DISSERTATION

MAKING MARKETS WORK FOR PEOPLE, CLIMATE, AND NATURE: APPLIED DEVELOPMENT ECONOMICS FOR BIODIVERSITY CONSERVATION AND CLIMATE CHANGE

Submitted by

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ABSTRACT

MAKING MARKETS WORK FOR PEOPLE, CLIMATE, AND NATURE: APPLIED DEVELOPMENT ECONOMICS FOR BIODIVERSITY CONSERVATION AND CLIMATE CHANGE

Climate change and biodiversity loss are being driven by unsustainable human behavior underpinned by market incentives and economic growth models that fail to adequately value nature. If global goals relating to people, climate, and nature are to be achieved, ambitious integrated approaches are required drawing on best practice from the conservation and development fields, pursuing transformational change in complex social-ecological systems, and directing scarce resources to their most cost-effective use. This dissertation contributes evidence in support of these objectives, applying tools and frameworks from the economic development field to global challenges of biodiversity loss and climate change.

Manuscript 1 outlines a framework for integrated conservation and development programming rooted in complex systems thinking, Green Market Systems Development, drawing on the lessons from Manuscript 2 and a wider collaboration between practitioners in both fields. Manuscript 2 features an evaluation of livelihoods programming in conservation projects, comparing the approaches of recent projects funded through the UK government's Darwin Initiative and Illegal Wildlife Trade Challenge Fund with the gold standard of "Market Systems Development" programming in the economic development field. We find most conservation projects to adopt outdated models of direct aid delivery that fall short of best practice in the economic development sector. Manuscript 3 uses a cost-benefit analysis of a wildlife corridor in Tanzania to demonstrate how

economic decision tools can help to allocate conservation funds to maximize conservation outcomes per dollar spent.

TABLE OF CONTENTS

CHAPTER 1: INTRODUCTION

Climate change and biodiversity loss are being driven by unsustainable human behavior underpinned by market incentives and economic growth that fails to adequately value nature (CBD, 2020; IPBES, 2019; IPCC, 2023; TEEB, 2010; WWF, 2024). If global goals relating to people, climate, and nature are to be achieved, ambitious integrated approaches are required drawing on best practice from the conservation and development fields, pursuing transformational change in complex social-ecological systems, and directing scarce resources to their most cost-effective use (IPBES, 2024). This dissertation contributes evidence in support of these objectives, applying tools and frameworks from the economic development field to global challenges of biodiversity loss and climate change.

Integrating conservation and development

Challenges to date

From agriculture to forestry, energy to extractives, construction to tourism, markets are behind most conservation threats (Salafsky et al., 2025). Conservation practitioners routinely intervene in these markets to mitigate threats through a combination of approaches, influencing incentives and behavior through taxation and regulation, direct payments (e.g., payments for ecosystem services), or seeking to influence consumer preferences (e.g., for ethically sourced produce) and corresponding interventions in sustainable supply chains. At the local level across the Global South, conservation practitioners intervene in markets to mitigate poverty, motivated by an understanding that poverty can drive environmental degradation, while at the same time conservation initiatives can restrict resource access in natural resource dependent communities, thereby exacerbating poverty (W. M. Adams et al., 2004). From local livelihoods to global value chains, markets play a key role in conservation.

The interrelationships between poverty, biodiversity loss, and climate change in complex social-ecological systems are widely recognized (W. M. Adams et al., 2004; Brundtland, 1987; Roe, 2008). Modern conservation practice emphasizes approaches that aim to respect the rights of, and build collaborative alliances with, natural resource-dependent local communities (Berkes, 2004, 2007; Kothari et al., 2013). Goals relating to improving livelihoods and raising incomes of the rural poor are now commonplace in conservation projects (Brockington et al., 2006; Timmer & Juma, 2005). At the same time, development practitioners are increasingly urged to mainstream climate and biodiversity concerns into programming and policy (Dasgupta, 2021). A growing number of initiatives are taking sophisticated, systemic approaches to the integrated pursuit of people, climate, and nature goals, such as World Wildlife Fund's Markets Institute, the Moore Foundation's Conservation and Markets Initiative, and the World Resources Institute's Systems Change Lab (The Moore Foundation, 2025; WRI, 2025; WWF, 2025).

However, despite these notions having been central to the sustainable development agenda for several decades, for the most part conservation and development practice have remained largely siloed (Brown, 2003; Lah, 2025; Tallis et al., 2024). Environmental concerns have remained fringe in economic development programming, with the "sustainability" aspect of sustainable development frequently being neglected (Hametner, 2022; Horodecka, 2024; Stafford-Smith et al., 2017). At the same time, despite the move towards more human-centered work in conservation, projects remain largely staffed by natural scientists with limited experience with (and even wariness of) markets and economics (Bennett et al., 2017; Detoeuf et al., 2025). The field continues to struggle to engage with complex systems, manage trade-offs between conservation and development, and produce evidence of meaningful impact – particularly in the subfields of community-based conservation and integrated conservation and development projects (Baylis et al., 2016; Blom et al., 2010; Ferraro & Pattanayak,

2006; Game et al., 2014; Mahajan et al., 2019; McShane et al., 2011). In both conservation and development, funding shortfalls necessitate difficult decisions about how best to distribute resources to maximize impact (McCarthy et al., 2012; United Nations, 2024).

Market Systems Development

In the development sector, the lack of perceived results from development aid by the 1990s had led to a legitimacy crisis (Doucouliagos & Paldam, 2009). Not only were demonstrable poverty reduction impacts limited, but donor dependence and aid handouts were thought to actively distort markets and undermine economic development (Easterly, 2002). In the early 2000s, the Market Systems Development (MSD) approach emerged as an alternative to the traditional "direct delivery" modalities at the core of the legitimacy crisis (Ramalingam et al., 2014; The Springfield Centre, 2015; USAID, 2024b). Instead of directly providing aid (e.g., free inputs and training), MSD projects sought to facilitate transformational change by working through local market actors. By viewing markets as complex systems, and pairing an analytical approach with flexible, entrepreneurial programming, MSD practitioners seek to treat root causes, rather than symptoms, of market failure. Under the mantra of "making markets work for the poor", the approach aims to remove systemic constraints to inclusive, pro-poor growth. A growing body of evidence suggests that these projects have outperformed older direct delivery models in delivering lasting results at scale (Conroy & Kessler, 2019; Hilton, 2024b; Osorio-Cortes & Albu, 2021).

Towards integrated approaches for transformational change

Despite the promising results of the MSD approach, it lacks consideration of the interactions between economic development, biodiversity, and climate change (The Springfield Centre, 2015). In the conservation field, despite many years of academic output on complex social-ecological systems

thinking, little has translated into useful practitioner guidance (Knight et al., 2019; Liu et al., 2007; Mahajan et al., 2019; Ostrom, 2009; Preiser et al., 2018). Driving transformational change in social-ecological systems requires systemic approaches that draw on expertise from both fields, while ensuring that scarce resources are directed to the most cost-effective initiatives (IPBES, 2024; Pienkowski et al., 2021). This dissertation seeks to address these gaps by outlining Green Market Systems Development, an integrated approach to systemic conservation and development practice (Manuscript 1), based on an evaluation of the current state of livelihoods programming in conservation projects (Manuscript 2).

Ensuring wise use of scarce resources

If global conservation goals are to be achieved, it is critical that scarce conservation resources are directed to the most impactful uses. In many fields, economic decision tools such as cost-benefit analysis are used to prioritize between potential projects, assessing the extent to which the benefits generated justify their costs. Uptake has been limited in conservation, however – partly due to technical challenges of quantifying and applying monetary values to nature benefits, and partly due to philosophical objections to "putting a price on nature". Manuscript 3 addresses these issues through the example of a cost-benefit analysis of a wildlife corridor in Tanzania.

Chapter outlines

The dissertation is structured as follows. Manuscript 1 presents the Green Market Systems Development ("Green MSD") framework, an integrated approach to conservation and development programming incorporating climate and biodiversity concerns into MSD. The manuscript is motivated by the growing calls for transformational, systemic approaches to global sustainability goals, and the limitations in corresponding practical guidelines in both the conservation and development fields to

date (ILO, 2025; IPBES, 2024; Mahajan et al., 2019; Schwartz et al., 2018). The Green MSD framework shifts the primary motive of MSD from "making markets work for the poor" to "making markets work for people, climate, and nature", based on a view of markets as nested within and dependent upon natural systems. It is the first of its kind to provide conservation practitioners with concrete guidance on transforming the way that markets work, while also providing development practitioners with the means to mainstream environmental concerns within market systems programming. The conceptual framework that forms this manuscript is a companion piece to the recently published Green MSD guidelines.

Green MSD is the product of several years of collaboration with conservation and development practitioners and donors, beginning with a 2021 evaluation of Fauna and Flora International's (FFI) portfolio of pilot MSD projects – the first of their kind in the conservation sector (Mohanan et al., 2018). Our study found that while FFI's application of conventional MSD showed promising results, it remained siloed in livelihoods components of projects, and lacked a holistic view of conservation and development outcomes within complex social-ecological systems. This finding motivated our later adaptation of the MSD framework to reflect nested human and natural systems.

The subsequent Green MSD framework was the product of a working group of conservation and development practitioners, in collaboration with the Conservation Measures Partnership (authors of the Conservation Standards, the foremost conservation project cycle guidelines) and the BEAM Exchange (the leading MSD knowledge platform), with support from USAID. The framework has been published via the BEAM Exchange, and reference to market systems approaches has been added to the latest version of the Conservation Standards, as well as to UK government guidance to applicants to the Darwin Initiative and Illegal Wildlife Trade Challenge Funds that are the focus of Chapter 1.

Manuscript 2 presents an evaluation of livelihoods programming in the conservation field, comparing the approaches of recent projects funded via the UK government's Darwin Initiative and Illegal Wildlife Trade Challenge Fund with best practice in economic development, characterized by the core principles of MSD programming. The manuscript addresses many criticisms of conservation livelihoods programming in the literature, including a lack of systemic approaches (Mahajan et al., 2019), limited use of theories of change (Rice et al., 2020), failure to address complexity (Game et al., 2014), insufficient integration of social science expertise (Bennett et al., 2017), and a lack of evidence supporting chosen approaches (Ferraro & Pattanayak, 2006; Natarajan et al., 2022; Roe et al., 2015). We found most reviewed conservation projects to be adopting outdated models of direct aid delivery, with uncertain prospects for lasting results at scale. Many projects lacked a clear rationale for the choice of focal market or livelihood strategy being supported, while few showed evidence of a robust understanding of the workings of these markets, and private sector engagement was limited. However, around one in six projects demonstrated sophisticated approaches on par with the gold standard in economic development, proving that such programming is possible in the context of small grants funding in the conservation field.

Finally, Manuscript 3 presents a cost-benefit analysis (CBA) of a wildlife corridor in Tanzania, demonstrating how economic decision tools can inform the efficient allocation of scarce resources in conservation. CBA is used in many fields to prioritize public spending options based on a comparison of project costs with the estimated value of benefits generated. However, its use has been limited in conservation – partly due to technical difficulties of assigning monetary values to conservation outcomes, and partly due to philosophical concerns around "putting a price on nature" (Naidoo & Ricketts, 2006; Pienkowski et al., 2021; White et al., 2022). On the former, we argue that advancements in nonmarket valuation (e.g., estimation of ecosystem service values) are increasingly helping

researchers to navigate these issues. On the latter, we argue that while "monetization" may sound discomforting to conservationists, assigning dollar values to, e.g., the existence of an elephant, is an innocuous – yet important – means of estimating the value of intangible factors that may otherwise be omitted from decision making. As with public unease with "putting a price on life" in health economics, no money (or elephants, or human lives) is exchanged – it is merely a widely understood unit of account representing the value (rather than price) of something.

Our study applies a multi-perspective CBA showing how perceptions of the corridor project may differ between international conservation actors and local communities given the different priorities of these stakeholder groups. We find that the corridor comfortably justifies its costs from a global conservation perspective, but that local communities would need to see a substantial reduction in human-elephant conflict as a result of the corridor to justify contributing land and labor to the project. Whilst in reality the local communities were fully compensated for their contributions to this specific project and bore no costs associated with the corridor, our analysis highlights the potential for future cost-sharing between donors and communities if conservation projects can be designed with community incentives in mind, thereby leveraging greater impact per dollar of donor funds invested in conservation.

Note on authorship

While I was lead author of the following chapters responsible for overall conceptualization, design, analysis, and writing, each was a collaborative effort. Manuscript 1 was co-authored by Andrew Panton (The Canopy Lab), Annette Stewart (Conservation Measures Partnership), Shauna Mahajan (WWF), Kiran Mohanan (Conservation International), Dilys Roe (IIED), Christopher Giordano (Blue Ventures), and Jonathan Salerno (CSU), with support from The Canopy Lab and USAID. Contributions to the wider Green MSD initiative came from Mike Albu (BEAM Exchange), Quiller

Brooke (Gatsby Africa), Stuart Cowell (Conservation Management), Luca Crudeli (ACDI/VOCA), James Foster (Gatsby Africa), Ben Fowler (MarketShare Associates), Clara Garcia Parra (The Canopy Lab), Julian Hamilton-Peach (independent), Jill Majerus (Eco Markets & Measures), Elizabeth O'Neill (Climate and Land Use Alliance), Kristin O'Planick (USAID), Nick Salafsky (Foundations of Success), Kevin Seely (Defra), and Vinaya Swaminathan (Foundations of Success). Manuscript 2 was co-authored by Dilys Roe (IIED), Piotr Sfezer (independent), and Jonathan Salerno (CSU), with support from the UK Department for Environment, Food, and Rural affairs, and NIRAS, the administrator of the Darwin Initiative and Illegal Wildlife Trade Challenge Fund. Manuscript 3 was co-authored by colleagues at the Southern Tanzania Elephant Programme Josephine Smit, Trevor Jones, Joseph Mwalugelo, and Kim Lim, as well as CSU colleagues Andrew Seidl, Kelly Jones, Brett Bruyere, and Jonathan Salerno.

CHAPTER 2: GREEN MARKET SYSTEMS DEVELOPMENT - MAKING MARKETS WORK FOR PEOPLE, CLIMATE, AND NATURE

Abstract

Climate change and biodiversity loss are driven globally by unsustainable human behavior, underpinned by economic growth in markets that fail to adequately value nature. Delivering on global goals will require transformational change in the way that markets work, from the local to the global, balancing human wellbeing with environmental concerns. To this end, we present the Green Market Systems Development approach, a framework for combined conservation and development programming drawing on best practice from both fields. The approach takes a widely used economic development framework, Market Systems Development, and puts environmental considerations at its core. By seeing markets as nested in – and dependent upon – natural systems, we ask not only how to make markets work for the poor (the defining question of Market Systems Development), but how to make markets work for people, climate, and nature.

Introduction

The dual crises of climate change and biodiversity loss are driven by unsustainable human behavior, underpinned by economic growth in markets at the expense of natural systems (CBD, 2020; IPBES, 2019; IPCC, 2023; WWF, 2024). Sustainable development requires transformational change in the way that markets work, balancing human wellbeing with environmental goals (CBD, 2022; Dasgupta, 2021; IPBES, 2024; Sachs et al., 2009; UN, 2015). Achieving this requires collaboration between conservation and development practitioners and policymakers, drawing on best practice from each field. To this end, we present the Green Market Systems Development (Green MSD) approach,

a guide to combined conservation and development policy and practice - the culmination of several years of collaboration between conservation and development practitioners (Hilton et al., 2025). Whilst our framework primarily draws on experience in the Global South, the approach has potential global relevance as an integrated approach to sustainable economic development. We begin by exploring the role of markets in conservation and development practice, before presenting the Green MSD framework and its applications.

Markets and conservation practice

From agriculture to fisheries, energy to extractives, construction to manufacturing, markets underpin most conservation threats (Conservation Measures Partnership, 2025; Salafsky et al., 2025). As such, conservation practitioners frequently intervene in markets at levels from global to local. Human development goals are now commonplace in conservation projects, which promote sustainable livelihoods to mitigate environmental threats and build local support for conservation (W. M. Adams et al., 2004). Compensatory approaches to conservation, such as payments for ecosystem services, biocredits, or easements, seek to provide market incentives via direct conservation payments. At the macro level, environmental taxes, subsidies, and regulatory regimes govern the overall functioning of markets throughout the global economy, while many organizations work to promote sustainable global supply chains. The list goes on – from conservation finance to illegal wildlife trade disruption, sustainable enterprise development, environmental certifications, and landscape and jurisdictional approaches, markets are central to modern conservation practice.

However, common shortcomings are apparent. Community-oriented projects often fail to recognize the scale and complexity of the wider system, while top-down policy and regulatory measures often lack nuanced understanding of the inner workings of the system (Lele et al., 2010; Natarajan et al., 2022; Salerno et al., 2021). In both, important meso-level institutions and relationships

tend to be overlooked (Minang et al., 2021), with panaceas frequently sought in the form of simple, linear solutions - addressing symptoms rather than root causes of market failure (Game et al., 2014; Ostrom, 2007).

At the local level, conservation projects are often staffed predominantly with personnel skilled in the natural sciences but with limited knowledge of markets or experience working with the private sector, many projects do not engage with market actors beyond primary producers, and common "conservation livelihoods" markets are repeatedly targeted despite little evidence of their commercial viability (e.g., beekeeping, handicrafts, non-timber forest products) (Hilton, 2024a). Short-term, grant-based funding incentivizes rapid delivery of readily quantifiable results rather than the patient pursuit of systems change, with little consideration given to post-project legacy (Roe et al., 2015).

At larger scales, alluring innovations on paper such as REDD+, biodiversity credits, and landscape and jurisdictional approaches have shown few practical successes to date – often due to limited consideration of the complex enabling environment conditions required for these mechanisms to succeed (Börner et al., 2017; Fletcher et al., 2016; Muradian et al., 2013; Reed et al., 2020; Sayer et al., 2017; West et al., 2023). Unless these can be addressed, many such innovations risk falling into the conservation 'fads' trap, whereby new approaches generate brief excitement before quickly falling out of favor (Redford et al., 2013).

To increase the likelihood of successful conservation work at all scales, we believe practitioners should pursue systemic change in markets through strategies that embrace complexity, plan for scale and sustainability, and are participatory, evidence-based, and tailored to local conditions. Several such examples already exist. At the macro level, initiatives such as the Moore Foundation's Conservation and Markets Initiative, WWF's Markets Institute, and the World Resources Institute Systems Change Lab are promoting systemic approaches to transforming markets (The Moore Foundation, 2025; WRI,

2025; WWF, 2025). Elsewhere, systems thinking at the intersection of markets and the environment features in high-level discourse and economic analysis (IPBES, 2024; Raworth, 2012; TEEB, 2010). At the local level, a recent review of small conservation grants found only one in six projects to be adopting practices on par with the gold standard in the development industry, featuring strong private sector engagement, a focus on commercial viability, and a clear exit plan to ensure sustainable results (Hilton, 2024a), while conservation nonprofit Fauna & Flora International have been experimenting with the market systems development approach for several years (Mohanan et al., 2018).

Our intention with Green MSD is to build on these examples to help a wider range of practitioners adopt best practices in driving transformational change in markets. Drawing on best practice from the development sector, the goal of Green MSD is to better equip conservation practitioners with the tools to intervene in markets, fundamentally shaping the way that they work in order to mitigate conservation threats originating in markets from agriculture to forestry, mining, extractives, and so forth. At the local level, Green MSD can strengthen livelihoods programming in conservation projects through an understanding of poverty as a result of structural inequalities and market failures in larger systems beyond local communities.

Markets and development practice

The history of economic development practice has featured many of the same shortcomings outlined above, leading to criticisms of inefficient resource use and perpetuated donor dependency (Doucouliagos & Paldam, 2009; Easterly, 2002). Early postwar development theory hinged on linear growth models focused narrowly on stimulating gross domestic product through investment and capital accumulation (Kuznets, 1955; Rostow, 1959). State-led industrialization, first through import substitution (Baer, 1972) and later more export-oriented policies (Balassa, 1978) involved protection of domestic industries from external competition and government intervention in support of domestic

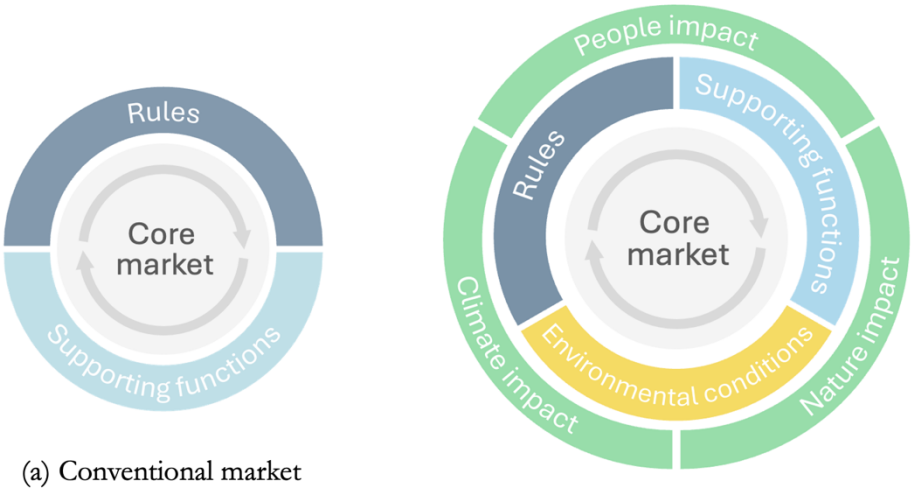
industries, while dependency theory posited that less developed countries were locked in poverty because of structural inequalities in the global capitalist system (Hays, 1964). By the 1980s, the neoliberal tenets of free markets, deregulation, and privatization took hold, driven by the Washington-based institutions of the World Bank and International Monetary Fund (Williamson, 2009). Across the decades, these top-down macroeconomic theories and policies had few success stories to show, and in the case of the US-led neoliberal structural reforms often had disastrous consequences for the global poor (Stiglitz, 2002).

