Herrero et al., 2020).

Recognising land use as central to agricultural productivity and biodiversity conservation is essential for addressing this challenge (Meyfroidt, 2018; Meyfroidt et al., 2022). In many African contexts, land use and access are governed by customary systems with social structures such as gender, kinship, ethnicity, and class (Layefa et al., 2022; Narciso & Henriques, 2020). These dynamics shape how resources are accessed and managed and are critical to understanding the socio-ecological dimensions of land use (Fedele et al., 2021; Meyfroidt, 2018; Tschirhart et al., 2018). Gender roles, in particular, influence agricultural practices, land tenure, and participation in conservation efforts. However, these social factors are frequently underrepresented in dominant land-use frameworks and models (Costa et al., 2017; Goldman et al., 2021; Lau, 2020; Lau & Scales, 2016).

Most research on the food-biodiversity nexus relies on global datasets and modelling, often derived from high-income regions (e.g., Laurance et al., 2014; Tilman et al., 2017; Williams et al., 2021). Such approaches may fail to capture the complexity of local contexts in sub-Saharan Africa, where empirical data are limited, and landscapes are simultaneously expected to provide food, income, and ecosystem services (Landis, 2017; Ritchie et al., 2022). Frameworks such as land-sparing and land-sharing offer practical conceptual clarity (Kremen, 2015; Phalan et al., 2011; Phalan, 2018) but have been critiqued for oversimplifying agro-ecological realities and neglecting local socio-cultural and institutional factors (Fischer et al., 2017; Baudron & Giller, 2014; Ceddia et al., 2013).

Given these challenges, there is a clear need for place-based, interdisciplinary research that integrates ecological, agricultural, and social dimensions to inform sustainable land-use strategies. Understanding how local communities interact with and perceive nature is key to developing inclusive solutions which can address both food security and biodiversity conservation goals.

1.2 Research aim

This research explores how agriculture and biodiversity conservation can be integrated within a shared landscape while respecting local peoples' priorities. The study uses an interdisciplinary approach applied to the Kasungu landscape in Malawi as a case study.

1.3 Objectives

Specifically, the research aimed to achieve the following objectives.

1. Assess people's interactions with nature and how they relate to their farming livelihoods.
2. Assess how gendered kinship systems dynamics influence land tenure and natural resource use.
3. Explore and predict local people's priorities for reconciling agriculture and biodiversity conservation.
4. Assess the predicted trajectory of biodiversity under a range of current and predicted trends in agricultural intensification, agricultural expansion, climate change, based on the insights from Objective 3, using spatial modelling.
5. Make recommendation for future research and policy to address the trade-offs and synergies between agriculture, biodiversity and human well-being in the Kasungu landscape and beyond.

1.4 Thesis outline

This thesis is divided into seven chapters. Chapters one and two introduce the research and provide background, including a review of relevant literature, the study context, and the methodological approaches used. Chapters three and four, respectively, examine the implications of human-nature interactions and gendered kinship systems on livelihoods and conservation. Chapter five explores local priorities for reconciling food security and biodiversity conservation using scenario-based approaches. Chapter six projects biodiversity trajectories under current agricultural trends using the Glob2loc spatial modelling tool. Finally, Chapter seven synthesizes the main research findings, discusses their implications for policy and practice, and recommendations for future research (Figure ***1.1***).

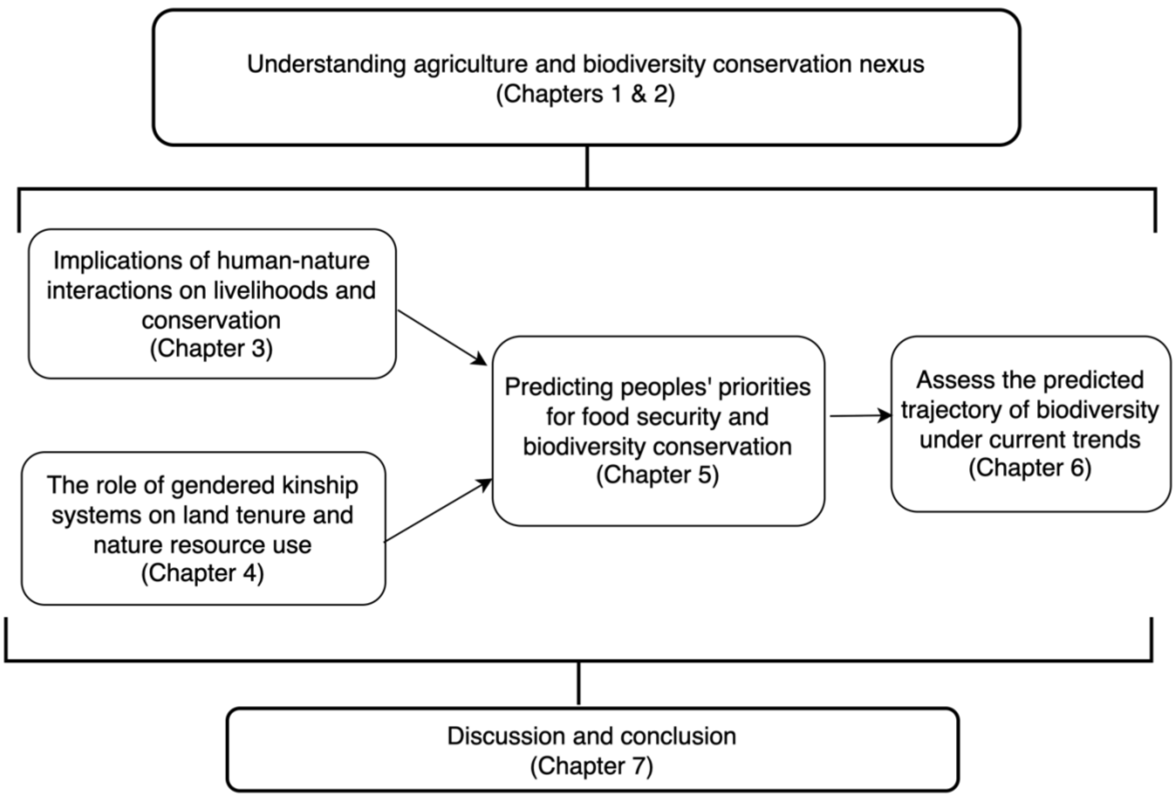

Figure 1.1: A diagram illustrating how each chapter fits within the overall structure of the thesis.

Chapter 1: Introduction

In this initial chapter, I introduce the thesis by outlining the research problem highlighting key knowledge gaps in the relationship between agriculture and biodiversity. I also present the research objectives and provide an overview of my positionality as a researcher, including how this influenced the research approach and the associated limitations.

Author contribution: this chapter is my work and has been reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, and Karl Hughes.

Chapter 2: Theoretical background and methodological approach

In this chapter, I review the literature that informed this thesis's theoretical and conceptual foundations. The chapter focuses on the relationship between agriculture and food security, particularly within the sub-Saharan African context, before narrowing it down to Malawian context. The chapter also introduces the selected study villages, a focal point throughout the thesis. The criteria for selecting the villages and the methodological approaches used in the research are also outlined.

Author contribution: this chapter is my work and has been reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, and Karl Hughes.

Chapter 3: Implications of human-nature interactions for livelihoods and conservation

I use a mixed-method approach to examine factors influencing people's use of nature, their perceptions of wildlife conservation and the associated implications for livelihoods and conservation in the Kasungu landscape. The findings highlight a strong dependence on Kasungu National Park (KNP) for social and economic well-being. While participants generally expressed positive attitudes toward wildlife and conservation, factors such as gender, proximity to the park, economic status, and food insecurity significantly shaped both resource dependence and conservation perceptions. These insights offer important guidance for designing and implementing conservation policies, particularly in communities where livelihoods are closely tied to natural resources.

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Author contributions: The ideas and research questions were conceived by me, E.J. Milner-Gulland, Michael Clark, Lauren Coad and Karl Hughes. I carried out the data collection and analysis and wrote the chapter. The chapter was reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, and Karl Hughes.

Chapter 4: Implications of gendered kinship systems on land tenure and natural resource use

Building on the dataset used in the previous chapter, this chapter explores how gendered kinship systems influence land tenure and natural resource use in the Kasungu landscape. After providing an overview of the kinship systems practised across Malawi, the chapter focuses on the specific system operating in the study area and its implications for livelihoods and resource governance. The findings reveal a hybrid kinship system where both men and women have access to land, but governance and ownership are predominantly male dominated. This challenges the notion that gender inequality is exclusive to patriarchal societies, demonstrating that structural inequalities also persist in matrilineal contexts. The chapter argues that land policies, legal reforms, and conservation programmes must consider these socio-cultural complexities to promote gender equity while respecting local traditions.

This chapter has been submitted to the journal *Rural Studies* and is under review

Author contributions: The ideas and research questions were conceived by me, E.J. Milner-Gulland, Michael Clark, Lauren Coad and Karl Hughes. I carried out the data collection and analyses and wrote the chapter. The chapter was reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, Karl Hughes and Jessica Kampanje-Phiri.

Chapter 5: Predicting people's priorities for reconciling agriculture and biodiversity conservation in Kasungu, Malawi

In this chapter, I explore local behavioural intentions and priorities under six future agriculture and biodiversity conservation policy related scenarios, developed based on insights obtained during my field work for three and four. Each scenario was assessed by respondents for its projected impact on food security, natural resource use, community well-being, relationship with Kasungu National Park, and perceived fairness. Results indicate that scenarios involving universal farm input subsidies and compensation for wildlife damage were viewed as fair and beneficial, improving food security, resource access, and well-being. However, expanding farmland under the input subsidy scenario risks wildlife habitats. In contrast, scenarios involving wildlife translocation and increased farm input prices negatively impacted well-being and food security. The findings highlight the importance of integrating local perspectives into policy design while recognising and managing the inherent trade-offs between conservation and food security goals.

This chapter has been submitted to the journal *Conservation Science and Practice* and is under review.

Author contributions: The ideas and research questions were conceived by me, E.J. Milner-Gulland, Michael Clark, Lauren Coad and Karl Hughes. I carried out the data collection and analyses and wrote the chapter. The chapter was reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, Karl Hughes and Henry Travers.

Chapter 6: Predicting biodiversity trajectories under current agricultural trends in a shared landscape

In this chapter, I use a spatial modelling tool (Glob2loc) to predict the potential impacts of current agricultural trends on biodiversity. The analysis evaluates species responses under multiple land-use scenarios. Results suggest that biodiversity outcomes are most positive under scenarios involving increased farm input prices and the restoration of buffer zones, with projected gains in species population and habitat range across taxa. Conversely, the universal farm input subsidy scenario is predicted to lead to significant declines in species populations and habitat areas, highlighting the ecological risks associated with widespread agricultural expansion. These findings underscore the importance of carefully evaluating the biodiversity trade-offs inherent in agricultural policy decisions.

This chapter is in draft and will be submitted to *Conservation Biology* once finalised.

Author contributions: The ideas and research questions were conceived by me, E.J. Milner-Gulland, Michael Clark, Lauren Coad and Karl Hughes. Me and Micheal carried out the analysis, and I wrote the chapter. The chapter was reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad, and Karl Hughes.

Chapter 7: Discussion and conclusion

I synthesise the key findings from the preceding chapters, highlighting emerging themes and reflecting on the broader implications of the research. The chapter draws attention to how local livelihoods and conservation outcomes are shaped not only by land-use patterns but also by historical relationships, governance structures, and community agency. I also outline the main contributions to understanding the complex relationship between agriculture, biodiversity conservation, and local socio-cultural dynamics in shared landscapes. Finally, I outline local and broader implications of the study findings, offering recommendations for integrating food security and biodiversity conservation goals in socially equitable and ecologically sustainable ways.

Author contribution: this chapter is entirely my work and has been reviewed by E.J. Milner-Gulland, Michael Clark, Lauren Coad and Karl Hughes

Other research contributions

Throughout my DPhil, I collaborated and contributed to other research related to broader topics within biodiversity conservation. Some of these efforts led to publications as follows.

- Mutinhima Y., Sibanda, L., Rono, B., Kulunge, S., Kimaili, D., Dickman, A.J., Madsen, E., Mandoloma, L., Tacey, J., Allred, S., & Hare, D. (2025). International disparities in conservation priorities are more complicated than Global North–Global South divisions. Biology Letters. 21: 20240571. https://doi.org/10.1098/rsbl.2024.0571
- Sibanda, L., Dickman, A., Hughes, C., Tacey, J., Madsen, E., Mandoloma, L., Mbizah, M. M., Mutinhima, Y., Rono, B., Kulunge, S., Kimaili, D., Bhujle, T., Macdonald, D. W., & Hare, D. (2025). Avoiding an impending collision in international conservation. Conservation Biology, e14450. https://doi.org/10.1111/cobi.14450

1.5 Positionality, biases and limitations

The beliefs and characteristics of people conducting research influence many aspects of research (Boyce et al., 2022; Holmes, 2020; Pienkowski et al., 2023), and I am no exception. Personal experiences and outlooks can determine the questions asked, methods used, how data is analysed, interpreted, and communicated, and the broader impacts of research (Beck et al., 2021; Boyce et al., 2022; Montana et al., 2020; Olmos-Vega et al., 2023; Pienkowski et al., 2023). Recognising these dynamics calls for better reflexivity (an individual or group's ability to examine themselves, their actions, and interactions with others) in conservation science, e.g. Beck et al., (2021), Boyce et al., (2022), Montana et al., (2020), and Pienkowski et al., (2023). I, therefore, reflect on my personal and professional background as a conservation professional, followed by reflections on my study approach, biases in my research and how these may have influenced specific aspects of my research.

1.5.1 My background

I was born and raised in a middle-class family in Malawi, one of the world's lowest-income countries. My early years were spent in Blantyre, the southern region of Malawi, though much of my adult life has been in the capital, Lilongwe. While Malawi is among the poorest countries globally, I was fortunate not to experience extreme poverty or lack of necessities. I spent most of my childhood in Catholic boarding schools, only returning home during holidays. My connection to wildlife was limited to the birds and trees in our family compound. My encounters with wildlife were mainly during school trips or family visits to nature reserves and national parks. Though I always enjoyed being close to nature, a career in natural resource management was not my initial aspiration.

Growing up in a matrilineal clan significantly shaped my career trajectory and many of my life choices. Coming from a family where women played leadership roles and made key land use decisions was inspiring and challenging. I was surrounded by female role models, including my mother, aunties, and a sister, who set high expectations. In our matrilineal ethnic group, family legacies are passed through female children, reinforcing the norm that women should work hard and excel. While many of my female relatives pursued careers in banking and finance, I wanted to carve my own path, leading me to study natural resource management. As I progressed through university, my interest deepened, mainly as I engaged more with ecology and conservation-related courses.

After completing my bachelor's degree, I participated in an Earth Watch Institute expedition, conducting ecological research in one of Malawi's game reserves. While my family worried about my safety, living in a tent and working close to wildlife, the experience was exhilarating. Later, during my master's degree, I researched the effectiveness of different wildlife management regimes in Malawi. This research project introduced me to communities living near protected areas, an experience that resonated deeply with me and shaped my research interests.

I then joined Lilongwe University of Agriculture and Natural Resources (LUANAR) as a lecturer in the Department of Environmental Science and Management. Teaching conservation-related courses to diverse students was incredibly fulfilling, knowing that the knowledge and skills I shared could have a lasting impact.

My journey to a DPhil at Oxford began a few years later with a fellowship from the Africa Oxford Initiative (AfOx) which allowed me to spend a month at the University of Oxford. I was hosted by the Interdisciplinary Centre for Conservation Science (ICCS), where I interacted with researchers, attended seminars, and observed how interdisciplinary conservation research was conducted. This exposure was transformative as it expanded my understanding of how conservation could be approached from both ecological and social perspectives and helped me reflect on how these ideas might be applied in Malawi. When I returned home after the fellowship, I felt inspired and more confident in pursuing further studies. I wrote a concept note grounded in insights from my time at ICCS, which later formed the foundation of my DPhil application. In this sense, the AfOx fellowship did not just open the door to Oxford, it helped shape the intellectual direction of my doctoral journey and deepened my commitment to bridging global and local perspectives in conservation.

1.5.2 My research approach

My personal and professional background played a significant role in shaping my doctoral research. I spent about eight months in the study villages throughout the DPhil, spread across three field trips: an initial scoping visit and two data collection phases. During this time, I lived in a small house alongside my research assistants, which helped build trust and foster meaningful relationships with community members. Immersing myself in daily village life provided invaluable insights into the local landscape, traditions, and social dynamics.

In this space, where I identified as a privileged female academic, I was conscious of the power dynamics inherent in my role. To navigate the insider/outsider dynamics, I fully engaged with village life, observed local customs, and participated in communal routines, including market days, which, though not directly linked to my research, offered a critical contextual understanding of the community. Although initially, I was perceived as an outsider (as a city-dweller and academic), this gradually shifted as I kept returning. Over time, people began to treat me with increasing familiarity and warmth; greetings became more personal, and some community members would stop by the house for conversations. A few students came for support with national exam preparations and advice on college choices, which made me, and the research team, feel of use to the community.

Women, in particular, seemed to open up more as I participated in domestic and social activities, and some older women began referring to me in kinship terms, such as "daughter" or "auntie," which subtly marked a shift in how they positioned me. Men, while often polite, tended to engage with me more formally, suggesting that gender did mediate some of these relationships.

My identity and positionality influenced many aspects of the research. For example, I collected data on sensitive topics such as the unauthorised use of natural resources (Chapter 3) and household gender dynamics (Chapter 4), which might otherwise be challenging to document. My fluency in the local language and familiarity with cultural norms greatly facilitated data collection and rapport-building. For instance, in interviews about firewood collection from protected areas, women were more willing to speak openly with me, often during informal conversations while preparing meals or walking to the market as they saw me as a trusted presence rather than an external authority. Similarly, my gender allowed me to sit in on and participate in domestic spaces giving me insight into intra-household decision-making processes and gendered labour divisions.

At the same time, I acknowledge that my background, values, and worldview inevitably shaped how I interpreted findings, particularly in Chapters 3, 4, and 5. For example, while I viewed certain gendered power dynamics as constraining, such as the expectation that women were solely responsible for subsistence farming and household care while men made most financial decisions, many women I interviewed expressed pride in their roles and emphasised that these responsibilities gave them a sense of purpose and identity. One woman described her daily work in the fields and at home as "*what makes the family strong*," and noted that major decisions were often made "*together, but with the man speaking for us*". These responses challenged my own assumptions about inequality and helped me see that empowerment and agency were often expressed in subtle or relational ways. I hope my extended community immersion helped mitigate some of this interpretive bias.

Participation was a central element of my research approach. Prior to formal data collection, I conducted preliminary fieldwork to build relationships and deepen my understanding of local concerns around agriculture and conservation. In Chapter 5, which focuses on scenario development, I collaborated with community members to co-create contextually relevant and meaningful scenarios. Beyond formal methods, I also engaged with the community in everyday ways, for example, offering informal academic support to students preparing for national exams, participating in local events, and spending time in domestic and public spaces. These interactions were not only key to building trust but also represented small ways of giving back during the research process.

While I aimed to foster participatory engagement, I also recognise that some aspects of the research were extractive in nature, offering no immediate benefits to participants. To minimise potential burdens, I scheduled focus group discussions during already planned farmer field school meetings, with participants' consent, and conducted household interviews after 8 a.m., once farmers had returned from their fields. Interviews were usually held in participants' homes to enable them to continue with their daily activities. Looking ahead, I intend to share findings in accessible formats, including translated summaries and community feedback meetings, in the hope that the research may inform local conversations about land, livelihoods, conservation, and development. While these efforts cannot fully compensate for the knowledge and time shared with me, they reflect my ongoing commitment to ethical and reciprocal research practice.

This research journey has deepened my appreciation for the complex interplay between fieldwork, community engagement, and ethical responsibility. It has reinforced the importance of inclusive, locally grounded approaches to conservation, especially those that recognise the roles of gender, land tenure, and socio-cultural dynamics in shaping biodiversity outcomes.

Chapter 2 : Theoretical background and Case study

One of the farms in my study site, at sunset

2.1 Linking agriculture and biodiversity conservation in Africa

Agriculture remains the backbone of most sub-Saharan Africa economies (Burke, et al., 2022; Li et al., 2021). Yet, despite increases in agricultural production, poverty and food insecurity persist across the region (Araya et al., 2023). Enhancing agricultural productivity is, therefore, a central development priority. However, this ambition is challenged by population growth, land and soil degradation, climate change, and limited access to agricultural innovations (Tadele, 2017). With agriculture predominantly rainfed and smallholder-based, these challenges pose significant risks to sustainable food production (Meyfroidt et al., 2022; Tschirhart et al., 2018). In Malawi, for instance, agricultural productivity is estimated to be approximately 30% to 60% below its potential (Anghileri et al., 2024; Leakey et al., 2021), exacerbating food insecurity.

Many countries including Malawi, have pursued strategies such as agricultural intensification and land expansion to address these gaps. However, these approaches often conflict with biodiversity conservation objectives (Wuepper et al., 2024). Cropland expansion frequently leads to deforestation and encroachment into protected areas, resulting in habitat loss and fragmentation (Pendrill et al., 2022). At the same time, intensification, often involving high use of synthetic fertilisers and pesticides, can degrade soil, disrupt ecosystem services, and pollute water bodies (Ball et al., 2024; Williams et al., 2021).

These trends are particularly concerning in tropical regions, which are among the most biodiverse globally (Chapman et al., 2022; Oakley & Bicknell, 2022). For example, between 1961 and 2019, the area of harvested land in the tropics more than doubled, with expansion accelerating in recent decades (Oakley & Bicknell, 2022). However, only 45–65% of land deforested for agriculture between 2011 and 2015 became productive in the short term, that is, was both brought under cultivation and achieved yields consistent with its intended agricultural use, as per FAO classifications (Meng et al., 2023; Pendrill et al., 2022). The remaining land remained underutilised, degraded, or was abandoned altogether. Projections suggest continued biodiversity loss in tropical areas due to agricultural activity (Laurance et al., 2014), highlighting the urgent need for sustainable land-use strategies supporting livelihoods and ecological integrity.

In sub-Saharan Africa, livelihoods depend not only on agriculture but also on natural resources and the ecosystem services they provide (Fedele et al., 2021; Meyfroidt, 2018; Tschirhart et al., 2018). Communities near conservation areas often rely on resources, such as firewood, bushmeat and medicine for subsistence, partially offsetting shortfalls in agricultural production (Meng et al., 2023; Meyer & Börner, 2022; Wunder et al., 2014). Indeed, farming practices and natural resource use jointly influence both biodiversity and wellbeing outcomes, necessitating integrated strategies that consider food security and ecosystem health (Meng et al., 2023; Meyer & Börner, 2022).

Climate change is expected to further compounds the agriculture-biodiversity relationship in southern Africa, where ecosystems such as Miombo woodlands, grasslands, and savannas are already under pressure from land-use change (Hall et al., 2021; Olson et al., 2017). In this region, rising temperatures, shifting rainfall patterns, and frequent droughts have contributed to water scarcity, declining soil moisture, and increased evapotranspiration (Cramer et al., 2018; Jägermeyr et al., 2021; Ray et al., 2019). These changes not only reduce agricultural productivity but also heighten the risk of soil degradation, bushfires, and vegetation loss (Ray et al., 2019; Stevens & Madani, 2016; Zinyengere et al., 2013). Given that rural communities often depend on biodiversity for fuelwood, wild foods, and ecosystem services, these combined pressures further exacerbate food insecurity and reduce household resilience (Senganimalunje et al., 2015, 2022). Mitigation strategies that integrate biodiversity conservation with climate-adapted agriculture are urgently needed to sustain both livelihoods and ecosystem integrity in the face of ongoing change.

2.2 Challenges and opportunities in the food-biodiversity nexus in Africa

Various strategies have been developed to reconcile agricultural development with biodiversity conservation. These include sustainable intensification, agroforestry, climate-smart agriculture, conservation agriculture, and input subsidies (Ajayi et al., 2011; Araya et al., 2023; Darko et al., 2018). While promising in theory, the effectiveness of these approaches varies significantly depending on local ecological, economic, and social contexts (Burke, et al., 2022).

Agroforestry, for example, integrates trees into agricultural landscapes to support ecological sustainability and food production. It has been promoted as a low-input, biodiversity-friendly strategy (Ajayi et al., 2011; Araya et al., 2023; Coulibaly et al., 2017), but it has also been criticised for being cost-intensive in its early stages and for potentially reducing crop yields due to resource competition (Ndoli et al., 2017). Furthermore, it is sometimes viewed more as a safety net for people experiencing poverty than as a primary solution to food insecurity (Araya et al., 2023).

Technological innovations such as digital agriculture and input subsidy programmes have shown mixed results in addressing agricultural productivity challenges (Conway et al., 2019). The digital agriculture revolution involving tools such as mobile-based advisory services, weather forecasting, and remote extension support, has generated enthusiasm for its potential to support smallholder decision-making (Conway et al., 2019; Mdee et al., 2021). However, access remains highly uneven, especially in rural areas where farmers often face barriers such as limited mobile phone ownership, unreliable cellular network coverage, high data costs, and lack of digital literacy (Mdee et al., 2021). Meanwhile, input subsidy programmes, though widely promoted across sub-Saharan Africa, have raised concerns about transparency, political manipulation, and elite capture (Darko et al., 2018; Mdee et al., 2021; Walls & Matita, 2023). These programmes alone are unlikely to close the region's persistent yield gaps, which are driven by a broader set of factors such as lack of access to improved crop varieties, appropriate agricultural inputs, soil degradation, and limited farmer education (Burke et al., 2020; Gollnow et al., 2025; Leakey et al., 2021).

A more recent concept, "land maxing", has emerged as an alternative to mainstream intensification strategies. It promotes the domestication and commercialisation of nutrient-rich, indigenous wild tree species that have been historically neglected (see Leakey, 2020, 2023). For example, wild loquat (*Uapaca kirkiana*) and baobab (*Adansonia digitata*) are widely valued across Malawi and southern Africa for their edible fruits, high micronutrient content, and cultural importance. These species can be integrated into farming systems through agroforestry, providing opportunities for biodiversity-friendly nutrition, climate resilience, and supplementary income. While this approach holds promise for biodiversity-friendly nutrition and income generation, its practical implementation, adoption, and potential trade-offs require further investigation.

A core challenge in the food-biodiversity nexus is the disconnect between the evidence available in the literature and the lived complexity of socio-ecological systems (Gollnow et al., 2025; Leakey, 2023). Many existing studies and policy frameworks fail to account for the interplay of ecological, social, cultural, and economic factors that shape land use and conservation outcomes. Interdisciplinary, context-specific research is therefore essential to develop equitable, effective solutions tailored to the realities of diverse landscapes (Brehony et al., 2020; Meng et al., 2023; Meyfroidt et al., 2022).

2.3 Malawi: national context

2.3.1 Geographical location and agricultural production

Malawi, a landlocked country in south-central Africa, spans 118,484 km², with Lake Malawi covering about 20% of this area. It borders Mozambique (east, south, southeast), Zambia (west), and Tanzania (north, northeast) (GoM, 2018; Kpienbaareh et al., 2022) (Figure ***2.1***). The population is growing rapidly, from 15 million in 2012 to an estimated 26 million by 2030 (Mungai et al., 2020; Nyamangara et al., 2019). About 85% of Malawians live in rural areas, primarily engaged in smallholder farming and 65% of farmers cultivate less than one hectare (FAO, 2017, 2024; Mungai et al., 2020).

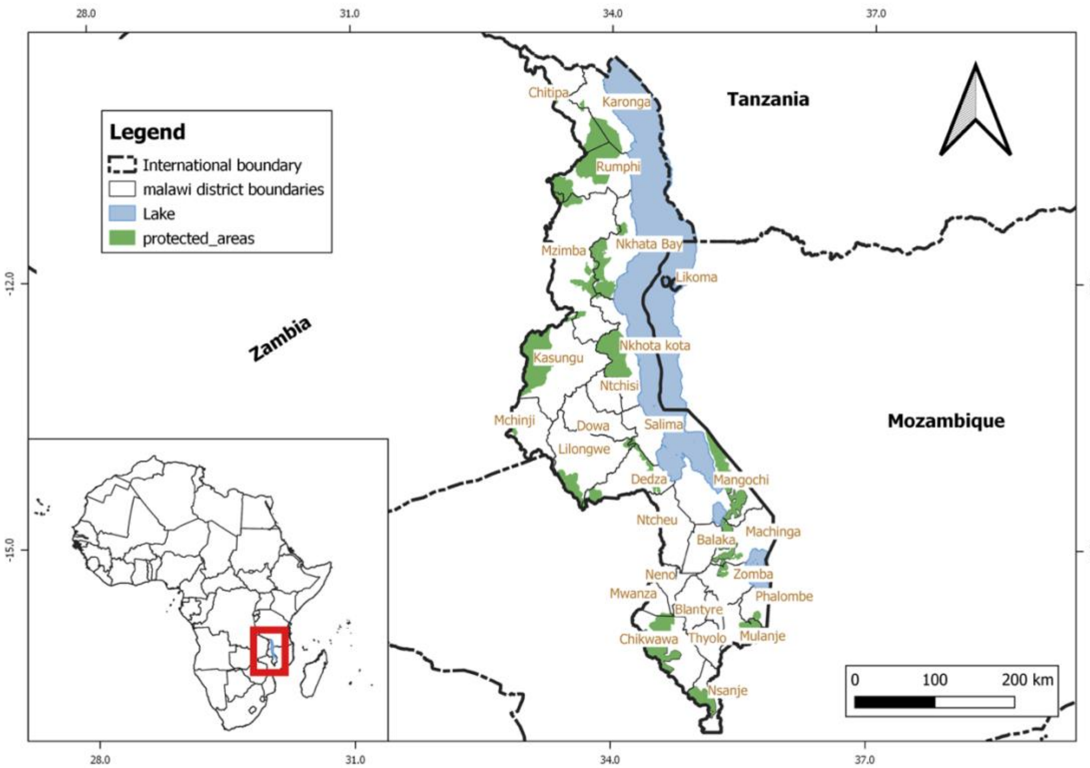

Figure 2.1: Map of Malawi indicating neighbouring countries and various districts across the country. The green patches highlight some of the key protected areas in the country. Source: Author

Agriculture is the backbone of Malawi's economy, employing over 80% of the workforce, contributing 39% to GDP, and generating 80% of export earnings (Tuni et al., 2022). The country relies on a single rain-fed growing season (November to April), which increases vulnerability to food shortages (Araya et al., 2023). Key exports include tobacco, tea, sugarcane, coffee, and macadamia (Darko et al., 2018; Ngwira & Watanabe, 2019). Since 2005, the Farm Input Subsidy Program (FISP)- now renamed as the Affordable Inputs subsidy Program (AIP) - has aimed to boost food security by improving access to fertilisers and improved seeds. However, its effectiveness remains debated (Burke et al., 2020; Darko et al., 2018; Mungai et al., 2020; Walls & Matita, 2023).

Despite economic growth and policy reforms, Malawi remains among the world's least developed countries. Rural areas in particular, face poverty, malnutrition, low life expectancy, and limited rural access to services (Araya et al., 2023; Tuni et al., 2022). Restricted access to education and healthcare in rural areas exacerbates these challenges (Tuni et al., 2022). Only 3.2% of the rural population has access to electricity and other clean and sustainable alternatives, leading to heavy fuelwood reliance and consequent environmental degradation (Senganimalunje et al., 2022; Tuni et al., 2022). Poor agricultural performance, rapid population growth, and limited non-farm employment compound poverty (GoM, 2010, 2018).

Climate change intensifies these existing challenges, as floods, droughts, and unpredictable rainfall continue to disrupt maize production, the country's staple crop (Burke, et al., 2022; Warnatzsch & Reay, 2020; Zinyengere et al., 2014). These negative impacts on crop yields are expected to increase in frequency and severity, particularly as climate models for Malawi predict more erratic rainfall patterns and higher temperatures in the coming decades (Chikabvumbwa et al., 2022). In response, there is a growing emphasis on irrigation and promotion of crop diversification, particularly in the climate-sensitive southern and central regions, with a focus on more drought-tolerant crops such as cassava and ground nuts (Chikabvumbwa et al., 2022; Olson et al., 2017).

2.3.2 Trends in protected area management and biodiversity conservation in Malawi

Malawi hosts 99 protected areas (PAs), covering 16.8% of its land area (Kpienbaareh et al., 2022; van Velden et al., 2020). These areas are crucial for biodiversity but face increasing threats from cropland expansion, illegal resource use, climate impacts, and chronic underfunding (Baghai et al., 2018; Jones et al., 2018; Wuepper et al., 2024). Forest loss, driven by agriculture, fuelwood, charcoal, and tobacco, is estimated at 1–3% annually (Kpienbaareh et al., 2022). High population growth and dependency on natural resources intensify pressures (Kpienbaareh et al., 2022; Senganimalunje et al., 2022).

Under colonial rule (1891–1964), protected areas were created for timber and game, often disregarding local land rights (Mauambeta, 2010; Morris, 2016). After independence, additional parks were established under the 1973 National Parks and Wildlife Act, but top-down policies continued, sidelining communities and fuelling land conflicts (Chana & Manomaivibool, 2016; Mauambeta, 2010).

Since 1994, a shift toward participatory conservation emerged, with Community-Based Natural Resource Management (CBNRM) aiming to integrate livelihoods and biodiversity goals (Manda et al., 2023; Mauambeta, 2010). However, conservation policies have remained largely top-down, with minimal community involvement (Chana & Manomaivibool, 2016). More recently, Public-Private Partnerships (PPPs) have become prominent, allowing NGOs and private actors to co-manage protected areas (Kalenga et al., 2024; Manda et al., 2023). While these partnerships show promise, they risk marginalising local communities through for example elite capture and therefore raising questions about long-term equity and sustainability (Kalenga et al., 2024; Manda et al., 2023; Zuka & Zuka, 2024).

Other recent policy changes include contested legal reforms (e.g., stricter wildlife crime penalties), wildlife translocations, and ecotourism development (van Velden et al., 2020).

Persistent issues such as land tenure disputes, deforestation, and weak governance continue to hinder effective conservation.

2.3.3 Policy frameworks on food security and biodiversity conservation

Malawi has developed multiple policies to align with regional and global development goals. Key frameworks include the Malawi Agenda 2063 (GoM, 2020), National Agriculture Policy GoM, 2024a), National Land Policy (GoM, 2002), Wildlife Policy (GoM, 2017), and National Irrigation Policy (GoM, 2024b). While these policies aim to integrate agricultural and conservation into development planning (Woolaston et al., 2021; Wuepper et al., 2024), a siloed policy approach creates contradictions (Kosamu, 2017). For instance, agricultural policies promote wetland use for food production, while environmental policies discourage it due to degradation risks (CEPA, 2010; Shine & De Klemm, 1999). This lack of policy coherence complicates implementation, undermining food security and conservation objectives. Greater integration and alignment across sectors are needed to address these interconnected challenges effectively.

2.4 The social-cultural context of Kasungu landscape

Bearing in mind the challenges faced by both the agricultural and conservation sectors, and the need for integrated management, I selected the Kasungu region as a study site for my research. This was due to its diverse socio-ecological context, including active biodiversity use, agricultural pressures, gendered resource use, accessible field conditions, governance support, and community willingness to engage (Table ***2.1***)

Table 2.1: Criteria for the selection of study landscape and case study villages for the DPhil research

Criteria	Justification
The existence of wild biodiversity and surrounding farms	Area of high biodiversity use (e.g., hunting) but is under pressure from agriculture, making it a relevant site to study biodiversity-farming trade-offs.
Gender-resource use dynamics	The presence of gendered resource-use patterns allowing for insights into how social and cultural factors influence biodiversity and food security interactions.
Safe work environment	The site had to be safe and accessible per the university's risk assessment.
Community participation	The willingness of local participants to engage in discussions on sensitive topics such as resource use and gender dynamics.
Supportive governance structures	The presence of governance structures that facilitate researcher-community interaction and integration.

Kasungu, Malawi's second-largest district (7,878 km^2), has a population of 842,953 (density: 105/km^2) (GoM, 2018). The local economy is mainly agricultural, with primary crops of tobacco, maize, soybeans, and groundnuts. Other activities include bee farming, small-scale businesses, charcoal production, tourism, and illegal hunting (Mkanda & Munthali, 1994; Tuni et al., 2022). Despite relatively good conditions, climate change has reduced crop yields and disrupted rainfall (Chikabvumbwa et al., 2022). It is found in the far west of Malawi, next to the Zambian Boarder (Figure ***2.1***). It fulfils all the criteria set out in Table ***2.1***, and so I chose it as my study site.

2.4.1 Kasungu National Park

Kasungu National Park (KNP), covering 2,316 km² (29% of the district), is part of the Malawi-Zambia Transfrontier Conservation Area (MZTFCA) and an Important Bird Area (Figure ***2.2***) (Davis et al., 2021, 2023). It supports diverse wildlife and facilitates transboundary animal movements between Malawi and Zambia (Davis et al., 2021, 2023). Managed by the government of Malawi with support from NGOs such as International Fund for Animal Welfare (IFAW), the park is surrounded by communities that depend on farming and natural resource extraction (Mkanda, 1995; Tuni et al., 2022).

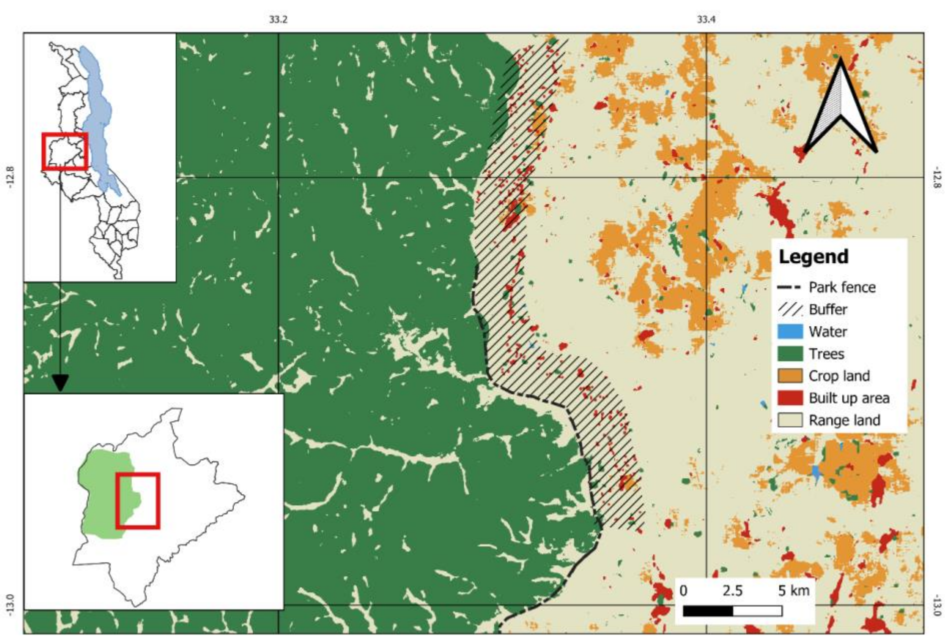

Figure 2.2: Map of Kasungu National Park showing various land uses. Source: Author.

Since its gazettement (formal legal designation as a protected area) in 1970, encroachment in the buffer zone surrounding Kasungu National Park, which spans approximately 75 km long and 2.1 km wide, has been substantial (Davis et al., 2023; Mkanda & Munthali, 1994). This includes the expansion of settlements and cultivation of farmlands.

From 2017 to 2022, Kasungu National Park (KNP) authorities constructed an electrified fence along 87.5 km of the park's eastern boundary, with the stated objective of reducing what they described as "elephant raids" and "wildlife crimes". In parallel, the park authorities also translocated 263 elephants and 431 other animals between June and July 2022, with the aim of restoring wildlife populations. While the fence reportedly reduced livestock predation and crop damage on the fenced side, it intensified human-wildlife interactions and conflicts on the unfenced side of the park boundary (Mandoloma et al., 2025). In November 2022, construction was halted by park authorities amid disputes over park boundaries and growing community concerns about farmland loss and escalating wildlife-related risks. As Malawi's Wildlife Policy (GoM, 2017) does not provide compensation for damage caused by wildlife, tension between the park authorities and surrounding communities have continued to increase since then.

2.5 Methodological approach and ethics

This research draws on eight months of fieldwork conducted during three seasons (Jan–Feb 2022, Sept–Nov 2022, Jan–Mar 2024). Initial visits focused on relationship-building and identifying research priorities; subsequent visits focused on data collection for later chapters.

Understanding human-nature relationships requires interdisciplinary approaches, particularly from the social sciences, which provide theoretical and methodological tools to examine people's attitudes, behaviours, and interactions with ecological systems (Jones & Milner-Gulland, 2024; Milner-Gulland & Rowcliffe, 2007; Newing et al., 2011). To address the research objectives of this DPhil, I used a combination of qualitative and quantitative methods: focus group discussions, key informant interviews, and household surveys.

2.5.1 Focus group discussions

Focus groups are a form of qualitative interview that generate insights through moderated group interaction (Newing et al., 2011). They explore participants' perspectives, motivations, and contrasting views in a reflective setting, allowing the free flow of information while maintaining the focus of the research topics (Newing et al., 2011; Nyumba et al., 2018). Typically consisting of six to eight purposively selected participants, they may follow a discussion guide or involve group exercises (Newing et al., 2011).

In my DPhil, I used focus group discussions to explore people's interactions with wildlife, farming practices, livelihoods (Chapter 3), and gender dynamics (Chapter 4). Discussions were guided but allowed to flow naturally, ensuring equal participation. Separate sessions were conducted for men and women to create comfortable spaces for open dialogue. Focus groups were also used to develop and refine the scenarios used in Chapter 5.

2.5.2 Key informant interviews

Key informant interviews are used to gather in-depth insights from individuals with specialised or experiential knowledge on specific issues (Crandall et al., 2018; Newing et al., 2011). They are especially valuable in exploratory research and in contexts where data is limited or uncertainty is high (Newing et al., 2011; Young et al., 2018).

I interviewed local leaders, ward councillors, and agricultural and park extension officers. These conversations helped contextualise the landscape and inform the design of the questionnaire survey for Chapters 3 and 5.

2.5.3 Questionnaire surveys

Questionnaire surveys provide structured, standardised data that can be analysed quantitatively. They are commonly used in conservation research to assess behaviours, attitudes, and perceptions (Crandall et al., 2018; Milner-Gulland & Rowcliffe, 2007).

I administered face-to-face surveys to collect information on natural resource use, views on wildlife and conservation (Chapter 3), and behavioural responses to hypothetical scenarios (Chapter 5). The resulting data were analysed using descriptive statistics and inferential models to explore relationships between variables.

2.6 Ethical considerations

Given the sensitive nature of conservation research, particularly where resource use may be illegal, ethical responsibility is paramount (Brittain et al., 2020; Milner-Gulland & Rowcliffe, 2007). Researchers must protect participants from harm and uphold ethical standards throughout the research process (Brittain et al., 2020; Pienkowski, Kiik, et al., 2022).

Prior to fieldwork, I underwent formal and informal training in social science methods and research ethics. All protocols for focus groups, key informant interviews, and surveys were reviewed and approved by the Central University Research Ethics Committee (CUREC – R79246/RE001, R79246/RE002). A research permit was also secured from Malawi's Department of Parks and Wildlife (Ref. No DNPW 10/10/14).

Chapter 3 : Implications of Human-Nature Interactions for Livelihoods and Conservation

A tree being pruned for firewood in one of the farms in the buffer zone of Kasungu National Park

Chapter published as Mandoloma, L., Clark, M., Coad, L., Hughes, K., & Milner-Gulland, E. J. (2025). Implications of human-nature interactions for livelihoods and conservation in Kasungu, Malawi. People and Nature, 00, 1–15. https://doi.org/10.1002/pan3.70008

3.1 Introduction

The complex interactions between people and nature have been conceptualised as "Nature's Contributions to People" (NCP), (Díaz et al., 2015; Pascual et al., 2017). People have diverse perceptions on how nature contributes to their wellbeing, which may relate particularly to their use of natural resources (Fedele et al., 2021; Isbell et al., 2017; Pascual et al., 2017). Understanding these relationships is critical to developing practical, inclusive and effective biodiversity conservation policies and interventions, especially in rural areas where people and nature share landscapes (as in most African countries). Although the evidence may be limited on which aspects of nature contribute to people's well-being (Pett et al., 2016), as it is context-dependent (L'Roe et al., 2023; Sibanda et al., 2020; Vedeld et al., 2007), people's relationships with nature are complex and multifaceted.

People's actions, particularly those whose livelihoods depend on natural resources, may sometimes not align with conservation efforts (Karanth et al., 2019; Karanth & Ranganathan, 2018; Salerno et al., 2020). For example, for communities living close to conservation areas, the lack of benefits from conservation and human-wildlife conflicts that destroy property, including agricultural produce and livestock, are often associated with poor attitudes towards conservation and limited participation in nature conservation efforts (Htay et al., 2022; Meyer & Börner, 2022). These interactions influence people's decisions and actions and may lead to behaviours that conflict with conservation efforts, such as retaliatory killing of wildlife, protected area encroachment, noncompliance to rules and regulations and over-extraction of natural resources (Felix et al., 2022; Ihemezie et al., 2021; Jędrzejewski et al., 2017; Viollaz et al., 2021).

Despite being one of the poorest countries in the world, Malawi has high levels of biodiversity endemism, and its agricultural-based economy heavily depends on rainfed agriculture (Davis et al., 2021, 2023; Kamanga et al., 2009; Kpienbaareh et al., 2022; van Velden et al., 2020). Expanding farmlands into conservation areas supports the country's food security needs and economic development but is a key concern for natural resource conservation (Phalan et al., 2011; Williams et al., 2021).

I used individual and key informant interviews and focus group discussions to examine human-nature interactions and the implications of such interactions for people's livelihoods and wildlife conservation in Kasungu, Malawi. Specifically, I looked at i) people's use of natural resources as part of their livelihoods, and what factors influence this use; and ii) people's perceptions towards wildlife and nature conservation, and factors associated with these perceptions. I defined perceptions as how a person observes, interprets and evaluates an experience, which is essential to understand because perceptions can influence how individuals assess the value of wildlife species and of conservation interventions (Boso et al., 2021; Sibanda et al., 2020).

3.2 Theoretical framework: Nature's contribution to people

Nature's Contribution to People (NCP), defined as "all the contributions, both positive and negative of living nature and their associated ecological and evolutionary processes, to people's quality of life" (Figure ***3.1***), is a framework that is used to understand and communicate how ongoing biodiversity decline may affect the complex relationships between people and nature

(Díaz et al., 2015; Peterson et al., 2018). NCP provides generalised and context-specific perspectives and analytical tools to represent nature-people interactions for different scales, audiences, and decision-makers. It also recognises the complex interactions between human activities and decisions, such as land and resource use and land management, and nature's ability to support people's well-being and emphasises the importance of cultural context as a cross-cutting factor shaping human perceptions of nature (Bruley et al., 2021; Díaz et al., 2015; Managi et al., 2022).

Understanding NCP can improve people's ability to manage ecosystems effectively, equitably and sustainably (Dressel et al., 2018; Managi et al., 2022). The framework has been applied in various studies (e.g. Cimatti et al., 2023; Dean et al., 2021; Martín-López et al., 2019; Smith et al., 2021). Its context-specific perspective highlights the diversity of framing of natural resources across different communities and geographies worldwide (Peterson et al., 2018).

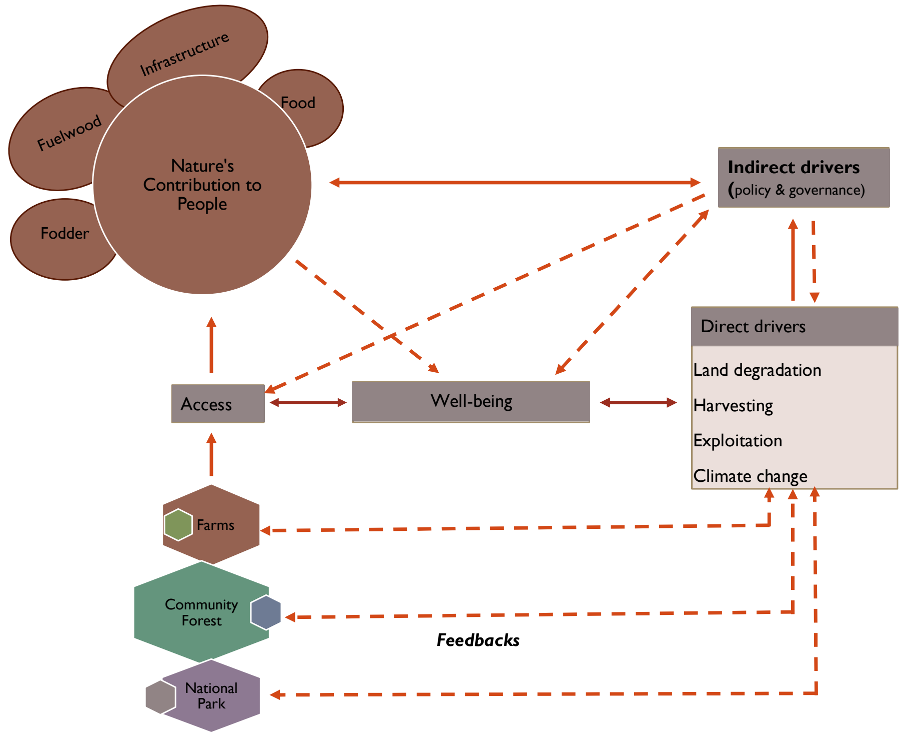

Figure 3.1: A modified framework for nature's contribution to people for Kasungu Landscape adapted from (IPBES, 2019). The dotted lines represent the feedback, and the solid lines and arrows represent the direct links. Nature contributes to the good quality of people's lives by providing beneficial NCP, including material, regulating and non-material contributions. Good quality of life includes access to basic materials, health, good social relationships, security, and freedom of choice. Direct drivers of change are internal pressures of the system that alter the state of nature and people's quality of life. Anthropogenic direct drivers of change include land-use changes, which include agricultural expansion, climate change, species introductions and overexploitation of resources. Indirect drivers of change refer to those underlying causes of changes external to the social-ecological system, such as changes in the economy, demography, culture or lifestyles.

This research focussed on perceptions and diverse uses of nature in Kasungu landscape in Malawi and sought to identify factors that influence these dynamics. Understanding factors affecting NCP is particularly important in highly biodiverse, low-income countries with high levels of nature dependence, as these countries urgently need to achieve development targets but are at high risk of unsustainable development projects that harm biodiversity and nature-dependent livelihoods (Pascual et al., 2017).

3.3 Methods

3.3.1 Study system

For study site description see **section 2.4**

3.3.2 Sampling and data collection

I selected the study villages based on their proximity to the park, accessibility, and safety for the research team to test our hypotheses about how NCP vary according to a range of contextual factors (Table ***3.1***). To ensure the study reflected diverse perspective of NCP, I used mixed methods, applying a combination of semi-structured household interviews (n=231), key informant interviews (n=18), and focus group discussions (n=16) in eight villages. We targeted households that farm close to (within 5km) and away from (5-15km) the national park boundary and interviewed male and female household heads (aged 18-70) to get a representative sample. Participation in the study was entirely voluntary, with informed consent.

While I purposively sampled participants for the focus group discussions and key informant interviews based on their location, position in the community, and gender, the participants for the household surveys were randomly selected by generating a household list for a particular village and choosing households using a random number generator. I conducted two focus group discussions in each village, one involving men only and the other women only, so each gender group could freely express themselves. I made sure community leaders were not part of the focus group discussions to reduce the potential for socio-cultural and power relations to affect results. Instead, I got their perspectives through key informant interviews. I conducted women's focus group discussions in the afternoons, and men's in the morning so I would not interfere with their farming and household activities. Each focus group constituted about six to ten people to ensure thorough participation by everyone involved. Key informants included community leaders, National Park staff, farmers, and agricultural extension officers.

I developed a semi-structured questionnaire (Appendix A1) in English based on information from the scoping study I conducted before data collection and translated it into "*Chichewa*", the local language. I piloted the questionnaire in one of the participating villages, ensuring that no one in the pilot was included in the study.

3.3.3 Data analysis

I used R (V 4.1.2), (R Core Team, 2024) and the NVivo software packages (1.7.1) to analyse individual household questionnaires and identify themes in the data obtained from focus group discussions and key informant interviews, respectively. Following Braun and Clarke's (2012) recommendations, I used inductive and deductive coding to develop themes and patterns and conduct thematic analysis. I developed codes based on the research questions and emerging issues in the data set. I then systematically collated the codes to develop themes for mapping analysis. While coding was done by myself, the re-coding was done by Beeges Mhango, my research assistant to check for coder bias.

The two broad outcome variables within the statistical analyses were natural resource use and positive perceptions towards conservation. The focal determinants of resource use and positive attitudes were, among others, proximity to the national park, gender, household wealth, and food insecurity (encompassing food-sufficient experiences as a continuum from worrying about not having enough to eat to reducing food consumption). These variables (Table ***3.1***) were determined by the literature of previous studies conducted and our knowledge of the study area during the scoping study conducted from February to March 2022. I used the Food Insecurity Experience Scale (FIES) developed by the Food and Agricultural Organisation (FAO) to create a food insecurity variable. This is an experience-based metric of the severity of food insecurity that relies on people's direct responses to a series of questions regarding their access to adequate food (Ballard et al., 2013; Pienkowski et al., 2022). I then adjusted it to estimate peoples' food insecurity experience over a farming season (12 months).

Asset ownership indicates household economic status (Hughes et al., 2020). I used the list of 20 common household assets to create an asset index, which I used as a proxy for household economic wealth. I then used Principal Components Analysis (PCA) to reduce the dimensionality of the input variables and identify major factors related to household wealth (e.g. in Hughes et al., 2020; Nguyen, et al., 2015). I weighted the assets based on average market prices to construct the principal component analysis measures and assessed their inter-item correlation (alpha = 0.73). I included the first principal component (capturing 61% of the variance) in the logistic regression models as a wealth index.

Resource use data was recorded in ordinal categories (high and low); therefore, I used an ordinal regression model to determine the relationship between resource use and explanatory variables. I explored this for resources with high variation in use between respondents, such as firewood, grass, and fruits.

To measure people's perceptions towards wildlife and conservation, I developed a set of nine questions on a 5-point Likert scale (strongly disagree =1 to strongly agree =5). I then selected six questions that showed high response variability. Having checked that they were congruent (Cronbach alpha = 0.7), I created a “positive perceptions” index. As this was a continuous variable, I used it as the dependent variable in a general linear model (GLM). I tested the dependent variables for collinearity using Variance Inflation Factors (VIF), and factors were not correlated (VIFs between 1 and 2). I used stepwise backward elimination and Akaike’s information criterion (AICc) for model selection to check the models were not overfitted (Appendix A2, A3 and A4).

Table 3.1: The hypothesised associations between natural resource use, perceptions of wildlife and conservation, and explanatory variables in the regression analyses and their prior hypothesised effects. For natural resource use, I examined three key resources in which there was variability in household use: grass, firewood and fruits. Predictions are based on previous findings in the literature.

Explanatory variable	**Predicted association**		
	Resource use	**People's perception of wildlife/conservation**	**Variable explanation**
Age	No prior expectation.	Positive association. As age increases, one is more likely to have positive perceptions *(Merz et al., 2023)*.	Age was recorded as the number of years of a person since birth. Continuous variable recorded as (years).
Gender	Women are more likely to collect resources from nature *(Beyene et al., 2020; Karanth & Ranganathan, 2018)*.	Women are less likely to have positive perceptions towards wildlife and conservation *(Merz et al 2023; Carter & Allendorf, 2016)*.	Either Male or Female, (binary).
Location	People living close to nature collect and use more resources for their livelihoods *(Angelsen et al., 2014;* Nguyen *et al*., 2015*)*.	People living close to nature have more positive perceptions towards nature because of the benefits obtained (Htay *et al*., 2022).	Distance from the household to the park boundary categorised as close (0-5km), and away (5-10km), (binary).

Education	No prior expectation.	More education will be associated with more positive perceptions towards nature *(Karanth et al., 2019; Carter & Allendorf, 2016.)*	The respondent's highest level of education, (ordinal),
Fence	No prior expectation.	People living on the fenced side are more likely to have positive perceptions due to having less human wildlife conflict *(Merz et al., 2023; Beyene et al 2020)*	Location of the study village whether on the fenced or the unfenced park boundary, (binary).
Household wealth	Better-off households will collect fewer resources. *(L'Roe et al., 2023; Beyene et al 2020)*	Better-off households are more likely to have positive perceptions towards nature *(Htay et al., 2022; Mogomotsi et al., 2020.*	An asset index (continuous variable).
Food insecurity	People with high food insecurity scale will more likely collect natural resources (*Fedele et al., 2021; Beyene et al 2020; Barbier, 2010).*	People with high food insecurity scale will more likely have negative perceptions towards nature due to crop raiding by wildlife *(Htay et al., 2022).*	Continuous variable derived from the Food Insecurity Experience Scale (FIES)

Farm size	Households with large farms will collect fewer resources *(Meyer & Börner, 2022).*	Households with large farms will have more positive perceptions towards nature *(Meyer et al., 2022; Fedele et al., 2021).*	Relative household farming size in acres
Crop loss from wildlife	High levels of crop loss will lead to high collection of natural resources *(Angelsen et al., 2014; Börner et al., 2015).*	High levels of crop loss will lead to negative perceptions towards nature *(Meyer & Börner, 2022; Htay et al., 2022).*	Quantity of crop produce lost in kgs
Livestock loss from wildlife	Loss of livestock will lead to high collection of resources (*Meyer & Börner, 2022).*	High numbers of livestock loss will lead to negative perceptions towards nature *(Htay et al., 2022).*	Quantity of livestock loss in numbers
Livestock owned	Households with high numbers of livestock will be less likely collect resources from the park (Meyer *et al.*, 2022; *Bayene et al 2020).*	High number of livestock will be associated with positive perceptions towards nature *(Meyer & Börner, 2022; Htay et al., 2022).*	Quantity of livestock owned in numbers

3.4 Results

3.4.1 Participants characteristics

The mean age of study participants was 45, with males constituting 55% of the sample. Eighty per cent of the participants were married; the rest were widowed, divorced, or separated. Female-headed households constituted 15% of the sample. Sixty per cent of the participants lived in the buffer zone, and 52% in the fenced part of the park. The level of education varied between genders; men had attended more years of formal education than women. Most participants were Chewa ethnicity (83%), with other ethnic groups including Tumbuka (11.3%) and a mix of Yao, Ngoni and Lomwe (5.7%). Agriculture was the main livelihood activity, and the principal crops (in order of importance) were maize, soy, groundnuts, and tobacco. Common livestock included chickens, owned by 47% of respondents, goats (22%), and pigs (20%). Other livestock included pigeons, rabbits and cattle, ducks and guinea fowl (11%).

3.4.2 Natural resource use

Study participants used diverse natural resources such as firewood (46%), grass (33%), food including bushmeat, fruits and vegetables (19%), and medicinal plants (2%) to sustain their daily lives (Figure ***3.2***). These resources are collected from various places, including farms, community forests, household compounds and the national park. While firewood is used for their daily cooking, heating and other energy needs, the grass is used for grazing animals and constructing bathrooms, vegetable gardens, and temporary dwelling houses in their farms (to live in when they guard their crops against wildlife during farming season). Timber is used for charcoal and brick production (for the kiln) and construction. When we asked participants about the collection of resources from the park, two people had the following to say:

"*The national park is the closest place to get herbs because that is where the ancestral trees with healing powers are. Even if I want to go to the modern hospitals, I cannot afford it since it requires a lot of money to get to town to seek medical attention from the government hospitals. It is worse to leave this place during the rainy season because most rivers are full. Even children stop going to school because it is too dangerous to cross the rivers*" (Female respondent, buffer zone, unfenced)

"*Because we have increased in numbers, the demand for firewood has also increased, and most of the trees we had are gone. It is only now that we are planting trees because our sources of firewood are dwindling, and the punishment when found harvesting firewood from the park has also increased*" (Male responded, non-buffer zone, unfenced).

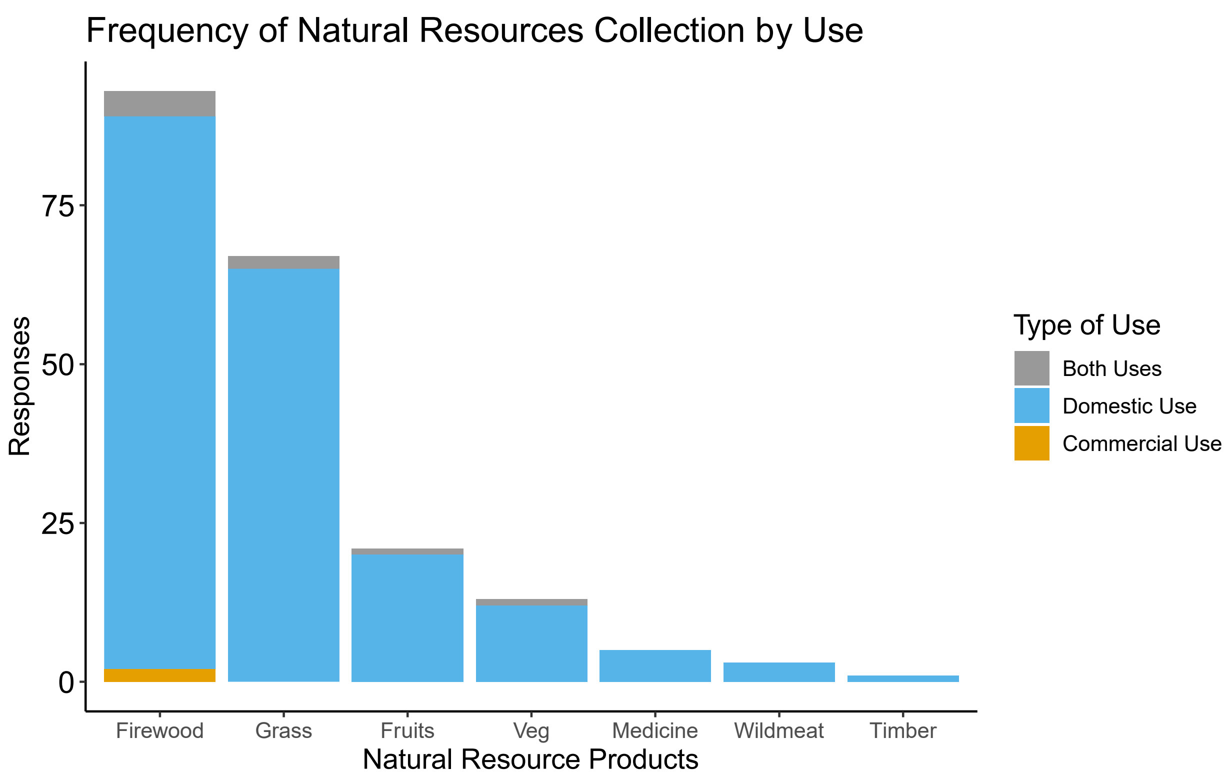

Figure 3.2: Resources used by study participants as measured by frequency of natural resource collection from the national park. The response number indicates households, which collect resources form the park, and the colours of the bars indicate the use of the resources. Blue indicates resources collected for domestic use, yellow indicates commercial use, and grey indicates household and commercial uses. The word "veg" in the natural resources products is shortened for vegetables.

Respondents reiterated that resource collection from the park is decreasing because the national park authorities have introduced an anonymous informant system for people to get compensation for reporting illegal harvests from the park.

"*Nowadays, when you are caught harvesting bushmeat, you either pay 12 million kwacha [approx. USD 7000] or spend 36 years in jail. Imagine, for example, if I go to jail for harvesting an animal as small as a pangolin that will take me less than a week to finish, then I have to spend 30 years in jail. My children will grow and marry without me and even have their own children while I am away. So, it is not worth the trouble, although other people are still risking it"* (Male respondent, buffer zone, fenced).

Using any resource significantly correlated with using another natural resource (Table ***3.2***). For example, if people collect firewood (p = 0.00, 95% CI: 3.6-7.9), they were likely to use the same opportunity to collect fruits (p = 0.00, 95% CI: 0.9-2.2), grass (p = 0.00, 95% CI: 2.8-5.6) and other resources. While males were less likely to collect fruits (p =0.01, 95% CI: -2.4-0.2), older people were more likely to collect fruits than others (p = 0.01, 95% CI: -0.0-0.1).

People who lived close to the national park (P = 0.00, 95% CI: 0.9-4.3) and who had experienced crop (P = 0.1, 95% CI: 0.8-4.9) and livestock loss (P = 0.00, 95% CI: 0.9-3.6) collected grasses more than others. Livestock ownership (p = 0.1, 95% CI: -1.6-0.25) and household wealth (p = 0.1, 95% CI: 0.1-0.4) showed a negative correlation with grass collection, indicating that economically well-off people are less likely to collect these resources. People with formal education were more likely to collect firewood than others (p = 0.1, 95% CI: -0.18-6.27).

Table 3.2: The resource collection best-fit model coefficients of variables tested with significant p-values for each selected resource. They include factors associated with people collecting firewood, grass and fruit from the national park.

	Grass use model				**Firewood use model**				**Fruit use model**			
		Confidence interval				Confidence interval				Confidence interval		
Variables	Estimate	Low	High	P-value	Estimate	Low	High	P-value	Estimate	Low	High	P-value
0|1	9.91	0.76	19.05	0.03	4.83	0.66	9.00	0.02	3.81	-0.98	8.59	0.12
Age	-0.03	-0.08	0.02	0.26	-0.01	-0.04	0.02	0.53	0.04	-0.01	0.08	0.13
Gender [Male]	0.59	-0.66	1.85	0.36	-0.08	-1.01	0.85	0.87	**-1.08**	**-2.35**	**0.19**	**0.09**
Location [Close]	**2.56**	**0.88**	**4.25**	**0.00**	-0.41	-1.36	0.55	0.40	0.03	-1.15	1.21	0.96
Fence [Unfenced]	**-1.38**	**-2.73**	**-0.03**	**0.05**	0.51	-0.45	1.46	0.30	0.26	-1.03	1.55	0.69
Education [Primary]	0.42	-2.88	3.73	0.80	**3.04**	**-0.18**	**6.27**	**0.06**	-0.99	-2.84	0.86	0.29
Education [Secondary]	-0.80	-4.67	3.08	0.69	**3.24**	**-0.15**	**6.64**	**0.06**	-0.30	-2.68	2.07	0.80
Maize loss	**2.86**	**0.78**	**4.94**	**0.01**	0.10	-1.52	1.71	0.91	1.49	-0.51	3.49	0.14

Soybeans loss	1.03	-1.15	3.21	0.35	0.26	-1.60	2.12	0.78	-0.31	-2.09	1.47	0.73
Groundnuts loss	**3.00**	**0.90**	**5.11**	**0.01**	0.54	-1.54	2.62	0.61	-0.94	-2.68	0.79	0.29
Livestock loss	**2.22**	**0.86**	**3.59**	**0.00**	-0.84	-1.84	0.15	0.10	-0.35	-1.55	0.84	0.56
Food insecurity	-0.03	-0.25	0.19	0.81	0.03	-0.13	0.19	0.71	0.00	-0.20	0.20	0.98
Wealth index	**-0.08**	**-0.24**	**0.09**	**0.35**	0.00	0.00	0.00	0.64	0.00	-0.03	0.02	0.69
Other resources	**4.21**	**2.84**	**5.57**	**0.00**	**5.74**	**3.58**	**7.91**	**0.00**	**1.55**	**0.89**	**2.22**	**0.00**
Livestock owned	**-0.67**	**-1.58**	**0.25**	**0.15**	0.06	-0.50	0.63	0.83	-0.43	-1.29	0.44	0.34
Farm size [Medium]	0.14	-3.31	3.59	0.94	0.43	-2.40	3.27	0.76	-1.47	-4.08	1.14	0.27
Farm size [Small]	-0.32	-3.59	2.94	0.85	0.67	-2.05	3.39	0.63	-1.12	-3.50	1.26	0.36

Significant levels are denoted by '0.1' For very low, 0.01 for intermediate level, and '0.001' for high level. Variables with relative importance are in bold; red font indicates a negative correlation, and blue indicates a positive correlation factor.

3.4.3 People's perceptions of wildlife and conservation

Overall, participants expressed positive perceptions towards wildlife and conservation. For example, over 90% of participants were interested in seeing animals in the national park, and 71% were interested in gaining wildlife knowledge (Figure *3.3*). Two of them had the following to say.

"It would be great to see the wildlife inside their natural habitat, not only when they have come to our village, and people are either chasing or running from them" (Male respondent, away from the park, unfenced).

"Most times when we are offered to go see animals in the national park, we are asked to pay very high bus fares and arrange food, which becomes very expensive since we have to use the main gate, which is very far. So, seeing wildlife in the park would be wonderful" (Female respondent, away from the park, fenced).

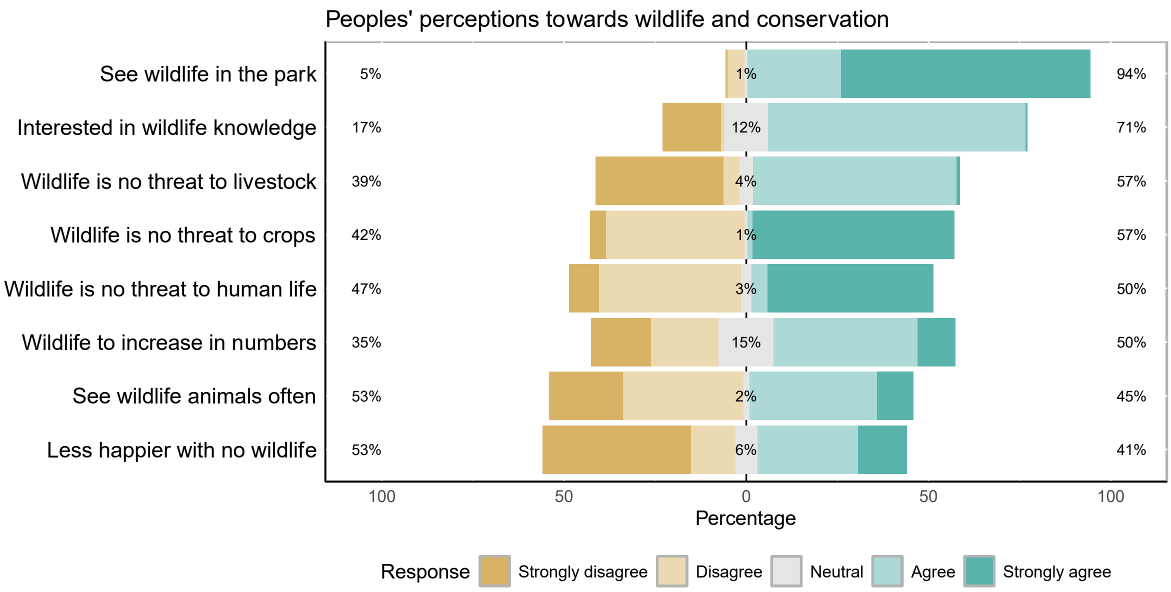

Figure 3.3: Graph summarising people's attitudes toward wildlife and conservation in the participating villages. The right green side shows the positive attitudes, and the left yellow side shows the negative attitudes. The grey middle part indicates neutral.

Positivity towards an increase in wildlife numbers and interest in seeing wildlife more often were relatively balanced between respondents. Fifty-seven per cent of households agreed that wildlife was a threat to their livestock, but interestingly, respondents from focus group discussions had balanced views on this topic:

"*As much as they bring forex [Foreign revenues] in the country, these animals, especially elephants, are very dangerous. I am glad to see them occasionally, but not often. When they want to eat your crops, they can finish the whole farm in one night*." (Female respondent, away from the park, fenced).

"I am not sure if I want the animals to increase in their numbers because, as it is, we only harvest what is left after the elephants, bush pigs, and monkeys have taken what they can. Now I no longer use that land, I have decided to rent a farm in the neighbouring village" (Female respondent, buffer zone unfenced).

Attitudes varied based on gender, location, resource use and food insecurity experience (Figure ***3.4***). For example, men showed more positive attitudes than women ($p = 0.1$, 95% CI: 0.0-0.2) and collecting natural resources from the park was linked to positive attitudes ($p = 0.1$, 95% CI: -0.0-0.1). Living close to the park ($p = 0.00$, 95% CI: -0.3-(-0.1)), experiencing food insecurity ($p= 0.01$, 95% CI: -0.0-(-0.1)), and losing crops ($p = 0.01$, 95% CI: -0.2-(-0.0)) and livestock ($p = 0.1$, 95% CI: -0.1-0.01) were associated with negative attitudes.

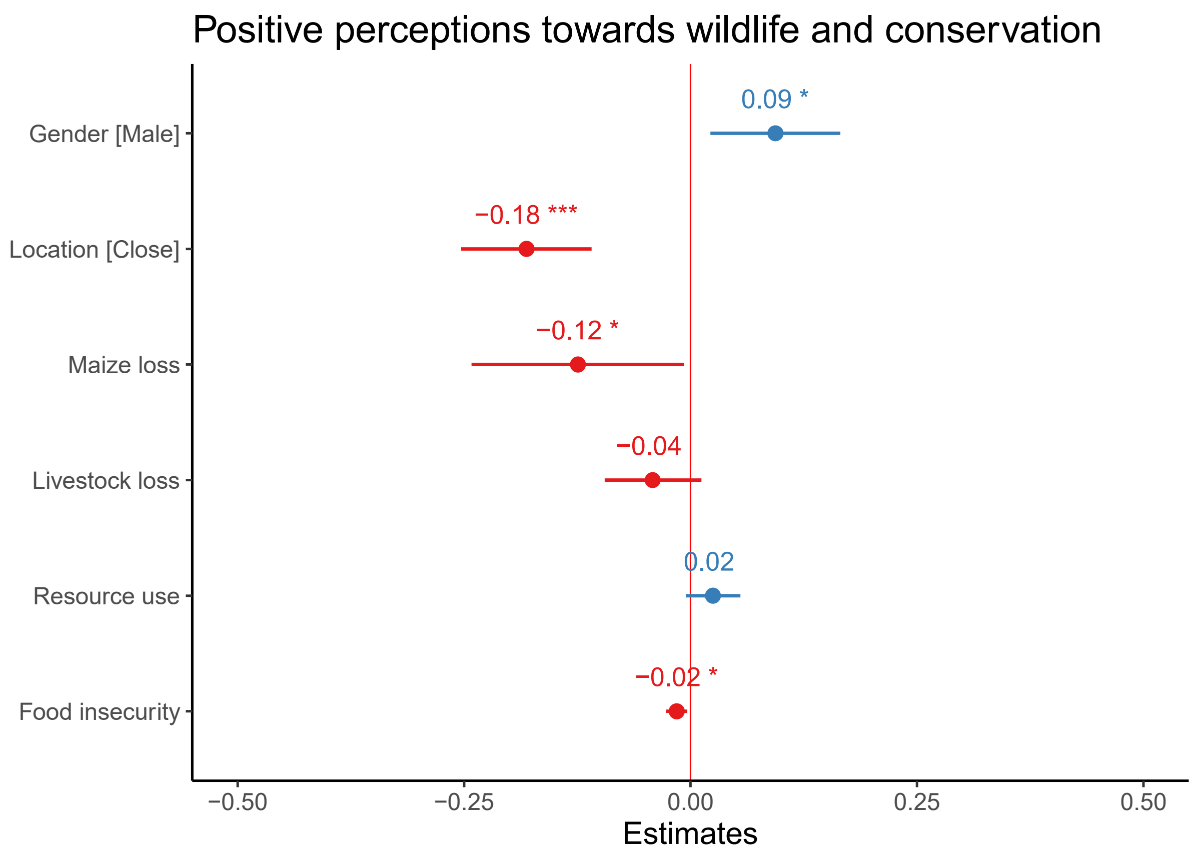

Figure 3.4: Results of a general linear regression model for perceptions towards wildlife and conservation. The red numbers indicate a negative association, the blue numbers indicate a positive association, and the stars indicate a significance level.

Discussions of solutions to protect crops and livestock from wildlife depredation revealed varied responses. For example, a focus group discussion with communities close to the park suggested that the fence be extended along the boundary to cover the rest of the eastern boundary where most communities farm. There was, however, worry for some people that the fence would restrict their access to resources in the park. We could not assess the balance of opinion due to the nature of the discussion and that resource extraction is illegal.

Since positive attitudes towards wildlife and conservation were negatively correlated with crop and livestock losses (experienced by 82% and 45% of participants respectively), I explored factors related to the losses (Figure ***3.5*** and Figure ***3.6***). Maize was the most affected (indicated by 77% of respondents), followed by soybeans (40%), groundnuts (27%), and tobacco (9%). Crop losses due to drought were high across all crops, followed by wildlife predation, diseases, and theft. Other reasons for crop losses were input-related challenges such as lack of fertiliser.

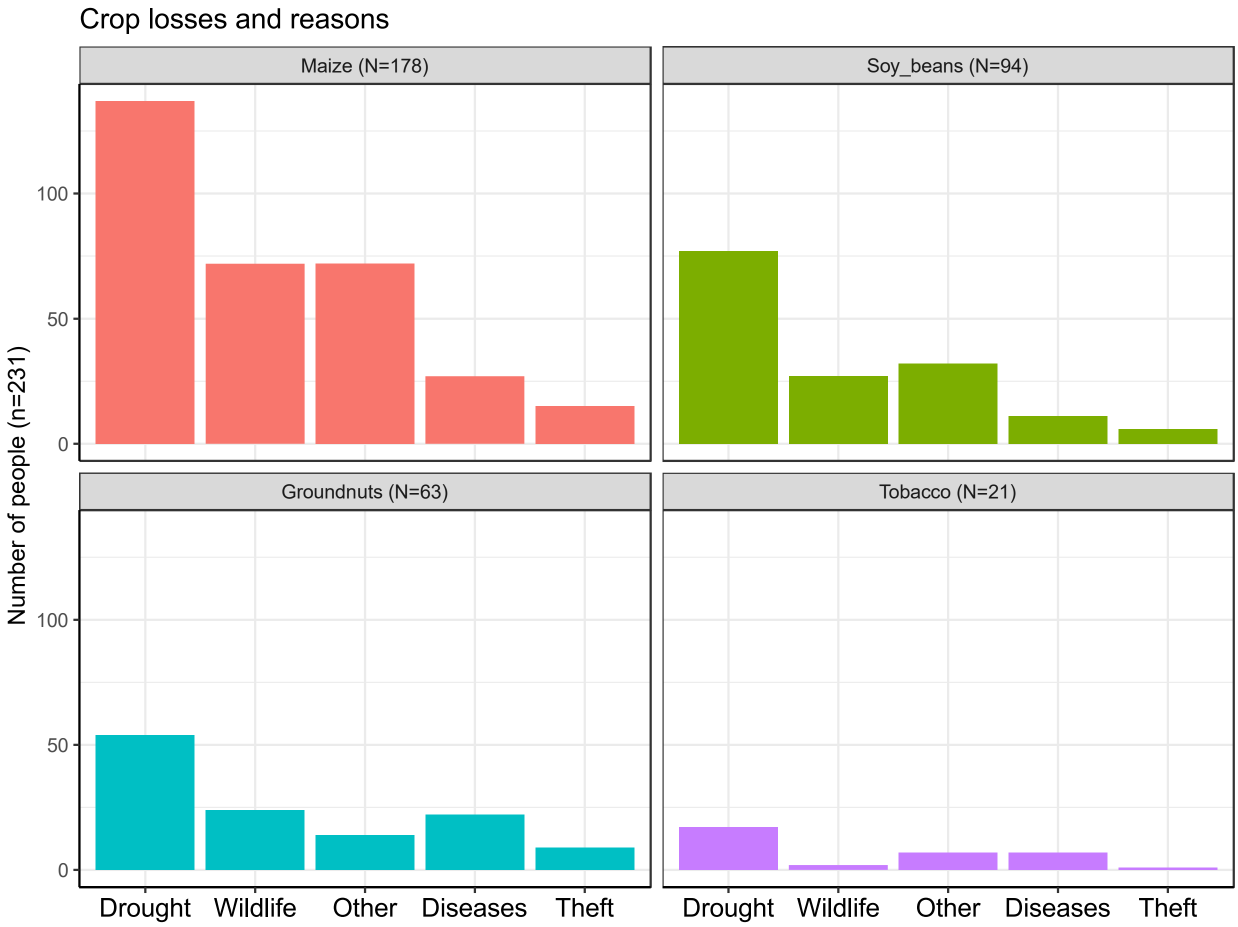

Figure 3.5: Graph showing the number of people (N) reporting crop losses as a result of various factors in the study area. Drought was the main reason for most crop losses, seconded by wildlife and other reasons.

Loss of chickens were the highest among all livestock (indicated by 83% of the respondents) followed by pigs (26%), and goats (24%). Diseases were the main reason for the losses, followed by wildlife predation, theft and other reasons.

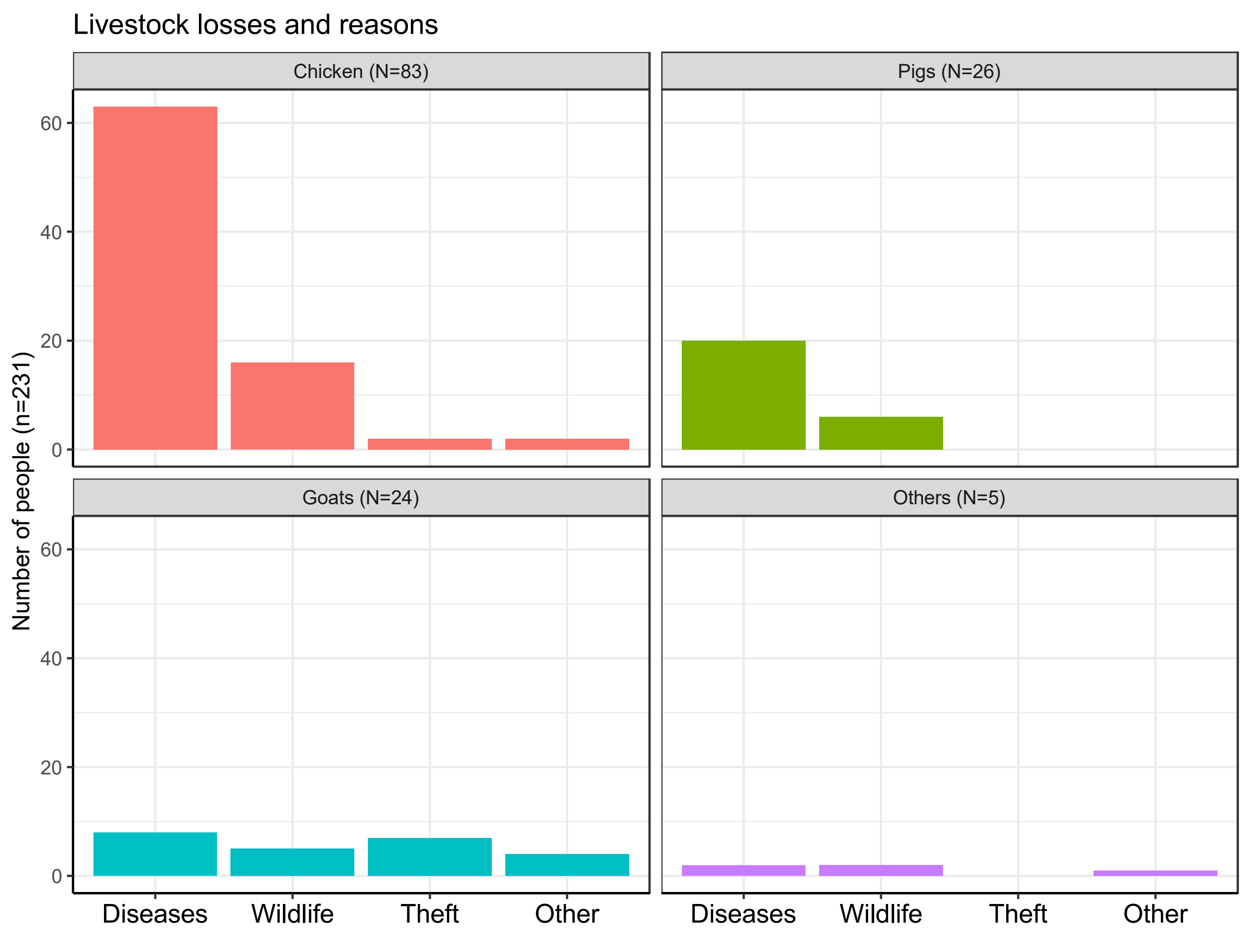

Figure 3.6: Graph showing the number of people (N) reporting livestock losses as a result of various factors. Losses due to diseases were top, followed by wildlife, theft, and other reasons, including poisoning.