The 1980s and 1990s saw the emergence of a more human-centered, rights-based approach, focused on capabilities and freedoms, basic needs, multidimensional poverty, and human development (Sen, 1980, 2001; UNDP, 1990). The sustainable development agenda merged economic development with environmental concerns – though in practice these endeavors remained largely siloed (Brundtland, 1987). From these theoretical foundations, the sustainable livelihoods framework became central to development programming in the Global South, seeking to build the assets and capabilities needed for poor households to make a living (R. Chambers & Conway, 1992; Scoones, 1998). However, these micro level, community-oriented approaches often failed to grapple with the meso-level institutions, complexity, and forces of power and politics driving poverty in much the same way as the preceding macro approaches. A lack of tangible results at scale ultimately led to a legitimacy crisis in development economics.

In response, the market systems development (MSD) approach emerged in the early 2000s as a more systemic, innovative, and entrepreneurial approach to development. The theoretical foundations of MSD drew on several schools of thought, from the importance of property rights, rule of law, and effective governance in institutional economics (Acemoglu et al., 2001; North, 1990), to the importance of knowledge and innovation in endogenous growth theory (Lucas, 1988; Romer,

1990), to the limits of rational economic behavior in behavioral economics – a direct challenge to the unrealistic assumptions and simplifications of the long-dominant neoclassical model (Kahneman & Tversky, 1979; Thaler, 1990). Beyond development economics, the MSD approach draws on business and finance as well as complex systems thinking (D. H. Meadows & Wright, 2008; Ramalingam et al., 2008).

MSD sees markets as complex systems made up of a core value chain of market actors (e.g., producers, processors, consumers) trading goods or services, plus a wider enabling environment of formal and informal "rules" that govern the system (e.g., laws, policies, traditions), and "supporting functions" that market actors depend upon to succeed (e.g., access to finance, skills, technology) (Figure 1a) (The Springfield Centre, 2015). Market systems are nested – for example, finance may be a supporting function for agricultural markets, but is itself a complex market system with its own set of rules and supporting functions. As such, MSD practitioners often intervene in market systems once- or twice- removed from their target beneficiaries. Market systems are also multilevel, from the local to the global. For example, MSD projects focused on rural development may work with global commodity buyers or regulatory bodies to bring about local impact. Through these complex, nested, multilevel systems, MSD practitioners follow where the analysis leads in search of systemic solutions to development problems.



(a) Conventional market system concept

(b) Green market system concept

Figure 1: The conventional MSD conceptual framework in (a) does not explicitly consider environmental issues. Our Green MSD conceptual framework in (b) expands conventional MSD to consider the climate and nature impacts of the market, as well as the supporting environmental conditions upon which the market depends.

Rather than directly delivering aid to communities (the traditional development modality), MSD interrogates how and why the wider market system is failing the poor, before seeking to facilitate lasting change in the behaviors, relationships, incentives, and institutions that perpetuate poverty (The Springfield Centre, 2015). MSD projects typically work with existing market actors to innovate new ways of working, guided by a vision of an ideal future state of the market once the project ends. Successful projects are flexible and opportunistic, taking a trial-and-error approach with an emphasis on learning and adaptation, and often staffed with individuals with private sector backgrounds. A growing body of evidence suggests that MSD programming is better able to deliver lasting results at scale compared to conventional direct delivery projects (Conroy & Kessler, 2019; Hilton, 2024b; Osorio-Cortes & Albu, 2021).

To illustrate the approach, consider a rural development project supporting rice farmers. Rather than directly providing free seeds to farmers, an MSD project might work with seed suppliers to develop more inclusive business models. Key to the approach is an understanding of why this isn't happening already – the root causes of system failure. Suppliers may be hesitant to sell to smallholder farmers given low sales volumes dispersed across hard-to-reach rural areas. The MSD approach seeks to overcome this by innovating models that work for both buyers and suppliers – perhaps by connecting seed suppliers to agribusinesses already buying rice from farmers who could serve as an intermediary in input supply, or by working with farmer cooperatives to establish nurseries that can bulk buy improved seeds, reducing transaction costs. If novel business models can be proven, MSD projects then move from piloting to scaling the model, encouraging wider actors to adopt the innovation, thereby driving lasting change in the system. Ultimately, reshaping input supply across the sector will likely be far more impactful than the short-term provision of free seeds.

The latest global MSD evidence review – periodically conducted by the BEAM Exchange, an MSD knowledge hub – points to several recent success stories (Hilton, 2024b). In Senegal, the Naatal Mbay project has transformed the way that agricultural finance works through an innovative credit model delivered by local financial institutions to growers and processors using the rice crop as collateral. The model has become the norm not only in the rice sector, but also expanding into other commodities in Senegal, improving access to finance across agricultural value chains, building trust between market actors, boosting production, and reducing dependence on rice imports. In Ethiopia, the Land Investment for Transformation program identified land tenure as a systemic constraint, and innovated an approach whereby second-level land certificates clarifying the rights to use land – rather than outright ownership – could be used as collateral for loans. The success of the scheme has led to nationwide policy changes around land rights and agricultural finance.

Green Market Systems Development

To date, environmental concerns have remained a fringe issue in MSD, and little guidance exists for the application of MSD to issues of biodiversity conservation and climate change – though there is growing momentum and interest in the topic within the sector (DCED, 2022; García Parra, 2023; ILO, 2025). At the same time, while conservation science has embraced complex social-ecological systems thinking, little of this has translated into guidance for conservation practice, and widely used frameworks such as the Conservation Standards do not include specific advice on engaging with markets (Ban et al., 2013; Mahajan et al., 2019; Schwartz et al., 2018).

To address this, our Green MSD approach broadens the guiding question of MSD from one of "how to make markets work for the poor," to one of "how to make markets work for people, climate, and nature," based on a view of markets as being embedded in, and dependent upon, natural systems. The result is an approach that can be used by both conservation and development practitioners seeking to drive transformational change in complex market systems.

The Green MSD framework is the result of a multi-year collaboration between a working group of conservation and development practitioners drawing together best practice from the BEAM Exchange – the leading MSD knowledge and practitioner hub (BEAM Exchange, 2025a) – and the Conservation Measures Partnership, who produce the Conservation Standards (Conservation Measures Partnership, 2025), the most widely used conservation project cycle guidelines. The Green MSD guidelines (Hilton et al., 2025) and corresponding theoretical foundations presented here resulted from several projects, including a review of markets interventions in Fauna & Flora International projects, a review of livelihoods programming in Darwin Initiative and Illegal Wildlife Trade Challenge Fund projects (Hilton, 2024a), and three design workshops with the Green MSD working group.

Conceptual framework

The Green MSD concept is shown in Figure 1b, based on the same core value chain, rules, and supporting functions of conventional MSD. However, Green MSD moves the focus beyond "people" impacts (e.g., poverty reduction) to also consider climate (greenhouse gas emissions and removals) and nature (biodiversity) impacts. While not all projects will have goals in every dimension, the framework draws attention to the complex interrelationships between each, allowing practitioners to seek synergies between elements in pursuit of sustainable development, while better managing trade-offs and unintended consequences.

Project cycle

From this conceptual starting point, a project cycle can be elaborated from design through implementation, learning, and adaptation. The following is intended to illustrate the broad potential of Green MSD, with more comprehensive guidance available in (Hilton et al., 2025).

Scope and goals

At the outset, Green MSD projects define their scope in terms of budget, timeframe, and geography, as well as people, climate, and nature goals – e.g., increased incomes for the rural poor, forest conservation, or reduced emissions. While projects need not have goals in all three dimensions, the framework encourages consideration of impacts across each dimension – intended or otherwise – to manage trade-offs and mitigate risks.

Market system assessment

As with conventional MSD, Green MSD is built on strong analytical foundations. The assessment phase includes prioritization of the market system(s) to work in, followed by a diagnosis of the systemic constraints that currently stand in the way of the project's goals.

Market system selection starts by drawing up a shortlist of markets relevant to your goals. For people goals, these may be the markets of most significance to the rural poor (e.g., farming, fishing, forestry). For climate and nature goals, these will be the markets responsible for the most emissions (or removals), or that pose the greatest threat (or opportunity) to biodiversity. For example, deforestation drivers may stem from agriculture, livestock, wood energy, and construction markets, while sustainable forest-based livelihoods in honey, timber, and ecotourism markets may offer positive opportunities and also make the shortlist.

The list is narrowed down by assessing the degree of relevance to your goals, economic prospects of the market, and feasibility of intervention. The latter two are important reality checks on the likelihood of success and potential impact, helping to warn against interventions in markets with limited commercial prospects, few potential partners to work with, or challenging external constraints such as corruption or conflict. Weights can be attached to the criteria as desired (e.g., to encourage work in challenging markets that pose critical conservation threats).

Once priority market systems are selected, a diagnostic exercise follows to identify root causes of market failure with respect to project goals – how and why is the market system currently failing people, climate, or nature? First we map the system (Figure 2), including the value chain, rules, supporting functions, environmental conditions, the position of human target groups defined in the people goals, plus the status quo climate and nature impacts of the market (positive or negative).

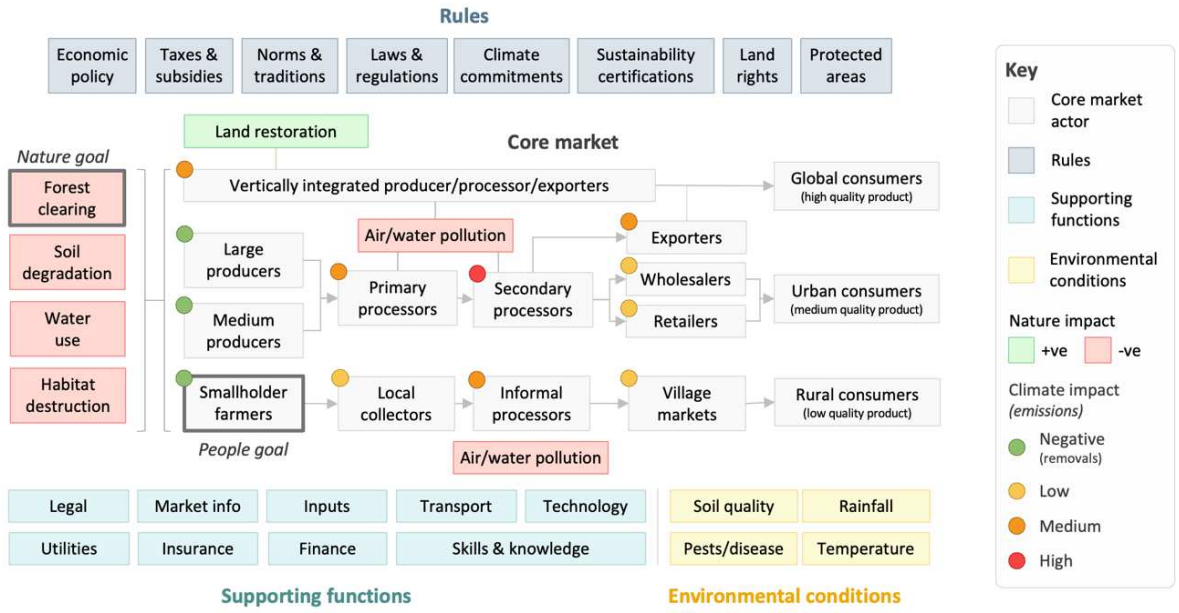


Figure 2: Green market system map. The Green MSD map is made up of core market actors, rules, supporting functions, supporting environmental conditions, nature impacts, and climate impacts. Relevant people, climate, and nature goals are highlighted on the map. Mapping the system begins with the core market, before building out the wider elements of the enabling environment and impacts.

From here, the project should assess the trends, dynamics, relationships, capacities, and incentives of the market system and actors. Analysis can draw on a combination of primary and secondary data, participatory exercises with stakeholders, or independent market studies, among others. Identifying systemic constraints requires careful investigation. Methods such as root cause analysis and constraints trees can help unpack problems, with the guiding principle that projects should never jump to a solution without a clear understanding of why it isn't already happening. Investigating markets through a Green MSD lens can often point to constraints far removed from the intended beneficiaries in the wider enabling environment or linked market systems, leading to intervention strategies that are not immediately obvious.

Plan

Once systemic constraints have been identified, interventions can be designed to bring about the desired systemic change to unlock them. Green MSD projects focus on working with existing market actors (not necessarily private companies – these could be government agencies or natural resource managers) to innovate new ways of working, playing a facilitative role where local actors take the lead. Common interventions include de-risking innovation through co-financing of pilot projects, brokering relationships between market actors, or amplifying success stories to encourage replication and crowding in.

Any intervention should begin with a vision of how the market system would ideally function in future, including clarity on the relationships and incentives required to enable this – with an emphasis on how the solution will be sustained once the project ends (see the example vision diagram in Figure 3, below). From there, a theory of change can be elaborated specifying how project activities will move the system from the status quo to the desired state. Once a shortlist of potential interventions has been identified for each systemic constraint, these are fed through a prioritization procedure to select those with the greatest potential impact per dollar spent.

Whilst conventional MSD typically involves exit strategies where the project ultimately becomes redundant, some conservation practitioners are long-term actors in landscapes, playing roles such as protected area management. Such practitioners can themselves be considered local market actors (e.g., in tourism markets), and need not have a conventional exit strategy whereby they play no future role. However, MSD principles of sustainability can still be applied, seeking to maximize local ownership and environmental incentives, and directing subsidy only to where it is needed most.

Implement

Implementation of market systems interventions follows a two-step process of piloting and scale-up, with the former focusing on testing innovations with selected partners. If successful, additional partners may be engaged to take innovations to scale, or projects may use communications strategies to amplify demonstration effects that lead to crowding in of additional actors (e.g., publicizing the availability of a new low-cost technology via local media or industry publications). Throughout, the project plays a facilitative approach, working through existing market actors, rather than directly providing solutions itself. Central to this is a strategy for identifying and managing relationships with implementing partners, seeking to shape their incentives and capacities over time in pursuit of the market system vision.

Measure and learn

Strong monitoring, evaluation, and learning systems are key to Green MSD, enabling projects to learn and adapt in a timely and innovative manner. Light-touch, responsive data collection and analysis is preferred to more traditional impact evaluations, allowing for an entrepreneurial approach more akin to that of the private sector. Particular attention is required to unintended impacts, trade-offs, or spillover/leakage effects. The approach also emphasizes evaluation of systems change, looking beyond conventional metrics relating to activities/outputs (e.g., farmers trained, kilometers patrolled) and outcomes/impacts (e.g., incomes, forest cover), to greater attention on a nuanced understanding of attitudes and behavior change (Posthumus et al., 2020). Are partners demonstrating genuine buy-in to piloted innovations? Are other actors in the system responding by replicating the demonstrated model, or otherwise adapting their own offerings?

Manage

Management of Green MSD projects requires appropriate skillsets blending a mix of conservation and development expertise, including experience working with (or in) the private sector, as well as an understanding of business and finance. Adaptive management is at the heart of market systems programming, emphasizing rapid innovation, learning, and adjustment, requiring nimble monitoring and evaluation systems, and comfort with the concept of 'failure' when testing interventions (J. M. Chambers et al., 2022). A fine balance is required between research and action, avoiding "paralysis by analysis" through continuous action learning. Finally, as well as monitoring the project's own performance, Green MSD projects should monitor developments in the wider market, and be on the lookout for emergent threats or opportunities to inform flexible programming over time.

Applications

The general objective of Green MSD is to reduce environmental harm caused by markets and promote markets with positive environmental impacts (Figure 3 [1]). In addition, several special use cases exist (Figure 3 [2]). Where markets are harming their own supporting environmental conditions (e.g., overfishing, overgrazing), Green MSD should focus on creating incentives for more sustainable resource use (e.g., sustainable fisheries) (Figure 3 [2a]). In other cases, markets may suffer from external environmental changes, such as climate change – in which case Green MSD should focus on building resilience (e.g., facilitating access to drought tolerant seeds) (Figure 3 [2b]).

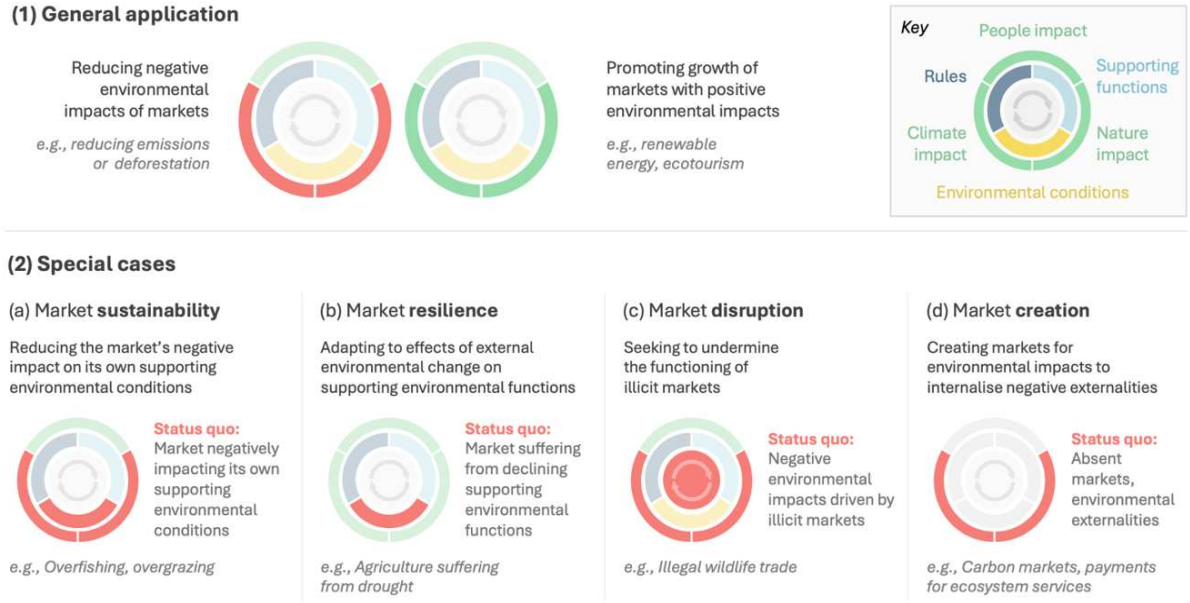


Figure 3: Green MSD applications. Green MSD has many applications. In general (1), the goal should be to reduce negative environmental impacts of markets and/or promote markets with positive environmental impacts. Various special cases exist (2) – including reducing a market's negative impact on its own required environmental conditions (a), building resilience to environmental change (b), disrupting illicit markets (c), and creating new markets for environmental goods and services (d).

In cases where the very existence of markets is undesirable (e.g., the ivory trade), Green MSD can help to identify weak points upon which to focus market disruption efforts, while being conscious of the potential negative livelihoods impacts (Figure 3 [2c]). Conversely, where market creation is the goal (e.g., the establishment of payments for ecosystem services schemes), a systems view of markets can help to ensure that the necessary enabling environment of rules and supporting functions is developed to ensure lasting success (Figure 3 [2d]).

Green MSD and existing planning tools

Green MSD is not intended to replace any existing approaches to project design and implementation, but rather to provide a complementary toolkit for conservation practitioners intervening in markets, or for development practitioners seeking to integrate climate and biodiversity

concerns in programming. In the conservation field, users of the Conservation Standards – the most widely used conservation planning tool – can use Green MSD to further interrogate market-based threats identified during the assessment stage, and to develop corresponding strategies to address them (Conservation Measures Partnership, 2025). Meanwhile, MSD practitioners should find Green MSD to be a readily adoptable adjustment to familiar practice. As a result of our Green MSD initiative, reference to market systems approaches has been added to the latest version of the Conservation Standards (Conservation Measures Partnership, 2025), while the BEAM Exchange, the leading MSD knowledge platform, has incorporated Green MSD into its guidance (BEAM Exchange, 2025a).

Examples

To illustrate potential applications, we provide three hypothetical cases – a small conservation project promoting beekeeping, a conventional MSD project working in the coffee sector, and a large-scale energy project seeking to combat charcoal-driven deforestation. The cases vary in scale and complexity, demonstrating the broad potential of Green MSD. While the first two show the potential impact of introducing Green MSD to existing conservation and development projects, the third considers what a new, large-scale Green MSD program might look like. Full details of each are available in the Green MSD guidelines (Hilton et al., 2025).

Honey

Consider a small-scale conservation project with goals relating to community livelihoods and forest conservation. Assume the project has decided to promote beekeeping (a common conservation livelihoods choice) given its relevance to both people and nature goals. Many such projects focus on providing free training and equipment to farmers, raising questions around post-project sustainability of results – particularly if the commercial viability of beekeeping is unclear (Hilton, 2024a). Instead, a

Green MSD project would first assess the honey market, verifying the commercial potential and availability of partners to work with, before diagnosing the systemic constraints to be addressed.

Assume that systemic constraints relating to beekeeper access to markets, information, and equipment are identified. From here, a pilot model with agribusinesses buying honey from farmers could be explored, with the buyer – rather than the project – taking the lead on technical support and input provision to farmers, potentially via a value chain credit model. The project would play a facilitative role, brokering relationships and providing finance and technical assistance for a pilot project. If successful, the model could be expanded and replicated to include additional farmers, agribusinesses, input providers, and other actors.

While conventional MSD projects tend to be large scale, large-budget operations, our honey example shows how core MSD principles – facilitating lasting change through a focus on commercial viability and private sector partnerships – can be applied in small-scale conservation livelihoods projects.

Coffee

Next, we consider a conventional coffee MSD project, which we assume to be working to reduce poverty by connecting large coffee buyers to smallholder farmers via outgrower schemes, complemented with policy work to streamline the export licensing process and facilitation of export market linkages.

Applying a Green MSD lens, which forces consideration of climate and nature impacts, may reveal that coffee sector growth is contributing to local deforestation, with forests being cleared to establish coffee plantations, while intensive growing practices are leading to soil degradation. To address this, we expand the business model to include climate smart agriculture practices and a

landscape carbon project, with carbon credits being generated through sustainable management of the wider landscape by the coffee company and local communities. Consequently, the model aims to secure premiums in export markets for sustainable coffee production. The proposed model is illustrated in the vision diagram in Figure 4. If successful, the project will work to promote the model as a norm across the coffee sector. This example shows the potential impact of Green MSD on conventional MSD programming, helping to mitigate environmental risks and identify nature-based commercial opportunities – even if the project does not have explicit conservation goals.

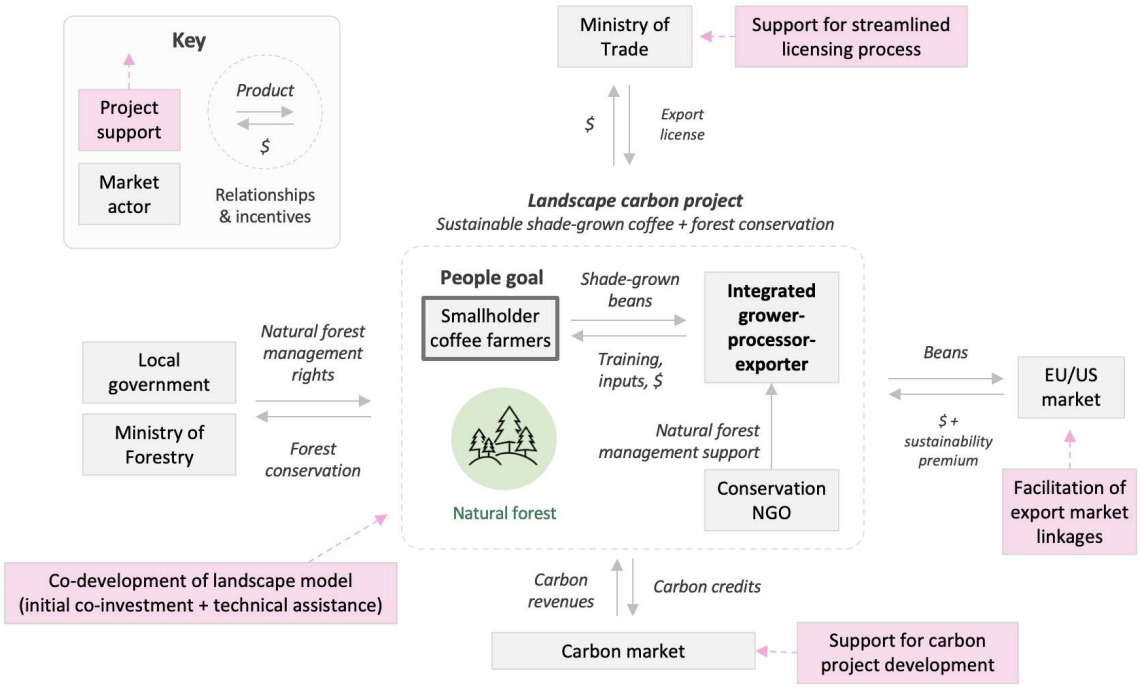


Figure 4: Green market system vision. Green MSD innovations can be illustrated via vision diagrams such as the coffee market example here. A vision diagram should clearly map the proposed relationships and incentives between market actors, as well as the specific role that the project will play in facilitating systems change.

Energy

Finally, we consider how Green MSD might be used to address some of the largest, most complex environmental problems of our time, using the example of charcoal markets. Assume that charcoal has been identified as a critical market driving deforestation and emissions, while also being crucial for rural livelihoods. Market analysis may reveal a range of systemic constraints including weak regulations and corruption, illegal cross-border trade, limited alternative energy sources, and slow uptake of fuel-efficient technologies. Several conclusions may be drawn – meaningful impact will likely require broader energy sector interventions, multi-agency government cooperation, dedicated strategies for urban and rural markets across multiple countries, and a patient, long-term approach. By asking what it would take to drive truly transformational change in the market, Green MSD avoids the "tinkering around the edges" effect of direct delivery approaches (e.g., small-scale tree planting or cookstove handouts) that treat symptoms rather than underlying causes of system failure.

As with the previous examples, a strategy could include private sector business models – around, say, rural wood energy supply or urban clean energy appliances. However, a strong policy and regulatory component would also likely be required, such as working with multiple government agencies to develop a national green energy strategy. While some may see these as "policy" or "governance" rather than "market" interventions, under Green MSD these "rules" are critical for the functioning of the market. By following the analysis to identify leverage points in wider systems, the project may shift its focus from forest frontier charcoal production to, say, working with commercial banks to develop financial products for investors in clean energy appliances, or with the finance ministry to negotiate tax breaks for imports of high efficiency kilns. If successful, the various pilot models could be combined and scaled into a multi-country initiative pursuing a large-scale green energy transition.

Practical implications

Development

For development practitioners, the Green MSD framework is novel in its integration climate and biodiversity impacts into market systems programming, forcing users to be aware of these potential effects. While we do not go as far as to recommend a "do no harm" approach given the inevitable trade-offs involved (McShane et al., 2011), users following the approach will be better placed to mitigate environmental harms, and to provide justifications for the expected balance of positive and negative effects across the three dimensions of people, climate, and nature. The inclusion of climate and nature impacts also necessarily broaden the relevant "rules" of the system to consideration of environmental governance, potentially leading development practitioners to engage with environmental NGOs, government agencies, and other stakeholder groups in ways that would not typically happen in conventional MSD programming.

The introduction of supporting environmental conditions into the framework is intended to sharpen MSD practitioner focus on building resilience to environmental change, particularly climate adaptation. Ultimately, this may help to reinforce the notion in mainstream development practice of markets being dependent upon natural systems, rather than only on technical inputs such as finance and skills. Finally, rather than simply placing environmental restrictions on development programming, Green MSD can draw attention to the growing range of "green" development opportunities relating to, e.g., conservation finance, nature-based solutions, and sustainability premiums.

Conservation

For conservation practitioners, the Green MSD framework opens the MSD toolbox to a wide new audience, emphasizing the need for systemic approaches focused on private sector partnerships and commercial incentives, with a view to fundamentally changing the way that markets work, rather than simply providing short-term direct aid to communities. Those using the Conservation Standards (or similar conservation planning approaches) may find Green MSD a useful tool to guide deeper analysis of market systems identified in preliminary situation analysis when designing interventions. For example, situation models such as those in the Conservation Standards tend to highlight elements such as "consumer demand", "high prices", or "need for income" as contributing factors to biodiversity loss, or point to multiple markets that threats originate from (Conservation Measures Partnership, 2025, Figure 6). Such analyses lack sufficient detail on underlying drivers or dynamics of the market systems to be able to prioritize between markets and design interventions – areas where Green MSD provides a range of analytical tools.

Critically, the initial market selection process helps practitioners to focus on markets where the greatest biodiversity and climate threats originate. While this sounds intuitive, it is deliberately designed to shift strategies away from bolt-on livelihoods support in local communities (as a largely compensatory or relationship-building effort) towards the strategic targeting of critical market-based threats, thereby integrating market interventions with wider conservation strategy.

Integrated approaches

Finally, the Green MSD approach encourages truly joined-up programming with teams staffed with a range of expertise from conservation science to business and finance – a rare setup in either conservation or development practice. At the same time, it challenges donors to rethink funding

models, encouraging the breaking down of thematic silos, and a shift towards investment in patient, transdisciplinary, systemic approaches capable of addressing some of the most intractable and complex socio-ecological challenges of our time.

Limitations

Two types of limitation are worth considering – those related to the MSD approach underpinning Green MSD, and those particular to the new framework. Like any development approach, MSD is constrained by donor funding modalities that favor fast, quantifiable results. As such, MSD projects tend to be disproportionately private sector oriented (where fast-moving, entrepreneurial work is possible) while engagement with the "rules" of the system is less common (given the inertia and bureaucracy more common in this area) (Hamilton-Peach, 2024). This poses a challenge for Green MSD, given the critical role of governments in correcting environmental market failures. Patient long-term funding models are therefore required, avoiding undue emphasis on "quick wins", and instead enabling ambitious, innovative strategies such as the charcoal example above that address root causes of environmental problems rather than "tinkering around the edges" via short-term direct aid delivery. Given the increasing pressure on aid budgets, systemic approaches to people, climate, and nature goals should also look beyond traditional project-based aid delivery to integrated models drawing on investment (both private and concessional), trade, and diplomacy, in line with wider trends (Calleja & Casadevall-Bellés, 2024; Kump, 2025; World Bank, 2020).

Conventional MSD projects often have budgets in the tens of millions of dollars and run for many years, with transformational change being slow to realize – a stark contrast with much of conservation funding. However, we believe core MSD principles of commercial viability, private sector engagement, and sustainability are applicable even in small grants programming, as in the honey example above. Practitioners may find it useful to develop an overarching Green MSD strategy to be

funded over time through multiple grants, spreading the cost of research and analysis and ensuring a coherent organizational strategy targeting long-term systemic change.

Finally, Green MSD requires a demanding mix of skillsets, combining both conservation and development expertise with an understanding of business and finance that enables effective private sector engagement. Beyond specific skills, it requires developing a common language, understanding, and goals between fields that are long-established, often siloed, and frequently at odds – challenges common to transdisciplinary working generally (Deutsch et al., 2023).

The way forward

This paper and corresponding practitioner guidelines in Hilton et al. (2025) are intended to start a conversation around systemic approaches to delivering on people, climate, and nature goals from local to global scales, drawing on best practice from the conservation and development sectors. Moving forward, our focus will be on testing Green MSD in the field, building a community of practice to share evidence and lessons, and refining the approach over time. Priorities will include raising funds to both design and implement new Green MSD projects, working with teams of conservation and development practitioners, as well as to provide capacity building support to existing conservation and/or development projects interested in strengthening their approach to people, climate, and nature programming. Our intention is to cement the relationship between the BEAM Exchange and Conservation Measures Partnership via a Green MSD community of practice, building on the working group that informed the development of the guidelines. Monitoring, evaluation, and learning will also be critical – not only in evaluating the impacts of Green MSD projects, but also in refining our understanding of how best to implement such an approach in practice, and thereby update future versions of the Green MSD guidelines. Finally, uptake of the approach will depend critically on

effective promotion, communication, and dissemination strategies, informing a wide audience of the potential of the approach, and clarifying its value proposition relative to alternative frameworks.

CHAPTER 3: EVALUATING LIVELIHOODS PROGRAMMING IN BIODIVERSITY CONSERVATION PROJECTS – A COMPARISON WITH THE MARKET SYSTEMS DEVELOPMENT APPROACH

Abstract

Strategies to support livelihoods and human wellbeing alongside biodiversity are widespread in modern conservation practice, yet limited evidence exists on their effectiveness. Concerns have been raised about projects' reliance on short-term aid delivery with uncertain post-project legacies, as well as a failure to adequately engage with the complexity of social-ecological systems. To assess the current state of livelihoods programming in conservation, we evaluated livelihoods interventions in projects funded through the UK's government's Darwin Initiative (one of the longest running conservation funds, established in 1992) and its sister fund the Illegal Wildlife Challenge Fund. We used an evaluation rubric based on the Market Systems Development approach, which is widely considered to represent best practice in the economic development field today. We found most projects to fall short of these standards. Direct aid delivery models were dominant, with insufficient focus on commercial viability, relatively weak market analysis, limited private sector engagement, and questionable prospects for lasting impact. However, one in six projects were found to be in line with core principles of the Market Systems Development approach, proving that sophisticated, systemic approaches are feasible in the context of relatively small conservation grants. Building on these successes, bringing conservation livelihoods programming in line with global best practice will require increased collaboration between conservation and development practitioners and donors, with a focus on flexible, innovative programming that drives lasting change in incentives and behavior.

Introduction

Local peoples' livelihoods – their means of securing a living - are of central importance to conservation practice, both because of the influence they can have on the success (or failure) of conservation, as well as the recognition that it is neither effective nor appropriate to pursue conservation goals independent of broader socio-ecological concerns (W. M. Adams et al., 2004; R. Chambers & Conway, 1992). While livelihoods interventions are now common in conservation, there is limited evidence on the effectiveness of these interventions, while questions remain as to the links between livelihoods interventions and biodiversity outcomes (Natarajan et al., 2022; Roe et al., 2015). In economic development, a field that has long sought to improve the livelihoods of the poor across the Global South, the Market Systems Development (MSD) approach is widely regarded as best practice in livelihoods programming, using a systemic approach to leverage lasting impact by "making markets work for the poor" (The Springfield Centre, 2015). To assess the state of livelihoods programming in conservation today, we evaluated a sample of projects from the UK Department for Environment, Food, and Rural Affairs' (Defra) Biodiversity Challenge Funds, assessing the extent to which their approaches adhered to key principles of MSD.

Conservation practice and livelihoods

Conservation projects frequently feature livelihoods interventions aimed at compensating for reduced natural resource access, building local support for conservation initiatives, encouraging sustainable natural resource use, or replacing environmentally harmful economic activity with alternative livelihoods (W. M. Adams et al., 2004; Roe, 2008). These efforts have faced various criticisms, particularly for their overreliance on simple linear approaches and pursuit of replicable "silver bullet" solutions, while failing to grasp the complexity of the social-ecological systems they

seek to shape (Game et al., 2014; IUCN, 2008; Ostrom, 2007; Wright et al., 2016). Projects often seek elusive win-wins without a realistic appreciation of the trade-offs between conservation and development (McShane et al., 2011), while teams still tend to be predominantly staffed by personnel with natural science backgrounds and lacking expertise in economic development and the wider social sciences (Bennett et al., 2017; Detoeuf et al., 2025). Projects often suffer from a lack of flexible, adaptive management (Salafsky et al., 2001) and weak theories of change (Rice et al., 2020), while evidence on the effectiveness of interventions is lacking (Ferraro & Pattanayak, 2006; Sutherland et al., 2019).

Lessons from economic development

If conservation projects are to generate meaningful livelihoods impacts it will be important to learn lessons from the economic development sector, where practitioners have spent decades grappling with many of the same problems outlined above. Over the years, development practice has undergone several paradigm shifts, from an early postwar focus on stimulating macro-level trade, investment, and gross domestic product, to the more micro-level concepts of human capabilities, sustainable development, and livelihoods approaches by the 1990s (Anand & Sen, 1994; R. Chambers & Conway, 1992; Scoones, 1998). Both macro and micro approaches struggled to grasp the importance of meso-level politics, power, institutions, and complexity that shape the functioning of interconnected global markets, whilst "direct delivery" of aid – whereby projects directly provide free goods and services such as agricultural inputs and training - led to short-lived impacts that quickly faded post-project (Ferrand et al., 2004; Natarajan et al., 2022). Ultimately, underwhelming results led to a legitimacy crisis in the sector, with aid dependency seen as hindering meaningful development across the Global South (Doucouliagos & Paldam, 2009; Easterly, 2002).

In the early 2000s, this led to the emergence of the Market Systems Development approach, which sought to leverage lasting change in complex systems through flexible, adaptive programming focused on behavior and incentives, commercial viability, local ownership, private sector engagement, and the targeting of root causes – rather than symptoms – of poverty (Albu, 2008; Donovan et al., 2015; Ramalingam et al., 2014; The Springfield Centre, 2015). Market systems practitioners look beyond core value chains (where goods are traded from producers to consumers) to the wider enabling environment of rules (e.g., laws, traditions, and policies) and supporting functions (e.g., access to skills, finance, and technology). Under this approach, local livelihoods are understood to be part of larger market systems, with poverty being perpetuated by market failures and structural inequalities that reach beyond local communities to wider regional and global systems. While market systems projects are not without their challenges, the approach has generally become regarded as best practice in economic development programming today, with a proven ability to outperform linear direct delivery approaches and generate lasting impact at scale (Conroy & Kessler, 2019; Hilton, 2024b; Osorio-Cortes & Albu, 2021).

Key components of a Market Systems Development approach

Key components of a market systems approach include (1) market selection, (2) market intelligence, (3) intervention design, (4) team capacity, (5) market actor engagement, (6) monitoring, evaluation, and learning, and (7) scale and sustainability (The Springfield Centre, 2015; USAID, 2024b). Market selection (1) involves choosing a focal market for intervention (e.g., agriculture, fisheries) based on relevance to project goals and feasibility of successful intervention (Practical Action, 2022). Market intelligence (2) involves developing a robust understanding of the relationships and dynamics of complex market systems, including the systemic constraints to be targeted with intervention (D. Meadows, 1999; USAID, 2024a). Intervention design (3) requires a robust theory of

change setting out the intervention logic leading from project activities to a desired future state of the system (BEAM Exchange, 2025b), while high-capacity teams (4) typically feature knowledge of business and finance and experience working with the private sector (Sarwar & Osorio-Cortes, 2018).

Interventions are implemented in partnership with existing market actors (5) (e.g., producers, processors, government agencies), with an emphasis on shaping incentives, behavior, and capabilities (The Canopy Lab, 2025). Monitoring, evaluation, and learning systems (6) generate evidence on project performance and inform adaptive management (Posthumus et al., 2020; Ripley & Nippard, 2014), whilst a clear exit strategy establishes a vision for a post-project legacy of scalable, sustainable results (7) (Davies, 2016). By taking a nimble, entrepreneurial, and facilitative approach to unlocking systemic constraints, market systems projects aim to leave a legacy of locally owned innovations that fundamentally change the way that markets work.

Market systems thinking and conservation

While the explicit use of market systems approaches is rare in conservation, it is a subject of growing interest, particularly given its long-established use in the development sector to address the criticisms of traditional livelihoods programming outlined above (Hilton et al., 2025; Mohanan et al., 2018). Moreover, despite not considering themselves "market systems" programs, some conservation initiatives feature key principles of the approach, such as complex systems thinking, private sector partnership, and adaptive programming (The Moore Foundation, 2025; WRI, 2025; WWF, 2025).

To assess the extent to which these principles are present in conservation livelihoods programming more broadly, we evaluated a sample of projects from the UK government's Darwin Initiative and Illegal Wildlife Trade Challenge Fund, some of the largest and longest-running conservation initiatives in the world, funding projects across the Global South (Biodiversity Challenge

Funds, 2025). Since projects are funded via the UK foreign aid budget, they are required to include poverty reduction goals, which most commonly takes the form of improving livelihoods (Darwin Initiative, 2019).

It is important to note that the projects examined here were never explicitly required or expected to take a "market systems" approach. As such, rather than critiquing the performance of individual projects against a benchmark established after the fact, our goal with this study is to compare the general standard of livelihoods programming between the conservation and development sectors. Despite this caveat, it is worth noting that several key elements of MSD *are* required in Darwin Initiative and Illegal Wildlife Trade Challenge Fund grants, even if they are not referred to as "MSD" – e.g., a robust theory of change, relevant team capacity and expertise for livelihoods programming, strong monitoring, evaluation, and learning systems, and a clear exit strategy detailing the plan for post-project sustainability.

Methods

Evaluation rubric design

To assess livelihoods approaches, we designed an evaluation rubric reflecting best practice under the MSD approach. First, we defined livelihoods in the narrow sense of income generation, as this was the most common interpretation in the portfolio of reviewed projects. We considered nine dimensions of programming – the seven components outlined above (market selection; market intelligence; intervention design; team capacity; market actor engagement; monitoring, evaluation, and learning; and scale and sustainability), plus two additional dimensions – the extent to which projects delivered against their livelihoods goals and the strength of the link between livelihoods intervention and conservation goals.

The basic structure, description of each dimension, and supporting literature behind the rubric is shown in Table 1, with the full rubric and scoring criteria included in Appendix 1. Our methodology follows best practice in the literature on rubric design, including choice of dimensions and drafting of scoring criteria based on a review of the Market Systems Development literature, piloting the rubric on a subset of projects, cross-checking results across multiple authors to ensure consistency in scoring, and making final adjustments to rubric wording before proceeding to the full evaluation (Better Evaluation, 2013; Davidson, 2005). Key guiding MSD literature for the rubric design included the Making Markets Work for the Poor Operational Guide (The Springfield Centre, 2015) – the foremost MSD project guidelines – and the leading online MSD knowledge hubs of the BEAM Exchange (BEAM Exchange, 2025a) and USAID MarketLinks Value Chain Development Wiki (USAID, 2024b). Additional literature used to inform specific dimensions are included in Table 1.