Our results revealed that even though wildlife was an essential cause of crop and wildlife losses, diseases and drought were as pertinent and led to significant losses.

3.5 Discussion

3.5.1 Factors influencing households' natural resource collection

I demonstrate that, in Kasungu landscape, natural resources are collected mainly for domestic purposes. Although the resources are sourced from various places, Kasungu National Park is an essential source of natural materials for people's social and economic well-being. This is commonly the case with communities close to conservation areas although in some areas access can be restricted (Beyene et al., 2020; Meyer & Börner, 2022; Shackleton & Shackleton, 2006; Vedeld et al., 2007; Angelsen et al., 2014). While previous research highlighted the contribution of income from forest resources (Nguyen et al., 2015; Wunder et al., 2014; Angelsen et al., 2014; Kamanga et al., 2009); in this case, most participants indicated household use except for firewood, grass and fruits, which were used for both household consumption and income. The association between resource dependence and poverty was also reported by L'Roe et al., (2023); Fedele et al., (2021); and Barbier, (2010). This suggests that, even though conservation policies restrict people's access to the national park, it contributes significantly to rural livelihoods. Therefore, it is important that conservation policies consider conserving wildlife while supporting nature's contributions to people's livelihoods (e.g. Díaz et al., 2015).

Collection of resources is highly gendered (Beyene et al., 2020; Karanth & Ranganathan, 2018; Thondhlana et al., 2012), and as predicted, this case was no different, as women were more likely to collect natural resources compared to men. As women are mostly household caretakers with limited access to the market, they tend to rely more on non-market products including natural resources from the park to meet household food security needs (Beyene et al., 2020; Karanth & Ranganathan, 2018).

As predicted (Table ***3.1***), better-off people were less likely to collect resources from the park, particularly grass. The implication is that people with a higher wealth index will have various sources of income rather than depending on the park's resources. The linkage of resource use and socio-economic and demographic factors was also reported by L'Roe et al., (2023); Meyer et al., (2022); Vedeld et al., (2007); and Beyene et al., (2020). Fedele et al., (2021) also characterised highly resource-dependent people as having high poverty rates, limited market access and strong ties to nature.

I found a positive association between resource collection and crop and livestock loss, suggesting that people who have experienced crop and livestock loss were likely to collect resources. Natural resources have been known to provide a safety net to shocks such as low agricultural yield, especially for poor rural households (Angelsen et al., 2014; Börner et al., 2015; Fedele et al., 2021).

3.5.2 Factors influencing perceptions of wildlife and conservation

People's perceptions towards wildlife and conservation were generally positive, which is consistent with most studies (e.g. Karanth et al., 2019; Karanth & Ranganathan, 2018; Merz et al., 2023; Mogomotsi et al., 2020; Mkanda, 1995). This suggests there is room to enhance collaboration between institutions and local people and improve the prospects for conserving wildlife species and reducing habitat loss (Merz et al., 2023). However, having positive attitudes does not guarantee positive behaviour (Biru et al., 2017; Htay et al., 2022; Yosef, 2015), as in this case, people still illegally harvest resources from the park. Factors including gender, closeness to the park, food insecurity experience and crop and livestock loss, among others, influenced attitudes towards wildlife and conservation in the landscape reflecting linkage of various socio-demographics to attitudes towards conservation (Merz et al., 2023; Mogomotsi et al., 2020).

Contrary to my initial prediction, negative perceptions were more likely registered to people living within 5 kilometres for the park. This can be attributed to the cost associated with living in proximity to dangerous wildlife which is higher than the potential benefits (De

Boer & Baquete, 1998; Merz et al., 2023). The negative perceptions were also observed amongst participants who experiences food insecurity, crop and livestock loss as was previously reported by Htay et al., (2022) and Meyer & Börner, (2022). Although harvesting any resource is illegal, people who harvested resources from the park registered positive attitudes towards conservation. This could reflect the benefits of harvesting resources in the park, as observed by Biru et al., (2017); Htay et al., (2022); and Merz et al., (2023).

Surprisingly, I found no association between household wealth and positive perceptions even though the association of economic well-being and positive perception was previously reported by Ochieng et al., (2021) and Mogomotsi et al., (2020). The premise that better off people potentially have a diversity of income streams and/or savings that can cushion them against the economic shocks from crop and livestock depredation by wildlife may not hold in this study area. This confirms the complex and multifaceted nature of attitudes and perceptions towards nature and conservation.

The contribution of gender to conservation attitudes was significant. As predicted, women were more likely to have negative attitudes as compared to men (Carter & Allendorf, 2016; Karanth et al., 2019; Karanth & Ranganathan, 2018; Merz et al., 2023). Several reasons could explain this. Firstly, studies have suggested that unfavourable attitudes of women towards wildlife could be attributed to a greater apprehension about dangerous species (Carter & Allendorf, 2016). Due to household gender dynamics and responsibilities, women are in constant contact with the environment, which increases the risk of encountering dangerous animals in the landscape (Ochieng et al., 2021; Merz et al., 2023). Secondly, the kinship system towards land tenure is patriarchal. This means males own land and usually dominate decisions at household and community levels, and these could include involvement in different conservation initiatives (Ochieng et al., 2021). Therefore, power relations and access to conservation opportunities could affect women's social well-being, leading to low trust in conservation institutions and wildlife conservation.

3.6 Study limitations

This study had limitations which may have impacted my analysis, interpretations and conclusions. My analysis was primarily based on information provided by the respondents, with the potential for reporting bias. For example, Malawi's conservation policies, which restrict access to national parks, may have influenced the data collected regarding resource use from the national park. I spent substantial time in the village building trust and therefore have no reason to think that people were being untruthful, however I would recommend that future studies make use of other methods of collecting sensitive data such as indirect questioning methods (Hinsley et al., 2019; Nuno & St. John, 2014).

Recent escalation in human-wildlife conflicts, which have led to tensions between local communities and national park authorities, are likely to have affected people's responses regarding their perceptions of wildlife and conservation (e.g. Davis et al., 2023). Human-nature interactions in Malawi are heavily influenced by seasons due to agricultural seasons and wildlife patterns. Because this study was conducted in one season of the year, it may not have captured the variations across the seasons, limiting the study's broader applicability despite asking the respondents to consider their interactions with nature broadly and not just in that season. Recognising these limitations, findings from this study are not generalisable to areas with different socio-political and environmental conditions.

3.7 Local and global implications of the study

The study findings underscore the complex relationship between communities near conservation areas and their surrounding environment, highlighting both the heavy dependence on natural resources and the communities' positive attitudes towards nature and wildlife conservation. This relationship is shaped by several social, ecological, and economic variables such as gender, food security and household wealth, which must be considered in conservation strategies.

The results have shown that communities around Kasungu National Park rely significantly on forest resources, to the larger extend for household hold consumptions and sometimes for income. This underscores the critical role of these resources in sustaining local livelihoods and current exclusionary policies limiting access to these resources may jeopardize both local livelihoods and long-term conservation goals. For example, the illegality of resource extraction complicates efforts to collect accurate data on usage levels, hindering the design of effective interventions. To address this, it is essential to integrate the contributions of natural resources into Malawi's conservation policy and intervention design (Díaz et al., 2015; Dressel et al., 2018). This includes developing participatory structures tailored to Kasungu's specific context, informed by social-ecological studies to ensure inclusivity and local support.

Although implementing community driven conservation policies has several challenges including power dynamics (as most conservation areas in Malawi including Kasungu National Park are managed by the government with support from international organisations), many communities lack financial and technical capacity to effectively mage conservation projects (e.g. Meyer & Börner, 2022), it is important that programs are put in place to deliberately bridge these gaps while ensuring external interventions do not undermine local priorities. These complexities underline the need for adaptive and participatory approaches that address the socio-economic and political dynamics of community-based conservation.

Additionally, given the community's dependence on natural resources, there is a need for initiatives that promote off-farm employment, reduce resource extraction, and support alternative livelihoods while managing potential trade-offs for conservation and human-wildlife conflict risks (Fedele et al., 2021; Meyer & Börner, 2022). Gender-sensitive programs that enhance returns from farming and other livelihood activities are particularly important.

While crop and livestock losses due to depredation were frequently reported, losses from drought and disease were even more significant. With the human population in the area continuing to grow (van Velden et al., 2020), the demand for natural resources is likely to increase unless effective mitigation strategies are implemented. Potential solutions include improving market access for farmers to maximize returns on their produce (Beyene et al., 2020), promoting drought-resistant crops, and expanding veterinary services to reduce agricultural losses. Addressing high population growth through family planning initiatives and youth education programs is another critical priority.

Targeted compensation programs could provide relief for the most vulnerable community members and, when combined with other strategies, help mitigate negative human-wildlife interactions. Effective engagement with local communities is crucial to leveraging their positive attitudes and fostering locally led conservation initiatives. Simplistic solutions, such as fencing or punitive measures against resource harvesting, may provide short-term relief but are unlikely to promote long-term stewardship of natural resources. Instead, sustainable solutions require re-evaluating and updating current policies to reflect local realities, ensuring they are inclusive, practical, and adaptable to changing socioeconomic and environmental conditions.

3.8 Conclusion

This chapter offers valuable insights into human-nature interactions and the role of nature in supporting livelihoods. Socioeconomic factors were found to strongly influence both resource use and attitudes toward conservation, emphasizing the need for programs that integrate poverty alleviation and economic incentives. Additionally, these relationships vary with proximity to protected areas, suggesting that one-size-fits-all conservation strategies are unlikely to succeed. Instead, localized approaches tailored to the unique environmental, social, and economic contexts of individual communities are essential.

Conservation policies that restrict resource access risk alienating local communities, leading to negative perceptions and non-compliance. To achieve sustainable conservation and livelihood outcomes, policies must adopt inclusive approaches that involve local communities in decision-making and acknowledge the essential contributions of nature to their daily lives.

Chapter 4 : Influence of Gendered Kinship Systems on Land tenure and Natural resource use

Bean counting with the women during one of the focus group discussions

4.1 Introduction

In many parts of the world, gender norms shape the spaces inhabited by different gender groups, their livelihood activities, and engagement in conservation (Costa et al., 2017; Lau, 2020). Feminist Political Ecology suggests that these gendered patterns are not only socially constructed but are also deeply rooted in intersecting systems of power (Sundberg, 2017). In African countries, ethnicity, economic class, and kinship systems intersect with gender to influence land tenure, natural resource use, and access rights (Goldman et al., 2021; Lau & Scales, 2016). Recognising how these intersections shape the access and meaning attributed to land, labour, and nature across different social contexts is crucial, as these elements also influence the structure of decision-making within families, communities, and institutions (Flintan & Šeberu Tadlā, 2010; Fonjong, 2008). In some contexts, they modify human-nature interactions (Costa et al., 2017; Lau, 2020).

Although substantial research has been conducted on the social dimensions of human-nature relationships, the complexities of gender and land tenure systems, as well as their associated implications for resource use, are often inadequately addressed in both policy and development initiatives (Alvarez & Lovera, 2016; Lau, 2020; Zimmerer et al., 2015). For example, land tenure is rarely discussed from the perspective of kinship systems (Asaaga & Hirons, 2019; Chigbu, 2019). This is problematic in the African context, where almost 80% of the land is owned and controlled under customary systems, and livelihoods are inextricably linked to access to resources (Layefa et al., 2022; Narciso & Henriques, 2020; Tschirhart et al., 2018).

While conservation and development programmes have identified the need to develop inclusive projects that integrate gender and increase women’s participation, gender is not often identified as a key component of local land tenure and governance systems (Alvarez & Lovera, 2016; Malakmohammadi et al., 2013). Sometimes, it is even viewed as an add-on rather than a fundamental element of conservation initiatives (Anthem & Westerman, 2021; Westerman, 2021). This view risks promoting inequitable processes and ineffective outcomes for people and nature (Lau, 2020).

Kinship systems, social institutions which describe how lineage and inheritance are traced, the obligations of family members, and the distribution of resources, form the fabric of gender dynamics associated with land tenure and resource use (Lowes, 2020; Tène, 2021; Lowes et al., 2022). These systems, commonly referred to as matrilineal and patrilineal, have a significant impact on the positions of men and women within the family and society (Layefa et al., 2022). They determine whether inheritance or privilege is passed through the maternal or paternal line. From a feminist political ecology perspective, these kinship systems are not just social arrangements but are key sites through which power is exercised and contested, influencing access to resources and environmental decision-making (Lau, 2020; Sato & Soto Alarcón, 2019). Usually, kinship systems determine how customary land is owned, and land ownership remains fundamental to land access, secure livelihoods, economic growth, and sustainable development (Asaaga & Hirons, 2019; Benjamin et al., 2021; Berge et al., 2014; Morogoro et al., 2022).

While land reforms are being implemented in various African countries, including Malawi, to increase equality in resource management (Chigbu, 2019; Chigbu et al., 2019), the nuances of differing kinship systems are rarely discussed or integrated into these reforms (Chikaya-Banda & Chilonga, 2021; Kaarhus, 2010). Limited understanding of the kinship systems which pertain in different parts of a country could undermine these reforms, thereby perpetuating or exacerbating inequalities.

I sought to understand how gendered kinship systems in Kasungu, Malawi, influence natural resource use, livelihoods, and the associated implications for conservation and development. I chose to explore these issues in Kasungu because, despite Kasungu being located in the matrilineal belt, it neighbours the patrilineal part of the country, and the presence of intermarriages could bring cultural and land-use dynamics that are important to explore. I defined gender dynamics as the relationships and interactions between and among people based on gender (Westerman, 2021). I specifically looked at (1) the existing kinship systems in the landscape, (2) how they affect women's and men's access to, and ownership of natural resources, (3) and the associated implications for conservation, development initiatives and land reforms.

4.2 Theoretical framework: Feminist Political Ecology (FPE)

This study draws on Feminist Political Ecology (FPE) to examine how gendered kinship systems influence land tenure and resource use in Kasungu (Sundberg, 2017). FPE provides a comprehensive framework for understanding how structural inequalities, shaped by factors such as gender, class, ethnicity, age, and others, mediate access to and control over natural resources (Clement et al., 2019; Massé et al., 2021).

Unlike conventional approaches that treat gender as a discreet or additive variable within conservation and development models, FPE conceptualises gender as a relational and dynamic process embedded in everyday life, institutional arrangements, and socio-ecological systems (Elmhirst, 2015; Lau, 2020; Lau & Scales, 2016; Sato & Soto Alarcón, 2019). This makes the framework especially relevant in contexts like Malawi, where land governance is rooted in customary law and gendered kinship norms.

FPE draws attention to how power is exercised not only through formal institutions but also through lived experience, social positioning, and embodied knowledge (Bacon et al., 2022; Massé et al., 2021). It emphasises the everyday practices through which people negotiate access, assert rights, manage conflict, and sustain livelihoods. Particularly important to this study is FPE's recognition that women's ecological knowledge, especially in food production, water collection, and forest resource use, is often undervalued or excluded from formal governance and decision-making processes (Elias et al., 2021; Sato & Soto Alarcón, 2019).

FPE has been applied in diverse contexts, including studies on gendered experiences of wildlife crime (Massé et al., 2021), waste management (Pewa et al., 2025), food insecurity, and agrarian change (Bacon et al., 2022). In this study, I used FPE to examine how men and women interact with natural resources in Kasungu and how these interactions both reflect and reinforce broader social norms and environmental outcomes.

4.3 Literature review

4.3.1 Gendered land tenure and kinship systems in Southern Africa

In Southern Africa, land tenure systems are predominantly shaped by customary institutions that predate colonialism but have been transformed by both colonial and postcolonial policies (Bae, 2023; Peters, 2010, 2022). Across the region, customary tenure governs most rural land, yet varies significantly in structure, from patrilineal inheritance systems in parts of Zambia, Zimbabwe, and Mozambique to matrilineal systems in areas of Malawi and southern Zambia (Alhola & Gwaindepi, 2024; Ambler & Kieran, 2020).

Colonial administrations often organised selective customary practices that privileged male landholders, sidelining women's informal rights (Doss et al., 2014; Peters, 2013; Peters & Kambewa, 2007). Post-independence reforms have continued to pursue formal titling and individualised land ownership, often assuming land is held by "neutral" households. In practice, however, gendered power relations within households and communities continue to determine land access and decision-making (Meinzen-Dick et al., 2019). As a result, gender disparities in land tenure persist, particularly where reform programs fail to engage with local cultural institutions and kinship arrangements (Bae, 2023; Phan, 2019).

Research across Southern Africa highlights that women's land rights remain conditional and relational, often dependent on their status within kinship hierarchies (e.g., as wives, daughters, or widows) (Doss, 2018; Doss & Mika, 2021; Pradhan et al., 2019). These gendered dynamics are further complicated by shifts in land value, population growth, and conservation interventions, all of which influence how resources are claimed, allocated, and contested.

4.3.2 Gender, land tenure and kinship systems in Malawi

Malawi reflects many of these regional dynamics but also presents unique features in its kinship and land tenure systems (Figure ***4.1***). The country is home to both matrilineal and patrilineal systems, which vary geographically. Patrilineal systems dominate in the north and parts of the south, while matrilineal systems are prevalent in the central and southern regions (Figure ***4.1***) (Berge et al., 2014; Lowes et al., 2022). These systems are further distinguished by post-marital residence patterns: uxorilocal (wife's village) and virilocal (husband's village), both of which influence land access and authority (Peters, 2010).

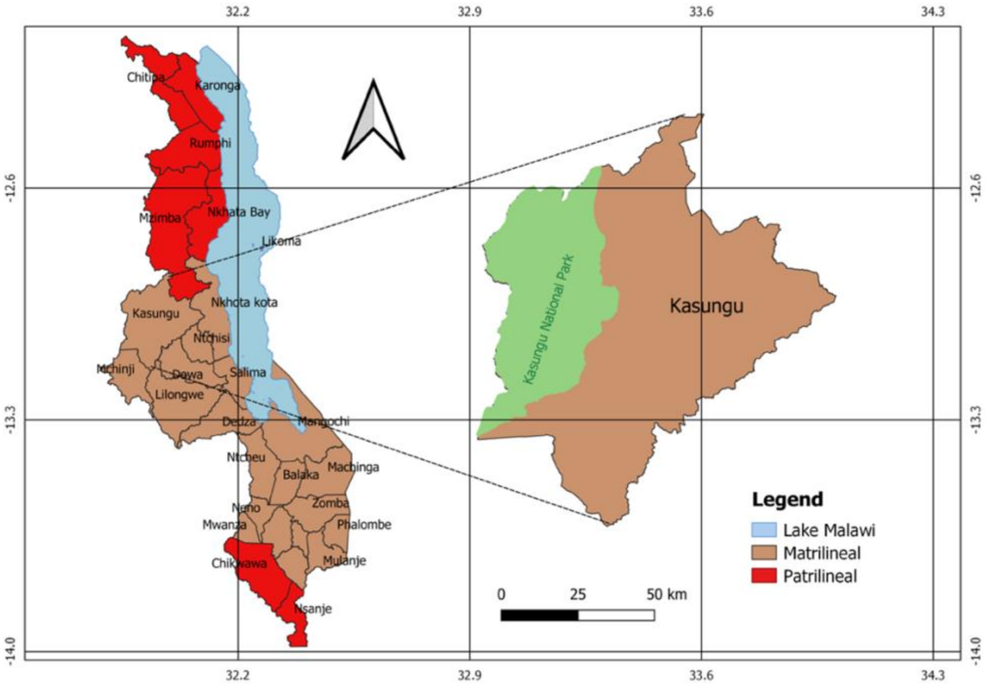

Figure 4.1: Map showing the distribution of Matrilineal and Patrilineal kinship systems in Malawi. Kasungu, the study area, is within the matrilineal part of the country. Data source: Berge et al., 2014

While leadership/chieftaincy and inheritance follow a paternal line of succession in patrilineal systems, in matrilineal systems, the line of succession is through the maternal line. The wife is essentially incorporated into her husband's lineage in patrilineal systems (Bacon et al., 2022), while in matrilineal systems, husbands and wives maintain strong allegiances with their own (different) lineages (Lowes, 2020; Lowes et al., 2022). The settlement after marriage is at the husband's home in patrilineal systems. In contrast, in matrilineal systems, settlement can depend on the system of matrilineality being practiced (see Table ***4.1***), whether uxorilocal (settlement at the wife's village, known in Malawi as "*chikamwini*") or virilocal (settlement at the husband's village, known in Malawi as "*chitengwa*") (Berge et al., 2014; Lowes, 2020, 2021).

Table 4.1: Key features of patrilineal and two different classes of matrilineal systems (uxorilocal and virilocal) concerning land use, inheritance, and marriage systems in Malawi, based on a review of the literature.

Key features	**Patrilineal**	**Matrilineal-uxorilocal**	**Matrilineal-Virilocal**
Leadership systems	Leadership is passed on to the firstborn son of the family.	Leadership was passed on to the first child, or sometimes to any child, regardless of gender, from the maternal line. This is determined by the elders in the family or the current chief, who appoints the successor before passing on.	Like matrilineal-uxorilocal except that, if it's a daughter and she is married, then she is called back to settle in her maternal village when the current leader of her line dies.
Decision making (Village level)	Decisions are made by paternal uncles and husbands, and, if old enough, the male children are involved as well	Decisions are dominated by maternal uncles, mothers and, if old enough (usually when a girl comes of age), their daughters as well.	Decisions are made by paternal uncles, the husband, and, if old enough, the male children are also involved.
Decision making (household level)	Negotiated between husband and wife within the household	Same as in patrilineal	Same as in patrilineal
Right to access and use natural resources	Both men and women (women tend to lose access and use rights	Both men and women	Same as in patrilineal

	to the spouse's family when widowed, especially in situations where they have no children).	(Men tend to lose access and use rights to the spouse's family when widowed).	
Right to own and govern resources.	Men and sometimes paternal uncles have influence	Women and sometimes maternal uncles have influence	Same as in patrilineal
Inheritance of family property, including land	Male children	Female children	Same as in patrilineal
Settlement after marriage	Husband's home	Wife's home	Husband's home
Associated tribes	Lambya, Ngonde, Tumbuka, Tonga, Sena, Lambya, Senga	Chewa, Lomwe, Yao, Ngoni (not in Mzimba district), Nyanja	Chewa, Lomwe, Yao, Ngoni

The matrilineal-uxorilocal system is almost the direct opposite of the patrilineal system; inheritance and leadership are passed down through the maternal lineage, and the husband and wife's settlement after marriage is in the woman's village. Authority over land access and control is transferred from a woman to her daughters or nieces. In the case of marriage, the husband will cultivate the land with the wife, but he has no decision-making power over transferring his wife's land rights. In case of divorce or death of the wife, the husband loses the use rights. He is expected to return to his original village, leaving the children with the wife or her family (since they belong to the matrilineal kin) (Tène, 2021b).

The notable difference between matrilineal-uxorilocal and patrilineal societies is that women often do not occupy the same position as men in patrilineal societies, as men may hold influential positions in their sisters' households (Lowes et al., 2022; Narciso & Henriques, 2020). For example, they would serve as the primary contact for negotiations in marriage arrangements and occasionally in business dealings when a family representative is needed. They can sometimes represent the family in village-level decisions. However, the matrilineal-uxorilocal system is the one in which women have the strongest land rights compared to other classes (Peters, 2010; Phan, 2019; Benjamin et al., 2021). Aspects of matrilineal-virilocal are like those of the patrilineal system except for the leadership, which follows the maternal line (Table ***4.1*** and Figure ***4.2***).

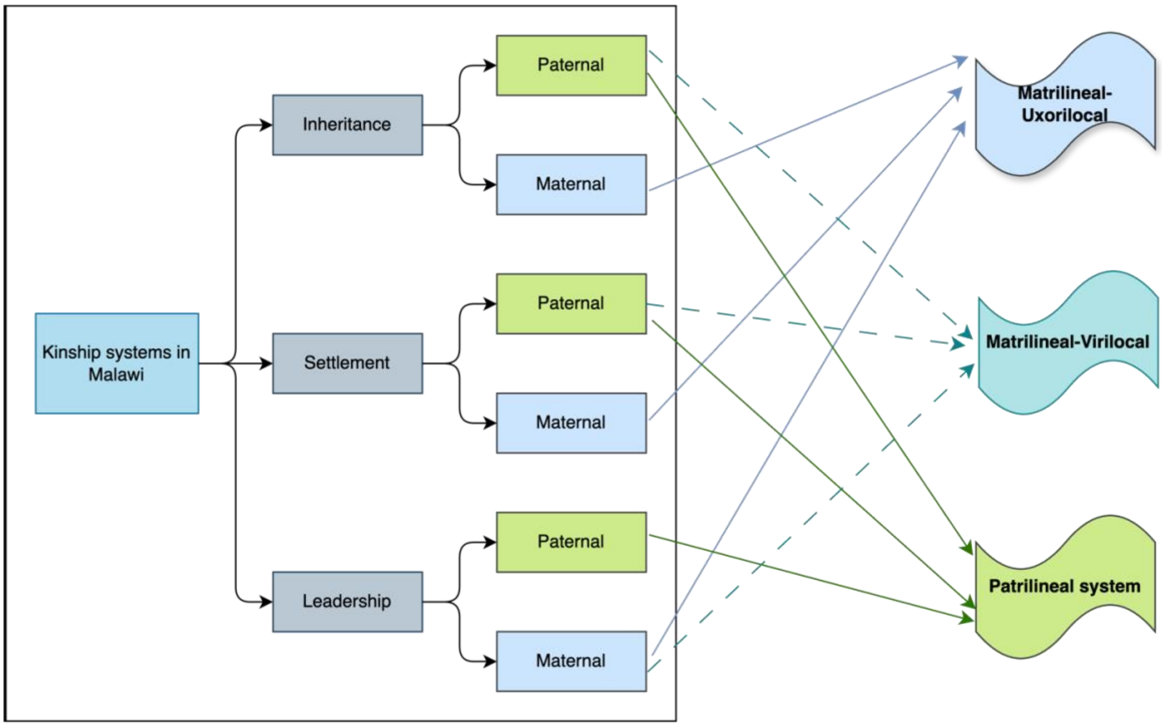

Figure 4.2: Summary of different classes of kinship systems in Malawi. Matrilineal-Virilocal with dashed lines is commonly practised in Kasungu.

A matrilineal-virilocal system dominates in the Kasungu landscape. Unlike the matrilineal-uxorilocal system, this system only follows the maternal lineage during the selection of village leadership. This means that women have access to use but not control the land, as it belongs to the paternal line, and they stand to lose it to the spouse's family when either a father or husband is deceased.

In all these systems, gender responsibilities, such as household chores, are socially embedded and negotiated within households and broader village norms, rather than being related to kinship systems (Berge et al., 2014; Djurfeldt et al., 2018).

While national reforms such as Malawi's National Land Policy, 2006 (Appendix B1), promote gender equity in principle, they lack clear mechanisms to address the underlying kinship and intra-household dynamics that shape how land is accessed, governed, and contested (Chikaya-Banda & Chilonga, 2021; Peters, 2010; Prowse, 2022). Without attention to these social foundations, reforms may fail to achieve their goals or inadvertently reinforce the very inequities they aim to resolve.

4.4 Methods

4.4.1 Study system

For study site description see **section 2.4**

4.4.2 Study approach

The study employed a qualitative, place-based approach rooted in Feminist Political Ecology, which practices local knowledge and lived experiences embedded in human-nature relationships. I conducted key informant interviews (n=18) and focus group discussions (n=16) in eight purposively selected villages located at varying distances (0-15 km) from the boundary of Kasungu National Park. This spatial stratification allowed me to examine how proximity to a conservation area shapes resource access and livelihood strategies. Four villages were between 0 and 5 kilometres from the park, and the others were 5 to 15 kilometres away. Key informants included local leaders, customarily called "*chiefs*", agriculture extension officers, Kasungu National Park staff, and elderly members of the villages.

To ensure a diversity of perspectives, focus group members were selected based on gender, age group, and location. I intentionally excluded community leaders from the focus group discussions to reduce the influence of socio-cultural and power dynamics on the results. Instead, their perspectives were captured through key informant interviews, which lasted about an hour each. Focus groups, consisting of six to ten participants, ran for approximately two hours to allow for in-depth discussion and were primarily used to triangulate the information obtained from the key informant interviews. To create a comfortable environment for open dialogue, I held separate focus group discussions for men and women. Women's discussions were scheduled in the late afternoon and men's in the mid-morning to accommodate their respective farming and household activities.

Although I had a set of guiding questions (Appendix B2 and B3), the discussions remained open-ended to allow the conversations to flow while ensuring equal participation. I asked the participants how decisions regarding resource use are made within households and in the village, and their perceptions of the relationships between resource use, gender, and kinship system. I then asked them to rank the importance of the different natural resources they access and explored the reasons behind their ratings. I also asked about their perceptions of the positive and negative aspects of their kinship systems. Despite the prevalence of its use as a natural resource, I did not ask the communities about their consumption of wild meat because it is illegal. All the interviews were conducted in "*Chichewa*", the local language in which both me and the research assistant are both fluent in. We both took detailed notes of the discussions, to ensure that we captured what the participants said regarding the issues discussed. Participation was voluntary with informed consent. All protocols for focus groups and key informant interviews were reviewed and approved by the Central University Research Ethics Committee (CUREC – R79246/RE001, R79246/RE002).

4.4.3 Data analysis

I used NVivo 1.7.1 (Version 13, 2020), a qualitative data analysis software package, to identify codes, themes, and patterns from the interviews and carried out thematic analysis following the recommendations of Braun & Clarke, (2012). Coding combined inductive (emergent from data) and deductive (informed by literature and FPE concepts) methods to identify key patterns around gender, kinship, access, authority, and environmental change. After coding and theme development, I constructed an analytical narrative by comparing field data with insights from the literature, highlighting both convergences and tensions. I considered the interviews and discussions enough for data saturation because by the end of the data collection period, they had ceased to generate new information (Newing et al., 2010).

4.5 Results

4.5.1 People's perceptions of the matrilineal-virilocal kingship system

Community perceptions of the kinship system revealed both positive and negative dimensions, with gendered differences in how these aspects were experienced (Table ***4.2***). Men often praised the system for promoting respectful and stable marriages, in which women were perceived as more obedient and adaptable to their husbands' cultural norms. Women, however, highlighted the risks of male dominance, noting that the system grants men unchecked authority, which discourages women from leaving abusive or inequitable relationships for fear of losing access to land and children, both of whom typically remain with the husband's family.

Both men and women agreed that the system provides clarity and security in terms of land inheritance, particularly for male children, who inherit land from their fathers. Unlike in matrilineal-uxorilocal systems, where elders often make inheritance decisions and can be contested, the matrilineal-virilocal is perceived as more straightforward. As a result, men are believed to have stronger incentives to invest in their land, for example, by building permanent homes or cultivating high-value crops such as tobacco and soybeans.

Both men and women respondents also acknowledged that the kinship system tends to limit women's freedom, especially in the early years of marriage. This is often because it often takes time for some newly married women to adapt to their husbands' cultural norms and to feel fully accepted by their husbands' families.

Table 4.2: Community perspectives on the positive and negative aspects of the matrilineal-virilocal kinship system, based on key informant interviews (KIIs) and focus group discussions. The KII sample included 18 respondents (nine women and nine men). Quotes are drawn from both KIIs and focus groups, which were used to triangulate findings. Numbers in parentheses indicate how many times a theme was mentioned during KIIs. A dash (–) denotes that the theme was not mentioned in the interviews.

Kinship aspect	**Men (n=9)**	**Women (n=9)**	**Associated quotes**
Inheritance security and land pressure	Yes (n=8)	Yes (n=6)	*"The system is praised for securing land for children, but it also tends to put pressure on men to secure more land, especially when they have many sons. In this case, those who have money, can buy extra land from other villages" (Male respondent, KII).*
Lasting marriages and family pride	Yes (n=5, n=1)	Yes (n=2, n=4)	"*Women do not want to leave their children to be raised by another woman, and in case they go back home, they also have to beg for land to farm from their brothers since they lose land once they marry. On top of that, they must return the dowry to the husband's family if they ask it back, so it is easier to stay" (Female respondent, FGD).* *"Our families are happy when one gets married" (Female respondents, KII).* *"Women get to receive many insults when you get out of your marriage, so it is easier for everybody just to stay" (Male respondent, FGD).*

Women's freedom of participation in development initiatives	Yes (n=2)	Yes (n=8)	*"Because I know that most of my actions are being watched, I have to be careful about what I do or say and even how I say it so that I am not labelled or given bad nicknames. Sometimes, with fertiliser subsidies, our names are the last to be considered since they start with the landowners" (Female respondent, FGD).*
Authority over decision-making	-	Yes (n=6)	*"Sometimes men go and sell produce without our knowledge, and when you ask, they will tell you that it is not your soil that has produced the crop" (Female respondent, FGD).* *"Decision-making differs between households. It is up to the individual men to consult their wives. When women ask, they are sometimes reminded that they are not the owners of the land and, therefore, do not contribute to its fertility" (Female respondent, FGD).* *"Women can suggest, especially when they are consulted. Otherwise, they do not want to appear to have authority over their husbands. They can contribute to farm activities, but the husband has the final say" (Male respondent, FGD).* *"In some cases, especially these days, we (men) are now flexible as we allow women to take the lead on some farm activities; the struggle comes when it is time for harvesting*

			and selling the produce because we differ in our spending habits" (Male respondent, FGD).
Limited land access for women	Yes (n=4)	Yes (n=6)	*"Access and use right to land and other natural resources is tied to a woman's relation to a man. Women tend to lose these rights when divorced or widowed, leaving them vulnerable" (Female respondent, KII).*

4.5.2 Gendered access to land and household decision-making

Findings reveal a persistent gender imbalance in land access and household decision-making. While women contribute significantly to both agricultural production and domestic responsibilities, they often do so without secure land rights. This lack of tenure security affects not only their capacity to make decisions but also their willingness to invest labour and resources in land they do not control. As one respondent explained, when women attempt to influence how household resources are used, they are frequently reminded: "*It is not your land that has produced this*" (Female respondent, KII).

Although some households were described as more collaborative, where men consulted their wives on farming and land use decisions, others upheld strict male authority. These variations appear to be shaped less by the kinship system alone and more by intra-household dynamics, including relationship quality, labour distribution, and economic need. However, the broader kinship context continues to underpin men's authority, allowing asymmetrical power relations to go unchecked. In cases of conflict or abuse, women often lack recourse, especially when local leaders, tasked with resolving disputes, are relatives of the husband.

Insecurity around land tenure was a concern expressed by both men and women, but it disproportionately affected women following divorce or widowhood. In such cases, women are typically expected to return to their natal villages, where access to farmland is uncertain and often dependent on the goodwill of male relatives. Without an independent income to rent or purchase land, many women face precarious livelihoods.

4.5.3 Gendered natural resource access and use

The study also revealed clear gendered patterns in how natural resources are used and valued. While both men and women identified firewood, timber, water, farmland, and grass as essential to their livelihoods, the purposes for which these resources are used, and the means of accessing them, diverged significantly along gender lines (Table ***4.3***).

For example, men reported frequent use of timber for brick burning, charcoal production, and construction of poles, while women predominantly use timber for building household structures such as fences or drying racks. When asked about the reason for the differences, respondents cited the high labour demands of charcoal and brick production. The high risk of charcoal production was another reason, as charcoal production is considered illegal and punishable by law, and the process is typically carried out at night. While men generally harvest timber themselves, women indicated that they either purchase it or rely on male family members when available.

Table 4.3: Gendered values and uses associated with natural resources collected by households in the study area, based on key informant interviews (KIIs). Numbers in parentheses indicate the total number of respondents and the number of individuals who mentioned a particular resource use.

Values and uses associated with selected natural resources		
Resources	**Men (n=9)**	**Women (n=9)**
Timber 	For brick burning, charcoal and house construction (n=8)	For house construction (n=2)
Farmland 	Mainly for farming (n=9)	Mainly for farming (n=6)

Water 	Drinking and washing (n=5)	Drinking, washing, cooking, etc (n=9)
Trees 	For rain (n=4) and cooking (n=5)	For cooking (n=8), fruits (n=7) and medicine (n=4) for different illnesses
Wetlands and Grass 	For livestock grazing (n=2) and roofing houses (n=9) for people and sometimes livestock	For livestock grazing (n=8), vegetable gardens (n=3) and sometimes roofing houses (n=8)

One female respondent described the limitations of participating in agroforestry programmes as follows:

"*When agroforestry programs come and give us tree seedlings, we sometimes don't know where to plant them, as we have to ask the owners of the land. Some of the seedlings end up dying as we wait to be guided on where we can grow them" (female respondent, KII*).

Women reported being primarily responsible for water collection, including activities such as brick production, although they are not involved in the actual brick-making process. Both men and women identified the importance of trees for cooking and rainfall generation, but women additionally emphasised their roles in providing fruits and medicinal resources. Water for drinking and washing was similarly valued by both men and women. However, cooking was largely identified as a female responsibility, with some exceptions, particularly among younger or unmarried men.

Grass was used by both men and women, but for different purposes: men primarily for livestock grazing, and women for housing materials and constructing vegetable gardens.

These findings highlight how gendered roles and kinship-based land access shape not only who utilises which resources, but also how they are valued, accessed, and managed in everyday life.

4.5.4 Gender roles in agriculture and implications for land governance

Gender differentiation also emerged in land use and agricultural production. Women described being primarily responsible for a range of domestic and agricultural tasks, including child-rearing, food preparation, and subsistence farming. Activities such as weeding, harvesting, and food processing were commonly associated with women, while land preparation and planting were typically assigned to men. However, respondents emphasised that these divisions were not rigid. In practice, tasks were often shared within households depending on labour availability and family dynamics.

While men and women were reported to have similar access to land and natural resources for everyday use, formal authority over land, particularly in terms of ownership and governance, remained with men. In some households, women were consulted on decisions about land use and agricultural production, but this appeared to be contingent on household dynamics rather than systemic rights. This complexity has important implications for how external agricultural interventions are experienced and negotiated along gendered lines.

A further challenge associated with the matrilineal-virilocal land tenure system arises in households with few male heirs. In such cases, even where large areas of land exist, constraints related to finance and labour may lead men to rent out unused land, while female family members, who are married and farming in their husbands' villages, remain excluded. As one male respondent noted:

"*My family owns forty acres of farmland, but I can only farm seven acres because I do not have the money to farm the whole land. The rest of the land is usually idle, or sometimes I rent it out, because all my sisters are married, settled, and farm in their husbands' homes, as is the cultural custom. All these families farm on less than half of what I have" (Male respondent, KII).*

This example illustrates how women's access to land remains contingent on their relationships to men, whether through their fathers prior to marriage or through their husbands after marriage, limiting their autonomy and long-term tenure security.

4.6 Discussion

Implications of the matrilineal-virilocal system on livelihoods, development initiatives, and conservation

This study builds on and extends literature on gendered land tenure and natural resource governance in Southern Africa by examining how the matrilineal-virilocal system in Kasungu shapes differentiated access, control, and use of land and natural resources. Study findings confirm the broader regional pattern noted by previous research, which indicates that women's land rights are often contingent upon relationships with male relatives and are mediated through kinship-based authority, rather than being held as autonomous entitlements (Alhola & Gwaindepi, 2024; Doss & Mika, 2021).

Although Malawi's legal and policy frameworks advocate gender equity, our results echo critiques by Chikaya-Banda & Chilonga, (2021) and Prowse, (2022) that statutory reforms frequently overlook the everyday dynamics of matrilineal customary systems (see Appendix

B1). In Kasungu, women's nominal inheritance rights under matrilineality are often undermined by virilocal residence and male-dominated governance. In such contexts, post-marital land access for women is conditional and often revoked upon divorce or widowhood (Benjamin et al., 2021a; Meijer et al., 2015). These insecure rights have broader implications for women's livelihoods and their participation in conservation and development initiatives. While there is limited evidence that land tenure security directly leads to increased productivity or sustainable natural resource management (Bhaumik et al., 2016; Djurfeldt, 2020; Djurfeldt et al., 2018), secure land rights are widely recognised as foundational for promoting equity, efficiency, and positive social and environmental outcomes, particularly for women (Feyertag et al., 2021; Holden & Otsuka, 2014; Kerr, 2005).