Table 1: Market systems evaluation rubric structure

Dimension	Best practice	References
a) Key components of a Market Systems Development approach		
Market selection: How the project decides which markets to work in (e.g., agriculture, fisheries, livestock)	Multiple potential markets compared and prioritized according to relevance to project goals, feasibility of successful intervention, and likely impacts. Strong evidence of commercial viability of focal livelihood strategy. Evidence of market selection decision being made based on scoping fieldwork and/or participatory processes with project target group/other stakeholders (vs. desk-based/remote decision).	Practical Action (2022)
Market intelligence: The project's understanding of how the market functions, including root causes of market failure.	Demonstrated understanding of overall market system, including value chain plus enabling environment of rules and supporting functions. Identification of priority systemic constraints / market failures and opportunities for intervention. Stakeholder analysis of the capacity and incentives of key market actors. Consideration of past market trends / dynamics and likely future directions.	Meadows (1999); USAID (2024a)
Intervention design: The logic behind proposed project interventions.	Intervention logic informed by priority constraints identified in the market analysis, multiple evidence sources, and participatory processes involving market actors. Intervention logic mapped in a theory of change linking activities to desired results, plus clear articulation of	BEAM Exchange, (2025b)

	risks/assumptions, and recognition of potential feedback loops and/or unintended consequences in complex systems.	
Team capacity: The skills and experience of the implementing team with regards to livelihoods interventions.	Team has very good livelihoods experience & expertise. Multiple partners with relevant credentials, including market / sector development work beyond immediate beneficiaries / communities. One or more market actors (beyond immediate beneficiaries) are part of the project consortium (e.g., private firms, finance providers, certification bodies, government development agencies, private training providers).	Sarwar & Osorio-Cortes (2018)
Market actor engagement: The degree to which the project partners with existing market actors (e.g., producers, processors, relevant government agencies)	Project features very strong partnership arrangement with multiple market actors in the target market (beyond target group).	The Canopy Lab (2025)
Monitoring, evaluation, and learning (MEL): How the project tracks its results and adjusts strategy accordingly.	MEL goes beyond essential logframe reporting to provide additional evidence with greater explanatory power around the success or failure of interventions. Inclusion of market metrics (e.g., production / yields, sales values / volumes, product quality). Triangulation of findings via mixed quantitative and qualitative methods. Evidence of MEL informing in-project learning & adaptive management. Insightful reflections on lessons for future programming.	Posthumus et al. (2020); Ripley & Nippard (2014)
Scale & sustainability: The prospect of results lasting beyond the project and growing beyond immediate beneficiaries.	Strong evidence of potential for results to be sustained beyond the project (e.g., farmers proven to make more money because of recommended practices, creating lasting incentives for sustained behavior change independent of donor subsidy). Evidence of results being scaled by market actors beyond direct beneficiaries (e.g., other farmers replicate observed behavior change; buyers start to demand sustainably sourced produce).	Davies (2016)
(b) Additional criteria		
Performance against logframe targets: The extent to which the project has delivered on its livelihood goals.	Results relating to livelihoods significantly exceeded project targets.	
Links to conservation goals: The extent to which livelihoods interventions contribute to	Explicit link between markets & livelihoods interventions & conservation goals, tested via MEL (e.g., did raising incomes lead to the desired conservation outcomes?). Detailed understanding of the relationship between target market and species/ecosystem of interest. Recognition & evaluation of potential risks	

conservation objectives.	and trade-offs between conservation and development goals in complex systems.

Sampling

We used a random number generator to randomly sample BCFs projects that were completed in the five years prior to the study (three year-long projects awarded between 2015-19 and ending 2018-22) that featured livelihood objectives (specifically, those with targets relating to increasing incomes in their "logframes" - the key document specifying intended results as part of each project's contract with the donor), stratified according to the most common focal markets. The five-year time window allowed us to assess recent trends in livelihoods approaches, while restricting the sample to completed projects allowed us to use end-of-project reports and monitoring data in our analysis. Of 526 total projects funded since 2015, 252 included livelihoods objectives (specifically, logframe targets relating to increasing household incomes), of which 150 had been completed at the time of our evaluation. To construct the sample, we first coded all 150 of these projects according to the focal market(s) they were working in, allowing for sample stratification to test for variation in approaches between markets. The most common focal markets were agriculture (n=92), tourism (n=46), fisheries (n=42), non-timber forest products (n=37), livestock (n=34), agroforestry (n=30), and beekeeping (n=20) (note that the total exceeds 150 since many projects work in multiple markets). To capture appreciable variation within market groupings, nine projects were randomly selected within each market strata (eight for beekeeping) for inclusion in the final sample, giving 62 in total, or 41% of relevant projects.

Analysis

We assessed projects against our rubric using evidence from project proposals, annual reports, completion reports, monitoring data, and final evaluations conducted by Defra, following standard

guidance on document review in project evaluations (CDC, 2018; OECD, 2010). Project proposals were the primary source of information on most rubric dimensions, since they contain the context of the project and rationale for intervention, the proposed strategy and theory of change, details of team members and any wider consortium partners, monitoring framework (including project targets captured in logframes), and exit strategy (i.e., vision for post-project sustainability). We used annual and completion reports prepared by the projects to incorporate more nuanced detail of what happened during implementation, and used donor-conducted final evaluations to triangulate findings against independent third-party review. Finally, we used project monitoring data (logframe reporting) to assess the extent to which livelihoods goals had been achieved. Based on review of these documents, two researchers scored each of the nine dimensions listed above on a scale of one (poor) to five (excellent) (see Appendix 1 for scoring criteria). We calculated an overall livelihoods approach score per project based on the degree of adherence with the core principles of MSD as the unweighted average score across the 9 dimensions.

Results

The assessed projects had an average budget of £483,000 (ranging from £247,000 to £947,000), with 48% of projects supporting existing livelihoods (e.g., increasing agricultural productivity), 39% promoting alternative livelihoods (e.g., encouraging farmers to take up beekeeping), and 13% featuring a combination of the two. Common interventions included training farmers and providing inputs (e.g., seeds) or equipment (e.g., beehives). Lead partners were typically international NGOs (68% of cases), followed by universities (16%), local NGOs (15%), and private sector (2%). Around a third (34%) featured a private sector partner in the consortium, and a little over half (58%) engaged with market actors beyond immediate beneficiaries (e.g., going beyond beneficiary farmers or fishers to engage buyers, processors, or relevant government agencies) during the project.

Overall, we assessed around two-thirds of projects as either "poor" or "inadequate" in their approach to livelihoods programming relative to best practice in the development sector (Figure 1). Weak points included market selection and intelligence, intervention design, private sector engagement, and prospects for scale and sustainability. Around one in six projects demonstrated practices in line with best practice in economic development (rated "very good" or "excellent" overall). Areas of relative strength included team capacity, delivery of targeted results, and MEL. Notably, projects achieving or exceeding their logframe livelihoods targets had an average score across the other eight livelihoods dimensions of 2.6, compared to 2.3 on projects falling short of their targets, lending weight to our rubric design. The distribution of scores is strongly clustered around the mean, suggesting limited variation in the quality and nature of livelihoods strategies across the sample.

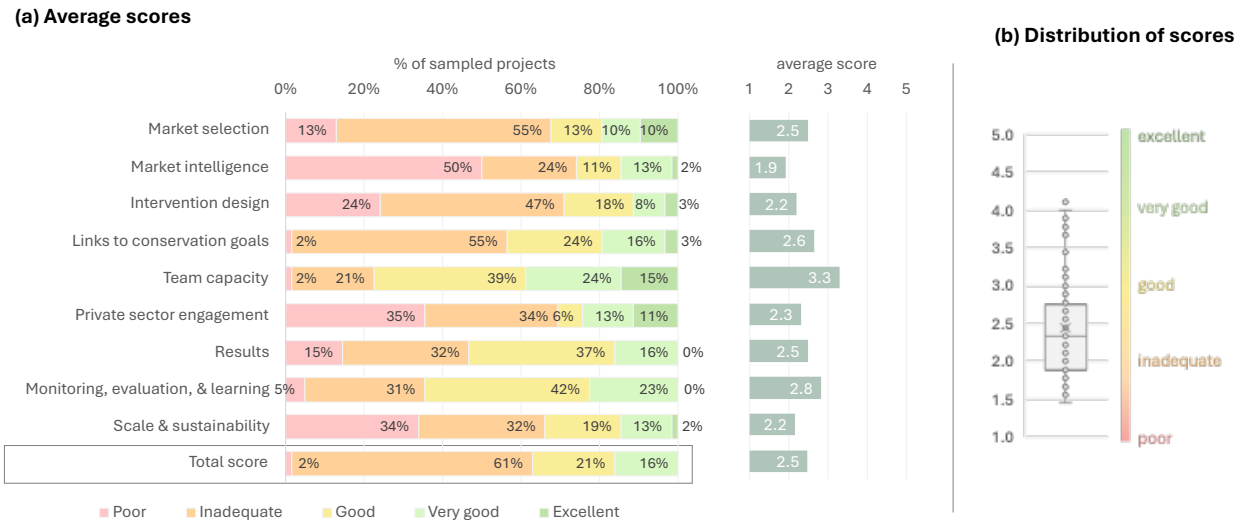


Figure 5: Results of the rubric-based evaluation of livelihoods interventions in conservation projects. Overall, most projects' approach to livelihoods programming was rated "poor" or "inadequate" – though around one in six demonstrated performances on a par with best practice in the development sector (Panel a). The distribution of results is shown in Panel (b), with most clustering around the mean of 2.5, suggesting limited variation in the quality and nature of livelihoods programming.

Most reviewed projects applied a model of livelihoods programming that does not reflect the latest best practice in the development sector. Interventions were often characterized by a lack of market analysis and limited private sector engagement, relying on "direct delivery" aid models rather than systemic approaches (which seek to leverage lasting change at scale beyond a project's lifetime). While more than half achieved their targets, these results tended to be limited in scope and uncertain whether they would endure beyond the life of the grant. Moreover, the links from livelihoods work to conservation goals were often based on implicit and sometimes tenuous assumptions that remained untested by projects. Commonly recurring interventions involved the free provision of training and/or inputs to farmers, fishers, or other primary producers, generating short-term gains for direct beneficiaries, but showing no sign of a commercially viable enduring livelihoods strategy.

Despite this, around one in six projects took approaches that were comparable to high quality programming in the development sector, demonstrating a strong understanding of the focal market, deploying evidence-based interventions to unlock market constraints, and facilitating lasting change in incentives and behavior through close relationships with private sector partners. In Uganda, Wildlife Conservation Society worked to connect farmers in Hoima District with local agribusinesses, facilitating contract farming models and demonstrating the commercial viability of the model via reporting on yield, price, and profitability. In Cambodia, Birdlife International established compliance contracts with an exporter whereby farmer sustainability premiums for local rice production were linked to observed conservation outcomes in nearby protected areas. The scheme was found to reduce deforestation and raise incomes, with the model expected to expand to more communities post-project (3ie, 2020). Both projects demonstrated a strong understanding of the market, core team members with agribusiness expertise, private sector partners in the project consortium, and a focus on commercial performance in their monitoring data. Whilst such projects remain the minority,

enough exist to give confidence that sophisticated, ambitious approaches to livelihoods programming are possible in a conservation context, even with the limited time and budget constraints of BCFs grants.

Cross tabulated results are shown in Figure 6. We looked for variations in livelihoods approaches according to the final report review score (the overall score awarded to the project by the donor, covering all elements of the project – not just livelihoods interventions), budget size (split evenly into small/medium/large terciles), livelihood strategy type (supporting existing livelihoods, promoting alternative livelihoods, or both), the type of lead partner on the grant (international NGO, local NGO, or university), the fund (Darwin Initiative or Illegal Wildlife Trade Challenge Fund), and the start year. Generally, the distribution of results by each crosstab are similar to the overall picture in Figure 5, suggesting a highly consistent approach to livelihoods programming across the diverse range of projects funded. Of all crosstabs, only the start year features an outlier, with the latest start year reviewed (2020) having a notably higher average score than past years. Caution in interpretation is required given the small sample size (n=5), and more research is needed to look for improvements in programming post-2020.

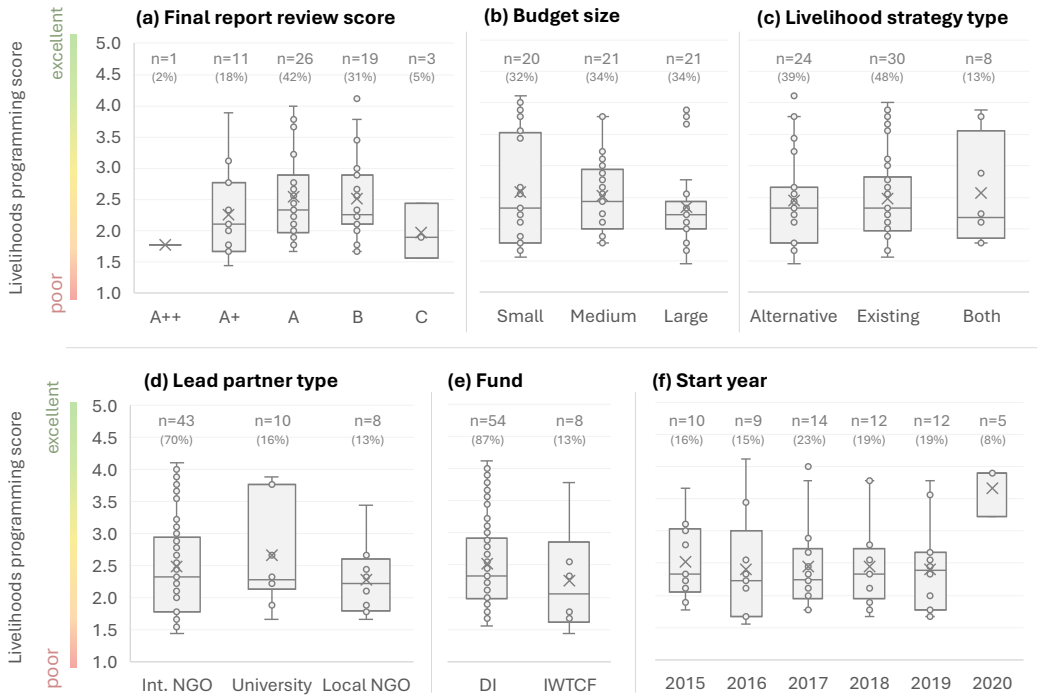


Figure 6: Cross tabulated results. Little variation is observed by final report review score, budget, livelihood strategy type, lead partner type, fund, or start year – suggesting largely consistent approaches to livelihoods programming across the diversity of projects funded by the Darwin Initiative and Illegal Wildlife Trade Challenge Fund.

Discussion

In general, these results suggest that most livelihoods programming in conservation projects funded through the Darwin Initiative and Illegal Wildlife Trade Challenge Fund falls short of best practice in the economic development sector as embodied in the MSD approach. While it is important to reiterate that this should not be interpreted as a negative reflection on projects that were never explicitly required to use such an approach at the outset, it is indicative of a general need in the conservation sector to strengthen livelihoods programming through systemic approaches and improved market interventions, drawing on lessons from the development sector (Hilton et al., 2025). Further discussion is provided around each rubric dimension below, before considering wider implications for conservation, as well as limitations and areas for further research.

Findings by rubric dimension

Market selection

While the choice of focal market is often self-explanatory (e.g., marine conservation organizations tend to work on fisheries), in many cases the rationale was unclear. Relevance to conservation and development goals is often more implicit than explicit. Most projects gave no indication of the commercial viability of the supported livelihood strategy at the proposal stage – a particular concern when introducing new and untested alternative livelihood strategies, or when operating in thin/niche markets (e.g., many non-timber forest products) (Belcher & Schreckenberg, 2007; Wright et al., 2016). In some cases, projects made commendable efforts to select focal livelihoods strategies via participatory processes, allowing for community inputs as to areas where support was most needed, either conducted prior to the grant or proposed as an in-project activity (Mohanan et al., 2018).

Market intelligence

Market intelligence was generally poor, with 50% of projects providing no information on the state of the market and the implications for intervention design. Without such information, it is difficult to assess the feasibility of intervention, both in terms of potential commercial viability and the relevance of the project's proposed activities in addressing market constraints. This reflects broader concerns in the literature around the ability of practitioners to effectively engage with complex systems (Game et al., 2014; Natarajan et al., 2022; Ramalingam et al., 2014).

In the case of support to existing livelihoods, an assumption can be made that the focal livelihood strategy is currently commercially viable, otherwise people would not be practicing it. However, a case still needs to be made that proposed changes to existing practices are commercially viable – e.g., how might fisher profit margins differ with temporary closures and no-take zones? For

sustainable practices to be upheld, they not only need to be profitable, but more profitable than the alternative (or coupled with enforcement, regulation, or compensation to bridge the gap).

The lack of market intelligence is even more problematic in the case of alternative livelihood promotion (e.g., introducing beekeeping), where there tends to be far greater uncertainty around commercial viability. In this case, questions go beyond the simple existence of demand (e.g., honey markets in local urban centers) – itself rarely evidenced in proposals - to questions of whether producers can navigate the vast array of new business challenges relating to skills, finance, transport, processing, marketing, quality control, packaging, regulations, and so forth.

Intervention design

Intervention design tends to suffer from a lack of supporting evidence for the proposed approach and weak theories of change. While most projects offered no supporting evidence to justify a chosen approach, where evidence was provided, the most common form was reference to earlier work by the grantee, either at the same project site or elsewhere. However, such evidence is often anecdotal and unsupported by specific references or details of past findings. Elsewhere, applicants often referred ambiguously to "research" or "studies" justifying an approach without verifiable references.

With regards to the theories of change, many projects' interventions feature large leaps of logic between low-level "outputs" (training farmers, providing inputs) and high-level "outcomes" (typically household income). This simplification of expected results overlooks a great deal of nuance and complexity present in any market system, including the values, attitudes, incentives, capacity, and behavior of a diverse array of market actors. Omitting these intermediate steps from the theory of change creates significant risks around the likelihood of successful intervention, as well as limitations in the explanatory power of monitoring and evaluation – consistent with wider findings in the literature

and calls for improved use of theories of change in conservation (Leisher et al., 2024; Margoluis et al., 2013).

Finally, in the absence of robust market analysis, it is unclear whether many projects are targeting the right constraints. Many default to "direct delivery" of training and inputs, an approach with two key shortcomings (Humphrey, 2014). First, it is often unclear how results will be sustained once the project's free provision of goods and services ends. Second, it presupposes that a lack of knowledge and inputs are the binding constraints standing between the status quo and the desired outcome. In reality, greater knowledge may not be sufficient – or even necessary – to achieve the desired results. Fishers may know that overfishing depletes fish stocks in the long run but choose to maintain an unsustainable level of fishing effort due to weak governance, short-term income necessity, or a lack of incentives for sustainable sourcing. Instead of assuming that people do not know how to practice desired behaviors, projects should make more effort to understand – and influence – the incentives that shape behavior (Cardenas & Carpenter, 2008; Rare and The Behavioral Insights Team, 2019).

Links to conservation goals

The sampled projects sought to influence conservation outcomes via livelihoods interventions along multiple impact pathways, including reducing the environmental impact of existing livelihoods strategies, promoting alternative livelihoods to discourage participation in less desirable livelihood strategies, fostering pro-conservation attitudes and behavior by enhancing nature-based incomes, reducing the need to convert natural areas by increasing agricultural productivity, and promoting livelihood strategies that are less vulnerable to human-wildlife conflict.

In most cases, however, the link between livelihoods and conservation goals remained implicit, with large leaps of logic in the theory of change, and critical assumptions remaining untested via

monitoring and evaluation. Many projects relied on hypotheses widely disputed in the literature – such as the land sparing argument that agricultural intensification reduces the total land needed for cultivation (rather than incentivizing agricultural expansion by increasing profitability) (Phelps et al., 2013).

In project reporting, success tended to be defined in terms of training and inputs provided by the project being converted into income gains, with little evidence on the resulting effect on conservation attitudes and behaviors. To have confidence in the proposed impact pathways, more evidence is needed on, for example, the relative commercial incentives of sustainable versus traditional agricultural practices (El Bakali et al., 2023), the likelihood of promoted alternative livelihoods (e.g., beekeeping) displacing, rather than complementing, less desirable income sources (e.g., poaching) (Roe et al., 2015), or the broader effects on conservation attitudes and behavior (Nilsson et al., 2016). Without this information, it is unclear whether livelihoods interventions are having any impact on conservation outcomes. Since robust impact evaluation of conservation outcomes may be beyond the capacity of the grantees, this may be an area for further research at the level of the fund manager.

Team capacity

While most BCFs applicants are conservation NGOs or conservation-oriented academic departments, the wide prevalence of livelihoods programming in conservation today means that many teams featured staff with extensive livelihoods experience. However, this experience does not necessarily translate into effective performance - given the lack of improvement noted in BCFs livelihoods programming over time, it is possible that some organizations have repeatedly applied an outdated approach to livelihoods programming that falls short of best practice in the development sector.