The study findings further demonstrate that gendered access to natural resources is shaped not only by tenure norms but also by kinship-informed social roles and expectations. Women primarily use resources for subsistence (e.g., water for cooking, timber for fencing), while men access resources like timber for market-oriented uses (e.g., charcoal production). These patterns are consistent with broader regional research, which shows that women's ecological knowledge and contributions to household and environmental management are often undervalued, despite being essential (Elias et al., 2021; Meinzen-Dick et al., 2019). In this context, female-headed households may face heightened vulnerability to food insecurity and livelihood shocks, especially when women are unable to return to their natal homes to negotiate access to farmland, or when they lack the means to purchase or rent land (Phan, 2019). This highlights the importance of considering how gendered kinship structures intersect with socioeconomic status to shape differential vulnerability.

Feminist political ecology scholars argue that power is not only institutional but relational and embedded in everyday practice (Elmhirst, 2015; Sato & Soto Alarcón, 2019). Our study shows these dynamics plays out in practice in Kasungu. Although some households exhibit collaborative decision-making, women's access to influence is often constrained by their social position within kinship hierarchies. As one woman reported, efforts to shape decisions about household resources are frequently dismissed with the claim that "*it is not your land*". These daily exclusions reinforce broader patterns of marginalisation, despite women's substantial labour contributions in farming and resource management (Doss & Meinzen-Dick, 2020; Doss, 2018; Meinzen-Dick et al., 2019).

The matrilineal-virilocal system also complicates assumptions that matrilineal systems are inherently more equitable for women. As observed by Lowes et al., (2017), and (2022), the matrilineal-virilocal model presents a paradox: women nominally inherit land, but live and farm in their husbands' villages, where land governance remains under male control. This limits their autonomy and undermines their ability to participate fully in development and conservation programs, including agroforestry initiatives that require secure planting sites. These findings support critiques that conservation efforts often fail to engage with the social complexities of land governance, particularly in relation to gendered kinship structures (Anthem & Westerman, 2021; Phan, 2019).

These results also nuance debates around marital stability and gendered power. While the matrilineal-virilocal system is perceived to foster family cohesion and "respectable" marital behaviour, it often does so at the cost of women's agency. As previous research has suggested, women in these systems may remain in difficult or abusive marriages due to fear of social stigma, land loss, or separation from children (Kusi et al., 2021; Kerr, 2005). In contrast, matrilineal-uxorilocal systems, where women retain stronger ties to their natal homes and land, tend to afford women greater bargaining power and lower tolerance for abuse (Lowes, 2020; Prowse, 2022).

These structural arrangements also influence how land is used and distributed. In some cases, male household heads control large tracts of underutilised land, while their married female relatives, excluded by kinship and custom, struggle to access farming land. This reinforces findings by Berge et al., (2014) that equitable land access and control are not guaranteed by formal systems alone but must be negotiated within and across households.

Finally, this chapter highlights the limitations of policy approaches that rely on binary classifications of patrilineal and matrilineal systems. Malawi's land laws and reforms continue to overlook matrilineal kinship arrangements, such as matrilineal-virilocal which is practised in Kasungu, thereby reproducing the very exclusions they aim to address (Asaaga & Hirons, 2019; Kaarhus, 2010). This oversight undermines the effectiveness of both land governance and conservation reforms. This is especially important in the current context, as many African countries including Tanzania, Ghana, Uganda, and South Africa, are pursuing land reforms aimed at enhancing inclusivity and improving governance through secure property rights (Chigbu, 2019; Chigbu et al., 2019; Phiri et al., 2022). In Malawi and elsewhere, ensuring that women's voices are meaningfully included in culturally appropriate, participatory ways, will be critical to ensuring that equity goals are realised in practice.

The findings underscore the need for intersectional, context-specific approaches that recognise how gender, kinship, and access intersect in complex and evolving ways (Chigbu et al., 2019; Pradhan et al., 2019). These insights are not only critical for equitable land reform, but also for designing development and conservation initiatives that are grounded in local realities and capable of fostering long-term socio-ecological sustainability.

4.7 Conclusion and Recommendations

This study contributes to a growing body of work on gender, kinship, and resource governance by demonstrating how matrilineal-virilocal land tenure systems perpetuate gendered inequalities in access to and control over land and natural resources. While matrilineal inheritance theoretically grants women access to land, virilocal residence and male-dominated governance structures significantly limit their ability to exercise authority or secure long-term tenure. These constraints are further exacerbated by everyday practices that exclude women from decision-making, despite their substantial contributions to subsistence agriculture, natural resource use, and household food security.

The findings underscore that gendered power relations in land and resource use are not merely the result of static cultural norms, but are actively negotiated through kinship systems, intra-household dynamics, and institutional arrangements. These dynamics have significant implications for women's participation in conservation and development programmes, including agricultural subsidies, agroforestry initiatives, and land reform efforts. Women’s marginalisation from such interventions risks perpetuating cycles of livelihood insecurity, underutilised land, and exclusion from decision-making processes critical to sustainable natural resource management. Achieving gender equity within such a system requires more than formal recognition of women’s land rights; it demands a deeper engagement with the structural and relational dimensions of power that shape everyday access and authority. One-size-fits-all land policies and conservation interventions that fail to account for the complexity of matrilineal kinship systems risk reinforcing rather than redressing existing inequalities.

Policy and practice must therefore recognise and engage with the nuanced realities of various kinship systems, rather than relying on binary classifications of patrilineal versus matrilineal. This could include designing land and conservation policies that are gender-sensitive, culturally appropriate, and informed by participatory processes that include both women and men; supporting context-specific approaches that consider intra-household negotiations, power asymmetries, and women's informal but influential roles in land and resource governance; and integrating Feminist Political Ecology principles to ensure that conservation and development programmes are not only inclusive in form but transformative in substance.

In sum, promoting equitable and sustainable land use in Malawi, and in similar socio-ecological contexts, requires moving beyond technical fixes to engage more fully with the embedded social and cultural structures that shape gendered access to land and natural resources. Without such efforts, current reforms and conservation strategies will fail to meet their equity and sustainability goals.

Chapter 5 : Predicting Peoples' Priorities for Reconciling Food Security and Biodiversity and Conservation

Maize farm outside my village house in Kasungu

5.1 Introduction

Achieving productive agriculture while conserving biodiversity remains a global challenge (Balmford, 2021; Herrero et al., 2020). This challenge is particularly acute in sub-Saharan Africa, where ecologically rich regions such as Miombo woodlands are increasingly threatened by persistent poverty and food insecurity. Agriculture plays a crucial role in food security and poverty reduction but is also a leading driver of biodiversity loss, with impacts expected to intensify (Tilman et al., 2017; Williams et al., 2021). Despite the importance of food security in rural Africa, policy frameworks both at local and international level often overlook the complex trade-offs between land use, agricultural production, and biodiversity conservation. This disconnect can create tensions between conservation goals, and local livelihood and well-being priorities (Habel et al., 2019; Sunderland, 2011). Fragmented national policy processes further complicate efforts to address the food-biodiversity nexus in a coherent and inclusive manner (Ferraro & Failler, 2024). To navigate these tensions, there is a growing need for integrated approaches that balance agricultural productivity with biodiversity conservation.

Understanding how people respond to agricultural and conservation-related changes, often driven by external factors, is crucial to designing effective strategies for reconciling competing land use demands (Travers et al., 2016). For instance, farm input subsidies are designed to boost crop yields (Kihara et al., 2016; Mdee et al., 2021), but their impact especially near conservation areas remain contested as they may incentivise agricultural expansion into ecologically sensitive zones, intensifying pressure on wildlife habitats and increasing human-wildlife conflict. Buffer zones, which serve as transitional areas around national parks, are often used for agriculture, further intensifying land use conflicts between farming and conservation (Kosamu, 2017; Nicholas et al., 2016).

In this chapter, I used scenario interviews to explore how possible future changes in conservation, agricultural policies and interventions could impact people and wildlife around Kasungu National Park in Malawi. Malawi, with its rich biodiversity, and smallholder agriculture-based economy, faces challenges in balancing food security with natural resource conservation (Davis et al., 2021; Kamanga et al., 2009). While farmland expansion into conservation areas may support national food security and economic development goals, it also undermines long-term conservation objectives (Phalan et al., 2011; Williams et al., 2021). To understand the trade-offs and synergies, I: (i) developed plausible scenarios related to conservation interventions, exogenous price changes, and welfare policy changes, ii) examined how people expected each scenario to affect their food security, natural resource use and well-being, and how fair they felt the scenario to be, and iii) assessed respondents' behavioural intentions under each scenario, and considered the associated implications for conservation and social outcomes.

5.2 Methods

5.2.1 Study system

For study site description see **section 2.4**

5.2.2 Scenario development

I developed five hypothetical scenarios (Table ***5.1***) along with a Business as Usual (BAU) baseline, drawing on insights from previous research in the area (Chapters 3 and 4). These scenarios were co-developed with communities through four focus group discussions (FGDs) and seven key informant interviews (KIIs) in villages neighbouring Kasungu National Park. This participatory process ensured that the scenarios reflected both current trends and locally salient issues, incorporating community perspectives alongside existing research findings. Focus groups were held separately with women and men on either side of the park, close and distant, fenced and unfenced sides, enabling us to capture diverse perspectives on conservation, land use, livelihoods, and food security. Discussions were semi-structured, and participants were prompted to reflect on past and present drivers of change, as well as plausible future developments. Key informants included traditional authorities, local government representatives, park officials, and agricultural extension workers, who offered expert and institutional perspectives on ongoing policy shifts and socio-ecological dynamics.

I piloted the questionnaire with ten households to assess the clarity, feasibility, and contextual relevance of the scenario descriptions and response questions. Feedback from the pilot helped refine wording, improve scenario comprehension, and ensure alignment with local realities and decision-making processes.

The final scenarios incorporated both biophysical and socio-economic dimensions and were designed to capture a range of plausible changes, including conservation investments, market fluctuations, and welfare interventions, with anticipated positive and negative impacts on resource use, food security, community-park relations, and overall well-being. These scenarios represented real-world policy discussions and allowed us to probe the perceived fairness, trade-offs, and behavioural responses associated with each intervention, rather than just their approval or disapproval. I acknowledge the limitations of scenario framing and discuss the implications of potential response biases and the challenges of eliciting nuanced trade-offs in the Discussion section 5.4.4.

Table 5.1: Description of each scenario, rationale for inclusion, and hypothesised outcomes based on our pilot studies and previous research. We asked respondents how each scenario would affect their food security, resource use, park relations and well-being, as well as perceived fairness.

Scenario name	Description	Rationale for inclusion	Hypothesised outcomes
Business as usual	Current conditions and trends would remain the same over the following five years (the detail of the trends expected are supplied by the respondent rather than pre-determined).	Provides a baseline for comparison; trends are included as conditions are unlikely to remain static for the next five years.	Under BAU, average food security will decrease, resource use will increase, people's relationships with the park will worsen and their wellbeing will worsen. For example, climate change-related factors such as prolonged dry spells, short rainy season, have increased over the last five years and this deterioration is expected to continue over the next five years.
Farm input price	Fertiliser prices increase by 100% over the 5-year period.	From the discussion with the communities, this scenario reflects pricing of commodities rising faster than current trends.	The increased cost of fertiliser inputs will decrease access to fertiliser, reducing crop yields and human well-being, and will lead to an increase in natural

			resource use to compensate for lost income. Respondents will consider this to be unfair. It will not affect their relationship with the park.
Universal farm input subsidy	A universal fertiliser input subsidy is implemented	To address the challenges of the current Affordable Inputs Program (AIP) which is targeted at only vulnerable farmers. Under this proposal, all farmers would have access to the universal subsidy, irrespective of their economic situation.	Universal subsidy will increase farmers' access to fertiliser thereby increasing crop yields, food security, and well-being, whilst reducing their natural resource use. Respondents will consider this to be fair. It will not affect their relationship with the park.
Buffer zone restoration	Buffer zone of the National Park restored. This would be mean that some farms will have to be shifted out of this area to allow restoration of vegetation cover.	Decreased vegetation in the buffer zone due to the unauthorised extension of farmlands has increased human-wildlife conflicts. Restoration of the buffer zone has been proposed by NGOs and	Buffer zone restoration will reduce farmland availability for affected households, therefore decreasing crop yield and wellbeing, increasing natural resource use and worsening people's relationship with the

		government in order to reduce farming activities in the park boundaries and reduce wildlife conflicts.	park. Respondents will consider this to be unfair.
Wildlife translocation	A further 250 elephants would be translocated into the park in the next five years, similar to what has already happened in the last five years.	Under the planned wildlife restoration programme for the park, it is likely that another translocation will occur in the next few years where elephants will be taken from other national parks into Kasungu national park.	Wildlife translocation will increase human wildlife conflict, therefore reducing crop yields, and well-being, increase natural resource use and worsen people's relationship with the park. Respondents will consider this to be unfair.
Compensation	People are compensated for the loss and damage caused by wildlife.	To reduce human wildlife conflict and improve people-wildlife relationships, communities have cited compensation as one way to resolve the issues they face.	Compensation will increase people's food security, improve people's well-being and relationship with the park, and decrease natural resource use. Respondents will consider this to be fair.

5.2.3 Study design

I randomly selected twelve villages from a list previously surveyed on human-nature interactions (Chapter 3). Six villages were located within zero to five kilometres of the park boundary (three on the fenced side and three on the unfenced side), and six were between six and fifteen kilometres from the park (also split evenly between fenced and unfenced areas) (Figure ***5.1***). I categorised these as fenced-close, fenced-distant, unfenced-close, and unfenced-distant. The 5km threshold between "close" and "distant" villages was chosen to differentiate communities experiencing the most frequent human-wildlife interactions (typically within the first few kilometres of the park boundary) from those further away. While the threshold was partially based on logistical considerations, it reflects patterns of wildlife damage reported in previous surveys (Chapter 3).

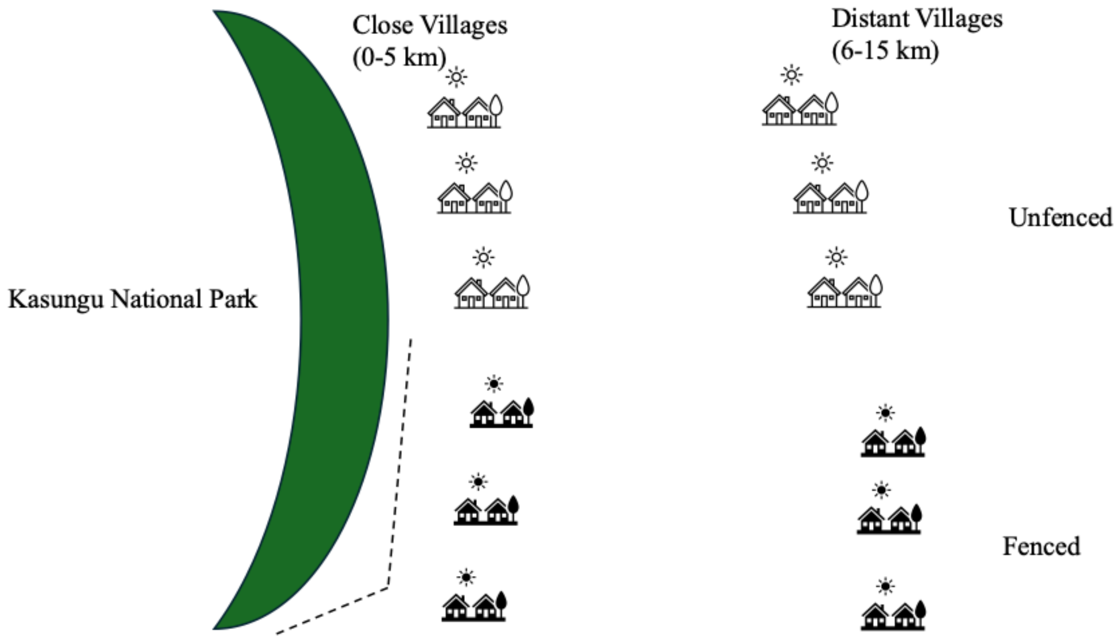

Figure 5.1: A diagram illustrating the sampled locations of the study villages in relation to Kasungu National Park. The dashed line represents the fence put up at the boundary of the park. Exact locations of villages not given to preserve confidentiality.

A total of 317 households were selected using a proportional stratified random sampling approach. Approximately 20% of households in each village were sampled, with the number of households selected from each village determined based on its share of the total household population. The 20% threshold was chosen to ensure sufficient representation across all villages while remaining feasible given time and resource constraints. Within each village, households were then randomly selected from a complete list of households to avoid selection bias and ensure representativeness. Within each sampled household, I conducted interviews with one primary respondent, typically the household head or, if unavailable, another adult member with knowledge of the household's livelihood, food security, and land use practices. While I aimed for gender balance where possible, women were more frequently available and therefore more often interviewed, as they were typically at home during survey visits. This may have introduced a bias toward female perspectives in the data, which I acknowledge and discuss as a limitation in interpreting scenario preferences and perceptions.

I asked the respondents about expected socio-economic and agricultural changes over the next five years under a Business as Usual (BAU) scenario. I then presented them with five alternative scenarios in a random order to minimize order effects and avoid bias (Newing et al., 2010). For each scenario, I asked the changes might affect their food security, resource use, community-park relations, and well-being, and how they would respond and adjust their behavior. Perceptions of fairness were measured using a five-point Likert scale (1 = very unfair to 5 = very fair), along with open-ended questions to understand their reasoning. I administered the questionnaire in Chichewa, the local language.

I emphasised that the scenarios were purely hypothetical to avoid raising expectations. I defined key terms with respondents before commencing the questionnaire to ensure shared understanding: food security was defined as having sufficient food in the household; well-being as a good quality of life; resource use as the extraction and use of natural resources such as firewood, wild foods, medicinal plants, timber and thatch. These resources are accessed from a range of sources including community forests, customary lands and sometimes illegally from within the national park. Community-park relations referred to positive engagement between the residents and the park authorities. I also asked respondents to assess the perceived fairness of each scenario, particularly whether the scenario felt just or equitable in terms of who benefits, who bears the cost, and how decisions are made.

5.2.4 Data Analysis

I used Cumulative link mixed models (CLMM) using an "ordinal" package (Archer, 2015) in R (V 4.4.1), (R Core Team, 2024) to explore the influence of the scenarios on respondents' wellbeing outcomes and perceived fairness. In each case, I calculated the predicted probability of either a decrease, no change or increase in the dependent variables for all scenarios, with business-as-usual as a reference scenario. In each model, respondent ID was included as a random effect to account for multiple responses per respondent. Graphs were produced in the "ggplot2" package in the R statistical package. I used thematic analysis (Braun & Clarke, 2012), to explore reasons for the respondents' responses.

5.3 Results

5.3.1 Respondent characteristics

The study participants (n=317) were evenly distributed across all four locations: close-fenced (n=73), close-unfenced (n=89), distant-fenced (n=76), and distant-unfenced (n=79)

(Table ***5.2***). Gender was relatively balanced across locations, with 45% of respondents identifying as male and 55% as female. A majority (83%) of participants identified as Chewa, while 17% were Tumbuka. Most respondents (84%) were married, and levels of formal education were generally low. Approximately 69% of participants had attained primary education, 24% had secondary education, and 7% reported having no formal education.

The primary source of income was farming, reported by 91% of households. Other sources included small-scale business (5%) and casual work (4%). Farming was most prevalent in the close-unfenced location, which also recorded the highest mean land owned (5.9 acres) and farmed (4.9 acres). Across all sites, the average farmed land area was approximately 4 acres, ranging from a minimum of 1 acre to a few outliers farming up to 27 acres. These larger landholdings were most frequently observed in the close-unfenced and distant-unfenced locations. In all locations, some respondents reported owning more land than they actively farmed, suggesting the presence of fallow land, land rented out, or land allocated for other uses.

Table 5.2: Demographic characteristics of respondents by location. The table shows the distribution of gender, ethnicity, marital status, education level, income sources, livestock ownership, duration of residence in the village, age, and land owned and farmed across four locations: close-fenced, close-unfenced, distant-fenced, and distant-unfenced.

Demographic variables	Close-fenced	Close-unfenced	Distant- fenced	Distant-unfenced
Gender (%)				
Male (45)	10	12	11	12
Female (55)	13	16	13	13
Ethnicity (%)				
Chewa (83)	21	23	21	18
Tumbuka (17)	3	5	3	6
Marital status (%)				
Married (84)	19	24	19	22
Unmarried (16)	4	4	5	3
Education (%)				
None (7)	2	1	2	2
Primary (69)	17	21	15	16
Secondary (24)	5	6	6	7
Source of income (%)				
Farming (91)	21	28	20	22

Business (5)	1	0	3	1
Casual work (4)	1	0	2	1
Livestock ownership (89%)	20	25	22	22
Time lived in the village (Years)				
Less than 10 (14)	3	3	3	5
10-20 (18)	4	6	3	5
More than 20 (68)	16	19	18	15
Age (years)	43	38	47	49
Land owned (acres)	4.3	5.9	4.7	5.1
Land farmed (acres)	3.8	4.9	3.9	4.3

The average age of respondents varied by location, ranging from 38 years in close-unfenced areas to 49 years in distant-unfenced areas. The mean household size was consistently around five people across all locations.

Livestock ownership was high, reported by 89% of respondents, with households commonly keeping chickens, goats, pigs, and other small livestock. In terms of settlement duration, most participants (68%) had lived in their respective villages for more than 20 years, with 18% reporting 10 to 20 years, and 14% reporting less than 10 years.

5.3.2 Business as usual

Under the business-as-usual (BAU) scenario, in which current socio-economic and environmental trends are expected to continue over the next five years, approximately 50% of participants across all locations anticipated a decline in food security. The proportion expecting decreased food security varied by location: close-fenced (39%), close-unfenced (73%), distant-fenced (39%), and distant-unfenced (51%). Commonly cited reasons included rising commodity prices, especially for agricultural inputs, and declining productivity. In the unfenced areas, respondents additionally highlighted crop and livestock losses due to wildlife depredation as a major contributor to expected food insecurity. As one farmer noted:

"*The animals keep destroying our crops, what we harvest, is what remains, which is very little*" (Female respondent, close-unfenced)

Conversely, 38% of respondents anticipated improved food security, attributing this to ongoing adaptation strategies such as crop diversification, planting early maturing and drought-resistant crops, and the use of organic manure as a cost-saving alternative to expensive chemical fertilisers. On average, 11% of respondents across all locations anticipated no change in their food security status.

In terms of natural resource use, 46% of participants expected an increase in reliance on forest and other resources. This was linked to both economic necessities, due to rising living costs, reduced agricultural output, and declining alternative livelihoods. However, 37% of respondents anticipated no change in resource use, stating that their current dependency levels would remain constant. Notably, 17% expected a decrease in natural resource use, especially in close-unfenced areas, citing the implementation of stricter penalties and enhanced security around the national park, from which many currently extract resources illegally. One female respondent from unfenced-close shared,

"*We used to go into the park, but now they have tightened the rules. You can be arrested even for collecting firewood".*

Regarding relations with the national park, a majority of respondents in close-fenced, distant-fenced, and distant-unfenced areas (over 80%) anticipated no change. However, in the close-unfenced area, 84% expected deterioration in relations, pointing to increased human–wildlife conflict, stricter enforcement and penalties by park authorities, and ongoing disputes over fence construction and land boundaries following recent wildlife translocations.

Despite the challenges, 63% of respondents across locations believed their wellbeing would improve under the BAU scenario, noting positive early results from adaptation strategies such as income diversification and organic fertiliser use. Meanwhile, 22% anticipated no change, and 15% expected their wellbeing to worsen, often due to deepening poverty or loss of livelihoods. "*Unless things change, I don't see our life improving. Prices are high, rains are poor, and animals destroy crops*," said an elderly woman from the close-unfenced area. Reflecting this tension, 54% of participants perceived the BAU scenario as unfair, linking it to persistent or worsening poverty and food insecurity.

5.3.3 Predicted impact of scenarios on food security, resource use, park relations and wellbeing

i. Food security

Predicted impacts of scenarios on food security varied considerably (Figure ***5.2***). For example, compared to business as usual, the farm-input price increase scenario was expected to significantly decrease food security in all four study locations ($p = 0.00$, 95% CI: -2.32- (-0.77)). Respondents anticipated reduced access to inorganic fertilisers, which they consider essential for maintaining crop yields. Many were sceptical that organic fertilisers could offset this reduction, citing limited production capacity.

"*Many of us will have little or no access to inorganic fertiliser, which will lower crop yield, especially for maize. This will mean less food to eat or sell" (*male, unfenced-distant).

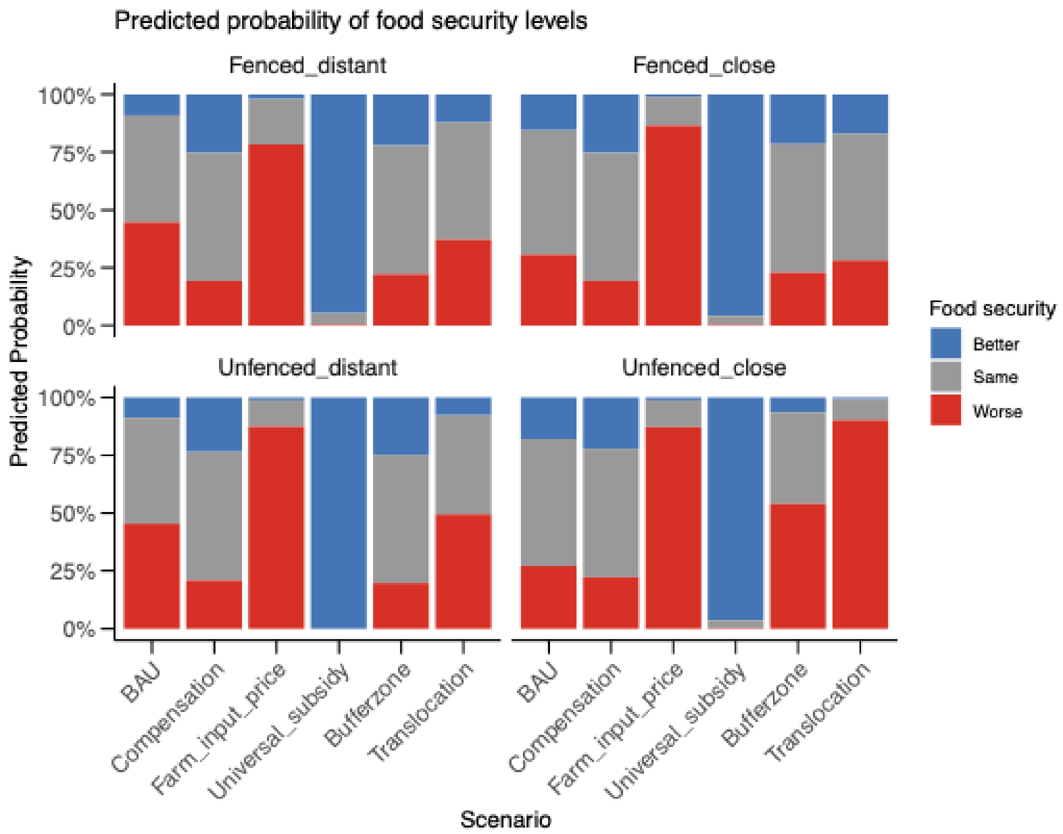

Figure 5.2: Predicted probabilities of perceived food security outcomes under different conservation and livelihood scenarios, disaggregated by household location. Bars represent the categorised responses as worse (red), the same (grey), or better (blue). While the farm input subsidy scenario was expected to increase food security across all locations, the farm input price scenario had the opposite effect. The buffer zone and translocation scenarios were expected to reduce food security for communities in the unfenced and close areas from the park

Under the universal input subsidy scenario, respondents anticipated significant improvements in food security compared to business as usual ($p = 0.00$, 95% CI: 4.07-6.38). Better access to farm inputs was expected to increase crop yields and strengthen household food supplies across all locations. The wildlife compensation scenario was also expected to improve food security as it would help household recover from crop losses ($p = 0.00$, 95% CI: 0.53-1.90).

There were two scenarios in which location had a substantial influence on perceived outcomes, particularly for respondents in close-unfenced areas, where exposure to wildlife and conservation restrictions is most acute. In both cases, these scenarios involved conservation interventions. The wildlife translocation scenario was expected to worsen food security outcomes in close-unfenced locations (p = 0.00, 95% CI: -4.73 to -2.39), as was the buffer zone restoration scenario (p = 0.00, 95% CI: -3.19 to -1.24). Respondents in these areas anticipated that translocation would increase crop losses due to elephant depredation. Meanwhile, the buffer zone scenario was seen as likely to restrict access to farmland, as communities expected conservation restoration activities to displace smallholder agriculture around the park.

ii. Natural resource use

In most locations, respondents anticipated minimal changes in natural resource use across scenarios (Figure ***5.3***). However, in close-unfenced areas, the BAU scenario was associated with a significantly higher likelihood of improved resource use (p = 0.00, 95% CI: 0.82–2.20), while the buffer zone restoration (p = 0.00, 95% CI: -2.38–(-0.57)), universal subsidy (p = 0.00, 95% CI: -2.72–(-0.80)), and compensation scenarios (p = 0.00, 95% CI: -2.48–(-0.66)) were associated with worse resource use.

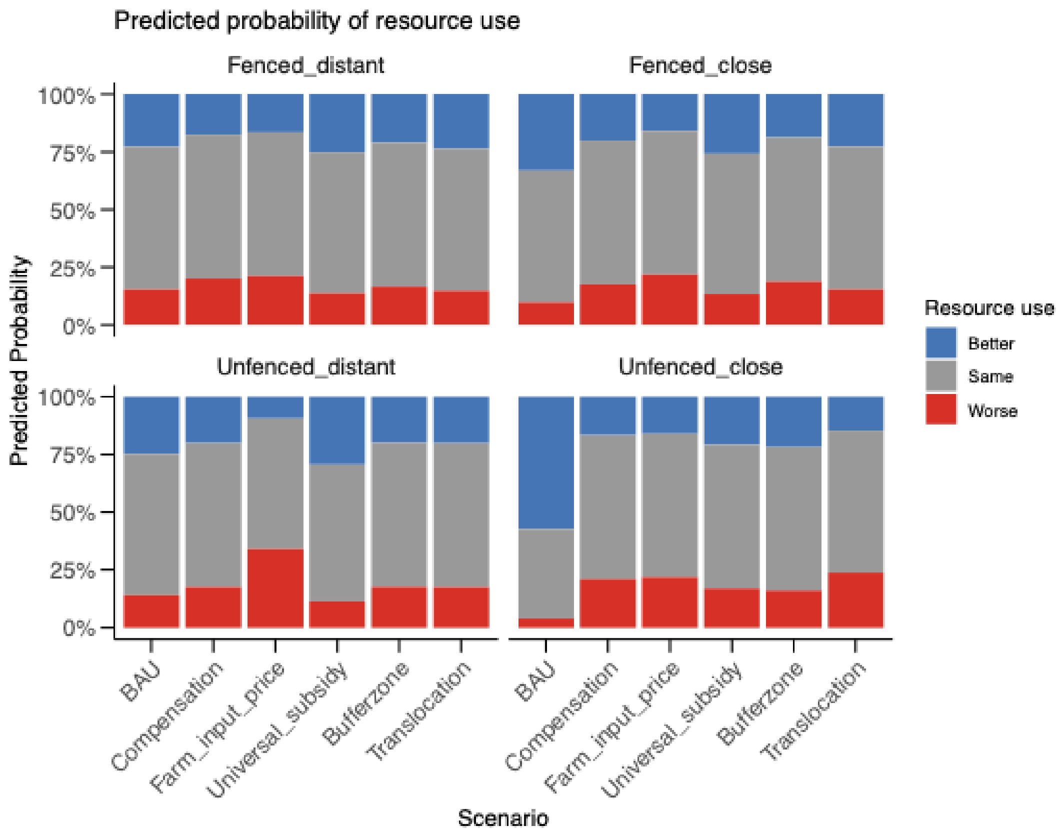

Figure 5.3: Predicted probabilities of perceived resource use under different scenarios, by location. Bars represent the categorised responses as worse (red), the same (grey), or better (blue). Results highlight that respondent anticipated minimal changes in their use of natural resources except in the close-unfenced areas, where respondents were more likely to expect improved resource use under the BAU scenario.

These results reflect respondents' perceptions that stricter park enforcement under the BAU scenario encourages more responsible use of natural resources, while interventions like buffer zone restoration would reduce access to forest resources altogether.

iii. People-park relations

Expectations about changes in people-park relations were also strongly influenced by scenario and location (Figure *5.4*). While participants expected their relationships to generally remain the same, the also expected that the universal input subsidy and compensation scenarios would significantly improve people's relationship with the park [(p

= 0.00, 95% CI: 0.99-2.51), and (p = 0.00, 95% CI: 0.66-2.20)] respectively. Respondents viewed these scenarios as a fair and inclusive policy compared to BAU, particularly those living close to the park (p = 0.00, 95% CI: 1.54-3.15):

"*Compensation will show the government cares as much for us as for animals*" (woman, fenced-close).

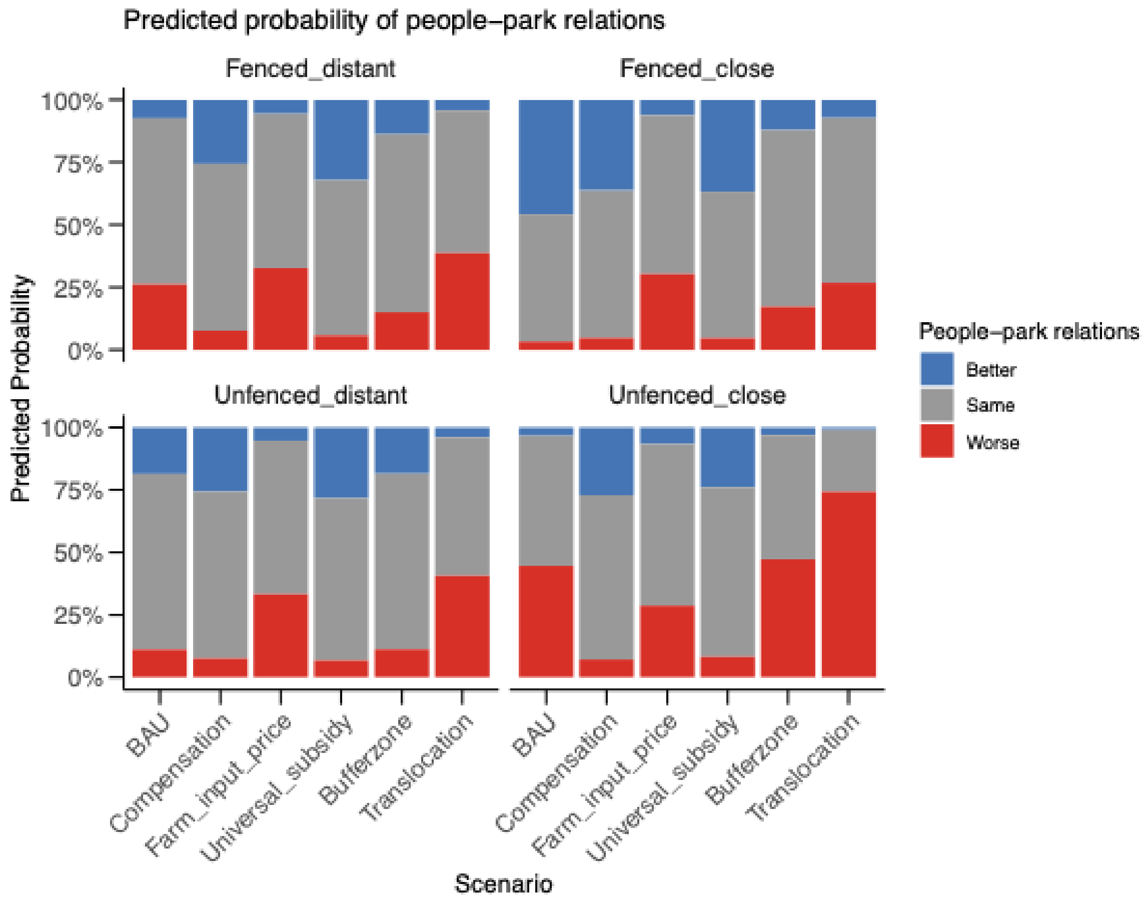

Figure 5.4: Predicted probabilities of people-park relationship under different scenarios, by location. Bars represent the categorised responses as worse (red), the same (grey), or better (blue). Results highlight that respondent anticipated minimal changes in their relationship in the park except for the communities in the close-unfenced site who expected worse outcomes under the translocation and buffer zone scenarios due to increase wildlife incidents and restricted access to farmland respectively.

However, respondents also raised concerns about anticipated corruption and underpayment in the compensation scenario.

"*Even if I support this compensation, how are these going to be calculated and how will they compensate life*?" (Man, unfenced-close).

The buffer zone restoration scenario was expected to significantly worsen the people-park relationship, particularly by those close to the national park ($p = 0.00$, 95% CI: -3.56-(-1.46), where it was perceived as the loss of community land without addressing wildlife damage.

"It's just a way for the park to take land without stopping animals from eating our crops" (woman, close, unfenced).

"We also want to restore the buffer zone, but where will we live and farm?" (man, close, unfenced).

The same trend was expected under the wildlife translocation scenario, where participants from both close and distant areas expected the scenario to worsen the people-park relationship ($p = 0.10$, 95% CI: -1.38-0.11), as respondents feared further loss of lives and property.

iv. People's Wellbeing

Regardless of the location, study participants expected their wellbeing to improve under the universal subsidy ($p = 0.00$, 95% CI: 0.62-2.09) (Figure ***5.5***). By easing access to farm inputs, participants expected the universal subsidy to enable them to achieve higher crop yields, thereby enhancing their livelihoods through income from their crop produce.

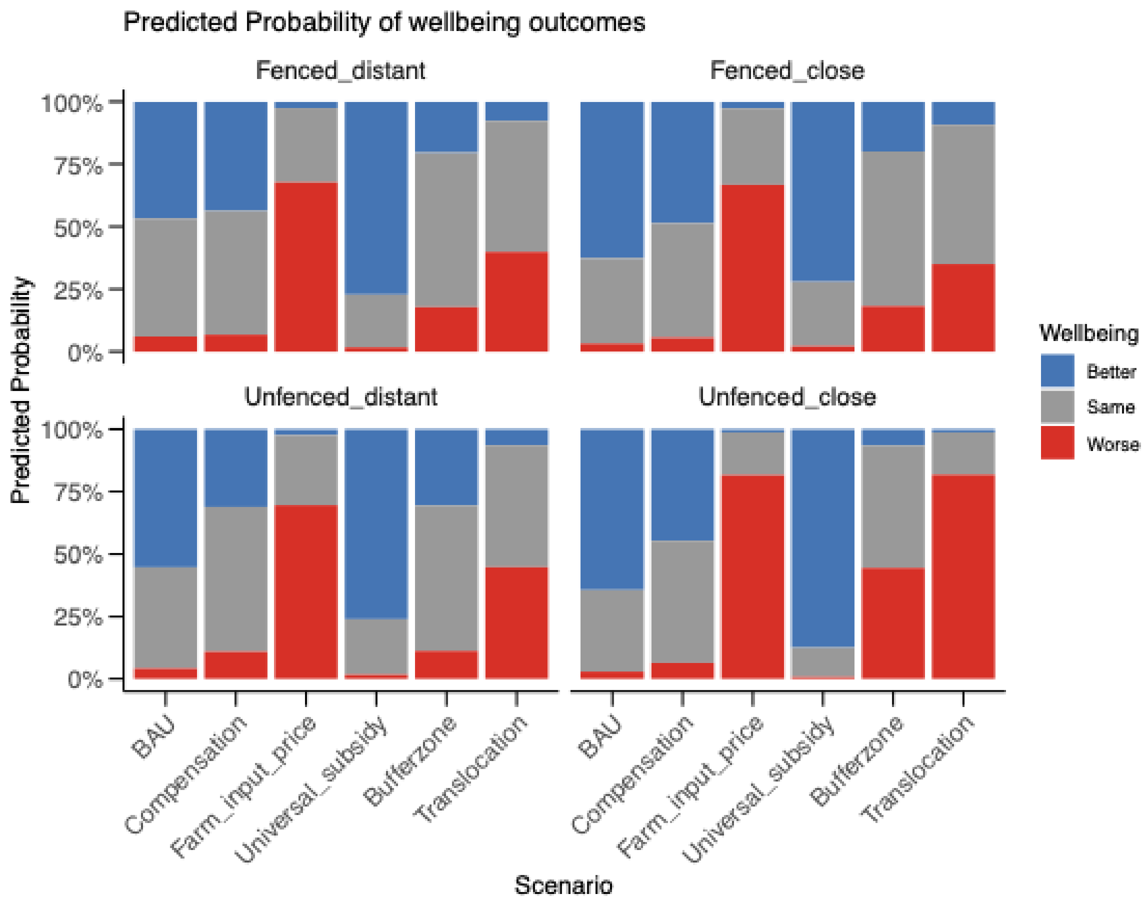

Figure 5.5: Predicted probabilities of people's wellbeing under different scenarios, by location. Bars represent the categorised responses as worse (red), the same (grey), or better (blue). Results highlight the universal input subsidy was anticipated to improve people's wellbeing across all locations while the increase in the farm input subsidy, translocation and buffer zone scenarios would have the opposite effect.

In contrast, participants in all locations anticipated that buffer zone restoration (p = 0.00, 95% CI: -1.89 -(-0.57)), translocation (p = 0.00, 95% CI: -3.03- (-1.68)) and increases in farm input price (p = 0.00, 95% CI: -4.23- (-2.80)) scenarios would significantly worsen their wellbeing. Although these scenarios were anticipated to directly impact residents in the unfenced-close part of the national parks, people living in the other areas nonetheless thought they would also be indirectly affected, as some of the people living in that area are their relatives.

Overall, close-unfenced communities were consistently the most negatively affected across scenarios, reporting reduced food security, worsened relations between people and parks, and a decline in overall wellbeing. Fenced and distant communities generally reported fewer negative impacts, particularly for buffer zone restoration and translocation, considering that they would be less affected.

5.3.4 Perceptions of fairness of scenarios

Overall, the universal input subsidy and wildlife compensation scenarios were perceived as fairer than BAU (Figure ***5.6***). In contrast, farm-input price increases**,** buffer zone restoration, and translocation were viewed as unfair, especially by communities in unfenced areas. Perceptions were shaped not only by the scenario content but also by the respondent's location, age, and gender.

The universal subsidy scenario was viewed as significantly fairer than BAU across all locations (p = 0.00, 95% CI: 1.73-3.18). Respondents saw this as a major improvement over the existing subsidy program, which they criticised for being prone to input shortages, delayed implementation, and inequitable distribution.

"*The current subsidy program sometimes registers people with no place to farm, and they end up selling the coupons to traders. In other cases, one household can have five people receiving coupons, including children, while other households have none, and this causes a lot of inequality and misunderstanding in the communities"*. (*Female respondent, unfenced-distant*)

Many participants also expressed frustration with the timing of input distributions and the lack of transparency in the selection process, which disproportionately affected low-income and land-dependent households.

The compensation scenario was also seen as significantly fairer than BAU (p = 0.00, 95% CI: 0.78-2.01). Respondents felt it could promote coexistence by easing the economic burden of human-wildlife conflict and recognising the community's losses:

"Compensation will show the government cares as much for us as for animals" (woman, fenced-close).

Despite concerns about corruption, exaggeration of damage, and underpayment, the compensation scenario was still preferred over BAU due to its potential symbolic and material value.

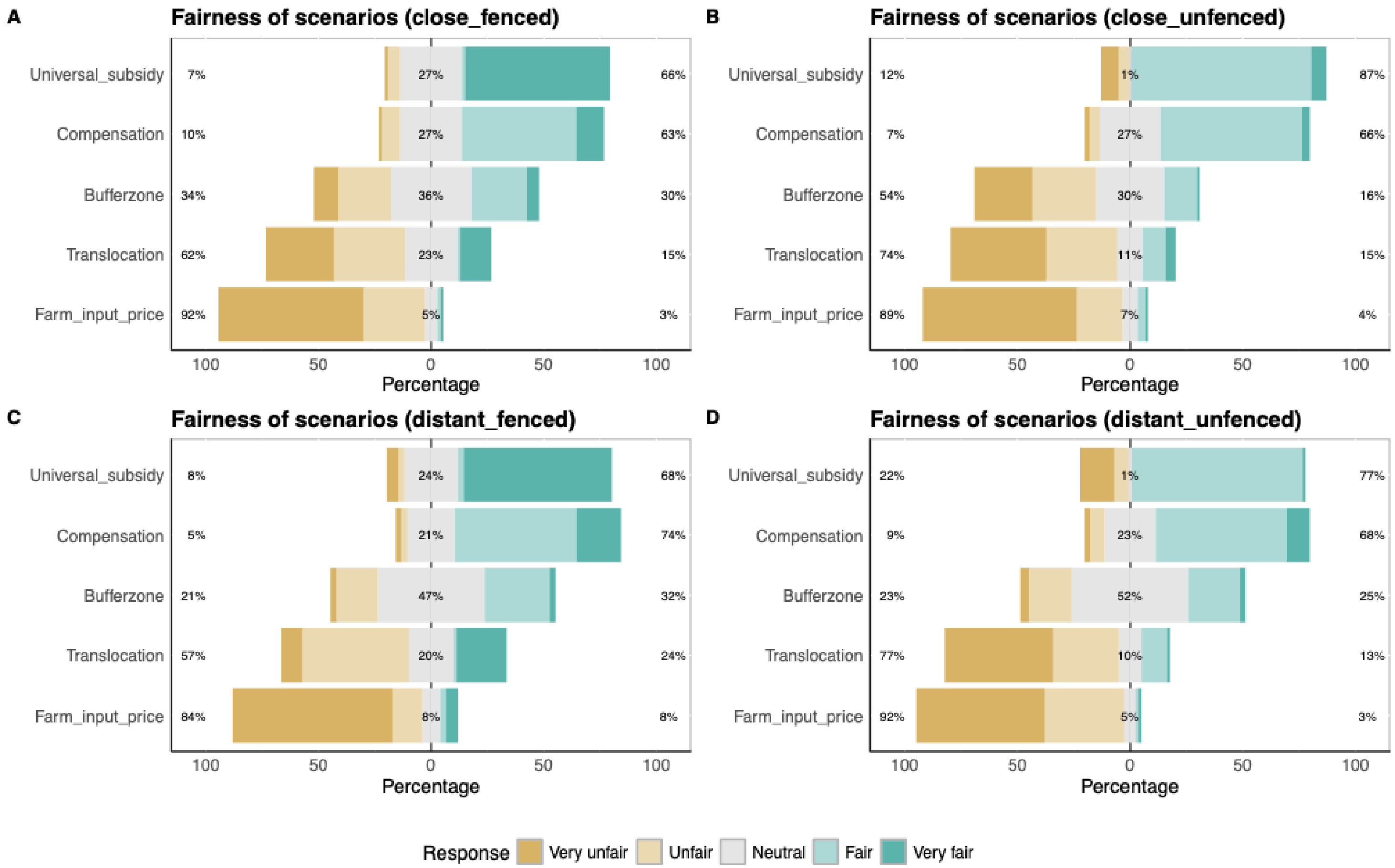

Figure 5.6: Respondents' perspectives on the fairness of scenarios, compared to BAU. While an increase in farm input prices and wildlife translocation scenarios were deemed unfair in all locations, the implementation of universal subsidies and wildlife compensation were seen as fair. The universal subsidy was perceived as particularly fair (compared to the BAU) by those in the fenced area. Perspectives on the fairness of buffer zone restoration varied based on location; respondents close to the park on the unfenced side found it much less fair than those further away or in the fenced area.

Both the translocation and farm-input price increase scenarios were perceived as unfair across all locations: translocation was deemed unfair by a majority (p = 0.00, 95% CI: -1.78 -(-0.57)), especially on the unfenced side of the park, where 74% of close-unfenced and 77% of distant-unfenced respondents viewed it negatively.

"Another translocation would show the government values animals more than us, especially since the park is failing to manage animals, and people have died from the last translocation" (man, unfenced, away).

For the farm-input price increase scenario, over 70% of respondents across all locations rated it as unfair (p = 0.00, 95% CI: -4.99- (-2.78)), largely due to current struggles affording inorganic fertilisers. This scenario was seen as worsening inequality by limiting access to essential agricultural inputs and increasing food insecurity.

Perceptions of fairness of the buffer zone restoration scenario varied significantly by geography. While 54% of respondents from unfenced-close areas perceived it as unfair, citing the loss of farmland without guarantees of resettlement or compensation, respondents from fenced and distant areas were neutral (e.g., 47% of distant-fenced and 52% of distant-unfenced remained neutral), recognising the conservation value of the buffer zone.

"*This scenario assumes that only park people know the importance of conservation, and we don't, which is untrue. We also want to restore the buffer zone, but where will we live and farm is the question"* (Man, close and unfenced).

While some agreed the buffer zone could reduce dangerous encounters with wildlife, concerns over displacement, lack of alternatives, and exclusion from decision-making shaped perceptions of unfairness.

In terms of demographic factors, older individuals were significantly more likely to perceive scenarios as unfair (Estimate = -0.01, p = 0.01, 95% CI: -0.02- 0.00). This may reflect accumulated experiences with unmet policy promises or vulnerability to change. Gender also influenced people's responses to scenarios; men were more likely to perceive scenarios as fair, although the effect was only marginally significant (p = 0.07, 95% CI: -0.02 to 0.48), suggesting subtle gendered dynamics in policy perceptions (see Chapter 3).

5.3.5 People's behavioural changes in response to scenarios of change

When asked how they would respond to each scenario (Figure ***5.7***), diversifying income was the most common strategy across all villages, particularly under the BAU scenario where 305 out of 317 participants (across all four locations) said that they would seek alternative sources. Participants explained that this would include reducing maize farming in favour of crops requiring less inorganic fertiliser (e.g., soy and groundnuts) or engaging in petty trade and labour to supplement income. Crop diversification also emerged as a key strategy under BAU, with many respondents (125/317) noting a shift towards drought-tolerant crops, such as cassava and early maturing maize, as a means to cope with increasingly erratic rainfall and ongoing wildlife depredation.

Farm expansion was the most common strategy under the universal subsidy scenario (288/317), where participants said they would expand land under cultivation to maximise yields if fertiliser became more affordable. In contrast, making organic manure was the dominant response under the farm input price increase scenario (237/317), with respondents noting this as a necessary adaptation in the face of rising fertiliser costs.

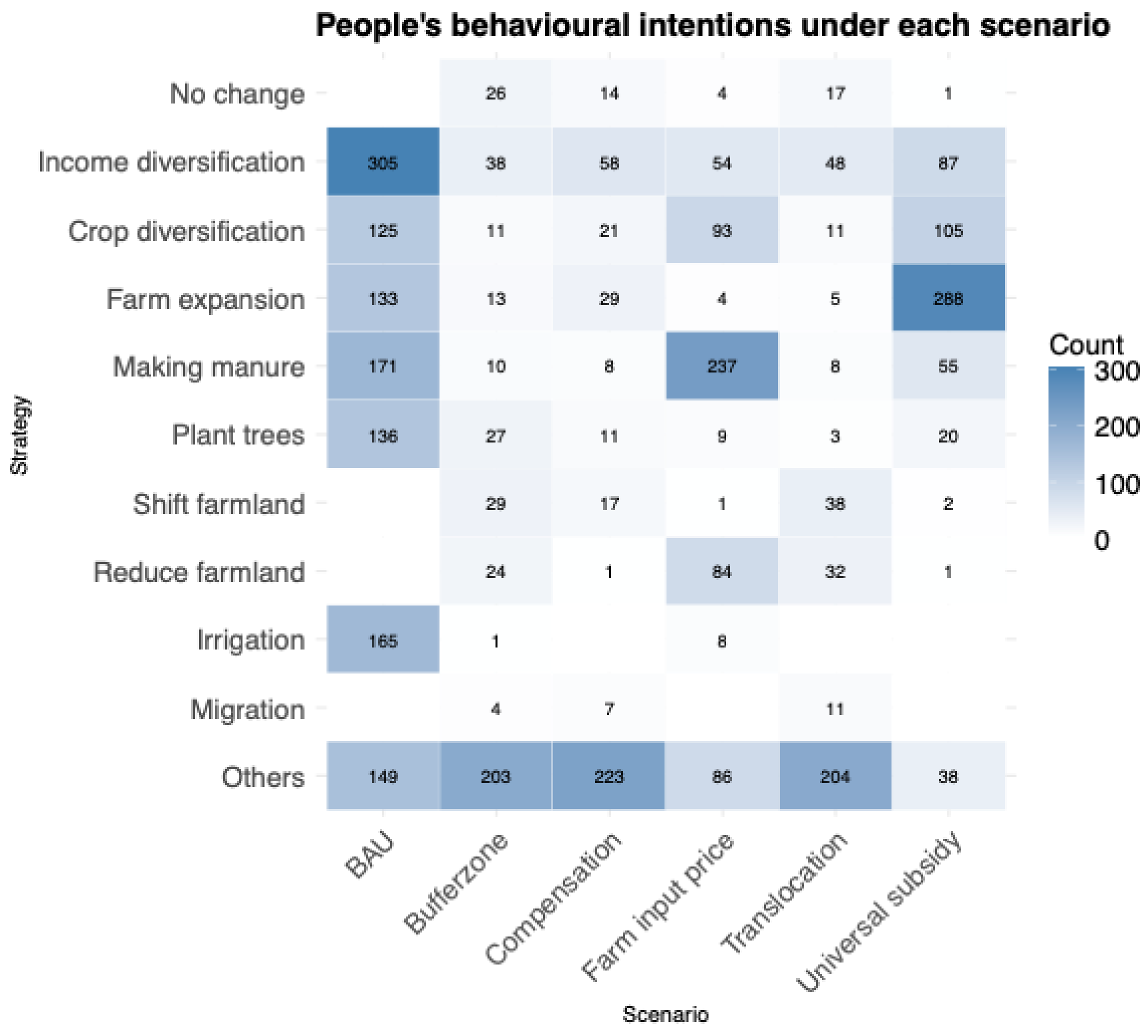

Figure 5.7: Heatmap of behavioural intentions in response to six land-use scenarios across all four locations (n = 317). Darker shades indicate higher uptake of specific strategies under each scenario. While income diversification, making manure, and farm expansion were common across all locations under BAU, input price increases, and subsidies, strategies such as shifting farmland and migration were particularly concentrated in close unfenced areas under the translocation and buffer zone restoration scenarios.

While strategies like income diversification, making manure, and farm expansion were common across locations under BAU, input price increase, and subsidy scenarios, migration and shifting farmland stood out as location-specific strategies, particularly in response to the wildlife translocation and buffer zone restoration scenarios. These were most reported in close and unfenced villages, which border the national park. Chi-squared analysis (Appendix C9) confirmed these differences: uptake of Shift farmland (χ^2 (3) = 126.38, p =

0.00), and migration (χ^2 (3) = 23.20, p = 0.00) were significantly higher in close unfenced than in other locations. Other behavioural responses included irrigation farming, food budgeting, family planning, and planting trees.

5.4. Discussion

5.4.1 Scenario impacts on food security, resource use, park relations and wellbeing

The results of this study illustrate that conservation and development interventions have complex and sometimes contradictory impacts on food security, natural resource use, people-park relations, and human wellbeing. Among the scenarios tested, the farm input price increase scenario demonstrated the most detrimental effects. Compared to the business-as-usual baseline, this scenario significantly reduced both food security and wellbeing across all four locations. Respondents linked these declines to the anticipated inaccessibility of inorganic fertilisers, which were already prohibitively expensive, and doubted the feasibility of switching to organic alternatives due to production constraints. This aligns with prior findings that rising input costs undermine household resilience (Pangapanga-Phiri et al., 2025; Wunder et al., 2014).

Although input price did not alter overall levels of natural resource use, it was associated with a significant increase in extraction of resources in close-unfenced communities, suggesting that people might turn to natural resources to compensate for farm losses. This pattern is consistent with studies that highlight natural resources as fallback safety nets in times of agrarian stress (Angelsen et al., 2014; Börner et al., 2015; Kamanga et al., 2009; Wunder et al., 2014). Additionally, the scenario was expected to exacerbate people–park tensions, which has been observed elsewhere, especially in contexts where wildlife-induced crop loss occurred (Chapter 3; Meyer et al., 2025; Meyer & Börner, 2022).

Conversely, the universal input subsidy scenario had strong positive effects on food security, wellbeing, and park relations. This was attributed to expectations of improved input access and higher yields, with the perceived fairness of this scenario being notably high, especially among communities with fenced areas. Respondents compared it favourably to the existing subsidy system, which was criticised for its inequitable distribution and inefficiencies. However, while the subsidy may enhance livelihoods, it could also encourage agricultural expansion, raising concerns about potential habitat loss, a classic food-conservation trade-off (Ceddia et al., 2014; Meyfroidt, 2018).

Compensation for wildlife losses was also positively associated with improved food security and park relations, with respondents appreciating its potential to ease human-wildlife conflict burdens. Nonetheless, implementation concerns, including corruption, underpayment, and feasibility, tempered enthusiasm. Despite these concerns, the scenario was broadly perceived as fair, echoing findings that monetary compensation can increase tolerance for wildlife (Braczkowski et al., 2023; Kalenga et al., 2024; Kansky et al., 2021), though its long-term financial sustainability remains a challenge (Rondeau & Bulte, 2007).

The translocation scenario revealed the most widespread opposition. It was viewed as harmful to wellbeing and park relations across all locations, and especially unfair in the unfenced locations. Respondents cited fear of crop loss, livestock depredation, and even fatalities resulting from previous elephant translocation. These concerns speak to the growing tensions between conservation-led initiatives and local safety, underscoring the need for equitable risk-sharing mechanisms (Büscher & Thakholi, 2024). Although not strongly linked to overall changes in resource use, close-unfenced communities anticipated an increased reliance on natural resources under this scenario, again reflecting their heightened vulnerability (Angelsen et al., 2014; Börner et al., 2015; Kamanga et al., 2009; Wunder et al., 2014).

The buffer zone restoration scenario presented a unique geographical divide. While respondents in most areas anticipated that it would improve food security by stabilising rainfall and enhancing growing conditions, those in close-unfenced communities expected it to significantly reduce food security due to restricted access to farmland and natural resources. These participants expressed concern about losing farmland without corresponding efforts to address wildlife conflict. This divergence highlights the spatial inequities of conservation land-use interventions (Fedele et al., 2021; Meyfroidt et al., 2022; van Velden et al., 2020). The scenario was also anticipated to negatively affect wellbeing and was seen as less fair by close-unfenced communities, reinforcing the importance of incorporating local perspectives into protected area design and governance (L'Roe et al., 2023).

5.4.2 Location and demographic influences

Geographic location had a significant influence on perceptions and outcomes across all scenarios. Close-unfenced communities consistently reported greater vulnerability, anticipating more negative impacts on food security and resource use, and more unfairness. These communities face compounded pressures of restricted access to land, heightened exposure to wildlife, and limited livelihood alternatives. This is in consistent with previous studies (Merz et al., 2023; Mogomotsi et al., 2020) which suggested that demographic characteristics including location shape people use of resources and perceptions. In contrast, distant or fenced communities were generally more optimistic about the potential benefits of certain interventions, such as buffer zones.

Age and gender also shaped people's perceptions. Older respondents were significantly more likely to view scenarios as unfair, potentially reflecting longer-term exposure to failed or unjust interventions. Male respondents tended to perceive scenarios more positively in terms of fairness, although the effect was marginal. These findings emphasise the need for inclusive approaches that address intra-community heterogeneity when designing and implementing conservation and development policies (Chapter 3).

5.4.3 Implications for policy and practice

The findings of this study reinforce the notion that no single intervention offers a panacea for simultaneously improving food security, wellbeing, and conservation outcomes (Estrada-Carmona et al., 2024). While policies like universal agricultural subsidies and wildlife loss compensation show promise for human wellbeing and coexistence, they may carry unintended environmental consequences or sustainability concerns, for example through incentivising the expansion of agriculture (Chibwana & Fisher, 2010; King et al., 2023; Mungai et al., 2022)

Conversely, interventions perceived as conservation-focused, such as translocation or buffer zone restoration, risk undermining local support if they disproportionately burden the most vulnerable groups. This underscores the need for integrated strategies that navigate trade-offs while recognising local contexts (Fischer et al., 2017; Kiesecker et al., 2009; Shackelford et al., 2015). Community engagement must go beyond consultation to co-creation, where scenario development, implementation, and evaluation are shared responsibilities between communities, government, and conservation actors. Such approaches are more likely to foster trust, legitimacy, and long-term buy-in (McDermott et al., 2013; Reed et al., 2009).

As global conservation targets, such as “30 by 30”, gain momentum (CBD, 2022), the success of these efforts will depend not only on ecological outcomes but also on the social contracts underpinning them (Sandbrook et al., 2023; Sibanda et al., 2025) . In this context, recognising heterogeneity, anticipating differential impacts, and embedding fairness into implementation are central to the sustainability and legitimacy of conservation outcomes (Sibanda et al., 2025). Policies must not only aim for biodiversity gains but also ensure that the costs and benefits of those gains are equitably shared across communities.

5.4.4 Limitations and future research directions

There are several limitations in this study that I acknowledge and that offer important directions for the future. First, spatial proximity to the park may interact with other unmeasured factors, such as land tenure status or local governance dynamics. Perceptions are likely to be affected by previous exposure to the scenario elements, such as previous wildlife conflicts or interactions with park staff. These underlying structural and historical differences are likely to affect responses but are not captured by the explanatory variables. While I captured some of this complexity through focus groups and key informant interviews, future research could explore more deeply how these lived experiences shape expectations, particularly among those living in the close-unfenced areas, where differences were most pronounced.

Second, while the use of ordinal outcome variables (e.g., “worse”, “same”, “better”) offered an interpretable structure for capturing perceptions, it may have constrained the nuance of participant views. Some respondents may have found these categories too coarse to express complex or ambivalent opinions, especially regarding trade-offs between ecosystem protection and livelihood outcomes. Additionally, the models were confined to main effects due to sample size issues, and I had to focus on a few simple scenarios to keep cognitive load to acceptable levels. This meant I couldn't capture interactions between explanatory variables, or between scenarios.

Despite these limitations, I believe combining quantitative scenarios with qualitative explanations of why people responded as they did, in a mixed-methods approach, provided a robust foundation for understanding how people see the future and how different external factors may shape social and ecological outcomes for the area.

5.5 Conclusion

This study highlights the crucial importance of basing conservation and development strategies on local realities. Community perspectives in Kasungu reveal that interventions, whether aimed at improving food security, addressing human-wildlife conflict, or expanding conservation efforts, carry varied and sometimes unequal impacts across social and spatial lines. Scenarios such as universal input subsidies and wildlife compensation were widely perceived as fair and beneficial to food security and wellbeing. In contrast, others, like translocation and buffer zone restoration, were viewed as unjust, particularly by those in more vulnerable locations.

Effectively navigating the trade-offs between biodiversity conservation and human wellbeing requires more than technical solutions. It calls for participatory policy design that centres equity, recognises historical grievances, and respects local livelihoods. Conservation initiatives, particularly those involving land-use restrictions or wildlife management, must be implemented with mechanisms to mitigate livelihood losses and ensure community buy-in. Similarly, external actors seeking to implement conservation efforts, such as translocations or buffer zone restoration, should consider and mitigate potential negative impacts on local livelihoods and perceptions of fairness.

This study emphasises integrating local perspectives in policymaking. Understanding community values and trade-offs is key to designing effective, context-specific interventions. Sustainable agriculture and conservation-friendly incentives must align food security with biodiversity goals. Involving communities in decision-making ensures policies reflect local needs. Ultimately, balancing food security and biodiversity conservation in Kasungu and similar contexts requires collaborative efforts from policymakers, local stakeholders, and conservation practitioners to navigate trade-offs and promote sustainable development.

Chapter 6 : Predicting Biodiversity Trajectories Under Current Agricultural Trends in a Shared Landscape

A beehive inside the park close to the park boundary

6.1 Introduction

6.1.1 Background

Agriculture is the dominant form of land use, covering approximately 37% of the Earth's land surface (Pienkowski et al., 2022). While it plays a vital role in ensuring food security (Burke et al., 2022; Conway et al., 2019; Zabel et al., 2019), agriculture also poses significant threats to biodiversity, especially in tropical regions, which host some of the planet's most diverse ecosystems (Baudron & Giller, 2014; Chapman et al., 2022; Shackelford et al., 2015). Projections suggest that by 2050, around 87.7% of species worldwide will experience habitat loss due to agricultural expansion, with approximately 1,280 species expected to lose at least 25% of their natural habitat (Williams et al., 2021). Biodiversity, which exists both in agricultural landscapes and protected areas, underpins key ecosystem services that sustain human life. These services include food and water provision, energy security, and the supply of raw materials critical for socio-economic development (Garibaldi et al., 2017; Karanth & Ranganathan, 2018; L'Roe et al., 2023).

In response to the global biodiversity crisis, the global community has emphasised the importance of protected areas, as outlined in Target 3 of the Kunming-Montreal Global Biodiversity Framework (CBD, 2022). This target calls for the effective conservation and management of at least 30% of the planet's terrestrial and marine areas by 2030 through approaches that are ecologically representative, well-connected, and equitably governed. Crucially, it highlights the need for respect for the rights of Indigenous Peoples and Local Communities (IP&LCs), and for conservation to be implemented in ways that are both socially just and ecologically effective. While protected areas remain central to conservation policy, agricultural expansion can intensify tensions over land use, particularly in rural landscapes where communities rely heavily on natural resources for their livelihoods

(Dawson et al., 2024; Sibanda et al., 2025). As such, the core question is not whether to expand protected areas, but how to do so in ways that align with these principles of equity, rights, and ecological effectiveness (Friedman et al., 2022; Sandbrook et al., 2023).

For countries like Malawi, where biodiversity-rich ecosystems such as Kasungu National Park are under increasing pressure from agricultural expansion and population growth, this global agenda presents both opportunities and challenges (Meng et al., 2023; Pendrill et al., 2022; Sibanda et al., 2025). On the one hand, it offers opportunities to secure international funding, technical expertise, and policy support for approaches that integrate biodiversity conservation with sustainable livelihoods. Notably, the Kunming-Montreal Global Biodiversity Framework (CBD, 2022). explicitly emphasises capacity-building, knowledge transfer, and resource mobilisation, particularly for developing countries, as key enablers of implementation (see Targets 19 and 20). On the other hand, while communities depend on both agriculture and natural systems for food security and economic sustenance (Pendrill et al., 2022), forests and conservation areas are increasingly being cleared for agriculture and other land uses (Ceddia et al., 2014; Kpienbaareh et al., 2022). Although the drivers of deforestation and habitat degradation vary, agricultural expansion remains the dominant factor (Kpienbaareh et al., 2022; Tscharntke et al., 2012, 2021).

With the global population projected to exceed nine billion by 2050, the pressure on agriculture and rural livelihoods is expected to intensify as well (Tripathi et al., 2018). Meeting the anticipated increase in food demand will require significant growth in agricultural production (Pendrill et al., 2022; Tripathi et al., 2018). This growth is likely to occur through either expansion into new lands or intensification of existing systems, both of which pose severe implications for biodiversity and ecosystem services (Baudron &

Giller, 2014; King et al., 2023). Simultaneously, climate change is expected to compound the challenge by increasing the frequency and severity of extreme weather events, including prolonged droughts and erratic rainfall, and therefore undermining agricultural productivity (Cramer et al., 2018; Newbold, 2018). Together, land-use and climate pressures are projected to severely impact biodiversity and livelihoods, particularly in tropical grasslands, where many species face severe range contractions and extinctions (Newbold, 2018). These dynamics highlight the urgent need for strategies that address food security and livelihood resilience alongside biodiversity conservation.

6.1.2 Modelling biodiversity impacts on land use

Modelling frameworks and biodiversity metrics are essential for monitoring, reporting, and predicting the impacts of land-use change on ecosystems (Mair et al., 2021; Newbold, 2018; Tilman et al., 2017; Williams et al., 2021). Various models have been used to estimate the potential reduction in extinction risks, guide habitat restoration efforts, and assess the implications of environmental changes on ecosystem functioning (Mair et al., 2021, 2023; Sykes et al., 2020).

Given that land-use change remains the most significant threat to species diversity and ecosystem functionality, it is crucial that modelling approaches and biodiversity metrics directly link land-use trends with biodiversity outcomes, while accounting for spatial, temporal, and contextual variations (Durán et al., 2020; Eyres et al., 2025). However, many existing models analyse stressors such as agricultural expansion or habitat fragmentation in isolation, even though these stressors often interact in complex and synergistic ways (Durán et al., 2020). Different stressors also impact different species in different ways, with their impact often varying across landscapes. This means that focusing on a single stressor risk misidentifying the species or landscapes at largest risk of biodiversity loss. Incorporating simultaneous measurements of multiple stressors is therefore critical for improving our understanding of ecosystem dynamics and enhancing model accuracy (Custer & Dini-Andreote, 2022; Durán et al., 2020).

In addition to these technical limitations, a major shortcoming of many global and regional models is their limited engagement with on-the-ground realities, particularly in relation to the social and institutional dimensions of land-use change (Landis, 2017; Ritchie et al., 2022). While models can provide valuable macro-scale projections, they often overlook the place-specific factors that influence how land is used and managed (Durán et al., 2020; Eyres et al., 2025). Predictive frameworks frequently rely on broad biophysical or economic assumptions that fail to reflect the lived experiences, constraints, and adaptive strategies of local communities (e.g., Laurance et al., 2014; Tilman et al., 2017; Williams et al., 2021). This disconnect is especially evident in agricultural landscapes like Malawi, where land-use decisions are shaped by socio-economic pressures, customary land tenure systems, cultural practices, and local governance structures (Chapters 3, 4 and 5). Without incorporating local knowledge, such as how farmers anticipate and respond to climate variability, policy shifts, or changes in land access, models risk misrepresenting both the feasibility and implications of projected land-use scenarios. As a result, they may underestimate pressures on agriculture and rural livelihoods or overlook pathways for more equitable and sustainable transitions.

6.1.3 The Glob2Loc model and its application to the Kasungu landscape

Glob2Loc is a modelling framework developed by Michael Clark (Clark et al., 2025 in review) to assess the cumulative impacts of multiple stressors on biodiversity at varying spatial scales by integrating ecological models with global datasets. Unlike models that examine single stressors in isolation, Glob2Loc incorporates various interacting stressors, including climate change, urbanisation, agricultural expansion and intensification, and habitat fragmentation, to assess their combined effects on biodiversity outcomes. The model operates in a three-stage process: (1) Identifying species distributions, (2) Assessing future trends in human activity patterns, and (3) Evaluating species responses to the changes.

In this study, I applied the Glob2Loc model to evaluate the implications of six land-use and policy change scenarios in Kasungu, Malawi, derived from local insights about what changes are likely to occur and how people will respond to them (Chapter 5). I measured the biodiversity impacts of each scenario using two metrics: population abundance and habitat area. The scenarios are: (1) Climate change, (2) Buffer zone restoration, (3) Farm input price increase, (4) Fertiliser subsidy, (5) a combination of farm input price increase, buffer zone restoration and climate change (FIP+BR+CC), and (6) a combination of fertiliser subsidy, buffer zone restoration and climate change (FS+BR+CC). The idea behind scenarios 5 and 6 was to integrate the three dimensions of conservation, climate change and agriculture as drivers of land use change to assess their combined influence on biodiversity outcomes. Scenario 5 represents a scenario where farmers face increased production costs, while scenario 6 represents a scenario where they face decreased production costs. This integration was particularly important to reflect realistic, multidimensional futures where pressures intersect, offering a more nuanced understanding of potential trade-offs and synergies for biodiversity conservation under Malawi's evolving development context. The analysis includes the 720 species of terrestrial vertebrates with ranges that include the Kasungu region, and which appear on the IUCN red list (IUCN, 2025), including 49 species of amphibians, 80 species of reptiles, 154 species of mammals, and 437 species of birds.

Given the current and projected increase in agricultural production, driven by Malawi's long-term development strategy, Malawi 2063 (GoM, 2020), there is an urgent need to assess how agricultural intensification and land management policies will influence biodiversity conservation goals. As the country aims to balance economic growth with environmental sustainability, comprehensive assessments are crucial to inform conservation and agricultural initiatives. By adapting the Glob2Loc model to this specific context, this study aimed to provide critical insights into the potential trade-offs between agricultural development and biodiversity conservation in Malawi. I specifically used Glob2loc to answer the following questions:

1. How does each of the six identified scenarios affect species abundance and habitat area in Kasungu?
2. Which scenarios present the most significant risks or opportunities for biodiversity conservation?
3. What trade-offs emerge between biodiversity conservation and agriculture under these scenarios? And how can these insights inform more sustainable and locally relevant land-use strategies?

6.2 Methods

6.2.1 Study site

For study site description see section **2.4**

6.2.2 Scenario selection, assumptions and scope of analysis

Figure ***6.1*** illustrates the simplified process I followed to assess the impacts of current agricultural trends on biodiversity outcomes using the Glob2Loc model. I identified the scenarios of agricultural and policy change based on my landscape knowledge and previous research in the area (Chapters 3 and 5). These scenarios were grounded in observed and anticipated shifts in agricultural input policies, climate change, and land-use management, factors that significantly influence agricultural productivity and land availability over time. Building on these scenarios, I developed hypotheses regarding their short and long-term impacts on agriculture (Table *6.1*). As model inputs, I used spatial data representing species distributions (i.e., Area of Habitat and population estimates) and the location of anthropogenic stressors such as agriculture, climate change, and urbanisation. These were integrated into the Glob2Loc model to project biodiversity outcomes under these different scenarios. The outcomes of the scenarios correspond with the potential biodiversity impact in 2020, if local populations were to respond in the way indicated during surveys (from Chapters 3 and 5).

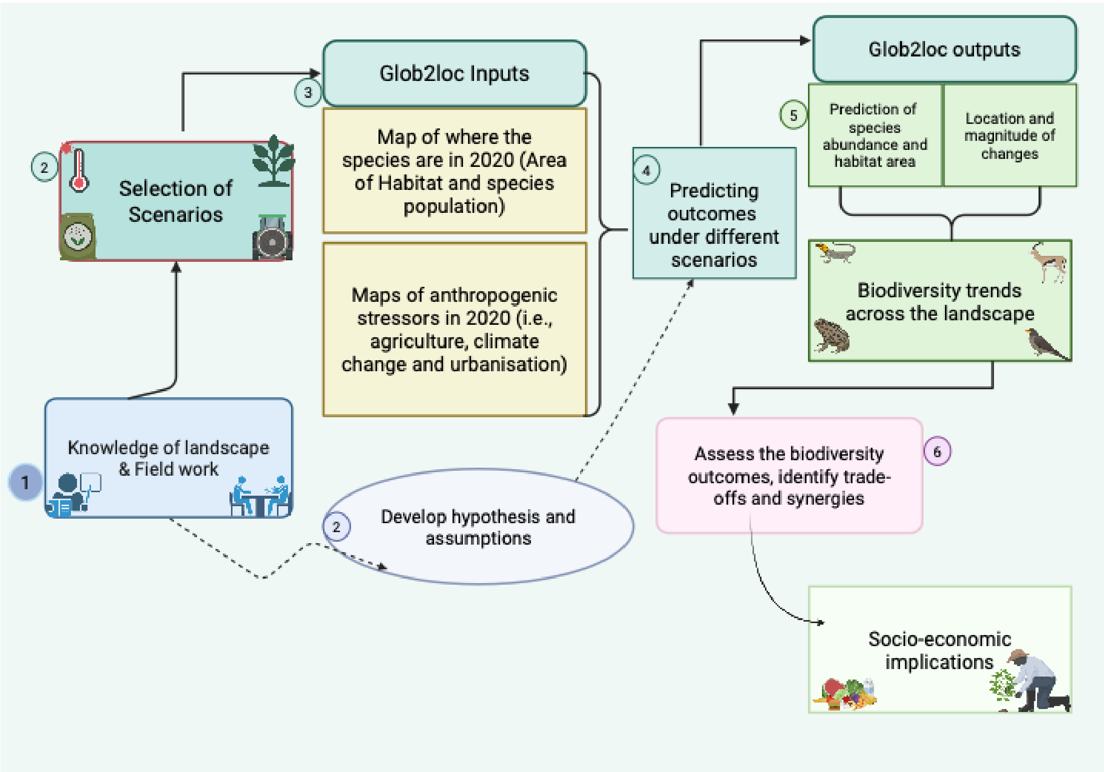

Figure 6.1: Workflow illustrating the application of the Glob2loc model to assess the impacts of agricultural change on biodiversity and food security in Kasungu. The process involved scenarios based on landscape knowledge and previous research, developing hypotheses on their potential

impacts (see Table 6.1), and using spatial data on species distributions and anthropogenic stressors as inputs. The Glob2Loc model then predicted species responses and biodiversity outcomes under each scenario, which were analysed to evaluate future trade-offs and synergies between biodiversity conservation and agricultural development. The solid arrows indicate direct links while the dashed arrows indicate indirect links.

We then analysed these outcomes for the Kasungu landscape, focusing on species-level responses to each scenario. Finally, we evaluated the broader implications of these trends for future conservation and food security planning in the region.

The model simulated the species responses from the 2020 baseline to projected conditions and outcomes under different scenarios, assuming that modelled outcomes were indicative of the biodiversity outcomes in 2020 if people's behavioural intentions and responses had changed in the ways indicated. I did this because the information on behavioural intentions and responses was collected with a five-year planning horizon – i.e. how respondents would change their behaviour in the next 5 years in the different scenarios. The information on behavioural intensions and responses reflect how farmers would likely respond to different scenarios of agricultural, policy, and environmental change, including shifts in fertiliser subsidy programs and buffer zone restoration (e.g. as investigated in Chapter 5). This approach is consistent with other socio-ecological models that incorporate stakeholder-elicited scenario inputs over fixed time intervals (e.g., Lacher et al., 2023; Meyer et al., 2025; Schlüter et al., 2014). The approach also aligns with established practice in participatory land-use scenario modelling, which often relies on time-invariant assumptions to explore plausible rather than predictive futures (IPBES, 2016; Pereira et al., 2019; 2020). Table ***6.1*** outlines the scenario-specific assumptions regarding agricultural land demand, crop yields, and behavioural responses to different land-use drivers in the Kasungu landscape.

The analysis was spatially bounded to the agricultural areas within the Kasungu landscape, including the national park. Although pressures may originate from surrounding areas and some farmers may relocate or shift their land use practices beyond the Kasungu boundaries, these dynamics were not incorporated in the model. This exclusion reflects the difficulty of robustly predicting mobility patterns and land-use displacement in the absence of relevant spatial or demographic data.

Each of the scenarios had potential consequences for household food security and livelihood resilience. However, my modelling framework focused specifically on biodiversity outcomes, rather than on direct social or economic impacts. As such, I assumed that farmers would adapt to emerging constraints, such as declining crop yields or land scarcity, through strategies such as crop diversification, adjustments in planting times, and substitution of low-input crops (Table 6.1, Chapter 5). Other non-biodiversity impacts of these scenarios were further examined in Chapter 5.

Table 6.1: Assumptions regarding the changes expected under each scenario, and their impacts related to agricultural land availability, crop yields, behavioural intentions and long-term implications.

Scenario	**Impact on land required for agriculture**	**Impact on crop yield (Short-term; present)**	**Impact on behavioural intentions (5-year period)**	**Long-term implications (2050)**
Climate Change (BAU)	Agricultural land demand is projected to increase by 50% due to high climate-related risk of crop failure and food demand (Mungai et al., 2020)	Mixed impacts: Drought-tolerant crops (e.g., cassava and wheat) may perform better, while maize decline by 5% in the next five years (Msowoya et al., 2016)	Farmers expect lower food production; they intend to diversify crops and adjust planting times	14% decline in total crop yield, crop shifts, and expansion of cultivated land by ~50% (Msowoya et al., 2016; Ray et al., 2019)
Increase in farm input prices	No expected increase in land demand (no incentive to expand agricultural land under high costs)	Reduced crop yield by 50% as reported by over 80% of farmers surveyed (Chapter 5)	Reduced maize cultivation; shift toward low-input crops (e.g., soybean, groundnuts)	Changes in crop types to meet food demand (Kachulu, 2018). Fieldwor). Greater reliance on low-input crops

Farm input subsidies	Likely increase in agricultural land demand due to expanded input use (Chibwana & Fisher, 2010; King et al., 2023; Mungai et al., 2022)	Increased yield by 10% to 50% due to more fertiliser (Chibwana & Fisher, 2010; Dorward & Chirwa, 2013)	Initial yield increases, but long-term soil fertility declines (Burke et al., 2020; 2022)	Likely demand for expansion of agricultural land by 10 to 50%, leading to deforestation, and biodiversity loss (King et al., 2023; Mungai et al., 2022)
Buffer zone restoration	Agricultural activity will be restricted in the buffer zone, reducing available farmland	Decreased farmland - household level land loss.	Reduced cultivated area; not all farmers find alternative land	Decline in cultivated area, potential increase in forest cover (Kachulu, 2018; Kpienbaareh et al., 2022)

In each scenario, agricultural expansion was only allowed to occur outside of Kasungu National Park and outside of the buffer zone. Any agricultural land cover in the national park was assumed to be abandoned, with an equivalent amount of agricultural production relocated elsewhere in Kasungu district. For the buffer zone restoration scenario, any agricultural land cover in the buffer zone was similarly assumed to be displaced and relocated to elsewhere in Kasungu District. While these assumptions are consistent with established scenario modelling practices aimed at exploring plausible under-defined constraints (e.g., IPBES, 2016; Kok & Zurek, 2007; Pereira et al., 2020), I acknowledge that this approach simplifies several complex socio-economic dynamics. Future work should therefore aim to integrate human well-being indicators and spatial feedback more explicitly.

For each species and each scenario, direct outputs from the Glob2Loc framework included estimated habitat availability (measured in square km) and estimated population abundance (measured in number of mature breeding individuals). I then calculated the proportional change in habitat availability and population abundance, comparing estimated outcomes in the BAU scenario to the modelled outcomes in the other scenarios.

6.2.3 Data analysis

I used generalised linear mixed-effects models (GLMMs) to assess the impacts of the six selected scenarios on projected proportional changes in species habitat area and population abundance. I did this in three steps.

Firstly, I conducted descriptive analyses to summarise the mean, standard deviation, and 95% confidence intervals of population change across scenarios and species groups. These descriptive summaries were visualised in plots and faceted figures to examine variation within and among groups.

Secondly, I then used the *lme4* package in R version 4.3.1 (R Core Team, 2024) to develop mixed-effects models that examined how different types of species responded to different potential agricultural and policy scenarios. In these models, the outcome variable was either proportional change in population abundance or habitat area. The explanatory variables were land use scenario and species taxonomic group (i.e. amphibians, birds, mammals, or reptiles). To account for repeated measurements of individual species across multiple scenarios, I added a random intercept for each species. I set the climate change scenario as the reference level, as it reflects a business-as-usual (BAU) trajectory and provides a meaningful baseline for comparison.

I estimated 95% confidence intervals for the model coefficients using the *confint ()* function and conducted post hoc visualisation results and group-level trends using the “ggplot2” and “dplyr” packages (Bates et al., 2015; Wickham, 2016). Complete model outputs and diagnostics are provided in Appendix D.