However, several teams demonstrated credentials on a par with high-performing teams in the economic development sector, including knowledge of markets and ability to work closely with private sector partners. In addition, we noted a marked increase over time in the proportion of projects with a private sector partner in the team (e.g., agribusinesses or seafood buyers), doubling from 20% in 2015 to 40% in 2019. This is a welcome improvement, drawing on vital real-world business expertise to facilitate lasting change in markets, and one of the few aspects of livelihoods programming assessed here that has seen a steady improvement over time.

Market actor engagement

A little over half of projects engaged with market actors beyond immediate beneficiaries. Market engagement beyond immediate beneficiaries tended to focus on either buyers (e.g., agribusinesses, tour operators) or actors in the wider enabling environment (e.g., trade associations, government agencies, or finance providers). The highest-scoring projects overall were characterized by close work with market actors to facilitate relationships between producers and buyers, creating lasting incentives for sustainable livelihoods practices through, e.g., contract farming or sustainability premiums, in line with broader calls for greater private sector engagement in conservation (Global Environment Facility, 2011; MacDonald, 2010).

Performance against logframe targets

Just over half (53%) of sampled projects either achieved or slightly exceeded their logframe targets relating to livelihoods, with around a third falling slightly below and 15% significantly below target. Logframe outcomes (the highest results level) almost always focused on household incomes, though lower-level results varied (e.g., numbers of farmers trained, adoption of improved practices, productivity, or sales). Overall, projects scoring highly on the other dimensions in our rubric performed better in terms of delivery of results, lending weight to our rubric design.

However, there were also several cases of projects scoring highly under our rubric failing to meet their logframe targets, as well as projects with lower scores exceeding their targets. This raises questions around the definition of success via logframes. Whilst being a convenient way of summarizing progress to donors via a handful of key metrics, logframes are known to incentivize quick wins and easily countable results via rigid, linear approaches – as such, they struggle to track progress in complex systems or accommodate adaptive programming, being more suited to the direct delivery of aid (Hummelbrunner, 2010). Among reviewed projects, reported successes most often took the form of direct training and input provision to a (typically small) group of beneficiaries who realized corresponding income gains. While short-term benefits should naturally be expected from free inputs, in most cases questions remained over the likelihood of lasting impact.

Conversely, projects with more sophisticated approaches to livelihoods programming sometimes struggled to deliver against their logframe targets. In economic development practice, lasting impacts are most commonly achieved via patient, innovative approaches that embrace complexity, learning and adapting via trial-and-error (Hilton, 2024b; Osorio-Cortes & Albu, 2021). To encourage effective programming, donor results frameworks need to distinguish between "failure" in terms of negative results from experimental approaches that generate useful lessons – a healthy feature of flexible, adaptive programming - and "failure" in terms of genuinely unsatisfactory performance.

This speaks to the funds' identities as "challenge funds", one objective of which is to nudge behavior towards more desirable outcomes through the de-risking of innovation using as little subsidy as possible (Pompa, 2013). Considering that business startup failure rates often exceed 90%, it is natural to expect that many (if not most) livelihood innovations may "fail" if they are grounded in the realities of business and finance rather than direct aid handouts (Keeler, 2012). The rationale of challenge funds (also embraced in market systems development programming) is that in funds seeking

to deliver lasting impact underpinned by genuine commercial incentives, if only 1 in 10 projects succeed, in the long run they may leverage greater impact than 10 "successful" direct aid delivery projects. Raising the risk appetite of donor funding, supported by results frameworks that incentivize flexibility and innovation, may help to deliver more meaningful impacts in the long run.

Monitoring, evaluation, & learning

Across the sample, monitoring, evaluation, and learning efforts were generally satisfactory insofar as essential logframe reporting was concerned, with most projects providing sufficient evidence to explain progress against targets. However, several areas for improvement were noted. First, project reporting is limited to the three-step logframe structure of activities, outputs, and outcomes. The leaps of logic implied by this simplified results chain often led to substantial evidence gaps and limited explanatory power of monitoring data. However, it should be noted that many grantees of donor programs - particularly small, local organizations - find logframe reporting onerous and unintuitive, and would prefer alternative (including verbal and visual) forms of reporting (Paul et al., 2022).

Second, evidence of commercial viability and incentives – critical for lasting impact – was largely missing from reporting, with projects instead often focusing on short-term effects of training and input delivery. While detailed commercial analysis can be challenging, the observed behavior of market actors can serve as a useful proxy. Farmers may adopt sustainable practices with project support in the first planting season – but are they voluntarily repeating this in subsequent seasons? Are there signs of replication and "crowding in" from other farmers, independent of project support? Are market linkages being established with buyers? Drawing on best practice in assessing market systems change can help to unpack some of these questions (Kessler, 2021; Posthumus et al., 2020).

Third, most reporting involved no attempt to estimate additionality (relative to a counterfactual) or attribution (isolating project impacts relative to external forces), making it difficult

to make a robust assessment of intervention effectiveness – a long-standing concern in conservation generally (Ferraro & Pattanayak, 2006). Whilst additionality and attribution can be challenging to estimate with any degree of confidence, and are often estimated using demanding statistical methods, lighter touch qualitative methods are available (and sometimes preferable) when intervening in complex market systems (O'Sullivan, 2016).

Fourth, as noted above, monitoring and evaluation efforts did little to unpack the relationship between livelihood interventions and conservation outcomes. Finally, none of the sample projects provided an analysis of potential negative side-effects of their actions, such as displacement of undesirable behaviors to other areas, or trade-offs between conservation and development outcomes.

Scale & sustainability

The likelihood of projects leaving behind a legacy of improved conservation and development outcomes because of livelihoods interventions is perhaps the most uncertain and contentious of the dimensions assessed here. Very few projects provide evidence of the commercial viability of supported livelihood strategies in the absence of continued subsidy, and none of the sampled projects sought to compare this with competing (less sustainable) strategies - a known issue in conservation livelihoods programming (Roe et al., 2015). All projects are required to detail "exit strategies" in proposals – proposed measures to ensure that results are sustained after the funding ends. Such strategies are increasingly being called for in the conservation literature, yet remain underused and understudied in the field (Le Cornu et al., 2023; Ruiz-Miranda et al., 2020). Assessed projects typically referenced generic factors such as a legacy of "increased capacity" after training in their exit strategies without meaningful consideration of the incentives needed to bring about lasting behavior change. For example, projects promoting conservation agriculture via the provision of free training and equipment rarely offered evidence of the likely commercial incentives for the approach once subsidy is removed,

leaving open the possibility of farmers reverting to traditional practices. With regards to scale, very few projects showed signs of crowding in or replication during project lifetimes – though this is perhaps unsurprising given the short timeframes involved.

The most promising projects in the sample shared a focus on these incentives, working closely with private sector actors to facilitate lasting change – connecting producers to buyers, facilitating contractual arrangements, and supporting innovative new business models led by local market actors. While such examples were relatively few, they stand as evidence that lasting change in the way that markets operate and fundamental shifts in livelihood strategies can be delivered within the short timeframe of the grants, so long as there is close cooperation with existing market actors and a clear vision for sustainability beyond the project based on a detailed understanding of the required commercial incentives.

Implications for conservation practice

Constraints and opportunities specific to conservation practice

While our study draws on best practice from the development field, we recognize that these practices often take place in programs with budgets in the tens of millions of dollars running for many years. By comparison, the average budget of projects evaluated for the present study was just under £500,000 - while these are not "small" projects, a market study procured through an external consultancy firm (common in development practice), for example, would likely be prohibitively expensive. As such, more affordable means of gathering and interpreting market intelligence are required than might be carried out in large-scale market development programs. In most cases, livelihoods interventions make up one of several project components, limiting the resources dedicated to livelihoods programming to a fraction of the total, further stressing the need for cost-efficient processes. To address this, it is important that market systems principles can be "right sized" to a

small grants conservation context, focusing on essential elements that can be carried out on a limited budget, such as improved private sector engagement and consideration of commercial viability. The Green MSD guidelines offer advice and examples to this end (Hilton et al., 2025).

Perhaps a greater constraint is the three-year timescale of most of the grants. Effective livelihoods programming often involves a substantial planning and analysis phase followed by an implementation process characterized by patient trial and error. Building partnerships, innovating new business models, and encouraging behavior change can be a gradual process. Careful consideration is needed on the definition of "success" with respect to incremental progress towards systems change versus rapid delivery of conservation and development outcomes. Donors should consider adjusting logframes to reward interim contributions towards meaningful systems change, rather than incentivizing "quick wins", while also adjusting their risk appetite to enable more innovative approaches.

Despite these limitations, many grantees have the advantage of a long-term presence in focal landscapes, with in-depth contextual knowledge of socioecological systems and strong relationships with local communities. While certain practices (e.g., in-depth market studies) may not be feasible within a single conservation grant, they may therefore be possible at an organizational or landscape level, spanning multiple grants.

Recommendations for future programming

For conservation practitioners implementing livelihoods interventions, we encourage drawing on best practice from the development field as per the rubric used in this study, drawing on resources from practitioner hubs such as the BEAM Exchange and Donor Committee for Enterprise Development (BEAM Exchange, 2025a; DCED, 2025). Specifically, the recently launched Green Market Systems Development framework includes detailed guidance tailoring the market systems

development approach to a conservation context, including advice on "right sizing" the approach to small grants programming (Hilton et al., 2025).

In local livelihoods programming such as in the projects reviewed here, particular attention should be paid on ensuring the commercial viability of proposed interventions, strong market actor engagement beyond primary producers, and a clear exit strategy focused on the incentives, capacities, and behaviors of relevant actors, based on a vision of how the market should work in future. Direct delivery models should be avoided where possible, with interventions instead targeting systemic constraints identified through market analysis. For practitioners working in a particular landscape or system over the longer term, an organization-level market system strategy can serve as an overarching guide for multiple grants.

For conservation donors, it will be important to provide additional guidance and capacity building to their grantees, drawing on economic development best practice, as captured in the Green Market Systems Development guidelines and elsewhere (Hilton et al., 2025). In addition, tools such as the rubric in the present study could help to better scrutinize livelihood strategies proposed in funding applications. Improved engagement between conservation and development teams within donor organizations should help to move from siloed funding streams towards a transdisciplinary approach to conservation and development (e.g., in the UK context, strengthening ties between Defra's global biodiversity programming and the Foreign, Commonwealth & Development Office's overseas development assistance) (Tallis et al., 2024). Donors could also help to build the evidence base for conservation livelihoods programming by commissioning studies and contributing to knowledge repositories such as Conservation Evidence (Sutherland et al., 2019). Finally, awarded grants should be designed to encourage ambitious, locally relevant, innovative working and

incremental progress towards systems change, rather than rigid results frameworks that incentivize "quick wins" and direct delivery approaches with limited scope for lasting impact.

Limitations and future research priorities

Several study limitations are noted. First, the research was based on project documents (from project design through completion) and did not include interviews with grantees or wider stakeholders. While enabling a large sample, this desk-based approach limited access to more nuanced project information, as well as evidence of post-project legacies. However, the level of narrative detail contained in proposals, progress reports, and end-of-project reporting were thought to be sufficient to inform the rubric. Second, since we focused on recently completed projects (with start years from 2015-19), our study cannot comment on longer term trends or more recent developments. Third, while our study focused on projects seeking to raise incomes via livelihoods interventions, it is noted that the funds take a broader view of poverty reduction, including health, education, and so forth (Darwin Initiative, 2019). Fourth, our study compares livelihoods programming in conservation to best practice – rather than actual practice – in the development field. As such, any criticisms of conservation practice should be caveated with a recognition that many development projects are unlikely to meet the high standards assessed here. Finally, we recognize that a fully-fledged, resource-intensive, market systems development approach may not be suitable for small grants programming. Instead, core principles of market systems development – such as focusing on commercial viability, behavior and incentives, private sector partnerships, and a feasible exit strategy – need to be "right sized" for conservation practitioners, as per the Green MSD guidelines (Hilton et al., 2025).

Going forward, further research should focus on legacy evaluations of conservation livelihoods interventions. Whilst our study has raised serious doubts about the sustainability of impact in many cases, post-project primary data collection is needed to verify these conclusions. In addition,

more research is needed to understand the interrelationships between conservation and development goals in such projects, as well as studies of the market systems that conservation actors frequently engage in, to establish a more robust evidence base to inform future programming.

CHAPTER 4: COST-BENEFIT ANALYSIS AS A DECISION TOOL FOR EFFECTIVE CONSERVATION PLANNING – THE CASE OF THE NYERERE SELOUS-UDZUNGWA WILDLIFE CORRIDOR IN TANZANIA

Abstract

Cost benefit analysis (CBA) is used in many fields to ensure efficient allocation of scarce resources but is rarely applied in conservation. By using a common metric to evaluate projects in complex social-ecological systems, CBA can help to maximize the impact of conservation funding. It can also help to interrogate issues of distributional equity, plan for effective community-based conservation, and inform future research and strategic priorities. We demonstrate this using the example of the Nyerere Selous-Udzungwa Wildlife Corridor in Tanzania, a wildlife corridor aiming to restore connectivity between two protected areas to enhance African elephant (Loxodonta africana) conservation outcomes and mitigate human-elephant conflict. We combine novel data on elephant crop depredation with crop price and productivity data, elephant valuation methods, and ecosystem service values to analyze corridor costs and benefits from contrasting global and local community perspectives. From the global perspective, we find benefits to outweigh costs by at least 4.6:1. From the communities' perspective, we find that while substantial benefits should secure buy-in to the project, continued subsidy will be required to cover the costs. Our findings support generalized recommendations for application of CBA across diverse systems and conservation priorities.

Introduction

Despite continued alarming rates of global biodiversity loss, only a fraction of the funds required to meet international conservation goals are available (Deutz et al., 2020; WWF, 2022).

Conservation planners must use the limited resources available to them wisely, pursuing strategies that maximize conservation outcomes from every dollar spent (Ferraro & Pattanayak, 2006; Wilson et al., 2007). Since the allocation of scarce resources is a central question of the economics discipline, economic evaluation tools may help to achieve this goal (Cook et al., 2017).

Recently, significant progress has been made in building evidence on conservation effectiveness through initiatives such as the Conservation Evidence database (Sutherland et al., 2019) and Collaboration for Environmental Evidence (Pullin & Knight, 2009). However, consideration of the costs of delivering conservation outcomes, and the use of economic evaluation methods, remains surprisingly limited in conservation (Pienkowski et al., 2021; White et al., 2022). Planning still largely relies upon 'benefit targeting' - selecting interventions according to their likely ecological impact irrespective of costs (Grand et al., 2017). This failure to incorporate costs into planning is likely to result in suboptimal use of resources and underperformance relative to conservation objectives (Moore et al., 2004; Naidoo & Ricketts, 2006; Polasky et al., 2001).

Cost-benefit analysis

Cost benefit analysis (CBA) is used in many fields to conduct pre-project appraisals or end-of-project evaluations to assess whether the benefits of an action justify its costs. Unlike cost effectiveness analysis, which assesses the cost per outcome of an action (e.g., cost per square kilometer protected), CBA assigns monetary values to all benefits and compares this value to total costs. Computing a single cost-benefit metric allows for appraisal of projects with multiple diverse outcomes (e.g., combined socioeconomic and environmental outcomes), as well as comparison between different kinds of projects (e.g., comparing investment in wildlife corridors with anti-poaching efforts) – particularly useful when considering multiple potential interventions in complex social-ecological systems, and more in line with the multi-criteria decision making field (Triantaphyllou, 2000). In

addition, CBA can be used to compare stakeholder perspectives and distributional implications of a project, which can help in the planning of how costs and benefits should be managed between different actors.

A standard CBA involves (a) quantifying all costs and benefits over the life of the project (forecasting into the future where necessary), (b) assigning monetary values to each factor (including to non-market factors such as environmental impacts), and (c) using a discount rate to calculate present values of costs and benefits (assigning less weight to values arising in future years in order to reflect a general preference for payoffs sooner rather than later) (Boardman et al., 2018). A present value benefit to cost ratio greater than one implies that a project is worth funding.

Cost-benefit analysis in conservation science

CBA has rarely been used in conservation science (Naidoo & Ricketts, 2006; White et al., 2022). Of the 1,987 studies in the current Conservation Evidence databased reviewed by White et al. (2022), only nine (0.5%) featured CBAs. We conducted a Web of Science search for CBA in the field of biodiversity conservation, yielding a further 28 studies. Of these 37 total studies, less than half considered environmental benefits, with most focusing on the financial impact of human-wildlife conflict, wildlife vehicle collisions, or wildlife tourism. Geographic coverage is uneven, with most examining projects in Europe and North America.

Moreover, most did not follow CBA best practice (as per Boardman et al., 2018 and elsewhere). Only 41% used a discount rate to calculate present values of projected future costs and benefits (with only two-thirds of these providing a rationale for their chosen rate), and only 30% conducted a sensitivity analysis (an assessment of the sensitivity of the CBA result to variations in underlying cost and benefit components). Overall, only three studies featured a combination of

consideration for financial and environmental benefits, discounting with a justified rate, and sensitivity analysis (De Groot et al., 2013; Kasimir et al., 2018; Newton et al., 2012). While CBA is therefore not entirely novel in the field, its use has been extremely limited and inconsistent to date.

Barriers to wider use

This limited use of CBA can be attributed to a combination of technical barriers and philosophical concerns. On the technical side, CBA in conservation is complicated by long timescales and difficulties with discount rate selection (Almansa & Martínez-Paz, 2011); significant non-market costs and benefits that lack readily available monetary values (Balmford & Whitten, 2003); distributional issues whereby locally borne costs generate globally diffuse benefits (Green et al., 2018); a high degree of uncertainty around future outcomes (Murdoch et al., 2007); and a lack of available cost data.

However, advances in conservation science are making many of these issues increasingly navigable. Research on ecosystem service valuation, and associated resources such as the Ecosystem Services Valuation Database (www.esvd.net), provide monetary values for many environmental factors (Costanza et al., 2014; Foundation for Sustainable Development, 2021; TEEB, 2010). The contentious issue of discounting in long-term environmental projects has been increasingly addressed in both mainstream guidelines (see, e.g., UK Government, 2022) and landmark reports (Stern, 2008). Going forward, distilling these various lines of research into conservation-specific CBA guidelines should help to increase uptake.

On the philosophical side, many conservation scientists remain wary of economic considerations (particularly those perceived as "putting a price on nature"), concerned that market-driven ideologies may come to override ecological goals or the intrinsic value of nature (Arponen et

al., 2010). However, CBA is flexible to diverse values. While costs and benefits are necessarily assigned monetary values in the analysis, there is no requirement for a project to make money in the real world - the dollar values of CBA simply serve as a common metric for comparison between heterogenous outcomes, given the familiarity of money as a measure of value. Indeed, when incorporated in CBA, recent developments in valuing the vast and diverse benefits of nature can lend substantial weight to conservation arguments relative to commercial alternatives (Bradbury et al., 2021; IPBES, 2022).

If conservation is to make the most of limited resources, generating the greatest outcomes per dollar spent, work is needed to overcome these technical and philosophical barriers, and to demonstrate the value of CBA as a tool that is flexible to the objectives of conservation planners, applicable to complex ecological problems, and transparent to the public. We demonstrate that this is possible using the example of the Nyerere Selous-Udzungwa Wildlife Corridor (NSUWC) in Southern Tanzania.

Costs and benefits of wildlife conservation corridors

Declining habitat connectivity is one of the greatest drivers of biodiversity loss today, as land outside of protected areas becomes increasingly human-dominated (Fahrig, 2003; Fischer & Lindenmayer, 2007; J. A. Foley et al., 2005; Newmark, 2008). The establishment and protection of conservation corridors – tracts of protected land connecting two or more larger habitats – has therefore become a popular approach for the mitigation of habitat fragmentation (Hilty et al., 2020). Conservation corridors can help protect migration routes, enhance gene flow, enable (re)colonization of habitats, mitigate human-wildlife conflict, and provide options for range shifting in the face of changing environmental circumstances, particularly in the context of climate change (Gilbert-Norton et al., 2010; Hilty et al., 2020).

Despite their growing popularity, there remains limited evidence on the cost effectiveness of conservation corridors (Beier & Noss, 1998; Brodie et al., 2016; Simberloff et al., 1992). Conservation corridor costs - including physical infrastructure, compensation for land or displaced persons, and opportunity costs of land (i.e., the foregone financial returns associated with leaving land unutilized) - can be substantial (Nyaligu & Weeks, 2013). To justify these costs to funders and other stakeholders, there is a critical need to demonstrate corresponding benefits from corridor projects.

Like many conservation strategies, corridors also raise significant questions around human wellbeing and distributional equity. By reducing community access to land and natural resources, setting land aside for corridors can appear contrary to human development goals - particularly in areas of high-density human settlement and economic activity - attracting accusations of green grabbing (Benjaminsen & Bryceson, 2012). While protection of community rights should be the minimum standard for conservation actors, seeking community support can also support the success of conservation initiatives (Bennett et al., 2019).