6.3. Results

6.3.1 Projected land cover changes under different scenarios in Kasungu landscape

Using the European Space Agency’s (ESA) land cover data, I projected cropland extent and intensity under the six scenarios (Figure ***6.2***). In 2020, I estimated that out of the district’s total area (7,992 km²; inclusive of the Kasungu National Park), approximately 5,140 km² was under cultivation as of 2020. Based on spatial overlay and classification of the land cover data and national administrative boundaries, I identified only ~250 km² of potentially cultivable land outside of protected areas and buffer zones. This translates to a projected maximum cropland expansion of 4.8% in Kasungu district. If expansion within the buffer zone surrounding Kasungu National Park (KNP) is permitted, agricultural land area could expand up to 9.1%. However, in all the scenarios examined in this Chapter, I did not allow for agricultural expansion to occur in the buffer zone because it is not legally permitted.

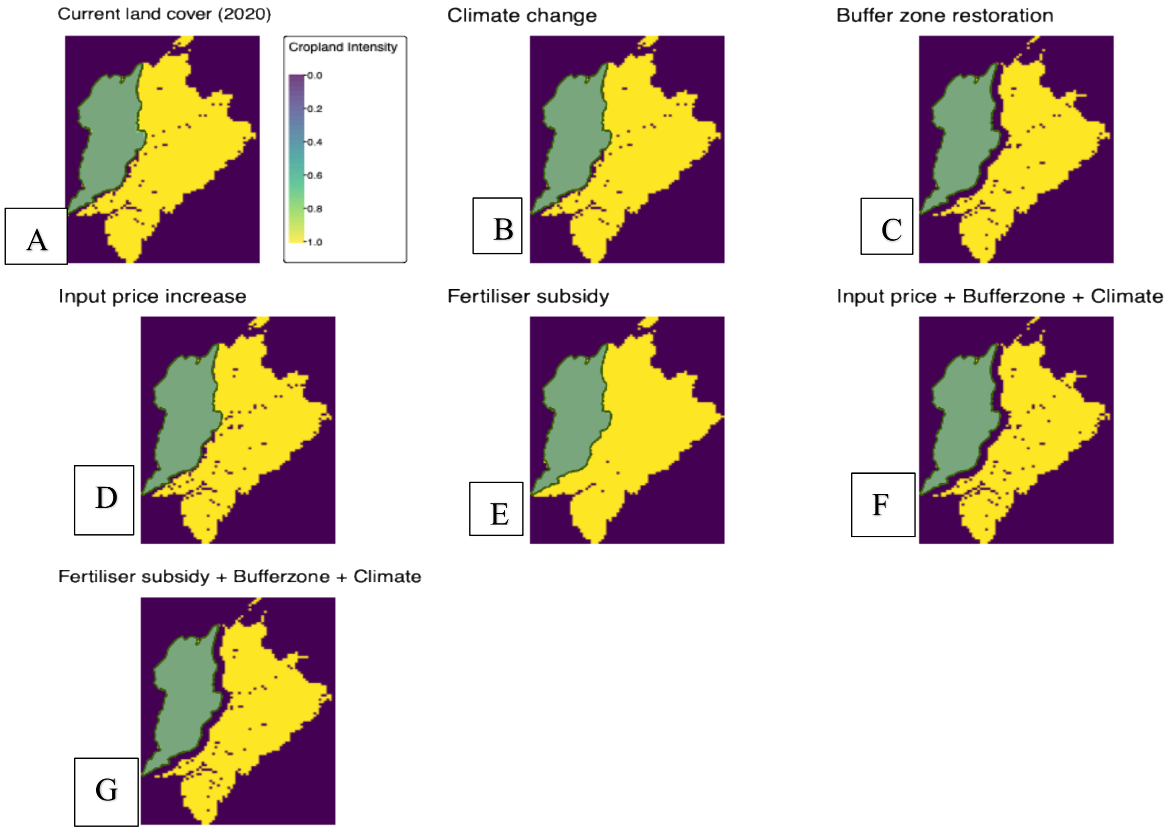

Figure 6.2: Projected land cover changes in cropland intensity across Kasungu District in the six scenarios- A: Current land cover in 2020. B: Climate change, C: Buffer zone restoration, D: Farm input price increase, E: Fertiliser input subsidy, F: Combined FIP+BR+CC, and G: Combined FS+BR+CC. Maps depict cropland extent and intensity, where green corresponds with Kasungu National Park, yellow corresponds with agricultural land (defined as cells where >20% of the cell is in agricultural production), and purple and dots indicates other land uses (e.g. non-agricultural land uses in and outside of Kasungu landscape).

The Climate Change only scenario projects relatively static land cover patterns, serving as a business-as-usual baseline with negligible changes in cropland extent or intensity. The rest of the scenario simulations revealed divergent pattern of cropland change. For example, the buffer zone restoration scenario projected modest but spatially distinct decreases in cropland extent and intensity, particularly around the edges of the national park reflecting the agricultural land use constraints imposed under the scenario. The farm input price increase, and Combined FIP+BR+CC were projected to lead to localised decreases in cropland extent and intensity, particularly on already cultivated lands, suggesting less intensification in response to high costs of input and restricted buffer zone cultivation. Conversely, the fertiliser subsidy scenario was projected to lead to increase in cropland extent and intensification.

6.3.2 Taxonomic and scenario-specific species responses

The projected species responses varied substantially across taxonomic groups and scenarios (Figure ***6.3*** and Figure ***6.4***). In general, species population and habitat area changes were strongly positively correlated across all scenarios (Spearman's $\rho = 0.86$, $p < 0.001$), indicating that species experiencing habitat expansion were also likely to experience increase in population abundance. Therefore, I only give results in the main text for species populations, with results for habitat area in the Supplementary material.

Among the scenarios examining single policies in isolation, the farm input price increase and buffer zone restoration scenarios were projected to produce moderate increases in species population and habitat area compared to the climate change baseline. Under the buffer zone restoration scenario, we predicted a moderate increase in species populations across all taxa by an average of 82% (95% CI: 0.57-1.07). Taxon-specific confidence intervals showed consistent gains for all taxon, but slight variations between taxon: [Birds: (95% CI: 1.46-1.78), Mammals: (95% CI: 1.94-2.46), Reptiles: (95% CI: 1.91-2.64), and Amphibians: (95% CI: 1.19- 2.12)].

Similarly, the farm input price increase scenario (i.e., adjusting the cost of farm inputs) was projected to result in a 101% population increase (95% CI: 0.76-1.26). This effect was again strongest in mammals and reptiles: [Birds:(95% CI: 1.61-1.92), Mammals: (95% CI: 2.23-2.76), Reptiles: (95% CI: 2.22-2.95), and Amphibians (95% CI: 1.31-2.24)]. These patterns suggest that mammals and reptiles were particularly responsive to these single-policy land-use interventions, likely due to their larger home ranges or higher habitat dependency.

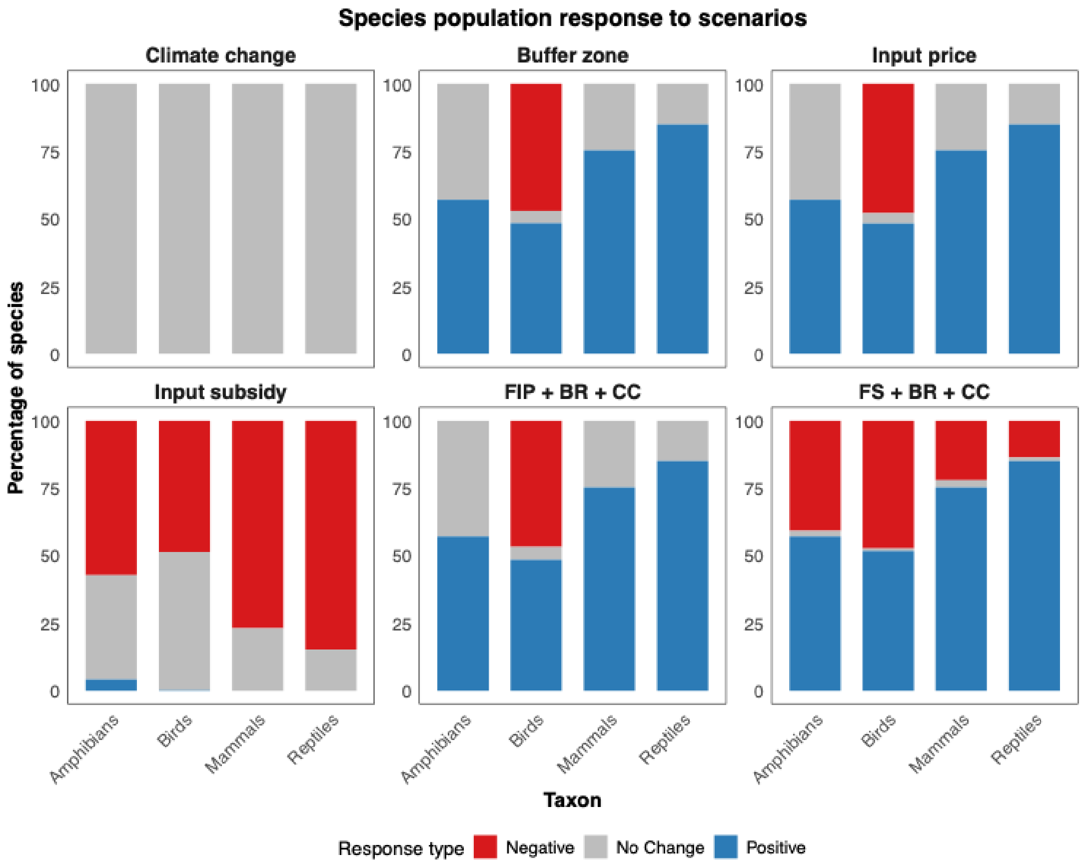

Figure 6.3: Stacked bar indicating the proportion of species projected to exhibit positive (blue), no change (grey), or negative (red) response within each taxonomic group under six policy and climate scenarios projected;

Conversely, the farm input subsidy scenario was projected to result in widespread population declines. Reptiles (95% CI: −0.20–0.54) and mammals (95% CI: −0.01–0.52) experienced reductions exceeding 50%, while amphibians declined by more than 20% (95% CI: −0.00–0.93). Several species, including Round-snouted Worm Lizard (*Zygaspis quadrifrons*) and Oribi antelope (*Ourebia ourebi*), were predicted to lose 100% of their population and habitat within the study landscape under this scenario.

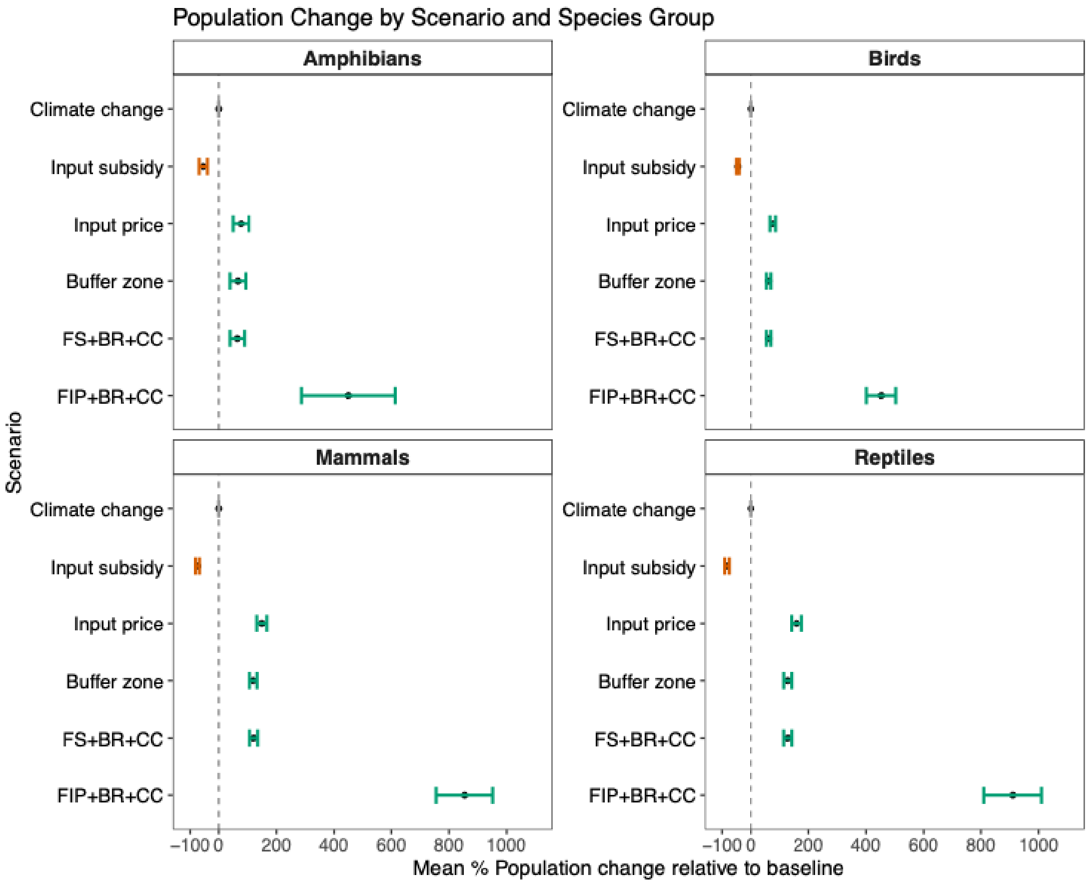

Figure 6.4: Taxon-specific species population responses to policy and climate scenarios, based on estimates from a mixed-effects model. Each point represents the mean predicted change in population (%) for amphibians, birds, mammals, and reptiles under each scenario, with horizontal lines indicating 95% confidence intervals. The climate change scenario serves as the reference baseline (grey) and had a mean % population change across all scenarios and taxonomic groups of zero. Green represents statistically significant positive effects, and orange indicates significant negative effects.

The FS+BR+CC scenario, which combines fertiliser subsidies, buffer zone restoration, and people's responses to climate change, was projected to lead to a population abundance increase of 64% across amphibians, and similar increases of 62% in birds. Among mammals and reptiles, this scenario resulted in population increases of 121% and 128% respectively. Despite the scenarios including otherwise detrimental fertiliser subsidies, it had improved outcomes compared to the farm input subsidy scenario. This is because the reversion of currently cultivated land in the buffer zone to natural vegetation outweighs the impacts of agricultural intensification caused by the fertiliser subsidy. As with the single-policy scenarios, mammals and reptiles were estimated to benefit most, potentially due to their greater sensitivity to improvements in habitat structure and reduced disturbance in restored buffer zones. However, these average gains mask some notable negative responses, particularly among birds and amphibians, which showed declines under the fertiliser subsidy-only scenario. This suggests that while FS+BR+CC offers considerable net benefits, certain species may still be at risk if agricultural intensification displaces specific microhabitats or alters trophic dynamics.

The FIP+BR+CC scenario was projected to produce the most substantial biodiversity benefits of all scenarios. Across all taxa, population abundance and habitat area were projected to increase dramatically: amphibians (451%), birds (453%), mammals (854%) and reptiles (910%). These gains were particularly striking for reptiles and mammals, which appear to respond strongly to the combined effects of reduced input costs (which may reduce pressure on marginal habitats), ecological restoration, and behavioural responses to climate change. Some species, such as the Reddish-grey musk shrew (*Crocidura cyanea*) and the Common sand frog (*Tomopterna cryptotis*), showed increases exceeding 1000%, likely reflecting low baseline populations that respond exponentially to even modest environmental improvements. In this scenario, there were virtually no negatively impacted species among amphibians, mammals, or reptiles. However, nearly 50% of bird species were negatively impacted, possibly due to altered land cover patterns or food web changes that reduce habitat suitability for more specialised or disturbance-sensitive birds. This underlines the need for avian-focused mitigation strategies in future land management plans. Despite this, the scenario represents a highly promising direction for policy, with multi-lever interventions producing broad and synergistic biodiversity gains.

6.3.3 Identifying species at risk

I analysed which species were predicted to experience the largest positive and negative changes in population and habitat area across the scenarios examined. These were identified by calculating the mean percentage change for each species across all scenarios and selecting the ten species with the largest absolute changes. These are predominantly species with small initial habitat areas in the landscape, which means that small absolute changes in habitat area would result in large shifts in percentage terms (Figure ***6.5***). The ten most sensitive species included Mammals; Dark musk shrew (*Crocidura cyanea*), Kaiser's rock rat (*Aethomys kaiseri*), and Ansell's epauletted fruit bat (*Epomophorus ansellii*); Birds; Eastern nicator (*Nicator gularis*); Amphibians; Common sand frog (*Tomopterna cryptotis*), Rough sand frog (*Tomopterna tuberculosa*), and Porous grass frog (*Ptychadena porosissima*); and Reptiles; llolo chameleon (*Trioceros goetzei*), Zambian grass lizard (*Chamaesaura miopropus*), and O'Shaughnessy's thick-toed gecko (*Pachydactylus oshaughnessyi*).

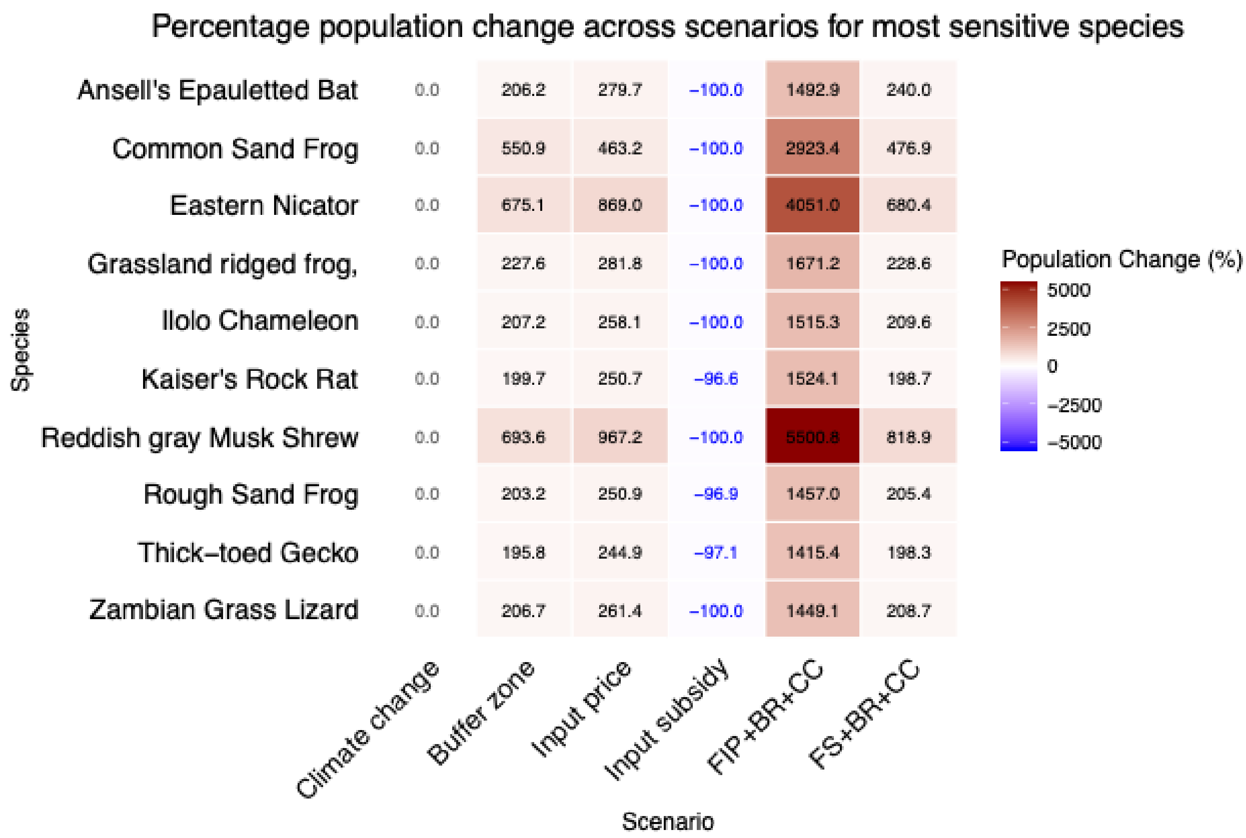

Figure 6.5: Heat map showing percent change in population abundance under each land use and policy scenario for the ten most sensitive species. Species were identified based on the average change in their response across all scenarios.

Under the FIP+BR+CC scenario, species like the dark musk shrew, common sand frog, eastern nicator, and porous grass frog showed >100% increases. Yet under the fertiliser scenario, these same species experienced severe declines, even extinction. These patterns affirm that sensitivity to land-use change spans to diverse ecological niches.

6.4 Discussion

This study provides insights into how various scenarios of change in land use and policy could affect biodiversity outcomes in Kasungu, Malawi. We modelled both direct interventions (e.g. removing agriculture from the buffer zone) and indirect changes mediated through farmer responses (e.g. their response to high fertiliser costs or input subsidies). Findings show that species population trajectories and habitat area changes as a result of land use and policy scenarios are strongly shaped by scenario design and taxonomic identity.

6.4.1 Socio-economic trade-offs and human wellbeing

Although this chapter focuses on biodiversity outcomes, the modelled land-use scenarios were grounded in extensive local engagement, including household surveys and participatory discussions with farmers, community leaders, and policymakers in Kasungu District (see Chapter 5). These engagements revealed a complex interplay between aspirations for agricultural development and concerns over conservation. The spatial analysis, in addition to current satellite-derived land cover estimates, showed that Kasungu's capacity for cropland expansion is already highly limited, despite respondents in Chapter 5 citing agricultural expansion as a strategy for adaptation to policy interventions and climate change. 90% of participants indicated they would expand their farmlands under fertiliser subsidy scenario (Chapter 5). This indicates that agricultural intensification, and not agricultural expansion, is likely to be the dominant pathway to meet growing food demands in the landscape (Kpienbaareh, et al., 2022).

While agricultural intensification can enhance food security in this case, it can exacerbate ecological degradation through habitat simplification, chemical runoff, and soil depletion, all of which disproportionately affect species (Beckmann et al., 2019; Makwinja et al., 2021; Tscharntke et al., 2021). This may be further amplified by Jevons' Paradox, which is where gains in input efficiency could lead to absolute increases in resource use –i.e. increases in crop yields could lead to an increased amount of land being used for crop production (Freire-González, 2021; Lange et al., 2021; Yu et al., 2022). This Paradox was also found to exist in the study landscape. For example, the qualitative research conducted during Chapters 3 and 5 indicated that the scenarios involving fertiliser subsidies would lead to an increase in crop yields and to an increased amount of land used for crop production. Although such interventions are viewed locally as pro-poor and pro-food security, the findings highlight their potential ecological costs.

Conversely, conservation-oriented strategies like buffer zone restoration were projected to reduce cropland, particularly near the edges of Kasungu National Park, suggesting a trade-off between ecological recovery and access to fertile farmland. These scenarios, while beneficial for biodiversity, may pose risks to local food security and livelihoods, particularly in a region already under spatial pressure. Collectively, these findings emphasise the necessity for context-specific, integrated land-use planning (Fischer et al., 2017; Jiren et al., 2020).

Sustainable intensification may offer a middle path, but this will require more than yield-boosting technologies (Ceddia et al., 2014; Tadele, 2017). Coordinated policy and behavioural shifts, including support for agroecological practices and land-efficient cropping systems, are needed to balance productivity and conservation goals (Glamann et al., 2017; Wittman et al., 2017). Although people's potential responses to climate change, i.e. changing the types of crops produced, or the amount of land used for crop production, did not emerge as a major direct driver of biodiversity loss in the modelled scenarios, the direct effects of climate change on species could amplify the biodiversity impacts here and climate change's direct effects on people could intensify socio-economic vulnerability (Chapter 5). This, in turn, could prompt coping strategies like illegal hunting or forest extraction that indirectly reduce biodiversity, and which we were not able to model here (Amadu et al., 2020; Börner et al., 2015; Schaafsma et al., 2018; Senganimalunje et al., 2022).

Future land-use planning in Kasungu will therefore need to align policy instruments with both ecological thresholds and the lived realities of land users seeking to sustain agricultural livelihoods within a spatially saturated system. A critical next step will be to model the socio-economic outcomes of these scenarios in parallel with ecological projections. Understanding the net effects on yield, food security, and income will be essential for crafting policies that are both socially and ecologically sustainable. In addition, given current spatial constraints, stated aims to expand agriculture will require careful consideration of where such expansion could realistically occur. Future modelling efforts should therefore assess not only on-site impacts but also the potential for agricultural "leakage" into neighbouring areas, where displacement of activities could generate unintended ecological or social consequences (Meyfroidt, 2018; Meyfroidt et al., 2022).

6.4.2 Biodiversity outcomes across scenarios

The study findings show that integrated land-use strategies combining increased farm input prices, buffer restoration, and climate change (FIP+BR+CC) would deliver the most significant biodiversity benefits. Species across all taxonomic groups experienced population gains, with mammals and reptiles showing particularly strong responses. This is because buffer zone restoration provides habitat and connectivity (Garibaldi et al., 2017, 2021), while higher farm input prices reduce agricultural profitability, thereby limiting incentives for intensification or expansion, especially given the model's constraints on further land conversion (Angelsen et al., 2014). In contrast, scenarios that applied only a single intervention tended to yield more modest benefits, with some taxonomic groups experiencing little to no improvement. These results suggest that biodiversity gains are maximised when strategies simultaneously address habitat quality, landscape connectivity, and the economic drivers of agricultural change, underscoring the value of policy mixes that integrate ecological restoration with market-based disincentives for land-use expansion (Garibaldi et al., 2021; Kremen & Merenlender, 2018).

While species with narrow habitat requirements, such as the Common Sand Frog (*Tomopterna cryptotis*) and Ilolo Chameleon (*Trioceros goetzei*), responded most strongly in scenarios with targeted buffer restoration, this likely reflects their reliance on specific microhabitats within the landscape. These conclusions are based on the modelling results, which showed positive population changes for these species under bufferzone restoration, as well as literature describing their limited dispersal and habitat specialisation (Netherlands, 2019; Tolley et al., 2018). In contrast, species with broader habitat tolerance, such as the Eastern Nicator (*Nicator gularis*), showed greater gains under scenarios involving combined scenarios because since they improved connectivity and reduced land conversion, consistent with studies on habitat generalists in fragmented systems (Henle et al., 2004; Lindenmayer et al., 2008). However, even under the best-performing integrated scenario, trade-offs emerged: while some species, such as the Greater Red Musk Shrew (*Crocidura flavescens*), increased markedly, others, including the Lanner Falcon (*Falco biarmicus*) and Verreaux's Mouse (*Myomyscus verreauxii*), exhibited declines. These contrasting responses highlight the need for adaptive, species-specific planning that accounts for both ecological diversity and differential vulnerability to land-use change (Baudron et al., 2019).

6.4.3 Taxonomic variation and conservation priorities

This study results reveal variations in species response by taxonomic groups. Mammals and reptiles consistently showed the strongest positive responses to integrated scenarios, while birds exhibited more modest gains, and amphibians were among the most vulnerable under intensification. These differences reflect ecological traits such as mobility and niche specialisation (Sykes et al., 2020), underscoring the importance of tailoring conservation to group-specific needs. While birds may be less sensitive to habitat fragmentation or small-scale habitat loss than amphibians and mammals, they are also more influenced by large scale landscape changes (Mair et al., 2021; Sykes et al., 2020). This highlights the need for targeted actions across taxa including species-specific plans.

6.4.4 Local and global policy implications

This study reinforces the need for integrated, landscape-level planning to reconcile conservation and agricultural development. Individual levers like input price shifts or habitat restoration deliver partial benefits, but the most promising outcomes arise from coordinated policy bundles that address land use, climate, and agriculture together (Kremen & Merenlender, 2018). As countries revise their National Biodiversity Strategies and Action Plans (NBSAPs) under the Kunming-Montreal Framework (CBD, 2022; Friedman et al., 2022), scenario-based, cross-sectoral planning at local levels should be prioritised. Findings also suggest context-specific conservation assessments are needed to identify hidden risks and direct resources more effectively (Betts et al., 2019).

Successful implementation, however, will depend on inclusive, locally grounded governance. In this study, scenario narratives and assumptions were co-developed with local stakeholders, enabling a detailed understanding of how people might respond to different interventions. This process not only improved the realism of the scenarios but also helped interpret species outcomes in light of livelihood strategies, resource access, and social dynamics. Such embedded engagement, combined with mechanisms for fair benefit-sharing, will be critical to ensuring that conservation strategies are equitable, legitimate, and supported by those most affected (L'Roe et al., 2023; Shackleton et al., 2023).

6.4.5 Study limitations and future work

Several limitations frame the interpretation of these findings and point to priorities for future research. First, while the scenarios incorporated spatial constraints, they did not explicitly model the feasibility of stated agricultural expansion targets; future analyses should assess where such expansion could realistically occur and the potential for agricultural "leakage" into neighbouring areas (Ewers & Rodrigues, 2008; Meyfroidt et al., 2022). Second, the modelling framework focused on land-use change and climate drivers but omitted other significant pressures relevant to the study area, such as invasive plant species (e.g., *Lantana camara*), human–wildlife conflict dynamics, and the capacity to enforce conservation policies, that can strongly influence biodiversity outcomes. Third, the absence of parallel socio-economic modelling means the potential trade-offs for households in Kasungu, particularly those related to livelihoods, food security, and income diversification, remain unquantified. Addressing these gaps will require integrated modelling frameworks that combine ecological and socio-economic outcomes, incorporate a wider range of locally relevant drivers, and assess how these interact over time under different policy and development pathways.

6.5 Conclusion and Policy Recommendations

To ensure effectiveness, conservation strategies should be informed by taxon-specific ecological traits and grounded in local socio-economic realities. Special attention should be given to sensitive taxa, such as amphibians, which serve as early indicators of environmental degradation. Policymakers should therefore prioritise effective approaches that promote sustainable agricultural practices while restoring and connecting natural habitats. Long-term biodiversity strategies in Malawi, and similar contexts, should combine ecological forecasting with socio-economic assessments to support equitable and resilient land-use futures. Ultimately, integrated, adaptive conservation planning is essential to building landscapes supporting ecological integrity and human livelihoods.

Chapter 7 : Discussion and Conclusion

Crossing the bridge that connects the buffer zone and the rest of the villages

7.1 Summary of research findings

Historically, agriculture and biodiversity conservation have evolved as distinct disciplines, each with its own epistemologies, frameworks, and methodologies. Recent literature, however, has increasingly highlighted the need to understand their interdependencies within socio-ecological systems (Dawson et al., 2016; Glamann et al., 2017; Ortiz et al., 2021). Nevertheless, policy and implementation practices often remain fragmented. Addressing complex sustainability challenges demands integrated, interdisciplinary approaches that can account for ecological dynamics, governance contexts, and local socio-economic realities.

In this DPhil, I employed such an approach to explore the food-biodiversity nexus in Kasungu, Malawi. I investigated social, ecological, and behavioural dynamics using focus groups, key informant interviews, and questionnaire surveys. Data were analysed using thematic coding and quantitative statistical methods. Ethical research protocols, including formal review, informed consent, and confidentiality, ensured the study was conducted responsibly and with cultural sensitivity.

Findings demonstrate that biodiversity and food security outcomes are co-constituted through interacting ecological baselines, institutional arrangements (e.g., land and resource tenure), and community-level perceptions and practices. Notably, trade-offs and synergies were not uniform but contingent on spatial context and livelihood strategies, underlining the necessity of context-specific, cross-sectoral interventions. These insights reaffirm the value of interdisciplinary research in diagnosing sustainability challenges and informing policy pathways that bridge conservation and development objectives (Jouzi et al., 2022; Vittis et al., 2021).

Beyond generating evidence and critical insights into the linkage between agriculture and biodiversity conservation, this research offered a valuable opportunity to collaborate with a diverse set of stakeholders both within and beyond academia. Key partnerships included local communities, the Malawi government (DNPW, MOA), and the international NGO CIFOR-ICRAF. These collaborations ensured that findings were relevant to academic discourse and applicable to policy and practice. I am deeply grateful for the chance to undertake this interdisciplinary DPhil, embracing its challenges and rewards.

I successfully achieved both the overarching aim of the DPhil and its specific objectives. The overall aim of this research was to explore how agriculture and biodiversity conservation can be integrated within a shared landscape while respecting local people's priorities.

My first objective was to understand the implications of human-nature interactions on livelihoods. I explored resource use and perceptions of wildlife through interviews, focus groups, and surveys. About 90% of respondents reported harvesting resources like firewood and medicinal plants, often from protected areas, despite legal restrictions. Dependence on natural resources was higher among women, poorer households, and those living closer to the park and experiencing crop/livestock losses. While overall attitudes toward wildlife and conservation were positive, negative perceptions were linked to food insecurity and human-wildlife conflict. These findings underscore the need for inclusive, community-led initiatives that benefit people and biodiversity.

My second objective was to apply a feminist political ecology framework to examine how gendered kinship systems and land use shape conservation and livelihoods. The research found that Kasungu communities follow a matrilineal-virilocal kinship system, which reflect matrilineal characteristics in land access but patrilineal in land ownership and governance. This challenges the assumption that gender inequality is limited to patriarchal systems, as women's access to land does not necessarily translate into decision-making power. These findings highlight the need for policies and conservation programmes to account for lineage-based norms, and for gender equity efforts to go beyond access by addressing issues of control, rights, and governance structures.

The third objective was to use scenario-based analysis to explore with community members how hypothetical conservation and agricultural policy changes, based on their own understanding of future trends, might affect food security, resource use, community wellbeing, the fairness of these scenarios, and people's behavioural intentions. Increases in farm input price and wildlife translocation scenarios were anticipated to worsen peoples' food security and wellbeing. In contrast, universal input subsidies and wildlife damage compensation scenarios were perceived as fair and beneficial. Buffer zone restoration was not seen as problematic by communities living adjacent to the wildlife fence dividing the park from agricultural land but was negatively perceived by communities in unfenced areas due to potential restrictions on farmland access. However, several of the scenarios favoured by communities, particularly those increasing access to inputs or compensating for wildlife damage, could entail trade-offs by reducing incentives for conservation-compatible behaviour or increasing pressure on natural resources, thus highlighting the complex balance between social equity and biodiversity outcomes.

These findings stress the need for adaptive, locally informed policies that avoid one-size-fits-all approaches and prioritise community input. External actors seeking to implement conservation interventions should prioritise understanding and integrating local perspectives to ensure that livelihoods and wellbeing are not negatively affected. Therefore, collaborative efforts that achieve food production while ensuring biodiversity conservation, food security, and wellbeing are crucial.

The fourth objective of this study was to project biodiversity outcomes under varying land-use and policy change scenarios. Using the Glob2Loc model, I evaluated six scenarios developed in the previous chapter (Chapter 5), to assess their potential medium-to-long term impacts on biodiversity in Kasungu, as a result of agricultural expansion, intensification, and climate change. The findings revealed that scenarios involving fertiliser subsidies were associated with the most severe biodiversity losses, with some species projected to lose 100% of their population and habitat in the Kasungu area. In contrast, the buffer zone restoration scenario and a scenario combining increased farm input prices, buffer zone restoration, and climate change were projected to result in increased species populations and habitat areas. Extending the modelling to include the socio-economic consequences of interventions could uncover ways forward to benefit biodiversity as well as livelihoods.

These results underscore the potential importance of scenario-based modelling approaches for ecological forecasting, particularly in data-deficient contexts such as Malawi. Incorporating such modelling frameworks into conservation planning can support proactive, evidence-based decision-making and promote more equitable and resilient land-use futures for both people and nature. Accordingly, policy frameworks should prioritise multi-objective strategies that foster sustainable agricultural practices while simultaneously restoring and reconnecting natural habitats.

This DPhil contributes to growing efforts to reconcile biodiversity conservation and agricultural development, particularly in sub-Saharan Africa. By using interdisciplinary methods and engaging diverse stakeholders, the research demonstrates the social-ecological systems' complex, and context-specific nature. Key findings advocate for:

- Integrated policy approaches that reflect the interconnectedness of food systems and biodiversity.
- Gender-sensitive and culturally grounded interventions.
- Inclusive, locally led conservation strategies; and
- Collaborative planning and policy formulation that bridges ecological and social priorities.

Ultimately, translating these insights into practice is essential for building sustainable, equitable, and resilient food and conservation systems in Malawi and beyond.

7.2 Cross-cutting themes and recommendations

7.2.1 Framing of the agriculture-biodiversity nexus

In shared landscapes like Kasungu, the links between agriculture and biodiversity remain under-explored despite local dependence on natural resources and ecosystem services. Traditionally, these sectors have been framed as competing, food production versus conservation, resulting in siloed policies and limited cross-sector collaboration (Fisher et al., 2017; Jouzi et al., 2022; Ortiz et al., 2021). However, this binary framing fails to reflect the lived realities of rural communities, where food security and biodiversity are deeply intertwined. A paradigm shift is needed where agriculture and biodiversity are recognised as interdependent systems (Jouzi et al., 2022), particularly in socio-ecologically complex settings such as Kasungu.

This thesis (Chapters 3, 4 and 5) found that many households in Kasungu face overlapping constraints, including limited land availability, declining soil fertility, and restricted access to agricultural inputs, which prevent them from achieving food security through farming alone. As a result, people rely heavily on non-timber forest products (NTFPs), often extracted illegally from Kasungu National Park, as alternative sources of food, fuel, and income (Chapter 3). This coping strategy contributes to pressure on forest ecosystems and wildlife habitats, while simultaneously placing communities in conflict with conservation authorities due to the criminalisation of resource access.

Such dynamics reflect deeper structural tensions between livelihood needs and conservation policies and are symptomatic of broader challenges across sub-Saharan Africa. For example, in western Uganda, Twongyirwe et al., (2022) documented how limited access to land and agricultural inputs pushed forest-edge communities to depend on NTFPs and charcoal production from protected areas, which in turn increased conservation conflicts. In northern Tanzania, Benjaminsen et al., (2013) showed that restrictions on land use and enforcement of conservation boundaries, without alternative livelihood options, led to resentment and non-compliance among pastoralist communities. In Mozambique and Zambia, integrated conservation and development projects have faced persistent difficulties due to mismatched expectations, insufficient local benefit-sharing, and a lack of long-term investment in rural livelihoods (Bae, 2023; L'Roe & Naughton-Treves, 2017). Together, these cases illustrate the need for context-specific strategies that address local livelihood needs, promote equitable benefit-sharing, and support sustained investment in integrated approaches (Fischer et al., 2017; Jiren et al., 2020).

In Kasungu, potential strategies could include improving access to agricultural inputs and extension services, promoting agroecological intensification, and establishing regulated, equitable access regimes for forest resources (Crespin et al., 2023; Wells et al., 2024). Establishing monitored mechanisms for access to forest resources could serve both social and ecological goals: by reducing unregulated extraction, they would enable better data collection on resource use, facilitate adaptive management, and improve conservation outcomes. At present, because access to the National Park is restricted and largely informal, park authorities lack reliable data on extraction patterns, undermining ecological monitoring and sometimes leading to unfounded assumptions about community impacts (Mavah et al., 2018). A shift toward inclusive, negotiated access would therefore enhance both accountability and conservation effectiveness.

Inclusive governance in this context could, in practice, entail devolved decision-making, transparent benefit-sharing, and the active inclusion of marginalised groups in planning and implementation. In Kasungu, this could involve revitalising community-based natural resource management (CBNRM), formalising co-management agreements, and embedding local knowledge and priorities into conservation planning and monitoring frameworks. Such arrangements have been shown to enhance legitimacy, compliance, and long-term conservation success when appropriately resourced and equitably managed (Garnett et al., 2018; Musakwa et al., 2020).

While the agriculture–biodiversity nexus is widely recognised in international policy discourse (Jouzi et al., 2022), this research highlights persistent and tangible misalignments between Malawi's national conservation (NBSAP, (GoM, 2015)) and agricultural development strategies (GoM, 2024a, 2024b). Although the country is a signatory to the Kunming-Montreal Global Biodiversity Framework (CBD, 2022) and has committed to achieving Target 3 (the 30x30 goal), national strategies continue to emphasise spatial conservation coverage and enforcement, with insufficient attention to the effectiveness, equity, and inclusion dimensions that are central to the target (Sandbrook et al., 2023; Sibanda et al., 2025). In Kasungu, conservation practice remains largely exclusionary, prioritising ecological protection through strict enforcement while offering few avenues for community participation or benefit-sharing. Simultaneously, agricultural policy (GoM, 2024), led by the Ministry of Agriculture, continues to focus on productivity gains via input subsidies and land intensification strategies, with limited integration of biodiversity or ecosystem service considerations (Fisher et al., 2017; Fisher & Kandiwa, 2014; GoM, 2020). This sectoral disconnect reinforces trade-offs on the ground and constrains the potential for more synergistic approaches to food security and conservation.

Findings from this thesis (Chapters 3–5) indicate that such policy fragmentation contributes directly to livelihood insecurity and conservation conflict in Kasungu. Households face constrained agricultural potential due to declining soil fertility and limited land access, and consequently rely on forest-based resources, often accessed illegally. Yet these coping strategies are criminalised under current conservation law, deepening tensions between communities and park authorities (Chapter 3). Addressing these conflicts requires institutional coordination between the Department of National Parks and Wildlife (DNPW), the Ministry of Agriculture, and the Ministry of Natural Resources and Climate Change.

Cross-sectoral planning, integrated land-use policy, and community-led governance models are essential to translating the aspirations of Target 3 into meaningful and context-responsive outcomes on the ground (Mitchell et al., 2023). Without such alignment, Malawi risks reproducing the very conflicts and inefficiencies that integrated conservation frameworks seek to overcome.

7.2.2 Intersectionality in food-biodiversity challenges

Despite growing recognition of social diversity in conservation and development practice, intersectionality remains underexplored in biodiversity research, particularly in African contexts where environmental governance intersects with longstanding structural inequalities (Tavenner et al., 2022; Vigil, 2024). While gender, class, and geography are increasingly acknowledged as shaping conservation outcomes (Tavenner et al., 2022), the ways in which these dimensions intersect to produce compounded disadvantage remain insufficiently addressed (Vigil, 2024). Much research continues to treat social categories such as “women” or “rural communities” as homogenous, thereby obscuring how multiple, overlapping forms of marginalisation, such as gendered land insecurity in remote areas, shape access to resources, vulnerability to conservation measures, and participation in decision-making processes (Erwin et al., 2021; Maina-Okori et al., 2018; Pandya, 2023; Thaler et al., 2023).