To explore these questions around the cost effectiveness of corridor conservation, as well as the wider potential for use of CBA in conservation, we demonstrate how CBA can be used to appraise projects from multiple stakeholder perspectives, seeking to answer two questions – first, does the project represent good value for money in terms of elephant conservation, and second, are local communities likely to be in favor of the project?

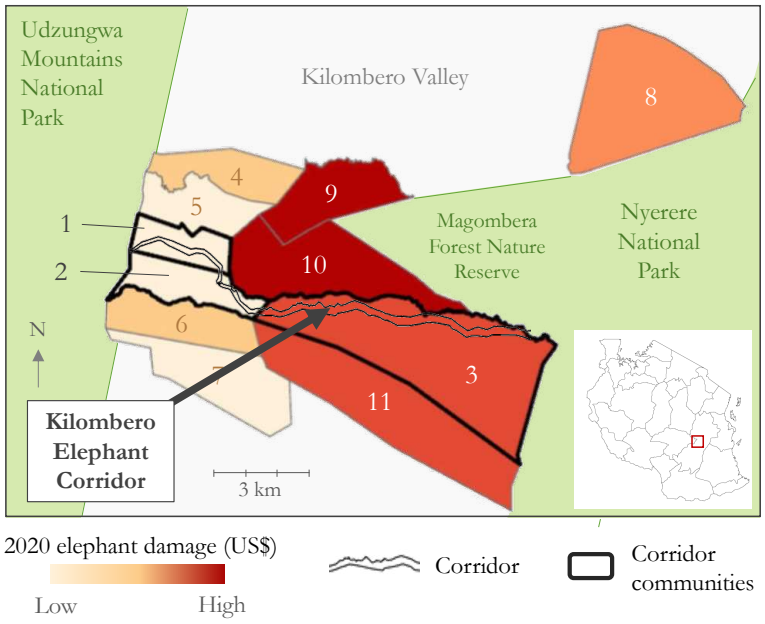
Methods

Study area

The NSUWC project, led by the Kilombero District (Ifakara Town Council) and the NSUWC Management Committee and facilitated by Southern Tanzania Elephant Program (STEP, a Tanzanian

NGO) and the USAID Tuhifadhi Maliasili project, aims to reestablish connectivity between the Udzungwa Mountains National Park and Nyerere National Park, which has recently been severed by intensive agricultural activity in the Kilombero Valley (STEP, 2018). The wildlife corridor is considered a priority within the country's vast corridor network, both in terms of conservation importance and severity of threat faced (Ministry of Natural Resources and Tourism, 2022). Connectivity loss has led to high and rising rates of human elephant conflict (HEC) - with elephant migration routes increasingly obstructed by human settlements and agricultural activities, elephants attempting to cross the valley can cause significant crop damage while also posing a risk to human safety, consistent with evidence elsewhere (Buchholtz et al., 2020).

The 174-hectare corridor will feature an electric fence and road and rail underpasses, spanning a narrow 13km route across the Kilombero Valley through three communities (Kanyenja, Mang'ula A, and Sole villages) (Figure 7). During 2022-23, all households identified as contributing small parcels of land to the corridor were compensated by the Government of Tanzania, using donor funds. All compensated landowners received financial training and are being included in local microfinance groups. Participating villages are also receiving annual conservation payments. The primary long-term benefit to local farmers is expected to be reduction of crop loss from elephants. Since this HEC mitigation benefit is expected to extend beyond the three corridor communities (as managing elephant movement across the valley is also expected to reduce elephant damage on neighboring village land), we broaden the study area to a 'corridor landscape' comprising 11 villages.



#	Community	Elephant damage (2020)
Corridor communities		
1	Sole	$0
2	Mang'ula A	$0
3	Kanyenja	$26,962
Wider landscape communities		
4	Mkula	$223
5	Sonjo	$0
6	Mang'ula B	$193
7	Mwaya	$0
8	Msolwa Station	$2,038
9	Magombera	$43,767
10	Katurukila	$48,162
11	Msalise	$34,462

Figure 7 Current elephant damage in the landscape around the proposed Nyerere Selous-Udzungwa Wildlife Corridor. The proposed corridor will re-establish connectivity between the Udzungwa Mountains National Park, Magombera Forest Nature Reserve, and Nyerere National Park via the Kilombero Valley, passing through three 'corridor communities' of Sole, Mang'ula A, and Kanyenja. We also consider a further eight communities expected to be affected by the corridor, making up an 11-community 'corridor landscape'. The total value of elephant damage in each community in 2020 is shown, based on STEP human-elephant conflict (HEC) data.

As well as HEC mitigation, the project is expected to support wider connectivity between Tanzania's southern and western elephant metapopulations, and to improve elephant population health in neighboring protected areas by restoring migration routes, gene flow, and dispersal feasibility, while also generating connectivity benefits for a range of other species (Epps et al., 2011; Jones et al., 2012). It is also expected to increase the provision of ecosystem services, such as climate regulation and erosion prevention, by converting existing cropland to a mixture of forest and grassland.

Perspectives and standing

To explore distributional considerations, we used three perspectives – a global conservation perspective, a landscape community perspective (11 communities), and a corridor community

perspective (three communities contributing land to the corridor). This allowed us to assess not only whether the project represents a sound conservation investment, but also how it might be perceived by local communities.

The issue of standing refers to the question of whose costs and benefits to count. In the conservation perspective, we included all costs and benefits of the project, including all establishment, maintenance, and opportunity costs, plus benefits relating to elephant population health, HEC mitigation, and ecosystem services. In the community perspectives, however, we focused only on the community-specific benefits of HEC mitigation (informed by STEP consultations with community members on their priority concerns relating to the corridor). While we recognize that this may overlook conservation values held by the communities, we assumed that most conservation benefits (e.g., the existence value of elephants, or carbon sequestration benefits of forest restoration) accrue nationally and globally.

We compared community benefits not only to the total cost of the project, but also to a subset of opportunity and maintenance costs since these may be considered a more reasonable threshold of community contribution to the project. In other words, we asked whether the expected local benefits might justify communities giving up land and contributing to ongoing corridor upkeep.

Costs

All cost data were taken from the project budget in STEP (2018). Direct costs were divided into the categories recommended in (Iacona et al., 2018) (labor, capital, consumables, and overhead) and presented in 2020 US dollars. The estimated establishment costs of the NSUWC are just over $2 million, including (a) labor ($399,000, including village game scout salaries, data collection efforts, corridor patrolling and monitoring, and per diems for meetings), (b) capital ($807,000, including 12km

of electric fencing on each side of the corridor, road construction, highway and rail underpasses, vehicles, and habitat restoration (c) consumables ($275,000, including consultancy and legal fees, fuel, and office equipment, and (d) overheads ($568,000, including organizational costs of STEP and partners). These are spread over a five-year project, with the corridor being operational from year 3. Maintenance costs are estimated at 6% of construction costs - $7,188 per year beginning in year 3 and continuing indefinitely. The replacement cost of infrastructure is expected to be $199,808 every 30 years.

We define opportunity cost of land as the potential income in the counterfactual scenario whereby communities continue to farm the corridor land. The opportunity cost of land was used in both the conservation and community perspectives to understand the value of land required to be set aside for the corridor. We estimated this using a 2019 Kilombero District land use survey over a 20-hectare sample of corridor (12% of the total area), which found current land use to be predominantly agricultural, with the most common crops being sugarcane followed by bamboo, oil palm, mango, and bananas. Potential agricultural revenue in the area was calculated by multiplying the area planted to each crop in the sample by productivity estimates and price data from Kilombero District Government and FAOSTAT to arrive at sample area revenue, before extrapolating to the wider corridor area. To estimate profits (i.e., remaining revenue after subtracting production costs), assumptions were drawn from the literature on smallholder agriculture profitability in Tanzania. The resulting potential annual returns to agriculture in the corridor area (opportunity cost of land) amounted to $73,773 per year.

Benefits

Benefits of the corridor include tangible benefits associated with reduced elephant crop damage in communities across the landscape, intangible benefits of reduced human-elephant

interaction in and around the communities, increased value of ecosystem services within the corridor area resulting from land restoration efforts, and elephant tourism revenues and existence values associated with improved elephant population health in neighboring protected areas. While all benefits were counted in the conservation perspective, only the benefits of reduced HEC were counted in the community perspectives, on the assumption that this is the primary concern of community members.

Tangible HEC benefits were defined as the value of elephant crop damage avoided because of the corridor, relative to the counterfactual of crop raiding continuing at current rates. While limited data exist on the behavioral response of elephants to corridors, evidence from the Mount Kenya Elephant Corridor (similar to the NSUWC in terms of its physical attributes, social-ecological context, and objectives) suggests that effectively managing elephant movement between protected areas can lead to significant reductions in HEC in nearby communities (S. Weeks, personal communication, October 13, 2021).

We estimated the potential for reduced elephant damage using data on current damage levels gathered by STEP in 10 of the 11 communities in the corridor area in 2020 (one community, Msalise, did not participate). Data were collected through a combination of twice-weekly surveys by local enumerators (paid by STEP to routinely survey elephant activity on village land) and direct community reporting to STEP. Data on each damage incident include details of the crop or tree affected, area damaged, and extent of damage within that area. These data were combined with the data on productivity and crop prices described above to monetize losses. Elephant damage in Msalise, for which no data were available, was modelled by assuming the community experienced comparable levels of damage to its neighbors, scaled by the number of households in each community.

Total elephant damage across the 11-community landscape in 2020 was estimated at $155,807. While data prior to 2018 are not available, STEP staff working in the valley since 2009 report

substantial crop losses in the area in each of the last 10 years. In addition, data collected since 2018 reveals a steady annual increase in elephant crop damage in the corridor area between 2018-2022. We conservatively assumed that future elephant damage would be comparable to 2020 in the without-corridor scenario.

Finally, a maximum avoidable annual crop damage of $154,838 was estimated by removing the 174-hectare corridor from the calculations (since the land will no longer be cultivated). While STEP monitoring was assumed to be close to a census of elephant damage in the area, the potential for underestimation is considered in the sensitivity analysis (below).

Intangible benefits of the corridor were defined as the reduced intangible costs of human-elephant interactions resulting from the corridor, compared with the same counterfactual level of HEC outlined above. Intangible benefits include reduced fear and stress associated with elephants, reduced time spent guarding crops, increased safety while walking at night, and avoided injury or death resulting from elephant interactions (Barua et al., 2013; Kansky et al., 2014).

While no data exist on the monetary value of such effects, several studies have found intangible costs to outweigh the tangible costs of living with wildlife, including with elephants specifically (Jacobsen et al., 2021; Kansky et al., 2016; Saif et al., 2020). We therefore included a conservative estimate that the annual value of intangible benefits may as much as equal the tangible benefits described above. However, given the uncertainty around this nascent research area, we present results with and without intangible benefits.

We modeled ecosystem services values (ESVs) by assuming that the corridor land will undergo a transformation from predominantly cropland to a 50%-50% split of grassland and forest, based on the corridor's habitat restoration plans (STEP, 2018). Monetary values of annual ecosystem service flows from each of these biomes were drawn from the Ecosystem Services Valuation Database

(Foundation for Sustainable Development, 2021). Summing the average global value of each of the 22 ecosystem services included in the database for each biome gave values of $9,174/hectare/year for forests and $6,500/hectare/year for grassland. Forest values are primarily made up of erosion prevention, maintenance of life cycles, and climate regulation, while grassland benefits primarily relate to soil fertility, air and climate regulation, and aesthetic values.

Food production services were removed from the cropland values as they are already included in the opportunity cost of land calculations, leaving a residual ESV of $1,261 per hectare per year (primarily relating to pollination and biological control) (Costanza et al., 2014; Power, 2010). We assumed that following the planned corridor landscape restoration efforts, converting cropland to the full ecosystem service provision of a new biome will take 30 years for grassland (Mbaabu et al., 2020) and 40 years for forests (Philipson et al., 2020).

Given the lack of evidence on the impact of corridors on elephant populations, we considered potential elephant population effects in the context of observed recent and potential growth rates and the carrying capacity of the system. We assigned monetary values using a Total Economic Value framework, counting strictly non-consumptive values (i.e., not hunting), including potential tourism revenues and existence values (the value associated with simply knowing that a species exists) (see, e.g., TEEB, 2010).

The Selous-Mikumi elephant population growth rate (including Nyerere National Park, on the east side of the corridor) is estimated at 0.5% per year – a marked stabilization since the poaching crisis of 2006-2011, but significantly below the potential growth rate of the species, observed at 7% per annum in Tanzania's Tarangire National Park (C. Foley & Faust, 2010; TAWIRI, 2019). Less is known about the Udzungwa National Park population, but estimates based on several years of observations in the park places it at 500-1,000 individuals (T. Jones, unpublished data).

We estimated the total elephant habitat on either side of the corridor at 87,000 km2 and an associated carrying capacity of 104,572 individuals, based on a maximum population density of 1.2 animals/km^2 (Armbruster & Lande, 1993). At the current growth rate, it would take over 400 years for the current population to reach the carrying capacity of the system, compared with just 30 years at the maximum observed growth rate of 7%. Given the uncertainty around population effects, we explored the potential impact of the corridor using a series of conservative 0.001 percentage point increments above the current growth rate, whereby adding 0.001% to the growth rate would lead to 25 additional animals after 100 years, 52 additional animals at 0.002%, and so forth. Future evaluation of the corridor should seek to refine these estimates.

To attach monetary values to these figures, we took estimates from a 2008 review of elephant economic valuations, which found annual per-elephant values of $1,562 from tourism (based on tourism revenues in Kenya) and $4,420 associated with existence value (based on the stated willingness to pay for elephant conservation in European and American households) (Blignaut et al., 2008). Inflating these figures to 2020 US$ gave values of $1,923 (tourism) and $5,443 (existence) respectively, or a combined value of $7,366 per elephant per year. Applying this to the incremental growth rates above, we see that the 25 additional animals associated with a 0.001 percentage point increase in the growth rate would ultimately be worth over $180,000/year by year 100.

Time horizons and discounting

The choice of time horizon and discount rate (the relative weight assigned to values in the future versus values today) is one of the most debated and subjective aspects of CBA, particularly for environmental projects with very long time horizons (Atkinson & Mourato, 2008). The higher the chosen discount rate, the stronger the preference for faster payoffs. Future values are discounted to

arrive at present values using the formula PV=FV/(1+r)^Y, where PV = present value, FV = future value, r = the discount rate, and Y = years into the future.

We used different timeframes and discount rates for our different CBA perspectives, reflecting different stakeholder preferences. Specifically, we assumed that local communities have a shorter-term outlook and more urgent preferences for faster payoffs than global conservation stakeholders, given the high degree of risk and uncertainty associated with rural agricultural livelihoods in the tropics (Cohn et al., 2017). For the conservation perspective we used a 100-year outlook, following best practice on the use of extended time horizons for environmental projects with significant long-term effects, along with declining discount rates of 3.5% for years 1-50 and 2.5% for years 51-100, intended to place greater emphasis on long-term results (Boardman et al., 2018; O'Mahony, 2021).

For the community perspectives, we used a 30-year outlook with a 10% discount rate, based on the expected useful life of the infrastructure before replacement is required, as per best practice in CBA for infrastructure projects (O'Mahony, 2021). The 10% discount rate aligns with those commonly used in international development programming (Bonzanigo & Kalra, 2014).

All annual costs and benefits were discounted to present value 2020 US$ and summed to give total present value costs and benefits, before calculating the benefit-to-cost ratio, with any result greater than 1 being considered a worthwhile investment.

Sensitivity analysis

As a decision tool used to appraise projects prior to implementation, CBA can involve a significant degree of uncertainty around future cost and benefit projections, particularly in long-term environmental projects (OECD, 2006). To address this, we conducted sensitivity analysis on a range of key variables to understand their influence on the overall CBA outcome.

On the cost side, we varied the opportunity cost of land by +/-10%, reflecting uncertainty around future profitability of alternative uses of the land. On the benefits side, we explored the potential for the baseline level of elephant damage to be 10% and 20% higher than that captured in STEP's reporting. We also present a range of scenarios for the corridor's potential to mitigate this damage, from 0% to 100% damage reduction. We similarly present a range of elephant population effects from no effect through a series of 0.001 percentage point increments in the population growth rate. A summary of assumptions and inputs under each scenario is presented in Table 2.

Table 2: Summary of CBA assumptions and input values.

Factor	Value [1]
Time horizon	Conservation perspective: 100 years Community perspectives[2]: 30 years
Discount rate	Conservation perspective: 3.5% (Y1-50), 2.5% (Y51-100) Community perspectives: 10%
Costs	
Establishment cost	$2,048,800 (Years 1-5)
Labor	$399,101
Capital	$806,588
Consumables	$274,922
Overhead	$568,189
Maintenance cost	$7,188 / year (from Year 3)
Opportunity cost of land	$73,773 / year (whole corridor area)
Replacement cost	$199,808 (every 30 years)
Benefits	
HEC reduction	
Expected reduction	0% to 100%
Tangible HEC benefit value (avoided crop loss)	$0 - $25,993 / year (3 corridor communities) $0 - $154,838 / year (11-community landscape)

Intangible HEC benefit value (other avoided HEC costs)	$0 - $25,993 / year (3 corridor communities) $0 - $154,838 / year (11-community landscape)
Ecosystem services	
Land conversion	100% cropland - 50% forest/50% grassland
Cropland value	$1,261 / hectare / year
Forest value	$9,174 / hectare / year
Grassland value	$6,500 / hectare / year
Total value after restoration	$1,155,473 / year (whole corridor area)
Elephant population effects	
Expected growth rate effect	Uncertain; we explore +0.001 percentage point increments
Elephant value	$7,366 / elephant / year

[1] All values are justified in the following methods subsections. Dollar values are 2020 US$.

[2] "Community perspectives" refer to both the 11-community landscape perspective and 3-community corridor perspective.

Results

Full CBA calculations and input data are attached in Appendix 2 and available online here.

Conservation perspective

From a global conservation perspective, the benefit/cost ratio ranges from 4.6 to 6.8, suggesting that the project should justify its costs over a 100-year outlook (Table 3). With a present value of $20.7 million, the ESV benefits alone are nearly five times the $4.5 million present value of costs. Judged on HEC benefits, a 40-50% reduction in HEC would be sufficient to cover the project costs irrespective of other benefits (although a 90% HEC reduction would be required if intangible HEC benefits are excluded).

Table 3: Summary of cost-benefit analysis results from the perspectives of global conservation, 11 landscape communities and three corridor communities.

Factor	Conservation perspective (global)	Community perspective (landscape)	Community perspective (corridor)
Costs (present value 2020 US$)			
Establishment	$1,871,069	$1,600,736	$1,600,736
Maintenance	$214,258	$55,286	$55,286
Opportunity	$2,286,025	$679,657	$679,657
Replacement	$113,085	-	-
Total costs	$4,484,438	$2,335,678	$2,335,678
Benefits (present value 2020 US$)			
HEC (tangible)	$0 - $4.9 million	$0 - $1.5 million	$0 - $245,031
HEC (intangible)	$0 - $4.9 million	$0 - $1.5 million	$0 - $245,031
Ecosystem services	$20.7 million	-	-
Elephant population	(uncertain)*	-	-
Total benefits	$20.7 - $30.5 million	$0 - $2.9 million	$0 - $490,061
Benefit/cost ratio	4.6 - 6.8	0.0 - 1.2	0.0 - 0.2
Ex. intangible benefits	4.6 - 5.7	0.0 - 0.6	0.0 - 0.1

* From the conservation perspective, a breakeven point based on elephant population benefits alone is achieved if 0.0031 percentage points are added to the elephant population growth rate, resulting in 75 additional animals after 100 years, or $4.5 million in present value benefits.

In terms of elephant population effects, each additional 0.001% added to the growth rate (equivalent to 25 additional animals after 100 years compared with the counterfactual) adds around $1.5 million to the present value of benefits. Adding a little over 0.003 percentage points to the population growth rate (75 additional animals after 100 years) would more than justify the costs of the corridor irrespective of any other benefits.

Overall, while there is little evidence upon which to make confident forecasts of HEC and elephant population effects, even modest improvements in either of these factors, coupled with the

wider ecosystem service effects, are likely to justify the project costs from a global conservation perspective.

Community perspectives

The present values of all costs and benefits are lower in the community perspectives than the conservation perspective due to the shorter time horizon and higher discount rate. Values up to Year 30 are more aggressively discounted, and values beyond Year 30 are not counted at all. As a result of these effects, the present values of total costs are $4.5m in the conservation perspective but only $2.3m in the community perspective – despite the underlying costs being the same.

More importantly, however, the benefit/cost ratios are less favorable, since certain benefits (ESVs and elephant population effects) are omitted entirely, making the cost effectiveness of the corridor from the community perspectives depend entirely upon the (uncertain) level of HEC reduction that will be achieved. The implications of this are shown in Figure 8.