I uncovered intersectionality related to gender and geographical location in the Kasungu landscape. Across the thesis chapters (particularly Chapters 3 and 5), gender and spatial location emerged as the most consistent axes of differentiation in how people experience and respond to environmental change. While these two dimensions were not statistically modelled as interacting variables, qualitative findings revealed clear patterns of overlapping disadvantage. For example, women living along the unfenced part of the park boundary, faced a dual burden: gendered constraints on land and decision-making, combined with high exposure to human-wildlife conflict. These compounding factors limited their access to forest-based resources, reduced their capacity to cope with shocks, and excluded them from formal policy processes, a clear case of intersectional vulnerability.

The electric fence itself became a symbol and instrument of contested conservation authority. In 2022, park authorities started a fence project, and a decision was made that they would use the original 1972 park boundary which includes the buffer zone. This decision overlooked the reality that many households had been living and farming in the buffer zone for over 40 years, often with no other viable place to go. During the period of my fieldwork, the fence project - supported by international organisations including International Fund for Animal Welfare (IFAW) - was temporarily halted following widespread local opposition, protests, and appeals to government. Communities argued that the fencing process was undertaken without proper consultation or compensation, and that their customary land rights had been ignored. While park authorities cited the legal legitimacy of the 1972 boundary, residents saw the project as an erasure of their history and livelihoods.

Since completing fieldwork, however, the fence has been extended and completed, and communities previously residing within the buffer zone have been forcibly removed without alternative land, formal relocation plans, or meaningful compensation (https://mwnation.com/fencing-out-the-vulnerable/). This is not just a matter of spatial exclusion; it reflects how conservation infrastructure can reinforce historical patterns of dispossession, especially for politically marginalised groups (Bontempi et al., 2023). For example, in Mkomazi National Park in Tanzania, pastoralist communities such as the Parakuyo were evicted in the late 1980s without adequate compensation or resettlement, despite long-standing residence in the area (Brockington, 2002; Lwanga, 2003). Similarly, in Botswana's Central Kalahari Game Reserve, the San people were forcibly removed from their ancestral lands under conservation and development schemes, only later regaining partial access through court rulings that acknowledged the violation of their rights (Hitchcock, 2019). These cases reflect a broader trend described by Dowie, (2009), in which Indigenous and rural populations across the Global South have become "conservation refugees," displaced in the name of biodiversity protection. These examples highlight the need for greater scrutiny of conservation interventions, particularly where infrastructure like fences can replicate and reinforce structural inequalities.

These dynamics were further reflected in the participatory scenario co-creation process (Chapter 5), where residents' policy preferences were deeply shaped by their spatial and social positioning. Households in unfenced and now-evicted areas overwhelmingly favoured the wildlife damage compensation scenario, viewing it as the most just and urgently needed. In contrast, residents from more distant or securely fenced locations were more supportive of buffer zone restoration, seeing it as beneficial for long-term ecological stability. Such diverging responses illustrate how intersectional lived experiences directly shape perceptions of risk, fairness, and conservation legitimacy.

A central insight from this thesis is therefore that intersectionality is not just a lens of critique, but a practical necessity for understanding and addressing differentiated vulnerability in conservation. In this case, the fence is not merely a boundary, it actively shapes livelihood options and alters risk exposure. The fact that the fence was ultimately completed despite significant resistance underscores the structural imbalance between conservation actors and the rural communities whose lives and histories are being reshaped.

Going forward, conservation and agricultural policy in Kasungu and similar contexts must engage more deeply with how multiple forms of disadvantage intersect and compound. This means recognising that not all “community members” are equally affected by external pressures and interventions, and that spatially and socially differentiated interventions such as gender-responsive extension services, participatory governance structures, and place-specific access regimes are essential (Meyer et al., 2022, 2025). It also means putting in place clear procedural safeguards to prevent forced evictions and land dispossession under the banner of conservation, particularly where customary rights are not formally recognised.

In sum, this thesis demonstrates that intersectionality provides a vital framework for designing conservation strategies that are both effective and just. In shared and contested landscapes like Kasungu, where ecological pressures intersect with long histories of inequality and marginalisation, recognising the interplay between gender, place, and power is not only essential for equity, but also a prerequisite for achieving socially legitimate conservation outcomes.

7.2.3 Land tenure, land-use change, and landscape management

Land tenure is a critical but often under-addressed dimension of both agricultural development and biodiversity conservation (Asaaga & Hirons, 2019). In many sub-Saharan African contexts, including Malawi, ambiguous and overlapping tenure arrangements, particularly the limited formal recognition of customary land rights, undermine both conservation initiatives and peoples’ food security (Chapter 4). This research reinforces the need to integrate customary tenure systems into formal land policies, not only to legitimise local authority but also to align land governance with broader conservation and agricultural objectives (Dawson et al., 2016; Layefa et al., 2022). In Kasungu, informal tenure and tenure insecurity contributed to increased pressure on forest resources, reduced participation in land-use planning, and tensions between communities and conservation authorities (Chapters 4 and 5).

Critically, gender remains a central but frequently overlooked factor in land tenure governance. In Kasungu, as in much of rural Malawi, women often face significant barriers to accessing, owning, and controlling land due to hybrid kinship systems and inheritance norms, despite being heavily involved in agriculture and natural resource use (Chapter 4). This gendered insecurity limits women's ability to make long-term land-use decisions, participate meaningfully in planning processes, or benefit equitably from land-based investments (Chiwona-Karltun et al., 2017; Doss & Meinzen-Dick, 2020; Quisumbing et al., 2021). Addressing land tenure reform in this context requires a gender-sensitive approach that both strengthens women's land rights and acknowledges the legitimacy of customary institutions. Inclusive tenure reform, attuned to both customary and gender dynamics, is essential to enabling sustainable land management and achieving socially just conservation outcomes (Agarwal, 2009; Kabeer & Natali, 2013; Meinzen-Dick et al., 2019; Peters, 2013).

While agricultural expansion continues to be prioritised in national development strategies (GoM, 2020) findings from this thesis highlight the physical and ecological limits to further expansion in Kasungu (Chapter 6). Much of the available farmland is already under cultivation, and encroachment into buffer zones or protected areas risks accelerating biodiversity loss and intensifying human–wildlife conflict. In this context, a shift from agricultural expansion to sustainable intensification is both necessary and urgent.

Sustainable intensification refers to practices that increase agricultural productivity without degrading the environment, and ideally, enhance ecosystem services (Araya et al., 2023; Burke et al., 2022). In Kasungu, this could include agroecological methods such as intercropping, composting, and integrating leguminous trees to restore soil fertility and reduce dependence on chemical inputs. However, as this thesis shows, sustainable intensification must be pursued in ways that are socially inclusive and responsive to local constraints (Burke et al., 2020, 2022; Darko et al., 2018). Many smallholders in Kasungu lack secure tenure or access to credit, which limits their ability to invest in soil restoration or adopt long-term practices (Benjamin et al., 2021a; Chigbu et al., 2019; Kaarhus, 2010). Women, in particular, often lack formal land rights and face systemic barriers to accessing extension services, land, or resources needed to participate in such transitions (Chigbu et al., 2019; Doss, 2018).

One example emerged during fieldwork in one of the villages, where a group of farmers had adopted pit planting and composting with support from agricultural extension officers. However, several households reported abandoning the practices after two seasons due to land disputes within extended families. In another case, a widow who had invested in rehabilitating fallow land through mulching and tree planting lost access to the plot after her husband died as she went back to her maternal home, citing lineage ownership. Without secure tenure or community dispute-resolution mechanisms, her investment yielded no long-term benefit. This reflects how tenure insecurity, especially for women and socially marginalised groups, can disrupt sustainable land management, even when technical support is available.

Similarly, an international NGO, ICRAF, introduced an agroforestry initiative that provided fruit tree seedlings alongside support for market integration. While the programme aimed to be gender-inclusive, some women reported being unable to plant the seedlings because they lacked decision-making rights over household land. In several cases, the trees were instead planted in husbands' or in-laws' fields, with little benefit or recognition for the women themselves. In other cases, the seedlings were never planted at all because the women had no secure land on which to plant them. These examples illustrate how well-meaning interventions can fail to deliver equitable outcomes without first addressing the structural barriers linked to land access and control.

Overall, my thesis and the insights I gained during my fieldwork underscore that sustainable intensification, if not supported by secure tenure and gender-sensitive approaches, risks excluding vulnerable groups and reinforcing existing inequalities. Policy efforts should therefore focus on building the enabling conditions that make intensification both viable and just (Conway et al., 2019; Gollnow et al., 2025; Tadele, 2017). These include strengthening customary and statutory land rights, expanding access to appropriate inputs and training, and supporting farmer-led experimentation and knowledge exchange. Spatial targeting is also essential: interventions should prioritise degraded and high-conflict areas where benefits are likely to be greatest and where further expansion would exacerbate ecological degradation (Crespin et al., 2023; Tscharntke et al., 2012; Zimmerer et al., 2015). As this thesis argues, integrated land-use planning and agricultural development must be grounded in the lived experiences and constraints of rural communities. Sustainable landscape management in Kasungu and similar regions requires policy coherence, secure and equitable land tenure, and participatory governance structures that centre the voices and rights of those most affected by land-use change.

7.2.4 Broader practical and policy implications for the agriculture-biodiversity nexus

The agriculture–biodiversity nexus in sub-Saharan Africa is not just ecological; it is deeply political, shaped by colonial legacies, donor-driven agendas, and entrenched power asymmetries (Dawson et al., 2024; Fischer et al., 2017). These dynamics were particularly evident in Kasungu, where many national and international interventions, such as input subsidies, wildlife translocations, and buffer zone restoration, were designed at higher levels but received with ambivalence or resistance by communities, especially those living near the unfenced boundary of the park. In these areas, where land scarcity, tenure insecurity, and human–wildlife conflict are most acute, residents often viewed these initiatives as disconnected from, or even threatening to, their livelihoods.

One powerful example of this disconnect was the 2022 elephant translocation, during which 263 elephants were moved into Kasungu National Park as part of an internationally praised ecological restoration effort (https://africageographic.com/stories/the-march-of-malawis-elephants/; significant-wildlife-translocation-completed-Malawi-). While the project was announced as a success for boosting elephant population and conservation, it had serious social consequences. Elephants used the unfenced side of the park boundary to move into neighbouring villages, resulting in multiple deaths, injuries, and crop destruction, even in areas far from the park's core. The lack of pre-consultation, poor risk communication, and insufficient compensation mechanisms soured relationships between local communities and conservation authorities. Rather than reinforcing conservation legitimacy, the initiative deepened mistrust and provoked retaliatory attitudes toward both wildlife and conservation authorities. This reflects a common but under-addressed pattern across conservation landscapes, where top-down ecological restoration projects can generate political resistance and social harm when they ignore local power relations and lived experience (Bontempi et al., 2023; Mavah et al., 2018; Ojeda, 2012)

As a researcher, I found myself negotiating these same dynamics. I began this project intending to study wildlife use alone, but my early field experiences revealed that people's relationships with wildlife were embedded in wider interactions with land, forest, and conservation institutions. This prompted me to expand my focus to human–nature relationships more broadly, leading to the development of Chapter 4. The unexpected disruptions of conservation interventions, particularly the elephant translocation and fence construction, also reshaped my research process. At one point, I considered shifting my project entirely to investigate the impacts of these events, but was constrained by time, ethical protocols, and the expectations of my funders. These tensions forced me to reflect on the fragility of research agendas in politically volatile landscapes, and the responsibility researchers have to remain flexible, critical, and responsive to changing contexts (Pienkowski et al., 2022).

Interdisciplinary and participatory research of this kind is also logistically and financially demanding (Hargreaves & Burgess, 2010). I conducted three separate field visits, across different seasons and project phases, to build relationships and gather the multi-dimensional data needed. While I was fortunate to receive support from multiple institutions and funders, this level of engagement is not always feasible, particularly for early-career researchers or those from underfunded institutions. Structural barriers such as short-term grants, can severely limit the capacity to do long-term, relational, and context-sensitive work (Carmenta et al., 2023; Gerrie et al., 2022; Obura et al., 2023). This suggests that research needs to be carried out by people based in in-country academic institutions, with appropriate long-term funding, who can then develop a long-term association to the places in question.

The experiences and insights from my research reinforce the need for locally grounded, power-aware, and participatory approaches to conservation and agricultural planning. Merely aligning policies at the national level is insufficient if such policies fail to engage meaningfully with local institutions, histories, and governance systems (Pangapanga-Phiri et al., 2025; Wells et al., 2024). In Kasungu, the limited inclusion of local voices in park management has contributed to informal resource use, and eroding trust between communities and authorities. Participatory processes, including the scenario co-creation exercises presented in this thesis (Chapters 5 and 6), revealed diverging priorities and values across different social and spatial groups. For example, the wildlife damage compensation scenario was strongly supported in high-conflict areas, while buffer zone restoration received more support in distant or fenced locations. These differences were shaped by material conditions, past experiences, and socio-political positionality, and they underscore the importance of spatially differentiated, socially responsive conservation (L'Roe et al., 2023; Wilkie et al., 2016).

Furthermore, in dynamic and rapidly changing landscapes like Kasungu, climate change is an increasingly critical pressure that must be explicitly addressed in conservation and development planning (Chikabvumbwa et al., 2022; Msowoya et al., 2016; Ray et al., 2019; Stevens & Madani, 2016; Warnatzsch & Reay, 2020). Shifts in rainfall patterns, temperature regimes, wildlife movement, farming practices, and population pressures mean that what works today may not be viable tomorrow (Mungai et al., 2020, 2022). In this context, adaptive and iterative policy design is essential (Jouzi et al., 2022). Conservation and agricultural policies should incorporate mechanisms for regular monitoring, community feedback, and responsive adaptation to remain effective under uncertain and evolving conditions (Kpienbaareh, Batung, et al., 2022; Kpienbaareh et al., 2024; Mungai et al., 2022). For instance, seasonal variation, exacerbated by climate change, affects both crop production and the intensity of human–wildlife conflict, underscoring the need for continuous, decentralised data gathering rather than one-off planning exercises (Mungai et al., 2022).

NGOs and other intermediary organisations have a vital role in providing enabling conditions for better outcomes by acting as bridging agents who can link communities, state actors, and technical experts. In areas where government presence is limited or contested, they can help build trust, deliver compensation schemes, and facilitate conflict resolution (Doss & Mika, 2021; Merz et al., 2023). While such integrated, multi-actor arrangements are not currently in place in Kasungu, they have been reported as successful in other parts of Africa. For example, the Northern Rangelands Trust (NRT) in Kenya supports community conservancies through mechanisms that couple wildlife protection with livelihood benefits, such as grazing agreements, peacebuilding programmes, and market access for livestock, demonstrating how iterative feedback and adaptive governance can address both ecological and social needs (Pas et al., 2023; Sambu, 2025). Similarly, the Gonarezhou Conservation Trust in Zimbabwe reflects an institutional model where an NGO, state authority, and local communities co-manage a national park, combining improved wildlife outcomes with community engagement and benefit-sharing (Musakwa et al., 2020). Such models offer relevant lessons for Malawi, where inclusive conservation approaches can balance protection goals with the realities of local livelihoods and socio-political constraints.

Importantly, while NGOs can catalyse innovation and bridge systemic gaps, they should also be held to account for whose voices they amplify and whose interests they serve (Holmes & Cavanagh, 2016; Massé, 2019). Critical questions remain about equity, representation, and legitimacy, especially in externally funded or top-down interventions (Ojeda, 2012; Redford et al., 2013). As illustrated by the trajectory of Zimbabwe's CAMPFIRE programme, early successes in devolving wildlife governance to communities were later eroded by political interference and elite capture, underscoring the importance of accountability and community oversight (Balint & Mashinya, 2006; Murombedzi, 1999). In contexts like Kasungu, where trust in conservation actors is uneven and historical grievances persist, intermediaries must be reflexive, locally grounded, and responsive to changing needs and power dynamics.

In sum, this thesis contributes a grounded, multi-level understanding of the agriculture-biodiversity nexus, demonstrating that effective action requires locally grounded, power-aware, and participatory processes. Without these, even the most well-intentioned interventions risk reinforcing existing inequalities, undermining biodiversity goals, and alienating the very communities whose cooperation is essential for long-term success.

7.3 Potential future research directions

This thesis has generated a range of findings with both site-specific implications for Kasungu and broader relevance for conservation in shared landscapes. Building on this foundation, several priority areas emerge for future research, particularly those that explore the long-term consequences of interventions, better integrate climate and land use dynamics, and deepen understanding on local governance and equity. Table ***7.1*** outlines key research questions that could guide a future research programme, whether through large scale funding or distributed student-led projects, in Kasungu and beyond.

Table 7.1: A proposed research agenda based on the findings and gaps identified in this thesis. The questions outlined here aim to guide future work that supports people-centred, adaptive, and interdisciplinary conservation in dynamic landscapes like Kasungu and beyond.

Thematic Area	Research question	Justification	Potential site/approaches
Human-wildlife relations	What is the long-term socio-ecological impacts of electrified fencing on human wildlife relations, mobility and safety?	The fence in Kasungu is a major intervention with ongoing implications for conflict, connectivity, and trust.	Kasungu; longitudinal mixed methods; participatory evaluation.
Climate change	How are shifting climate patterns affecting crop reliability, resource use, wildlife movements, and adaptation strategies?	Climate change was a cross-cutting but under-quantified pressure in this thesis; deserves deeper integration.	Regional studies using climate models, local perception surveys
Biodiversity and hunting	What are the spatial, ecological, and social drivers of hunting pressure, and how does it affect different species across seasons?	Hunting is widely acknowledged but poorly quantified; therefore, vital for understanding pressures, actors and consequences	Comparative study across protected area buffers; quantitative surveys and ecological monitoring
Agriculture and land use	How do smallholder and commercial agriculture interact in frontier landscapes, and what are the impacts	The expansion and intensification of agriculture poses growing pressures on land rights and conservation.	Southern Africa; remote sensing, land tenure analysis

	on land tenure, food security, and biodiversity?		
Sustainable livelihoods and intensification	What sustainable intensification options are locally acceptable and ecologically viable in shared landscapes?	Alternatives to expansion are urgently needed but context-specific; requires testing.	Farmer-led field trials; ecological monitoring; participatory design
Governance and equity	What forms of community-led governance promote equitable conservation outcomes, and under what conditions?	Scalable governance and innovation that supports equity and accountability are necessary for long-term conservation and social outcomes	Comparative governance case studies in different cultural/policy contexts
Cross-scale conservation planning	How can local conservation needs and knowledge be better integrated into national and global targets?	Current conservation agendas risk reinforcing exclusion; need for mechanisms of translation and accountability.	Policy analysis; co-design workshops with policymakers and communities

Together, these proposed questions reflect an ambitious but necessary shift toward more adaptive, inclusive and context sensitive research. By centring local voices, addressing emerging pressures such as climate change, and integrating socio-ecological dynamics across scales, while remaining responsive to local realities, this agenda point to the opportunities for deepened understanding and tackling unresolved challenges in conservation and development. Advancing this agenda will require coordinated, interdisciplinary inquiry that connects site-specific insights with cross-regional perspectives, ensuring that future conservation efforts are informed by robust evidence and grounded in both ecological and social priorities. By pursuing these questions, future conservation practice can move toward approaches that genuinely serve both people and nature particularly in Kasungu and similar landscapes.

7.4 Conceptualising the agriculture-biodiversity conservation nexus in Malawi

Reconciling biodiversity conservation with agricultural development presents a persistent challenge in contexts like Malawi, where rural livelihoods are closely tied to natural resource use and pressures on land and ecosystems continue to intensify (Jouzi et al., 2023; Chapter 4). Drawing on empirical insights from this study, I developed a conceptual framework (Figure 7.1) to organise the key interrelated factors necessary for addressing the agriculture-biodiversity challenge. The framework consists of four interconnected domains: Foundational conditions, key actors and institutions, processes and mechanisms, and supporting factors. Together, these shape the integration of agriculture and biodiversity as dual outcomes, and provide an agenda for future research on this topic

At the core of the framework lie the two interdependent goals: First, agriculture, as evidenced throughout Chapters 1 to 6, is a key driver of land use change and fundamental to economic livelihoods in Malawi. However, this study has highlighted that agricultural systems must transition towards sustainability because current practices, particularly low-input, land-extensive methods, are resulting in deforestation, soil degradation, and encroachment into conservation areas. Chapters 3 to 5 revealed widespread use of protected natural resources for firewood and cultivation, driven in part by declining yields and limited access to farm inputs. Moreover, biodiversity modelling (Chapter 6) showed that intensifying agriculture through fertiliser subsidies alone would accelerate habitat loss in the landscape. These empirical findings demonstrate the need for agricultural systems that balance productivity with environmental sustainability through agroecological practices, climate-resilient inputs, and investments in soil fertility management.

Second, biodiversity and the conservation of ecosystems are the foundation of the ecosystem services (e.g., pollination, soil regulation, climate stability) that agriculture and other land uses depends upon (Chapman et al., 2022). Yet in Kasungu, conservation goals can conflict with human safety and livelihoods, as the 2022 elephant translocation highlighted. This tension between international biodiversity targets (e.g. species recovery) and local development needs (e.g., food security, safety) illustrates the need for reconciling global ambitions with community priorities through participatory, negotiated planning (Vittis et al., 2021; Wells et al., 2024).

Foundational conditions such as land tenure and political economy also shape these tensions. As discussed in Chapters 2, 3, and 4, Malawi's predominantly customary land tenure system often lacks formal recognition. This discourages long-term conservation investments and creates uncertainty about who can access or make decisions about land. Additionally, power asymmetries in subsidy and conservation resource allocation are evident in Kasungu. For example, residents in better-connected villages, closer to roads or with stronger political links, are more likely to receive fertiliser subsidies, while more remote communities are largely excluded. This has contributed to perceptions of unfairness, mistrust in institutions, and increased informal forest use (Feyertag et al., 2021; Holden & Otsuka, 2014; Walls & Matita, 2023). Addressing these inequalities between communities and state authorities is essential for inclusive and just conservation outcomes.

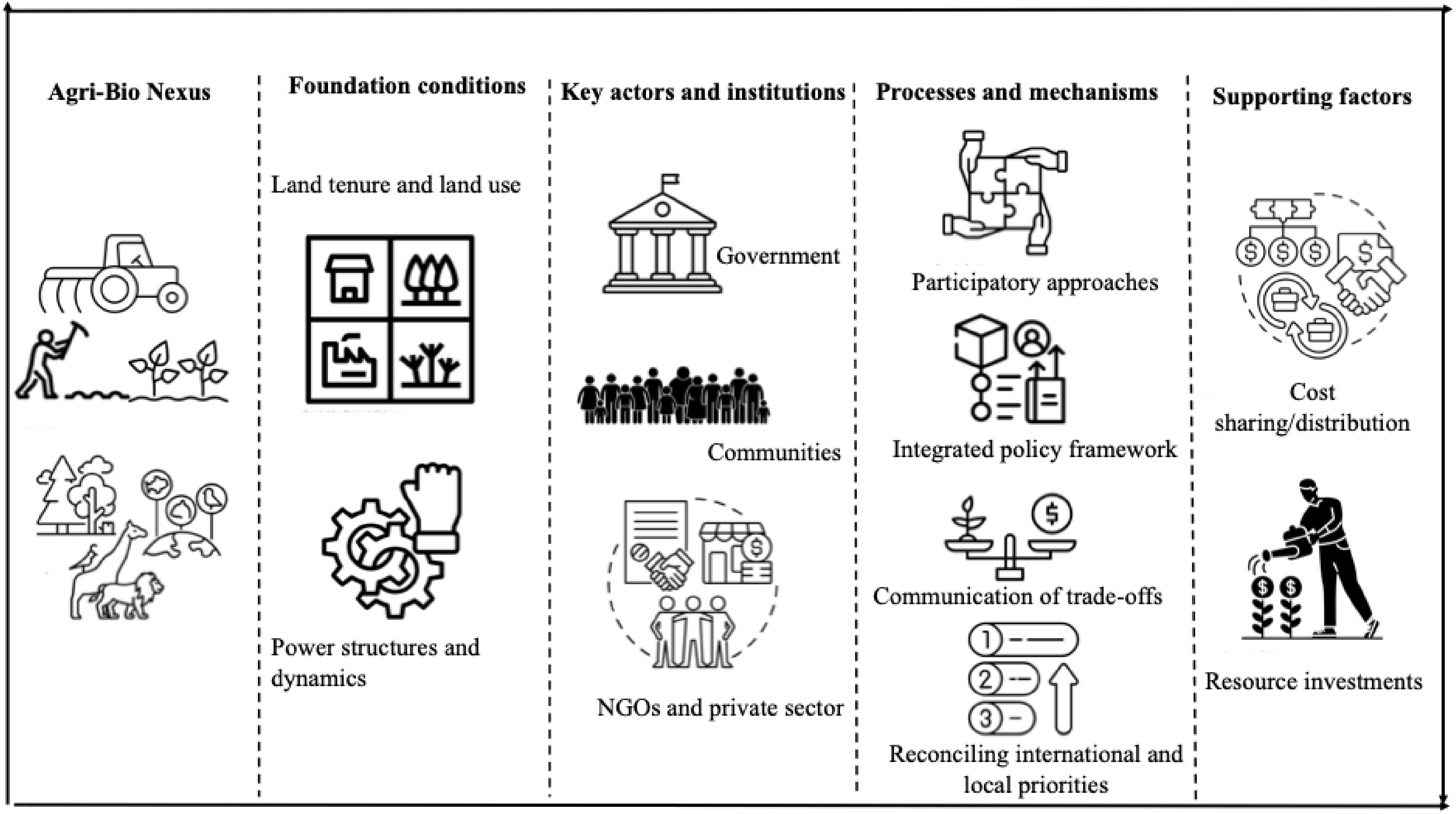

Figure 7.1: Conceptualised framework for reconciling agriculture and biodiversity conservation in Malawi.

Actors and institutions, including national and local governments, NGOs, traditional authorities, private sector actors, and community-based organisations, could play a central role in shaping outcomes. Their coordination, capacity, and responsiveness determine whether policies are effectively implemented and socially supported (Cramer et al., 2018; Fischer et al., 2017). Local perspectives are equally critical. Interviews and focus groups (Chapters 3 and 5) showed that while many residents value biodiversity, their daily decisions are governed by immediate livelihood needs and perceived risks. This reinforces the need for policies grounded in local realities, which acknowledge diverse priorities, particularly in areas like Kasungu where land scarcity, conflict, and conservation infrastructure (e.g., the wildlife fence) intersect with community wellbeing (Fedele et al., 2021; L'Roe et al., 2023; Meyer & Börner, 2022).

The third component of the framework focuses on processes and mechanisms, which are the operational strategies that translate institutions into action. Findings from this study (Chapters 5 and 6) support participatory governance as essential to effective reconciliation. Inclusive decision-making fosters legitimacy and local ownership of interventions (Crespin et al., 2023; Dawson et al., 2024). At the same time, sectoral coordination is vital: misaligned policies between conservation and agriculture can create implementation gaps or competing mandates. Scenario analysis showed that policies perceived as fair or beneficial in one area or to one group of people (e.g., input subsidies) could lead to unintended consequences elsewhere (e.g., biodiversity loss), underscoring the need for transparent dialogue on trade-offs (Kiesecker et al., 2009; Shackelford et al., 2015). A further challenge lies in balancing global environmental commitments (e.g., CBD, SDGs) with local development goals. As Chapters 3, 5, and 6 illustrate, these often diverge in practice due to limited capacity and mismatched priorities.

Adaptive governance is needed to bridge these scales and support locally meaningful conservation (Wells et al., 2024).

Finally, supporting elements are critical to sustaining transformation. As shown in Chapter 3, conservation in Kasungu often imposes costs on communities without delivering clear or equitable benefits. Where resource access is restricted, it can fuel resentment and undermine conservation efforts. Mechanisms for more equitable benefit and cost sharing are essential for long-term support (Beyene et al., 2020; C. M. Shackleton & Shackleton, 2006). These could include wildlife damage compensation schemes, ecosystem service payments, subsidised extension for agroecology, or benefit-sharing from tourism revenues. Sustainable transformation will also require long-term investments: financial (e.g., targeted subsidies, insurance), institutional (e.g., community-based governance structures), and technical (e.g., monitoring systems, conflict mitigation) (Angelsen et al., 2014; Börner et al., 2015; Fedele et al., 2021; Merz et al., 2023).

In summary, this conceptual framework shows that reconciling agriculture and biodiversity in Malawi is not simply a matter of balancing ecological and economic objectives; it is a multi-layered socio-political challenge. The evidence across Chapters 3 to 6 reinforces the need to align foundational conditions, build inclusive and accountable institutions, strengthen local mechanisms, and mobilise long-term support. Only through the integrated coordination of these domains, tailored to local context but responsive to national and global priorities, can Malawi move toward resilient, inclusive, and sustainable outcomes for both people and nature.

7.5 Conclusion

This DPhil has explored the complex and dynamic interconnections between agriculture and biodiversity conservation in Kasungu, Malawi. The research has shown that reconciling agricultural production and biodiversity conservation requires close collaboration between conservationists and farmers, grounded in interdisciplinary approaches that generate context-specific, actionable strategies. One-size-fits-all solutions are insufficient; instead, tailored interventions that reflect local realities and community priorities are essential. Sustained monitoring of socio-ecological systems can help manage trade-offs and identify synergies, while participatory research and knowledge co-production must inform every planning and implementation stage. While agricultural expansion should not be pursued at the cost of long-term ecosystem destruction, conservation should as well not disproportionately burden the most vulnerable. Equitable distribution of costs and benefits and meaningful community participation are vital. This research offers insights into how these dynamics unfold within a shared landscape, demonstrating the necessity of inclusive governance, adequate financial investment, and robust institutional frameworks to achieve ecological and social outcomes. Strengthening food systems while conserving ecosystems will be central to building sustainable and resilient landscapes in Malawi and sub-Saharan Africa. Although this DPhil provides a case-specific snapshot, its findings can inform broader efforts to meet global conservation targets while promoting justice, sustainability, and improved livelihoods in resource-dependent communities.

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Appendices

Appendix A: Supporting information for Chapter 3

A1: Individual Questionnaire

Introduction

Hi, my name is Lessah Mandoloma. I am an independent research student at Oxford University in England, and we are looking at how people interact with nature in their day to day lives and how these interactions influence livelihoods. I would like to invite you to participate in this survey which will take about 1 hour. What is said during this meeting is private so please do not share the information with anyone else. I will make sure that your answers are kept anonymous, and we will not share them with other members of the community, the local authorities or any other authorities. If you have any questions, please feel free to ask. If you have a concern about any aspect of this project, please speak to me and I will do my best to answer your query. If you remain unhappy or wish to make a formal complaint, I can give you the contact details of the Research Ethics Committee at the University of Oxford. Is this, ok? (Get agreement from everyone – nodding is fine) Do you have any questions or concerns so far? (Pause here to give people enough time to think and comment) Would you like to continue with the meeting? (Get consent from every participant). Would you mind if we take photos and audio record this meeting so that we can make sure that we don't miss anything important that you tell us? (Get consent as well).

Section 1: Demographic information

	QUESTION	RESPONSE
1.1	General information	
1.1.1	Village Name	
1.1.2	Sex of respondent	1= Male 2= Female
1.1.2	Location (in-built GPS) [NOTE] Wait for "Using GPS. Accuracy is…" to appear, then click "Save GeoPoint".	……………………
1.1.3	Ethnic group	Chewa Tumbuka Others Don't know
1.1.4	How old are you?	

	[NOTE] The respondent must between 18 and 60.	_______yrs Don’t know Refused
1.1.5	Where did you stop in your education?	No education Started primary Finished primary Started secondary Finished secondary Tertiary
1.1.6	What is your marital status?	Single Married and living with spouse Married and not living with spouse Divorced or separated Widowed/widower
1.1.7	How long have you lived in this area (years)	Less than 10 years 10-20 years More than 20 years Don't know
1.1.8	What is the main source of income in your household?	Farming (crops &livestock) Farming (crops only) Agro-trader (middleman) Business Casual work Remittances Other (please specify) ________________ Don’t Know
1.1.9	In the last 12 months, did your household engage in the following activities for income?	Seasonal farming Casual work Business Others (please specify)
1.1.10	How many people including yourself live in your household?	

Section 2: Socio-economic status

	QUESTION	RESPONSE
2.1	I am now going to read to you some things. For each thing I am going to read to you, I would like you to tell me if your household has it. Does your household have…?	

		Yes	No
2.1.1	Television		
2.1.2	Having one or multiple livestock (goats, cows, pigs, chickens)		
2.1.3	Electricity		
2.1.4	A solar panel		
2.1.5	Brick walls for your house		
2.1.6	A motorbike		
2.1.7	A bicycle		
2.1.8	Iron sheets on your roof		
2.1.9	A radio		
2.1.10	A basic mobile phone		
2.1.11	A car		
2.1.12	Improved stove		
2.1.13	A cemented floor		
2.1.14	Mattress		
2.1.15	Sofa		
2.1.16	Table		
2.1.17	Chairs		
2.1.18	A smart phone		

Section 3: Farming activities and land use

3.1.1	Thinking about your farmland, how much land does your household have? Count all the land you own and rent together. (In plots, or acres or hectares) [NOTE] Put 98 if does not know. One and a half is 1.5, a half is 0.5, a third is 0.33, and quarter is 0.25. (4 plots = 1 acre & 2 and ½ acre = 1 hectare).	
3.1.2	How much of that land do you farm? (Estimations)	
3.1.3	Where is your farm? (Estimate the distance from the farm to the house)	Within a kilometre more than 1 kilometre but less than 2

		More than 2 but less than 5km More than 5km
3.1.4a	Do you rent in or out some proportion of your farmland Rent in	Yes No
3.1.4b	Rent out	Yes No
3.1.5a	What proportion do you rent out and at what price?	
3.1.5b	What proportion do you rent in and at what price?	
3.1.6	How much/proportion of that land did you farm in the last farming season (2021-2022)? Estimation	
3.1.7	when did you start cultivating your plot	
3.1.8	what was there before?	Forest Grassland Someone else crop farm Don't know Other (Specify)
3.1.9	What crops did you farm in the last farming season?	Maize Tobacco Soy bean Sunflower Cassava Potatoes Groundnuts Others Please specify Others
3.1.10 a	Do you have trees on your farm?	Yes No
3.1.10 b	If you have, are they planted or regenerated	Yes No Both
3.1.11	What type of trees do you have?	

3.1.12	Of what purpose do they serve?	Increase fertility Local medicine Shelter Firewood Fruits Don't know Others
3.1.13	What agricultural practices/system do you practice	Monocropping Mixed cropping Agroforestry Crop rotation Others Don't know
3.1.14 a	Have you always used that system	Yes No
3.1.14 b	If no, why did you change?	
3.1.15	Are you planning to expand your farmland?	Yes No Don't know
3.1.16	Where are you planning to expand?	Forest Another village Rent from another person Don't know Please specify other
3.1.17	For each crop that you farmed during the last season (2021-2022), can you please tell me how much you produced, sold and earned Crop Details Type of crop Total amount produced (Kgs) Total amount kept for household use (kgs) Total amount sold (kgs) Income earned (malawi kwacha)	

3.2	Perception of land holding size We would like to hear how you feel about some sayings. These sayings are going to be read to you. We would like you to tell us if you agree or disagree with these sayings using the answers given.	
3.2.1	Your household's farm is bigger than most others in this community. Do you agree, you disagree, or you are in the middle?	Agree In the middle Disagree Don't Know Refused
3.2.2	Your household's farm is big enough for you to get the things you need, like food, school fees, or medicine. Do you agree, you disagree, or you are in the middle? Do you agree, you disagree, or you are in the middle?	Agree In the middle Disagree Don't Know Refused
3.2.3	Your household struggles because you do not have enough land. Do you agree, you disagree, or you are in the middle?	Agree In the middle Disagree Don't Know Refused
3.2.4	Your household's farm is smaller than most others in this community. Do you agree, you disagree, or you are in the middle?	Agree In the middle Disagree Don't Know Refused

Section 4: Food Insecurity Experience Scale (FIES)

	QUESTION	RESPONSE
4.0	Now I would like to ask you some questions about food and your experience.	

4.1.1	During the last 12 months, was there a time when you or others in your household worried about not having enough food to eat?	Yes No Don't Know/remember Refused
4.1.2	Still thinking about the last 12 months, was there a time when you or others in your household were unable to eat healthy and nutritious food?	Yes No Don't Know Refused
4.1.3	Was there a time when you ate only a few kinds of food because of a lack of money or other resources?	Yes No Don't Know Refused
4.1.4	Was there a time when you or others in your household had to skip a meal because there was not enough money or other resources to get food?	Yes No Don't Know Refused
4.1.5	Still in the 12 months, was there a time when you or others in your household ate less than you thought you should?	Yes No Don't Know Refused
4.1.6	Was there a time when your household ran out of food?	Yes No Don't Know Refused
4.1.7	Still in the 12 months. was there a time when you were hungry but did not eat because there was enough money or other resources for food?	Yes No Don't Know Refused
4.1.8	Still in the 12 months. was there a time when you went without eating for the whole day?	Yes No Don't Know Refused

4.1.9	Can you tell me the exact months in which you did not have enough food to meet your household needs?	
4.1.10	If you were not to run out of food in your household, how much bags would you require to harvest/have?	

Section 5: Crop and Livestock losses

	QUESTION	RESPONSE
5.1.1	Was 2021-2022 a normal year in terms of your farming or not Yes No Don't know	
5.1.2	If not, why?	
5.1.3	Did you experience any challenges with the crops that you farmed in the last 2021-2022 farming season?	Yes No Dont remember Don't know
5.1.4	What challenges did you face?	Marketing/Prices Inputs like fertilizer Drought Theft Diseases Wildlife Late onset of rains Early offset of rains Dry spells Please specify others
5.1.5	Did you experience any challenges that led to crop losses?	Yes No Don't know

5.1.6	For the crops that you farmed in the last season, can you tell me again how much you harvested? and how much you lost? How many bags harvested Proportion of loss due to Diseases Proportion of loss due to Drought Proportion of loss due to Theft Proportion of loss due to Wildlife Proportion of loss due to other reasons	
5.1.7	How did this affect your livelihood	Changed Jobs Ganyu/sold labour Sold possessions Went into debt Remittances Job diversification Others
5.1.8	Are there ways to avoid this?	Yes No Don't Know
5.1.9	What ways do you use?	Change Crops Change farm location Paid guards/protectors Stay on farm during farm season Others
5.2	Now I will ask you some questions about all the livestock in your family and mortality what livestock do you have/own?	Goats Sheep Cows Pigs Chicken Guinea Fowl None Others

5.2.1	In the last 12 months did you own any livestock?	Yes No Don't know
5.2.2	How many of each livestock did you own? Livestock ownership details Livestock Name How many?	
5.2.3	Over the last 12 months, did you have any challenges with your livestock?	Yes No Don't know Don't remember
5.2.4	What challenges did you have?	Diseases Theft Wildlife Drought Others
5.2.5a	Over the last 12 months, did you lose any livestock? Livestock details Livestock name Number of losses	Yes No Don’t know
5.2.5b	Reason for the loss	Diseases Theft Wildlife Drought Others Not applicable
5.2.6	How did this affect your livelihood?	
5.2.7	Are there any ways to avoid these losses?	Yes No Don’t know
5.2.8	What ways do you use?	What ways do you use it? Pay for guards/protectors.

		Build strong animal houses. There is no way to avoid this.

Section 6: Natural Resource Use

	QUESTION	RESPONSE
6.1.1	Now I will ask you questions regarding the natural products that you collect off- the farm Do you collect natural resources off-farm? Yes No Refused Don't know	
6.1.2	What things does your household get from the park	Firewood Fruits Mushrooms Meat Mopane worms Others Nothing Refused to say
6.1.3	Do you use them for selling or domestic purposes? Or both Type of product Usage Selling Domestic use Both	
6.1.4	How often did you do that in the last 12 months?	1 to 4 times 5 to 10 times More than ten times Throughout the year

Section 7: People's attitudes and perceptions of wildlife and conservation

	QUESTION	RESPONSE
7	I would like to ask you to tell me the extent to which you agree with the following sentences	
7.1.1	I would be happier if there were no wildlife at all	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.2	It would be nice to see animals more often	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.3	It would be nice to go and see animals in the national park	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.4	Wildlife should be conserved and protected	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.5	Wildlife if a threat to human life	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.6	Wildlife is a threat to livestock	Strongly disagree Disagree Neither agree nor disagree Agree

		Strongly agree
7.1.7	Wildlife is a threat to crop produce	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.8	I would like wildlife to increase in numbers	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.9	I am not interested in knowing anything about wildlife	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.10	I am happy that i live close to the national park	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.11	A solution to the problem of human-animal conflicts needs to be found	Strongly disagree Disagree Neither agree nor disagree Agree Strongly agree
7.1.12	Wildlife predation on livestock is a problem that local authorities should adress	Strongly disagree Disagree Neither agree nor disagree Agree Strongly disagree
7.1.13	Human-wildlife conflict is a problem for each community to solve on its own	Strongly disagree Disagree

		Neither agree nor disagree Agree Strongly disagree
7.1.14	I would like to receive help in solving the wildlife depredation issues	Strongly disagree Disagree Neither agree nor disagree Agree Strongly disagree
7.1.15	The existing laws are useful in protecting wildlife	Strongly disagree Disagree Neither agree nor disagree Agree Strongly disagree
7.2.1	Finally, I would like to ask about your participation in village natural resources committee (VNRC) Are you a member of Village Natural Resource Committee (VNRC)?	Yes No Don't know
7.2.2a	Do any member of your household participate in VNRC activities?	Yes No Don't know
7.2.2b	If yes, which household member	Spouse Children Parents Other
7.2.3	If not a member, why not?	

Thank you very much for taking the time to respond to the questions. Please let us know if there are any questions or issues that you may want to raise regarding the questionnaire.

A2: Resource Use Models Diagnostics: Goodness-of-fit test

We used McFadden pseudo R-squared value to get insights into the good ness of fit for the resource use models (firewood, grass and fruits). McFadden's framework:

$$R^2 = 1 - \frac{log - likelihood\ of\ full\ model}{log - likelihood\ of\ null\ model}$$

Firewood model

R-squared value of 0.57 indicated that approximately 57% of the variability in the dependent variable (Fuelwood collection) is explained by the model. This suggests a reasonably good fit for the logistic model, as McFadden pseudo R-squared values between 0.2 and 0.4 are often considered to represent an excellent fit for categorical or ordinal regression models (McFadden, 1974).

Grass collection model

The R-squared value of 0.71, suggests that the model explains about 70% of the variability in the data. This suggests a great fit for the model.

Fruit collection model

The R-squared value of 0.397, indicated that the model explains approximately 40% of the variability in the response variable. While not as high, this value still reflects a moderate level of explanatory power since a value of around 0.4 suggests that the model captures some meaningful patterns in the data.

A3: Linear regression models for positive perceptions towards wildlife and conservation

Positive perceptions linear regression models												
	Perceptions full model						Perceptions_best_fit_model					
Variables	Estimate	Conf.level	Conf.low	Conf.high	P.value	Significance	Estimate	Conf.level	Conf.low	Conf.high	P.value	Significance
Age	-0.002	0.950	-0.005	0.001	0.189							
Gender Male	0.094	0.950	0.019	0.170	0.013	*	0.094	0.950	0.022	0.165	0.010	*
Education Primary	-0.068	0.950	-0.218	0.078	0.363							
Education Secondary	-0.072	0.950	-0.246	0.100	0.411							
Location Close	-0.185	0.950	-0.261	-0.109	0.000	***	-0.181	0.950	-0.253	-0.109	0.000	***
Fence Unfenced	-0.037	0.950	-0.113	0.040	0.344							
HH_size	0.005	0.950	-0.010	0.020	0.558							
Farm_size Medium	0.056	0.950	-0.159	0.261	0.603							
Farm_size Small	0.099	0.950	-0.108	0.296	0.336							
Maize_loss	-0.142	0.950	-0.269	-0.015	0.027	*	-0.124	0.950	-0.242	-0.007	0.037	*
Soybeans_loss	0.025	0.950	-0.109	0.160	0.719							
Gnuts_loss	0.028	0.950	-0.109	0.165	0.687							
Livestock_loss	-0.037	0.950	-0.094	0.021	0.206		-0.042	0.950	-0.095	0.012	0.121	

Livestock_owned	-0.013	0.950	-0.060	0.035	0.599							
Resource_use	0.025	0.950	-0.008	0.059	0.131		0.025	0.950	-0.005	0.055	0.105	
Wealthindex	0.000	0.950	0.000	0.000	0.477							
Food_insecurity	-0.016	0.950	-0.028	-0.004	0.012	*	-0.015	0.950	-0.027	-0.004	0.011	*

A4: AIC for the positive perception models

Positive perceptions model selection based on AIC						
Models	K	AICc	Delta_AICc	AICcWt	Cum.Wt	LL
Positive Perceptions (best fit)	8.00	472.97	0.00	1	1	-228.16
Positive Perceptions (full model)	19.00	490.76	17.79	0.00	1.00	-224.58

Lower AIC value indicates better model fit with fewer predictions

Appendix B: Supporting information for Chapter 4

B1: Selected Land policy reforms in Malawi and associated implications on Kinship systems

Policy/Reform	Description	Implications
Registration of family holding	Described in Malawi's land policy 2002 and the land act, 2016. These reforms are aimed to allow small holder farmers to get a legal title to their land and therefore be protected from encroachments and other interests.	Assuming the land title will be registered in the name of household head (male for those married) which is the normal practice, then the question will be whether the matrilineal kinsmen will allow a person they consider a 'stranger' since they come from other villages to become titleholder on land, they consider their heritage (Chikaya-Banda and chilonga 2021; Berge et al., 2014; Kinshindo, 2004). Another issue is whether, on the death of a wife, a resident man who is the titleholder, will be allowed to remarry and bring the new wife into the village where he is resident (Phiri et al 2022; Kishindo, 2004).
Formal registration of customary land	Described in the land policy, 2002 and the customary land act, 2016. This provided conditions for decentralisation of land management at regional level involving locally established customary land committees.	This presents political implications since most traditional authorities would rarely support this change as they will no longer have exclusive authority for allocation of land to the members of their communities (Chikaya-Banda and chilonga 2021; Berge at al., 2014). The success of this reform heavily depends on the strength and influence of that committee as well as support from the head chiefs (Kishindo, 2004).

All children inherit land and any other property belonging to the parents equally	Described in the land policy, 2002 and the land act, 2016.	While this removes the existing inequalities experienced by the children, there remain an issue of cultural acceptability and could cause resentment among those who benefit from the status quo (Harris et al., 2020; Berge et al., 2024; Kishindo, 2004).

B2: Interview guide for key informant

[Actors]: Tell me about the people that live in this area?

- History of the community and people within it
- Kinship systems practiced in the communities
- How things have changed in the last 5 years regarding kinship systems and resource use
- Who has been affected by these changes and how
- What gendered dynamics influence land use in the community?
- [Resource systems]: Tell me about the important places in and around the community?
- Important places
- Important resources
- Access to areas/resources
- How do people use nature?
- Seasonality of resources over time

[Resource units]: What are the most important resources in your daily lives?

- Resources
- Location of resources
- State of resources
- Changes over time
- [Interactions and Outcomes]: What do people do in the area?
- Livelihoods
- Spiritual and cultural
- Information sharing
- Conflicts
- Land use

[Governance systems]: How are decisions made about the community, land use, and environment?

- Laws and rules
- Governance organizations
- Access and property rights
- Informal and formal decision making

[Related ecosystems]: Changes in the wider community?

- Climate change
- Agriculture production
- Use of resources

B3: Focus group discussion guide

- Describe your kinship systems. How does it work and what are the rules?
- Has it always been this way? If not how and when did it change
- What resources are regarded as important by men, women and both?
- What changes have been happening regarding the use of natural resources in the last five years? (both positive and negative changes)
- What do you think is the reason for the changes?
- How have these changes affected your lives/wellbeing? And different groups of people
- How are you dealing or plan to deal with the changes in your communities?
- What things from nature are used for daily lives of households in this village.
- Where do people in this village go to access these things?
- How does the kinship system influence how women/men can make decisions on land and natural resources use.
- What are the good and bad aspects of this system for you?

Appendix C: Supporting information for Chapter 5

C1: Scenarios through focus group discussions and key informant interviews

BAU exploration:

- What trends have you/community experienced in the last five years regarding the following:
- Climate Change
- Livelihoods
- Food security
- Income
- Natural resource use
- Relationship to the park
- How have the changes affected you/community? (Your livelihoods, income, household roles, food security, etc
- What changes do you expect to experience in the next 5 years regarding these trends? (Climate change, livelihoods, food security, income, natural resource use, relationship to the park?).
- How would you respond to these changes? Or (how is your behaviour going to change in response to the changes?) (In climate, livelihoods. Food security-agric practices/diet, income, natural resource use, relationship to the park)
- How will your livelihood be affected?
- Why would you make these changes?
- How have these things affected the entire community? (Livelihoods, gender roles, land use, food security, income, etc.)

C2: List of future scenarios

1. Farm inputs: Imagine that all the trends you have just mentioned will happen over the next five years, and fertiliser prices will increase by 100% (from 86,000 to 172,000).
2. Universal subsidy: Imagine that all the trends in climate change, livelihoods, and agriculture production continue. On top of this, there is a universal subsidy programme where every farmer will have access to subsidised fertiliser.
3. Buffer zone: Imagine that all the trends (climate change, food security, livelihoods, and agricultural production) continue in the next five years. On top of this, there is a plan/programme to restore the buffer zone.
4. Translocation: Imagine that all the trends (climate change, food security, livelihoods, and agricultural production) continue in the next five years. On top of these, 250 elephants (like last time) have been translocated into Kasungu National Park.

5. Compensation: Imagine that, with all these trends in place, there is an initiative to ensure that people are compensated for the loss and damage caused by wildlife.

C3: Household questionnaire

Introduction

Hi, my name is Lessah. I am an independent researcher, and we are looking at the likely future changes regarding your livelihoods and well-being and how you will respond to the changes. I would like to invite you to participate in this survey, which will take about 1 hour. What is said during this meeting is private, so please do not share the information with anyone else. I will ensure that your answers are kept anonymous, and we will not share them with other members of the community, the local authorities or any other authorities. If you have any questions, please feel free to ask. If you are concerned about any aspect of this project, please speak to me, and I will do my best to answer your query. If you remain unhappy or wish to make a formal complaint, I can give you the contact details of the Research Ethics Committee at the University of Oxford. Is this, ok? (Get agreement from everyone – nodding is fine) Do you have any questions or concerns so far? (Pause here to give people enough time to think and comment) Would you like to continue with the meeting? (Get consent from every participant). Would you mind if we took photos and audio recorded this meeting to ensure we didn't miss anything important that you told us? (Get consent as well).

Section 1: Demographic information

	QUESTION	RESPONSE
1.1	Respondent ID	
1.1.1	Group Village Name (GVH)	Kansichi Kapatuka Mpata Mndaka Kavika Kashereka Mitawa Chidula Nkhuzikuzi
1.1.2	Sex of respondent	Male Female
1.1.2a	Location (in-built GPS)	……………………

	[NOTE] Wait for "Using GPS. Accuracy is…" to appear, then click "Save GeoPoint".	
1.1.2b	Location in relation to park boundary	Close/buffer zone (0-5km) Away/non buffer zone(5-15km))
1.1.2c	Location in relation to fence	Fence side Unfenced side
1.1.3	Ethnic group	Chewa Tumbuka Others Don't know
1.1.4	How old are you? [NOTE] The respondent must between 18 and 60.	________yrs Don't know Refused
1.1.5	Where did you stop in your education?	No education Primary Secondary Tertiary
1.1.6	What is your marital status?	Single Married and living with spouse Married and not living with spouse Divorced or separated Widowed/widower
1.1.7	How long have you lived in this area (years)	Less than 10 years 10-20 years More than 20 years Don't know
1.1.8	What is the main source of income in your household?	Farming Business Casual work Remittances Other (please specify) _________________

1.1.9	How many people including yourself live in your household?	
1.1.10	Thinking about your farmland, how much land does your household have? Count all the land you own and rent together. (In plots, or acres or hectares) [NOTE] Put 98 if does not know. One and a half is 1.5, a half is 0.5, a third is 0.33, and quarter is 0.25. (4 plots = 1 acre & 2 and ½ acre = 1 hectare).	
1.1.11	How much/proportion of that land did you farm in the last farming season (2022-2023)? Estimation	

Section 2: Socio-economic status

	QUESTION	RESPONSE	
2.1	I am now going to read to you some things. For each thing I am going to read to you, I would like you to tell me if your household has it. Does your household have…?		
		Yes	No
2.1.1	Television		
2.1.2	Having one or multiple livestock (goats, cows, pigs, chickens)		
2.1.3	Electricity		
2.1.4	A solar panel		
2.1.5	Brick walls for your house		
2.1.6	A motorbike		
2.1.7	A bicycle		
2.1.8	Iron sheets on your roof		
2.1.9	A radio		
2.1.10	A basic mobile phone		
2.1.11	A car		
2.1.12	Improved stove		
2.1.13	A cemented floor		
2.1.14	Mattress		

2.1.15	Sofa		
2.1.16	Table		
2.1.17	Chairs		
2.1.18	A smart phone		

Section 3: Food Insecurity Experience Scale (FIES)

	QUESTION	RESPONSE
3.0	Now I would like to ask you some questions about food and your experience.	
3.1.1	During the last 12 months, was there a time when you or others in your household worried about not having enough food to eat?	Yes No Don't Know/remember Refused
3.1.2	Still thinking about the last 12 months, was there a time when you or others in your household were unable to eat healthy and nutritious food?	Yes No Don't Know Refused
3.1.3	Was there a time when you ate only a few kinds of food because of a lack of money or other resources?	Yes No Don't Know Refused
3.1.4	Was there a time when you or others in your household had to skip a meal because there was not enough money or other resources to get food?	Yes No Don't Know Refused
3.1.5	Still in the 12 months, was there a time when you or others in your household ate less than you thought you should?	Yes No Don't Know Refused
3.1.6	Was there a time when your household ran out of food?	Yes No Don't Know Refused
3.1.7	Still in the 12 months. was there a time when you were hungry but did not eat because there was enough money or other resources for food?	Yes No Don't Know Refused

3.1.8	Still in the 12 months. was there a time when you went without eating for the whole day?	Yes No Don't Know Refused
3.1.9	Can you tell me the exact months in which you did not have enough food to meet your household needs?	
3.1.10	If you were not to run out of food in your household, how much bags would you require to harvest/have?	

Section 4: Scenarios (BAU exploration)

	QUESTION	RESPONSE
4.0	Now I will ask for understanding and learn about the changes that you have experienced in the last 5 years and how they have affected your well-being	
4.1.1	What trends have you experienced in the last five years regarding the following (multiple responses allowed)	
4.1.1a	Climate Change	Late onset and early offset of rains Too much rains Frequency of dry spells Heat waves New pests and diseases No change Don't know
4.1.1b	Livelihoods	More livelihood options Less livelihood options No change Don't know
4.1.1c	Food security	Increase Same Decrease Don't know
4.1.1d	Income	Increase Same Decrease Don't know

4.1.1e	Natural resource use	Increased use Same use Decreased use Don't know
4.1.1f	Relationship to the park	It has gotten better It has gotten worse Remained the same Don't know
4.1.2	How much better or worse have you been in light of these changes?	Much better-off Better Same Worse Much worse off
4.1.3	What changes do you expect to experience in the next years regarding the trends?	
4.1.3a	Climate Change	Late onset and early offset of rains Too much rains Frequency of dry spells Heat waves New pests and diseases No change Don't know
4.1.3b	Livelihoods	More livelihood options Less livelihood options No change Don't know
4.1.3c	Food security	Increase Same Decrease Don't know
4.1.3d	Income	Increase Same Decrease Don't know
4.1.3e 1	Natural resource use	Increased use Same use

		Decreased use Don't know
4.1.3e 2	How much more or less do you think you will use the natural resources	Much more A little more A little less Much less No use at all
4.1.3f	Relationship to the park	It has gotten better It has gotten worse Remained the same Don't know
4.1.3. g	Other changes (please specify)	
4.1.4	How would you respond to these changes? (Livelihoods, climate, income, natural resource use)	
4.1.4a	Climate change	Change crops to farm Stop farming Plant trees Crop diversification Income diversification Planting early maturing crops Making manure Others (specify)
4.1.4b	Livelihoods	Increase livelihood options Move out of the community Decrease livelihood options Casual work
4.1.4c	Food security	Plant more food on a small land Extend the farm land Eat less food Eat more food
4.1.4e	Natural resource use	Increased use Same use Decreased use Don't know

4.1.4f	Relationship to the park	Much better-off Better Same Worse Much worse off
4.1.5	How much better or worse do you think you will be compared to now	Much better-off Better Same Worse Much worse off
4.1.6	Why would you make these changes?	
4.1.7	How have these changes affected the community in general	Increased crop yield Decreased crop yield Strained relationships with the park
4.1.8a	Do you think the experiences are similar to most households in the community?	Yes No Don't know
4.1.7b	How similar or different do you think the experience are	Very similar Somewhat similar Somewhat different Very different Don't know

Section 5: Future scenarios

Scenario A: Agricultural expansion and intensification (Input prices)

	QUESTION	RESPONSE
5	Now, we will talk about a few change scenarios beyond the trends we have already discussed. Imagine that all the trends you have just mentioned will happen over the next five years, and on top of this, fertilizer prices have increased by 100% (from 86,000 to 172,000).	
5.1.1	How would you respond to these changes	Change crops to farm

		Increase farmland Stop farming Plant trees Use organic manure Crop diversification Income diversification Others (specify)
5.1.2	Why would you make these changes?	
5.1.3	How will this affect your food security?	Will have more food Will have less food No effect Don't know
5.1.4	How much more or less will you use natural resources?	Use much more Somewhat more Somewhat less Much less Same as before (no change)
5.1.5	How better off or worse off do you think you will be with this scenario?	Much better-off Better Same Worse Much worse off
5.1.6	How fair or unfair do think this scenario is?	Very unfair Unfair Neutral Fair Very fair
5.1.7	What is the reason for the answer in (5.1.6)	

Scenario B: Agricultural expansion and intensification (Subsidy programme)

	QUESTION	RESPONSE
6		

	Imagine that all the trends in climate change, livelihoods, and agriculture production continue to happen. On top of this, there is a programme (e.g., Cash transfer) to help vulnerable farmers to afford farm inputs such as fertiliser.	
6.1.1	How would you respond to these changes	Increase farmland Plant more crops Reduce farmland No changes Others (specify)
6.1.2	Why would you make these changes?	
6.1.3	How will this affect your food security?	Will have more food Will have less food No effect Don't know
6.1.4	How much more or less will you use natural resources?	Use much more Somewhat more Somewhat less Much less Same as before (no change)
6.1.5	How better off or worse off do you think you will be in this scenario?	Much better-off Better Same Worse Much worse off
6.1.6	How fair or unfair do think this scenario is?	Very unfair Unfair Neutral Fair Very fair
6.1.7	What is the reason for the answer in (6.1.6)	

Scenario C: Conservation initiative- buffer zone

	QUESTION	RESPONSE
7		

	Imagine that all the trends (climate change, food security, livelihoods and agricultural production) continue to happen in the next five years. On top of this, there is a plan/programme to restore the buffer zone	
7.1.1	How would you respond to these changes	Shift farmlands Increase farming on small land Migrate from the village
7.1.2	Why would you make these changes?	
7.1.3	How will this affect your security?	Will have more food Will have less food No effect Don't know
7.1.4	How will this affect your use of natural resources?	Use much more Somewhat more Somewhat less Much less Same as before (no change)
7.1.5	How much better or worse will your relationship with the park be?	Much better-off Better Same Strained Very strained
7.1.6	How better off or worse off do you think you will be with this scenario?	Much better-off Better Same Worse Much worse off
7.1.7a	How fair or unfair do think this scenario is?	Very unfair Unfair Neutral Fair Very fair
7.1.7b	What is the reason for the answer in (7.1.7a)	

Scenario D: Conservation Initiatives (translocation of wildlife species)

	QUESTION	RESPONSE
8	Imagine that all the trends (climate change, food security, livelihoods and agricultural production) continue to happen in the next five years. On top of these, 250 elephants (like last time) have been translocated into Kasungu National Park.	
8.1.1	How would you respond to these changes	Shift farmlands Increase farmland Change crops for farming Migrate from the village
8.1.2	Why would you make these changes?	
8.1.3	How worse or better off do you think your food security will be?	Much better-off Better Same Worse Much worse off
8.1.4	How much more or less do you think you will use natural resources	Use much more Somewhat more Somewhat less Much less Same as before (no change)
8.1.5	How much better or worse do you think your relations with the park?	Much better-off Better Same Strained Very strained
8.1.6	How better off or worse off do you think you will be with this scenario?	Much better-off Better Same Worse Much worse off
8.1.7a	How fair or unfair do think this scenario is?	Very unfair

		Unfair Neutral Fair Very fair
8.1.7b	What is the reason for the answer in (8.1.7a)	

Section 6: Well-being Questions

	QUESTION	RESPONSE
10	Finally, beyond these scenarios, if a programme/initiative was to be implemented in this area to improve your well-being, what would that be?	
		Compensation for injury/loss due towildlife Government to moderate prices of produce

Thank you very much for taking the time to respond to the questions. Please let us know if there are any questions or issues that you may want to raise regarding the questionnaire.

C4: Food security full model from GLMM

Variables	Estimate	Lower CI	Upper CI	Std. Error	z value	Pr(>|z|)	Sig
RL=No intervention							
Buffer zone	1.03	0.36	1.71	0.35	3.00	0.00	**
Compensation	1.22	0.53	1.90	0.35	3.48	0.00	***
Farm inputs	-1.54	-2.32	-0.77	0.40	-3.90	0.00	***
Translocation	0.30	-0.39	0.99	0.35	0.85	0.40	
Universal subsidy	5.22	4.07	6.38	0.59	8.85	0.00	***
Fence Close	0.61	-0.15	1.38	0.39	1.57	0.12	
Unfenced away	-0.03	-0.76	0.70	0.37	-0.08	0.94	
Unfenced close	0.78	0.04	1.53	0.38	2.06	0.04	*
Gender Male	-0.06	-0.29	0.16	0.12	-0.55	0.58	
Buffer zone: Fenced close	-0.65	-1.63	0.32	0.50	-1.32	0.19	
Compensation: Fenced close	-0.61	-1.58	0.36	0.50	-1.24	0.22	

Farm_inputs:Fenced_close	-1.18	-2.34	-0.03	0.59	-2.00	0.05	*
Translocation:Fenced_close	-0.21	-1.20	0.78	0.50	-0.42	0.68	
Universal_subsidy:Fenced_close	-0.33	-2.04	1.39	0.87	-0.38	0.71	
Bufferzone:Unfenced_away	0.20	-0.73	1.12	0.47	0.42	0.68	
Compensation:Unfenced_away	-0.07	-1.02	0.87	0.48	-0.15	0.88	
Farm_inputs:Unfenced_away	-0.64	-1.79	0.51	0.59	-1.09	0.28	
Translocation:Unfenced_away	-0.49	-1.44	0.46	0.49	-1.01	0.31	
Universal_subsidy:Unfenced_away	20.62	-390.41	431.66	209.72	0.10	0.92	
Bufferzone:Unfenced_close	-2.21	-3.19	-1.24	0.50	-4.45	0.00	***
Compensation:Unfenced_close	-0.97	-1.94	0.00	0.50	-1.95	0.05	.
Farm_inputs:Unfenced_close	-1.42	-2.56	-0.28	0.58	-2.45	0.01	*
Translocation: Unfenced_close	-3.56	-4.73	-2.39	0.60	-5.96	0.00	***
Universal_subsidy:Unfenced_close	-0.35	-2.05	1.35	0.87	-0.40	0.69	

Significant levels are denoted by '.' For very low (0.1), '' for low level (0.05), '**' for intermediate level (0.01), and '***' for high level (0.00). RL=Reference level/baseline factor.*

C5: Resource use model

Variables	Estimate	Lower CI	Upper CI	Std. error	Statistic	Pr(>|z|)	Sig
RL=No intervention							
Bufferzone	-0.10	-0.78	0.59	0.35	-0.27	0.78	
Compensation	-0.32	-1.02	0.37	0.35	-0.92	0.36	
Farm_inputs	-0.39	-1.12	0.33	0.37	-1.07	0.29	
Translocation	0.05	-0.65	0.74	0.36	0.13	0.90	
Universal_subsidy	0.13	-0.61	0.86	0.37	0.34	0.73	
Fenced_close	0.52	-0.23	1.27	0.38	1.36	0.17	
Unfenced_away	0.11	-0.62	0.83	0.37	0.29	0.77	

Unfenced_close	1.51	0.82	2.20	0.35	4.30	0.00	***
GenderMale	-0.02	-0.21	0.16	0.09	-0.23	0.82	
Bufferzone:Fenced_close	-0.67	-1.63	0.29	0.49	-1.37	0.17	
Compensation:Fenced_close	-0.36	-1.33	0.61	0.49	-0.73	0.47	
Farm_inputs:Fenced_close	-0.56	-1.57	0.45	0.52	-1.09	0.27	
Translocation:Fenced_close	-0.57	-1.54	0.41	0.50	-1.14	0.25	
Universal_subsidy:Fenced_close	-0.49	-1.51	0.53	0.52	-0.93	0.35	
Bufferzone:Unfenced_away	-0.18	-1.12	0.76	0.48	-0.38	0.71	
Compensation:Unfenced_away	0.05	-0.90	1.00	0.49	0.11	0.91	
Farm_inputs:Unfenced_away	-0.76	-1.74	0.22	0.50	-1.52	0.13	
Translocation:Unfenced_away	-0.31	-1.27	0.65	0.49	-0.64	0.52	
Universal_subsidy:Unfenced_away	0.11	-0.89	1.11	0.51	0.21	0.83	
Bufferzone:Unfenced_close	-1.48	-2.38	-0.57	0.46	-3.18	0.00	**
Compensation:Unfenced_close	-1.57	-2.48	-0.66	0.46	-3.39	0.00	***
Farm_inputs:Unfenced_close	-1.55	-2.50	-0.61	0.48	-3.23	0.00	**
Translocation:Unfenced_close	-2.10	-3.02	-1.18	0.47	-4.47	0.00	***
Universal_subsidy:Unfenced_close	-1.76	-2.72	-0.80	0.49	-3.60	0.00	***

C6: People and Park Relationship Model

Variable	Estimate	Lower CI	Upper CI	Std. error	Statistic	Pr(>|z|)	Sig.
RL=No intervention							
Bufferzone	0.67	-0.10	1.43	0.39	1.72	0.09	.
Compensation	1.43	0.66	2.20	0.39	3.63	0.00	***
Farm_inputs	-0.37	-1.11	0.38	0.38	-0.96	0.34	
Translocation	-0.63	-1.38	0.11	0.38	-1.66	0.10	.

Universal_subsidy	1.75	0.99	2.51	0.39	4.52	0.00	***
Fenced_close	2.34	1.54	3.15	0.41	5.71	0.00	***
Unfenced_away	1.02	0.18	1.86	0.43	2.37	0.02	*
Unfenced_close	-0.86	-1.64	-0.08	0.40	-2.16	0.03	*
Gender:Male	0.13	-0.08	0.35	0.11	1.20	0.23	
Bufferzone:Fenced_close	-2.51	-3.56	-1.46	0.54	-4.68	0.00	***
Compensation:Fenced_close	-1.80	-2.83	-0.77	0.53	-3.42	0.00	***
Farm_inputs:Fenced_close	-2.23	-3.25	-1.20	0.52	-4.26	0.00	***
Translocation:Fenced_close	-1.78	-2.81	-0.74	0.53	-3.37	0.00	***
Universal_subsidy:Fenced_close	-2.11	-3.13	-1.08	0.52	-4.03	0.00	***
Bufferzone:Unfenced_away	-0.67	-1.73	0.40	0.54	-1.22	0.22	
Compensation:Unfenced_away	-1.00	-2.07	0.07	0.55	-1.83	0.07	.
Farm_inputs:Unfenced_away	-1.05	-2.10	-0.01	0.53	-1.97	0.05	*
Translocation:Unfenced_away	-1.12	-2.17	-0.07	0.54	-2.08	0.04	*
Universal_subsidy:Unfenced_away	-1.20	-2.25	-0.14	0.54	-2.22	0.03	*
Bufferzone:Unfenced_close	-0.79	-1.79	0.22	0.51	-1.54	0.12	
Compensation:Unfenced_close	0.94	-0.07	1.95	0.52	1.83	0.07	.
Farm_inputs:Unfenced_close	1.05	0.06	2.04	0.50	2.08	0.04	*
Translocation:Unfenced_close	-0.73	-1.74	0.28	0.52	-1.41	0.16	
Universal_subsidy:Unfenced_close	0.45	-0.55	1.45	0.51	0.89	0.38	

C7: Wellbeing Model

Variable	Estimate	Lower CI	Upper CI	Std. error	Statistic	Pr(>|z|)	Sig.
RL=No intervention							
Bufferzone	-1.23	-1.89	-0.57	0.34	-3.64	0.00	***
Compensation	-0.13	-0.79	0.53	0.34	-0.37	0.71	
Farm_inputs	-3.51	-4.23	-2.80	0.36	-9.65	0.00	***
Translocation	-2.36	-3.03	-1.68	0.34	-6.83	0.00	***
Universal_subsidy	1.35	0.62	2.09	0.37	3.62	0.00	***
Fenced_close	0.65	-0.04	1.34	0.35	1.84	0.07	.
Unfenced_away	0.34	-0.35	1.03	0.35	0.97	0.33	
Unfenced_close	0.72	0.05	1.38	0.34	2.12	0.03	*
Gender:Male	0.17	-0.02	0.36	0.10	1.72	0.09	.
Bufferzone:Fenced_close	-0.68	-1.61	0.25	0.47	-1.43	0.15	
Compensation:Fenced_close	-0.45	-1.38	0.47	0.47	-0.96	0.34	
Farm_inputs:Fenced_close	-0.60	-1.57	0.37	0.49	-1.22	0.22	
Translocation:Fenced_close	-0.44	-1.37	0.49	0.48	-0.93	0.35	
Universal_subsidy:Fenced_close	-0.92	-1.93	0.09	0.52	-1.79	0.07	.
Bufferzone:Unfenced_away	0.20	-0.71	1.11	0.46	0.43	0.67	
Compensation:Unfenced_away	-0.88	-1.80	0.04	0.47	-1.87	0.06	.
Farm_inputs:Unfenced_away	-0.42	-1.39	0.54	0.49	-0.86	0.39	
Translocation:Unfenced_away	-0.54	-1.46	0.38	0.47	-1.16	0.25	
Universal_subsidy:Unfenced_away	-0.41	-1.42	0.60	0.52	-0.79	0.43	
Bufferzone:Unfenced_close	-2.03	-2.94	-1.13	0.46	-4.40	0.00	***
Compensation:Unfenced_close	-0.68	-1.58	0.22	0.46	-1.48	0.14	

Farm_inputs:Unfenced_close	-1.47	-2.45	-0.48	0.50	-2.92	0.00	**
Translocation: Unfenced_close	-2.64	-3.60	-1.67	0.49	-5.37	0.00	***
Universal_subsidy:Unfenced_close	0.00	-1.06	1.07	0.54	0.00	1.00	

C8: Fairness model

Variable	Estimate	Lower CI	Upper CI	Std. error	Statistic	Pr(>|z|)	Sig
Gender Male	0.23	-0.02	0.48	0.13	1.82	0.07	.
Age	-0.01	-0.02	0.00	0.00	-2.79	0.01	**
Away unfenced	0.41	-0.18	1.00	0.30	1.35	0.18	
Close fenced	0.23	-0.37	0.83	0.31	0.74	0.46	
Close unfenced	-0.89	-1.47	-0.31	0.30	-3.00	0.00	**
Compensation	1.40	0.78	2.01	0.31	4.46	0.00	***
Farm inputs	-3.89	-4.99	-2.78	0.56	-6.91	0.00	***
Translocation	-1.17	-1.78	-0.57	0.31	-3.80	0.00	***
Universal subsidy	2.46	1.73	3.18	0.37	6.63	0.00	***
Compensation: Away unfenced	0.16	-0.73	1.04	0.45	0.34	0.73	
Compensation: Close fenced	0.68	-0.24	1.61	0.47	1.44	0.15	
Compensation: Close unfenced	0.70	-0.14	1.53	0.43	1.63	0.10	
Farm inputs: Away unfenced	0.09	-1.31	1.50	0.72	0.13	0.90	
Farm inputs: Close fenced	1.00	-0.33	2.33	0.68	1.48	0.14	
Farm inputs: Close unfenced	1.20	-0.20	2.59	0.71	1.68	0.09	.
Translocation: Away unfenced	-0.70	-1.56	0.15	0.44	-1.61	0.11	
Translocation: Close fenced	0.39	-0.46	1.25	0.44	0.90	0.37	
Translocation: Close unfenced	-0.69	-1.61	0.22	0.47	-1.48	0.14	
Universal subsidy: Away unfenced	0.44	-0.70	1.57	0.58	0.75	0.45	

Universal subsidy: Close fenced	0.31	-0.80	1.43	0.57	0.55	0.58	
Universal subsidy: Close unfenced	2.15	0.93	3.38	0.62	3.46	0.00	***

Significant levels are denoted by '.' For very low (0.1), '' for low level (0.05), '**' for intermediate level (0.01), and '***' for high level (0.001).*

C9: Chi-square tests results for differences in strategy uptake by location (n=317) and standardized residuals by location and scenarios.

Chi-square results

Strategy	**χ^2 Statistic**	**df**	***p*-value**
Shift farmland	126.38	3	< 0.001
Others	23.45	3	< 0.001
Migration	23.20	3	< 0.001
Crop diversification	13.42	3	0.004
Reduce farmland	12.28	3	0.006
Plant trees	11.54	3	0.009
Irrigation	11.29	3	0.010
No change	11.05	3	0.011
Making manure	7.37	3	0.061
Income diversification	5.10	3	0.164
Farm expansion	1.90	3	0.593

Standardized residuals by location for shift farmland and migration

Location	Shift farmland	Migration
Close fenced	5.27	0.58
Close unfenced	-11.13	-4.69
Distant fenced	3.51	2.12
Distant unfenced	2.96	

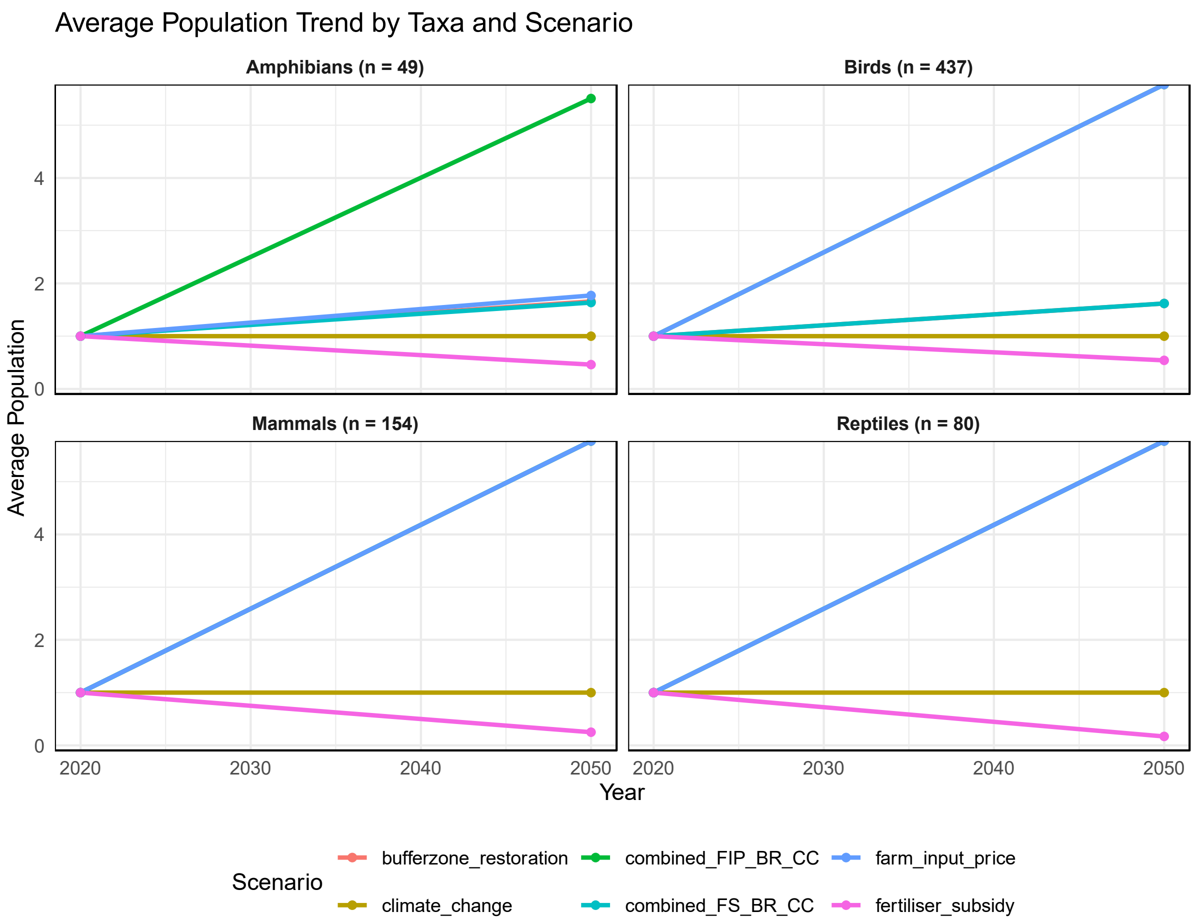
Appendix D: Supporting information for Chapter 6

D1: Summary of results

- Data not normal
- 720 species from 974 ((i.e. birds: 437, Mammals: 154, Reptiles: 80, Amphibians, 49)
- No deviant species
- $R^2 = 0.463$, indicating a moderate model fit.

Population vs. Habitat Area Change

A strong positive correlation was found between population and habitat area change (Spearman's $\rho = 0.86$, $p < 0.001$), indicating that as habitat area increases, population change tends to increase too (and vice versa) across all scenarios.



Average Population Trend by Taxa and Scenario
Amphibians (n = 49)
Birds (n = 437)
Mammals (n = 154)
Reptiles (n = 80)
Average Population
Year
5
4
3
2
1
1.50
1.25
1.00
0.75
0.50
1.0
0.8
0.6
0.4
1.00
0.75
0.50
0.25
2020
2030
2040
2050
Scenario
bufferzone_restoration
climate_change
combined_FIP_BR_CC
combined_FS_BR_CC
farm_input_price
fertiliser_subsidy

Summary of averages changes in population, habitat area and patches in all Taxa

Taxa	Malawi scenario	Average pop change (%)	Average area change (%)
Amphibians	Combined FIP+BR+CC	451	422
Amphibians	Farm input price	77	153
Amphibians	Buffer zone restoration	66	134
Amphibians	Combined FS+BR+CC	64	134
Amphibians	Climate change	0	0
Amphibians	Fertiliser subsidy	-54	-40
Birds	Combined FIP+BR+CC	453	340
Birds	Farm input price	76	122
Birds	Buffer zone restoration	62	108
Birds	Combined FS+BR+CC	62	108
Birds	Climate change	0	0
Birds	Fertiliser subsidy	-46	-33
Mammals	Combined FIP+BR+CC	854	571
Mammals	Farm input price	150	208
Mammals	Combined FS+BR+CC	121	182
Mammals	Buffer zone restoration	120	181
Mammals	Climate change	0	0
Mammals	Fertiliser subsidy	-75	-51
Reptiles	Combined FIP+BR+CC	910	617
Reptiles	Farm input price	159	224
Reptiles	Combined FS+BR+CC	128	195
Reptiles	Buffer zone restoration	127	195
Reptiles	Climate change	0	0
Reptiles	Fertiliser subsidy	-83	-58

Top Five gainers and losers

Binomial	Malawi scenario	2020	2050	pct_pop_change	status
Mammals/Crocidura_cyanea	combined_FIP_BR_CC	1	56.01	5500.81	Top Gainer
Birds/Nicator_gularis	combined_FIP_BR_CC	1	41.51	4051.04	Top Gainer
Amphibians/Tomopterna_cryptotis	combined_FIP_BR_CC	1	30.23	2923.38	Top Gainer
Amphibians/Ptychadena_porosissima	combined_FIP_BR_CC	1	17.71	1671.19	Top Gainer
Mammals/Aethomys_kaiseri	combined_FIP_BR_CC	1	16.24	1524.12	Top Gainer
Amphibians/Hylarana_darlingi	fertiliser_subsidy	1	0	-100	Top Loser
Amphibians/Hyperolius_kachalolae	fertiliser_subsidy	1	0	-100	Top Loser
Amphibians/Hyperolius_mitchelli	fertiliser_subsidy	1	0	-100	Top Loser
Amphibians/Leptopelis_flavomaculatus	fertiliser_subsidy	1	0	-100	Top Loser
Amphibians/Ptychadena_porosissima	fertiliser_subsidy	1	0	-100	Top Loser

D4: Methods for glob2loc

For estimating outcomes for each species, the high level general process of the Glob2loc is:

- Overlay a species' habitat area with location of human activities
- Remove human activities from the species' habitat range, that the species cannot exist in.
- Information on human activities a species can exist in comes from the IUCN.
- For human activities a species can exist in (e.g. urban, agriculture, etc), then estimate the quality of these habitats
- There are separate habitat quality estimates for urban and agriculture.
- These habitat qualities are based on species traits
- Habitat quality estimates for agriculture is split into low, medium, and high intensity areas
- Habitat quality for urban areas is not split into different levels (e.g. all urban areas are considered identical)
- This habitat quality estimate is not used to calculate the amount of habitat, but is used to calculate population density (see below)
- Estimate population density for the species
- This accounts for two factors:
- How a species' population density varies based on climate characteristics.
- This means that a species' population density will vary across its habitat range
- The quality of the habitat (from 3 above)
- This quality of habitat is only relevant for agricultural and urban land covers
- Identify habitat patches for the species
- Patches are defined as sets of cells that are touching
- As long as the cells contain >20% suitable habitat for that species
- Cells with <20% suitable habitat count towards the species' total habitat area and population abundance, but are not considered to be part of any habitat patch
- Identify populations for the species
- Populations are defined as sets of habitat patches that a species can disperse between
- A species' capacity to disperse is based on previously published estimates.
- For amphibians and reptiles: Generally, no to limited dispersal
- For mammals: dispersal is positively correlated with body mass
- For birds: dispersal is based on morphological traits (wing size, body mass, etc)
- Calculate total habitat area and population abundance in each habitat patch or population
- This is done by summing across all cells in the habitat patch (or population)
- Calculate total habitat area and population abundance for the species
- As above - is done by summing across all cells in the species' population

This process is repeated for all species, for all the land cover scenarios, and for different ways of defining a species' habitat. The different ways of defining a species' habitat is based on uncertainty in model outputs from the species distribution models.