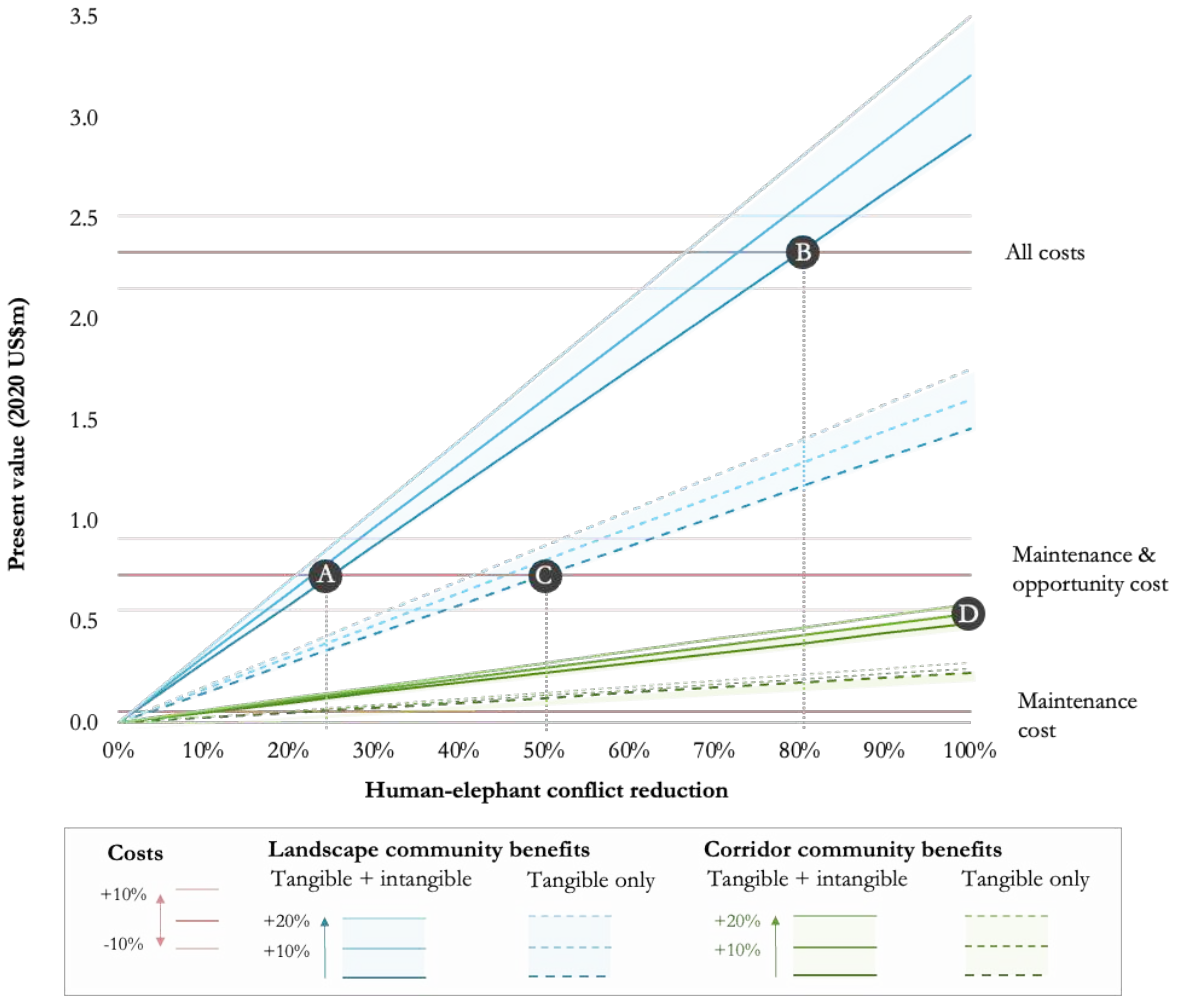


Figure 8: Projected community costs and benefits associated with the Nyerere Selous-Udzungwa Wildlife Corridor. At the landscape level, a 25% human-elephant conflict (HEC) reduction would generate enough benefits to cover maintenance and opportunity costs of the corridor (A), while an 80% HEC reduction would cover all costs (B). If intangible benefits are excluded, a 50% HEC reduction is required to cover maintenance and opportunity costs (C), and even a 100% HEC reduction would not cover all costs, necessitating external funding from conservation stakeholders. From the perspective of the three corridor communities, even full HEC eradication is insufficient to cover the maintenance and opportunity costs, so substantial external subsidy will be required. Sensitivity analysis is presented for opportunity costs (+/-10%) and HEC benefits (+10%, +20%).

At the landscape level (11 communities), if both tangible and intangible benefits are considered, a 25% reduction in HEC would justify the opportunity and maintenance costs of the corridor (Figure 8, A), while justifying the entire costs of the corridor would require an 80% reduction in HEC (Figure 8, B). Fully eradicating HEC across the landscape would generate almost $3m in

benefits, giving a benefit/cost ratio of 1.2 (Table 3). If we limit the analysis to tangible benefits only, a 50% reduction in HEC at the landscape level would be required to cover maintenance and opportunity costs (Figure 8, C), but even a 100% reduction in HEC would not justify the full corridor costs.

From the more specific perspective of the three corridor communities, the project costs substantially outweigh the benefits. The benefits of fully eradicating HEC, and counting both tangible and intangible benefits, are valued at $508,000, and a benefit/cost ratio of 0.2 (Table 3) - even at this level, the benefits would fall short of the opportunity cost of land (Figure 8, D).

Discussion

Nyerere Selous-Udzungwa Wildlife Corridor

From a conservation perspective, the expected combination of benefits relating to elephant populations, ecosystem services, and HEC mitigation appear to comfortably justify the costs of the project, notwithstanding the uncertainty in future outcomes. However, since this positive result is largely driven by the ESV benefits, the corridor's effect on elephant outcomes (HEC and elephant population health) will need to be empirically tested once the corridor is operational in order to assess the corridor's cost-effectiveness for elephant conservation specifically. Judged on elephant outcomes alone, the corridor would be considered cost effective if it achieved either a 40-50% reduction in HEC, a 0.003% increase in the elephant population growth rate, or some combination of the two.

From the community perspectives, the benefit/cost ratios suggest that insufficient incentives exist for the three corridor communities to fund such a project themselves (even if they possessed the required resources). In reality the corridor will be entirely financed from external sources, with participating households being fully compensated for the opportunity cost of land contributed to the

corridor. However, if the project is successful in partially mitigating the high levels of HEC in the area, the communities stand to benefit both financially (in terms of avoided crop loss) and through a range of intangible benefits associated with reduced conflict. Delivering on these goals should improve the community's perception of the project. The spillover benefits in neighboring communities should further bolster support for the project in the wider landscape. Developing additional corridor revenue sources for the community (e.g., tourism, carbon finance, agroforestry income) would further lower the threshold for the project's justification.

Finally, while HEC-related deaths and injuries in the corridor were not evaluated due to insufficient data for future projections, two human deaths and six elephant deaths have been reported in the corridor area between 2019-2022 (T. Jones, unpublished data). Under the above CBA methodology, avoidance of six elephant deaths today would be valued at $1.4 million over the 100-year outlook. While valuation of human life is controversial in CBA, it is common practice in many sectors, with the avoidance of a single human death often being valued at multiple millions of dollars (Viscusi & Aldy, 2003) found a median value of $7 million). If the human and elephant deaths from 2019-2022 alone could have been avoided by the presence of a fenced corridor, the costs would have been more than justified on these terms.

Wider corridor planning

Globally, successful implementation of corridor projects has lagged behind advances in habitat connectivity science, as models of ecologically optimized connectivity come up against complex socioeconomic realities on the ground (Brodie et al., 2016; Correa Ayram et al., 2016). Where projects have succeeded, they have been characterized by an ability to build a common vision and buy-in from diverse stakeholders, and the delivery of socioeconomic benefits for local communities (Keeley et al., 2018). The CBA methodology above can help to identify and prioritize such projects by not only

seeking investments with the greatest conservation impact per dollar spent, but also balancing this with the interests of local stakeholders.

With reference to Tanzanian corridors specifically, a new national corridor action plan sets out a prioritized list of 61 potential corridor projects across the country, ranked by a combination of conservation value and vulnerability (Ministry of Natural Resources and Tourism, 2022). Conducting CBA on the list of candidate corridors identified in the plan, and specifically incorporating socioeconomic impacts, could help to further prioritize corridor projects that represent the greatest value for money, while also being most likely to meet the success criteria noted in Keeley et al. (2018). Given the diverse range of corridor contexts, CBA can provide a common metric to compare capital-intensive projects such as the NSUWC (requiring substantial infrastructure and compensation investments in a densely settled landscape) with corridors that face very different types (as well as scales) of costs and benefits (e.g., much larger corridors traversing more sparsely populated areas).

While the methodology presented here is relatively data-intensive, data requirements could be reduced by using satellite imagery to assess prospective land use changes and the associated opportunity costs, compensation payments, and ecosystem service benefits in corridor areas, combined with spatial assumptions on wildlife conflict as used in Di Minin et al. (2021), and generalized infrastructure costs-per-km depending on corridor type (fenced/unfenced). Such high-level assumptions would decrease confidence in corridor-specific estimates, but would serve as a guide for initial prioritization, after which specific projects could be appraised using more site-specific data as demonstrated in the NSUWC case.

Wider use of cost-benefit analysis in conservation

Appraising projects using CBA during the design phase can help to ensure that limited funds are directed toward projects that represent the greatest value for money in terms of outcomes generated per dollar spent – a critical concern amidst calls for greater accountability in conservation spending (V. M. Adams et al., 2014; Ferraro & Pattanayak, 2006). Moreover, whereas cost effectiveness analysis and cost minimization exercises require a single narrowly defined outcome (e.g., cost per unit area protected), CBA's common value metric is better suited to the evaluation of (increasingly common) complex projects with multiple social-ecological outcomes, as well as comparisons between projects with different outcomes (Pienkowski et al., 2021). As an evaluation tool, it also lends itself to ready integration within existing planning frameworks that seek to guide conservation interventions within complex social-ecological systems (Schwartz et al., 2018).

From the perspective of local communities, limited conservation resources will be most impactful when local stakeholders support conservation initiatives (Bennett et al., 2019). While such narratives are central to community-based conservation, efforts to date have struggled to deliver on socioeconomic outcomes, and win-wins remain elusive (W. M. Adams et al., 2004; Galvin et al., 2018; Salerno et al., 2021). By helping to assess community perceptions of a project, our multi-perspective CBA may be valuable when communicating potential cost and benefits to communities during project design.

While some uncertainties are inevitable at the outset, ex-ante CBA can help to guide future project monitoring and evaluation efforts - and associated strategic adjustments - by highlighting the key assumptions on which the success of the project depends. In the NSUWC example, determining through the CBA that a certain level of HEC reduction will be critical for community approval should ensure that this outcome is closely monitored in future, with complementary interventions being

deployed as necessary to pursue this goal (Cassidy & Salerno, 2020). Similar principles could apply to projects elsewhere, whereby a range of ecological and socioeconomic impact targets can be set, monitored, and managed based upon an initial CBA appraisal.

Finally, we demonstrate the importance of transparency around the influence of individual cost and benefit components on end results. While developments in quantifying the diverse values of nature increasingly lend weight to arguments for conservation over commercial land uses (Bradbury et al., 2021), many stakeholders are unlikely to be motivated by abstract values unless they can be converted into financial flows through mechanisms such as payments for ecosystem services (Naidoo & Ricketts, 2006). While CBA can incorporate a broad spectrum of values, from agricultural profits to the existence value of species, care must be taken to consider which elements will be prioritized by the target audience, and which are driving the CBA results.

Limitations and areas for future research

CBA typically involves a degree of uncertainty around assumptions required to monetize various project elements and forecast them into the future - a challenge exacerbated when estimating outcomes in complex social-ecological systems over long time horizons (OECD, 2006). Our sensitivity analysis seeks to address this uncertainty, and highlights areas for future research, particularly relating to corridor impacts on elephant populations and HEC, for which very limited evidence currently exists.

Other limitations to the NSUWC analysis include assumptions around projecting current observations into the future, particularly with regards to HEC and opportunity costs. While the 2020 snapshot of HEC is considered consistent with broader trends, our assumption that future years will see similar levels of conflict as in 2020 may underestimate the intensification of conflict reported from

the project site - crop damage rates were higher in 2021 and comparable to 2020 levels in 2022 (T. Jones, unpublished data) - which would in turn underestimate the potential HEC mitigation benefits of the corridor. Similarly, current economic activity in the landscape may be an underestimate of future opportunity costs, particularly if more financially profitable land use options become feasible in future due to, e.g., increases in agricultural productivity or the emergence of higher-value economic activities in the manufacturing and service sectors. In the latter case, corridor benefits relative to the counterfactual would be overestimated in the analysis. Finally, while a growing number of studies find intangible costs of human-wildlife conflict to outweigh tangible costs, more work is required to quantify these effects (Kansky et al., 2016).

More generally, CBA for conservation remains challenged by a lack of data (particularly location-specific data) on monetary values for conservation variables, such as the existence value of certain species, the intangible costs of living with wildlife, and the value of ecosystem services (Turner et al., 2003; van de Water et al., 2022). More work is needed to develop site-specific non-market valuation estimates, and to make these readily available to researchers and practitioners for input into analysis. This is particularly true for local community values, especially for non-market social phenomena in complex social-ecological systems (e.g., attitudes towards nature). In our CBA, for example, we acknowledge that our reliance on Western existence values of elephants, and our choice to limit community benefits to those related to HEC reduction, likely overlooks local community values associated with elephant conservation or values and benefits associated with nature and benefits from local ecosystem services, potentially leading to underestimation of community benefits from the project (Milheiras et al., 2022). More broadly, while much progress has been made in incorporating nature values into economic analysis in recent years, concerns remain around subjectivity,

incommensurability, uncertainty, and "putting a price on nature", all of which require further work to address both technical and philosophical barriers (Sukhdev et al., 2014).

CBA always involves a degree of simplifying assumptions in deciding which costs and benefits to count (Boardman et al., 2018). While our focus is on HEC-related benefits from the community perspective in the corridor area, we recognize that local perceptions of conservation projects may be subject to a broader range of complex determinants. For example, while we have characterized HEC reduction as a benefit to communities, HEC may be perceived by communities as a cost that conservation actors are responsible for addressing, given their work to promote elephant population health in nearby areas. Similarly, we recognize that community costs, and specifically the opportunity cost of land, may be driven by more than the commercial earning potential of the land, including factors such as place-based attachment to landscapes. Future research should seek to better understand the values and perspectives of local communities in relation to conservation initiatives, and to quantify and monetize these where possible to enable the incorporation of complex non-market factors into CBA and conservation decision making. Given the controversies around choice of time horizon and discount rate in environmental CBA (OECD, 2006), further work is also required to build consensus and establish common guidelines within the conservation field on which parameters to use in which circumstances.

The lack of published CBA analyses in the field means that while this individual project appears to justify its costs (from a global conservation perspective), it is hard to say whether it is the best use of funds relative to other potential options. In future, increasing use (and publishing) of CBA in conservation should enable benchmarking of estimated benefit/cost ratios against comparators when deciding whether a proposed project represents good value for money.

Finally, it should be noted that while CBA can provide useful information, it should not be the final say in decision making. Other critical aspects such as stakeholder consultation, free, prior, and informed consent, recognition of land and resource rights, and conflict resolution and grievance mechanisms all have important roles to play alongside any economic analysis.

Overall, while continued work is needed to overcome both the technical and philosophical barriers to mainstreaming CBA in conservation, recent developments in areas such as non-market valuation of environmental benefits are making it an increasingly viable tool whose application could be central to helping limited budgets deliver against global conservation goals.

CHAPTER 5: CONCLUSION

The research presented here contributes to the evidence base and wider debate among practitioners, policymakers, and researchers on integrated conservation and development programming, with an emphasis on maximizing the impact of scarce resources to leverage transformational change in complex social-ecological systems. The finding that most conservation livelihoods programming falls short of best practice in the economic development sector in Manuscript 2 informed the design of the Green Market Systems Development framework in Manuscript 1, which calls for increased use of systemic approaches to market transformation in the conservation field, and more meaningful integration of environmental goals in the development field. Finally, Manuscript 3 demonstrates how cost-benefit analysis can be used to more efficiently allocate scarce resources to impact-maximizing causes in conservation.

Impact

The work presented in this dissertation has always been motivated by a desire for real-world application in conservation and development practice. As of mid-2025, the Green MSD framework in Manuscript 1 has been published on the BEAM Exchange, the primary MSD knowledge and practitioner hub, while a call for the use of market systems thinking was integrated into the latest version of the Conservation Standards (BEAM Exchange, 2025a; Conservation Measures Partnership, 2025). The Green MSD approach is being tested in multiple projects around the world, and work is underway to develop the working group behind the guidelines into a lasting community of practice connecting the BEAM Exchange and Conservation Measures Partnership.

Manuscript 2 has led to changes in the guidance provided to both applicants and grant reviewers across the Darwin Initiative and Illegal Wildlife Trade Challenge Fund, encouraging adoption of market systems thinking among prospective grantees, and equipping reviewers with the means to better scrutinize proposed livelihoods interventions. Work is underway to design capacity building support for future cohorts of grantees in this area.

Following the publication of the corridor cost-benefit analysis in Manuscript 3, guidance on the use of CBA to prioritize wider corridor investments was incorporated into Tanzania's Wildlife Corridors Assessment, Prioritization, and Action Plan (Ministry of Natural Resources and Tourism, 2022).

Moving forwards

A range of future research topics are relevant to build on the work presented here. For Chapter 1, ex-post evaluations of conservation livelihoods projects could shed more light on the effectiveness of the various approaches and their post-project legacies. For Chapter 2, evaluations of pilot Green MSD projects would help to build the evidence base behind the approach, and to inform future refinements to the guidelines. For Chapter 3, more work is needed to build datasets of context-specific nonmarket valuation estimates such as ecosystem service values, while evaluations of wildlife corridors would address the unanswered questions of their effects on human-wildlife conflict and species health.

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APPENDIX 1: LIVELIHOODS EVALUATION MATRIX

Dimension	Poor	Inadequate	Good	Very good	Excellent
Market selection	No explicit rationale given for the choice of target market.	Target market selection justified in terms of relevance to either conservation or development goals. No evidence of commercial viability of focal market or livelihood strategy. No comparison with other potential target markets.	Target market selection justified in terms of relevance to conservation and development goals. Moderate evidence of commercial viability of focal market or livelihood strategy. No comparison with other potential target markets.	Multiple potential markets compared and prioritised according to relevance to conservation and development goals, feasibility of successful intervention, and likely impacts. Strong evidence of commercial viability of focal livelihood strategy.	Level 4, plus: Evidence of market selection decision being made based on scoping fieldwork and/or participatory processes with project target group/other stakeholders (vs. desk-based/remote decision).
Market intelligence	No documented market analysis to support proposed interventions.	Basic understanding of potential demand for target products / services (e.g., potential sales volumes, prices, or customers).	Demonstrated understanding of wider value chain, including actors, structure, and relationships. Identification of challenges faced by the target group to be addressed by the project.	Demonstrated understanding of overall market system, including value chain plus enabling environment of rules and supporting functions. Identification of priority systemic constraints / market failures and	Level 4, plus: Stakeholder analysis of the capacity and incentives of key market actors. Consideration of past market trends / dynamics and likely future directions.

				opportunities for intervention.	
Intervention design	No evidence provided to justify proposed intervention strategy.	Intervention strategy justified based on anecdotal past experience, albeit with no documented evidence. Theory of change features large leaps of logic (e.g., farmer training leads to increased incomes), and no recognition of underlying assumptions.	At least one evidence source provided to justify the chosen approach. Theory of change considers multiple steps linking interventions to desired results (e.g., changes in attitudes, capacity, behaviour). No consideration of underlying assumptions.	Intervention logic informed by priority constraints identified in the market analysis and at least one evidence source. Robust theory of change linking activities to desired results, plus clear articulation of risks / assumptions to be tested.	Intervention logic informed by priority constraints identified in the market analysis, multiple evidence sources, and participatory processes involving market actors. Intervention logic mapped in a theory of change linking activities to desired results, plus clear articulation of risks/assumptions, and recognition of potential feedback loops and/or unintended consequences in complex systems.

Links to conservation goals	No apparent link between markets & livelihoods component of the project and conservation goals.	Vague/implicit link between markets & livelihood interventions and conservation goals. Not tested via MEL.	Explicit link between markets & livelihoods interventions & conservation goals. Not tested via MEL.	Explicit link between markets & livelihoods interventions & conservation goals, tested via MEL (e.g., did raising incomes lead to the desired conservation outcomes?).	Level 4, plus: Detailed understanding of the relationship between target market and species/ecosystem of interest. Recognition & evaluation of potential risks and trade-offs between conservation and development goals in complex systems.
Team capacity	Team does not feature any livelihoods expertise or experience.	Team has limited prior experience in livelihoods programming. Team has mostly natural science backgrounds and limited markets & livelihoods expertise.	Team has good livelihoods experience & expertise. At least one (non-leading) partner with relevant credentials, albeit primarily focused on community development, rather than wider market development.	Team has very good livelihoods experience & expertise. Multiple partners with relevant credentials, including market / sector development work beyond immediate beneficiaries / communities.	Level 4, plus: One or more market actors (beyond immediate beneficiaries) are part of the project consortium (e.g., private firms, finance providers, certification bodies, government development agencies, private training providers).
Market actor engagement	No market actor engagement beyond target group.	Minimal market actor engagement beyond target group (e.g., one-off meeting).	Project engages with market actors beyond target group, albeit in a limited or temporary way.	Project features ongoing partnership arrangement with market actors in the target market (beyond target group).	Project features very strong partnership arrangement with multiple market actors in the target market (beyond target group).

Performance against logframe targets	Results relating to livelihoods were significantly below project targets.	Results relating to livelihoods were slightly below project targets.	Results relating to livelihoods were broadly on target by project end.	Results relating to livelihoods slightly exceeded project targets.	Results relating to livelihoods significantly exceeded project targets.
Monitoring, evaluation, and learning (MEL)	No MEL efforts relating to markets & livelihoods work.	MEL focuses on low-level results only (activities, outputs - e.g., number of farmers trained). No evidence of higher-level results (e.g., farmer incomes).	MEL reports on all logframe essentials (activities, outputs, outcomes).	MEL goes beyond essential logframe reporting to provide additional evidence with greater explanatory power around the success or failure of interventions. Inclusion of market metrics (e.g., production / yields, sales values / volumes, product quality).	Level 4, plus: Triangulation of findings via mixed quantitative and qualitative methods. Evidence of MEL informing in-project learning & adaptive management. Insightful reflections on lessons for future programming.
Scale & sustainability	No consideration of potential scale or sustainability of results beyond project lifetime.	Consideration of project "exit strategy" during design phase, but no evidence to demonstrate potential scale or sustainability of results by end of project.	Moderate evidence of potential for results to be sustained beyond the project (e.g., farmers are positive about new practices, but long-term commercial viability remains untested).	Strong evidence of potential for results to be sustained beyond the project (e.g., farmers proven to make more money because of recommended practices, creating lasting incentives for sustained behaviour change independent of donor subsidy).	Level 4, plus: Evidence of results being scaled by market actors beyond direct beneficiaries (e.g., other farmers replicate observed behaviour change; buyers start to demand sustainably sourced produce).

APPENDIX 2: CORRIDOR COST BENEFIT ANALYSIS

The following data underpinning the cost-benefit analysis is available to download in Excel format with the published article at Conservation Science and Practice here.

Cost-benefit analysis

Total cost:	4,484,438								
Total benefits:					**Benefit/cost ratio:**				
	HEC effect →					*HEC effect →*			
Elephant pop effect ↓	no effect	-25%	-50%	-75%	*E pop effect ↓*	no effect	-25%	-50%	-75%
no effect	20,728,236	23,182,988	25,637,740	28,092,492	no effect	4.62	5.17	5.72	6.26
+0.001% (25 animals)	22,162,968	24,617,720	27,072,472	29,527,224	+0.001%	4.94	5.49	6.04	6.58
+0.002% (50 animals)	23,742,079	26,196,831	28,651,583	31,106,335	+0.002%	5.29	5.84	6.39	6.94
+0.003% (75 animals)	25,034,786	27,489,538	29,944,290	32,399,042	+0.003%	5.58	6.13	6.68	7.22
+0.004% (100 animals)	26,471,873	28,926,625	31,381,377	33,836,129	+0.004%	5.90	6.45	7.00	7.55
Discount rate:	*High:*	10.0%	*Low:*	declining	(3.5% for Y1-50, 2.5% for Y51-100)				

Manuscript results table (Table 2)

	Conservation		Community (landscape)		Community (corridor)	
	Low	High	Low	High	Low	High
Costs						
Establishment	1,871,069		1,600,736		1,600,736	
Maintenance	214,258		55,286		55,286	
Opportunity	2,286,025		679,657		679,657	
Replacement	113,085		-		-	
Total costs	4,484,438		2,335,678		2,335,678	
Benefits						
HEC (tangible)	0	4,909,504	0	1,459,642	0	245,031
HEC (intangible)	0	4,909,504	0	1,459,642	0	245,031
Ecosystem services	20,728,236		-		-	
Elephant population	0	(uncertain)	-		-	
Total benefits	20,728,236	30,547,244	0	2,919,284	0	490,061
Benefit:cost ratio	4.6	6.8	0.0	1.2	0.0	0.2
Ex. Intangible benefits	4.6	5.7	0.0	0.6	0.0	0.1

Costs (30 year)

			Opportunity cost of land			Opportunity + maintenance				Total costs		
	ablishment	Maintenance	High	Medium	Low	High	Medium	Low	Replacement	High	Medium	Low
NPV 30 (high discount)	00,736	55,286	859,021	679,657	500,293	914,307	734,943	555,578	0	2,515,042	2,335,678	2,156,314
1	,010	0	91,124	72,098	53,071	91,124	72,098	53,071	0	423,134	404,108	385,081
2	,721	0	91,124	72,098	53,071	91,124	72,098	53,071	0	949,845	930,819	911,792
3	,466	7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	406,778	387,752	368,725
4	,002	7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	359,314	340,288	321,261
5	,601	7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	386,913	367,887	348,860
6		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
7		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
8		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
9		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
10		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
11		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
12		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
13		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
14		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
15		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
16		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
17		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
18		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
19		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
20		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
21		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
22		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
23		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
24		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
25		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
26		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
27		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
28		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
29		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259
30		7,188	91,124	72,098	53,071	98,312	79,286	60,259	0	98,312	79,286	60,259

Benefits (30 year)

Reduction in elephant damage (tangible only)									
-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
145,964	291,928	437,893	583,857	729,821	875,785	1,021,750	1,167,714	1,313,678	1,459,642
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838

Benefits (30 year)

Reduction in elephant damage (tangible + intangible)											
-10%	-20%	-25%	-30%	-40%	-50%	-60%	-70%	-75%	-80%	-90%	-100%
291,928	583,857	729,821	875,785	1,167,714	1,459,642	1,751,571	2,043,499	2,189,463	2,335,428	2,627,356	2,919,284
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675
30,968	61,935	77,419	92,903	123,870	154,838	185,805	216,773	232,257	247,740	278,708	309,675

Benefits (30 year)

ESV	Reduction in elephant damage (tangible only) + ESV									
	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
2,009,945	2,155,909	2,301,873	2,447,837	2,593,802	2,739,766	2,885,730	3,031,694	3,177,658	3,323,623	3,469,587
0	15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
0	15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
32,722	48,206	63,690	79,174	94,657	110,141	125,625	141,109	156,592	172,076	187,560
61,609	77,093	92,577	108,060	123,544	139,028	154,512	169,995	185,479	200,963	216,447
90,496	105,980	121,463	136,947	152,431	167,915	183,399	198,882	214,366	229,850	245,334
119,383	134,866	150,350	165,834	181,318	196,802	212,285	227,769	243,253	258,737	274,220
148,270	163,753	179,237	194,721	210,205	225,688	241,172	256,656	272,140	287,624	303,107
177,156	192,640	208,124	223,608	239,091	254,575	270,059	285,543	301,027	316,510	331,994
206,043	221,527	237,011	252,495	267,978	283,462	298,946	314,430	329,913	345,397	360,881
234,930	250,414	265,898	281,381	296,865	312,349	327,833	343,316	358,800	374,284	389,768
263,817	279,301	294,784	310,268	325,752	341,236	356,720	372,203	387,687	403,171	418,655
292,704	308,187	323,671	339,155	354,639	370,123	385,606	401,090	416,574	432,058	447,541
321,591	337,074	352,558	368,042	383,526	399,009	414,493	429,977	445,461	460,945	476,428
350,477	365,961	381,445	396,929	412,412	427,896	443,380	458,864	474,348	489,831	505,315
379,364	394,848	410,332	425,816	441,299	456,783	472,267	487,751	503,234	518,718	534,202
408,251	423,735	439,219	454,702	470,186	485,670	501,154	516,637	532,121	547,605	563,089
437,138	452,622	468,105	483,589	499,073	514,557	530,041	545,524	561,008	576,492	591,976
466,025	481,509	496,992	512,476	527,960	543,444	558,927	574,411	589,895	605,379	620,862
494,912	510,395	525,879	541,363	556,847	572,330	587,814	603,298	618,782	634,266	649,749
523,798	539,282	554,766	570,250	585,733	601,217	616,701	632,185	647,669	663,152	678,636
552,685	568,169	583,653	599,137	614,620	630,104	645,588	661,072	676,555	692,039	707,523
581,572	597,056	612,540	628,023	643,507	658,991	674,475	689,958	705,442	720,926	736,410
610,459	625,943	641,426	656,910	672,394	687,878	703,362	718,845	734,329	749,813	765,297
639,346	654,830	670,313	685,797	701,281	716,765	732,248	747,732	763,216	778,700	794,183
668,233	683,716	699,200	714,684	730,168	745,651	761,135	776,619	792,103	807,587	823,070
697,119	712,603	728,087	743,571	759,055	774,538	790,022	805,506	820,990	836,473	851,957
726,006	741,490	756,974	772,458	787,941	803,425	818,909	834,393	849,876	865,360	880,844
754,893	770,377	785,861	801,344	816,828	832,312	847,796	863,280	878,763	894,247	909,731
783,780	799,264	814,747	830,231	845,715	861,199	876,683	892,166	907,650	923,134	938,618
812,667	828,151	843,634	859,118	874,602	890,086	905,569	921,053	936,537	952,021	967,505

Benefits (30 year)

Reduction in elephant damage (tangible + intangible) + ESV										
0%	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
2,009,945	2,301,873	2,593,802	2,885,730	3,177,658	3,469,587	3,761,515	4,053,444	4,345,372	4,637,301	4,929,229

0	30,968	61,935	92,903	123,870	154,838	185,805	216,773	247,740	278,708	309,675
0	30,968	61,935	92,903	123,870	154,838	185,805	216,773	247,740	278,708	309,675
32,722	63,690	94,657	125,625	156,592	187,560	218,527	249,495	280,463	311,430	342,398
61,609	92,577	123,544	154,512	185,479	216,447	247,414	278,382	309,349	340,317	371,285
90,496	121,463	152,431	183,399	214,366	245,334	276,301	307,269	338,236	369,204	400,171
119,383	150,350	181,318	212,285	243,253	274,220	305,188	336,156	367,123	398,091	429,058
148,270	179,237	210,205	241,172	272,140	303,107	334,075	365,042	396,010	426,977	457,945
177,156	208,124	239,091	270,059	301,027	331,994	362,962	393,929	424,897	455,864	486,832
206,043	237,011	267,978	298,946	329,913	360,881	391,849	422,816	453,784	484,751	515,719
234,930	265,898	296,865	327,833	358,800	389,768	420,735	451,703	482,670	513,638	544,606
263,817	294,784	325,752	356,720	387,687	418,655	449,622	480,590	511,557	542,525	573,492
292,704	323,671	354,639	385,606	416,574	447,541	478,509	509,477	540,444	571,412	602,379
321,591	352,558	383,526	414,493	445,461	476,428	507,396	538,363	569,331	600,298	631,266
350,477	381,445	412,412	443,380	474,348	505,315	536,283	567,250	598,218	629,185	660,153
379,364	410,332	441,299	472,267	503,234	534,202	565,170	596,137	627,105	658,072	689,040
408,251	439,219	470,186	501,154	532,121	563,089	594,056	625,024	655,991	686,959	717,927
437,138	468,105	499,073	530,041	561,008	591,976	622,943	653,911	684,878	715,846	746,813
466,025	496,992	527,960	558,927	589,895	620,862	651,830	682,798	713,765	744,733	775,700
494,912	525,879	556,847	587,814	618,782	649,749	680,717	711,684	742,652	773,620	804,587
523,798	554,766	585,733	616,701	647,669	678,636	709,604	740,571	771,539	802,506	833,474
552,685	583,653	614,620	645,588	676,555	707,523	738,491	769,458	800,426	831,393	862,361
581,572	612,540	643,507	674,475	705,442	736,410	767,377	798,345	829,312	860,280	891,248
610,459	641,426	672,394	703,362	734,329	765,297	796,264	827,232	858,199	889,167	920,134
639,346	670,313	701,281	732,248	763,216	794,183	825,151	856,119	887,086	918,054	949,021
668,233	699,200	730,168	761,135	792,103	823,070	854,038	885,005	915,973	946,941	977,908
697,119	728,087	759,055	790,022	820,990	851,957	882,925	913,892	944,860	975,827	1,006,795
726,006	756,974	787,941	818,909	849,876	880,844	911,812	942,779	973,747	1,004,714	1,035,682
754,893	785,861	816,828	847,796	878,763	909,731	940,698	971,666	1,002,633	1,033,601	1,064,569
783,780	814,747	845,715	876,683	907,650	938,618	969,585	1,000,553	1,031,520	1,062,488	1,093,455
812,667	843,634	874,602	905,569	936,537	967,505	998,472	1,029,440	1,060,407	1,091,375	1,122,342

Benefits (30 year)

Elephant pop growth effect			
+0.001%	+0.002%	+0.003%	+0.004%
78,096	164,013	234,318	312,444

0	0	0	0
0	0	0	0
0	0	0	0
1,208	2,537	3,625	4,833
2,428	5,098	7,283	9,710
3,658	7,682	10,975	14,633
4,900	10,291	14,701	19,602
6,154	12,923	18,462	24,616
7,419	15,580	22,257	29,677
8,695	18,261	26,087	34,784
9,984	20,966	29,953	39,938
11,284	23,697	33,854	45,140
12,596	26,452	37,790	50,389
13,919	29,232	41,762	55,686
15,255	32,038	45,770	61,031
16,603	34,869	49,815	66,424
17,963	37,725	53,896	71,867
19,336	40,608	58,015	77,358
20,720	43,516	62,170	82,899
22,117	46,451	66,363	88,491
23,527	49,411	70,593	94,132
24,949	52,399	74,861	99,824
26,384	55,413	79,168	105,567
27,832	58,453	83,512	111,361
29,292	61,521	87,896	117,207
30,766	64,616	92,318	123,104
32,253	67,739	96,780	129,055
33,752	70,889	101,281	135,058
35,265	74,067	105,822	141,113
36,791	77,273	110,403	147,223

Costs (100 year)

			Opportunity cost of land			Opportunity + maintenance				Total costs		
	Establishment	Maintenance	High	Medium	Low	High	Medium	Low	Replacement	High	Medium	Low
NPV 100 (low discount)	1,871,069	214,258	2,889,317	2,286,025	1,682,734	3,103,575	2,500,283	1,896,992	113,085	5,087,729	4,484,438	3,881,146

Present values using declining rates

1	320,783	0	88,043	69,659	51,276	88,043	69,659	51,276	0	408,825	390,442	372,059
2	801,625	0	85,066	67,304	49,542	85,066	67,304	49,542	0	886,691	868,929	851,167
3	278,219	6,483	82,189	65,028	47,867	88,672	71,511	54,350	0	366,891	349,730	332,569
4	227,448	6,264	79,410	62,829	46,248	85,674	69,093	52,512	0	313,122	296,541	279,960
5	242,994	6,052	76,724	60,704	44,684	82,776	66,756	50,736	0	325,771	309,751	293,730
6	0	5,847	74,130	58,651	43,173	79,977	64,499	49,020	0	79,977	64,499	49,020
7	0	5,650	71,623	56,668	41,713	77,273	62,318	47,363	0	77,273	62,318	47,363
8	0	5,459	69,201	54,752	40,302	74,660	60,210	45,761	0	74,660	60,210	45,761
9	0	5,274	66,861	52,900	38,940	72,135	58,174	44,214	0	72,135	58,174	44,214
10	0	5,096	64,600	51,111	37,623	69,695	56,207	42,719	0	69,695	56,207	42,719
11	0	4,923	62,415	49,383	36,351	67,339	54,306	41,274	0	67,339	54,306	41,274
12	0	4,757	60,305	47,713	35,121	65,061	52,470	39,878	0	65,061	52,470	39,878
13	0	4,596	58,265	46,099	33,934	62,861	50,695	38,530	0	62,861	50,695	38,530
14	0	4,441	56,295	44,541	32,786	60,736	48,981	37,227	0	60,736	48,981	37,227
15	0	4,290	54,391	43,034	31,677	58,682	47,325	35,968	0	58,682	47,325	35,968
16	0	4,145	52,552	41,579	30,606	56,697	45,724	34,752	0	56,697	45,724	34,752
17	0	4,005	50,775	40,173	29,571	54,780	44,178	33,576	0	54,780	44,178	33,576
18	0	3,870	49,058	38,814	28,571	52,928	42,684	32,441	0	52,928	42,684	32,441
19	0	3,739	47,399	37,502	27,605	51,138	41,241	31,344	0	51,138	41,241	31,344
20	0	3,612	45,796	36,234	26,672	49,408	39,846	30,284	0	49,408	39,846	30,284
21	0	3,490	44,247	35,008	25,770	47,738	38,499	29,260	0	47,738	38,499	29,260
22	0	3,372	42,751	33,825	24,898	46,123	37,197	28,270	0	46,123	37,197	28,270
23	0	3,258	41,305	32,681	24,056	44,564	35,939	27,314	0	44,564	35,939	27,314
24	0	3,148	39,909	31,576	23,243	43,057	34,724	26,391	0	43,057	34,724	26,391
25	0	3,042	38,559	30,508	22,457	41,601	33,549	25,498	0	41,601	33,549	25,498
26	0	2,939	37,255	29,476	21,697	40,194	32,415	24,636	0	40,194	32,415	24,636
27	0	2,839	35,995	28,479	20,964	38,835	31,319	23,803	0	38,835	31,319	23,803
28	0	2,743	34,778	27,516	20,255	37,521	30,260	22,998	0	37,521	30,260	22,998
29	0	2,651	33,602	26,586	19,570	36,252	29,236	22,220	0	36,252	29,236	22,220
30	0	2,561	32,466	25,687	18,908	35,027	28,248	21,469	0	35,027	28,248	21,469
31	0	2,474	31,368	24,818	18,269	33,842	27,292	20,743	68,780	102,622	96,072	89,523
32	0	2,391	30,307	23,979	17,651	32,698	26,370	20,041	0	32,698	26,370	20,041
33	0	2,310	29,282	23,168	17,054	31,592	25,478	19,364	0	31,592	25,478	19,364
34	0	2,232	28,292	22,385	16,477	30,524	24,616	18,709	0	30,524	24,616	18,709
35	0	2,156	27,335	21,628	15,920	29,491	23,784	18,076	0	29,491	23,784	18,076
36	0	2,083	26,411	20,896	15,382	28,494	22,980	17,465	0	28,494	22,980	17,465
37	0	2,013	25,518	20,190	14,861	27,531	22,202	16,874	0	27,531	22,202	16,874
38	0	1,945	24,655	19,507	14,359	26,600	21,452	16,304	0	26,600	21,452	16,304
39	0	1,879	23,821	18,847	13,873	25,700	20,726	15,752	0	25,700	20,726	15,752
40	0	1,815	23,015	18,210	13,404	24,831	20,025	15,220	0	24,831	20,025	15,220
41	0	1,754	22,237	17,594	12,951	23,991	19,348	14,705	0	23,991	19,348	14,705
42	0	1,695	21,485	16,999	12,513	23,180	18,694	14,208	0	23,180	18,694	14,208
43	0	1,637	20,759	16,424	12,090	22,396	18,062	13,727	0	22,396	18,062	13,727
44	0	1,582	20,057	15,869	11,681	21,639	17,451	13,263	0	21,639	17,451	13,263
45	0	1,529	19,378	15,332	11,286	20,907	16,861	12,815	0	20,907	16,861	12,815
46	0	1,477	18,723	14,814	10,904	20,200	16,291	12,381	0	20,200	16,291	12,381
47	0	1,427	18,090	14,313	10,536	19,517	15,740	11,963	0	19,517	15,740	11,963
48	0	1,379	17,478	13,829	10,179	18,857	15,207	11,558	0	18,857	15,207	11,558
49	0	1,332	16,887	13,361	9,835	18,219	14,693	11,167	0	18,219	14,693	11,167
50	0	1,287	16,316	12,909	9,502	17,603	14,196	10,790	0	17,603	14,196	10,790
51	0	2,040	25,865	20,465	15,064	27,906	22,505	17,104	0	27,906	22,505	17,104
52	0	1,991	25,234	19,965	14,696	27,225	21,956	16,687	0	27,225	21,956	16,687
53	0	1,942	24,619	19,478	14,338	26,561	21,420	16,280	0	26,561	21,420	16,280
54	0	1,895	24,018	19,003	13,988	25,913	20,898	15,883	0	25,913	20,898	15,883
55	0	1,848	23,433	18,540	13,647	25,281	20,388	15,496	0	25,281	20,388	15,496
56	0	1,803	22,861	18,088	13,314	24,664	19,891	15,118	0	24,664	19,891	15,118
57	0	1,759	22,304	17,647	12,990	24,063	19,406	14,749	0	24,063	19,406	14,749
58	0	1,716	21,760	17,216	12,673	23,476	18,933	14,389	0	23,476	18,933	14,389
59	0	1,675	21,229	16,796	12,364	22,903	18,471	14,038	0	22,903	18,471	14,038
60	0	1,634	20,711	16,387	12,062	22,345	18,020	13,696	0	22,345	18,020	13,696
61	0	1,594	20,206	15,987	11,768	21,800	17,581	13,362	44,305	66,105	61,886	57,667
62	0	1,555	19,713	15,597	11,481	21,268	17,152	13,036	0	21,268	17,152	13,036
63	0	1,517	19,232	15,217	11,201	20,749	16,734	12,718	0	20,749	16,734	12,718
64	0	1,480	18,763	14,845	10,928	20,243	16,325	12,408	0	20,243	16,325	12,408
65	0	1,444	18,306	14,483	10,661	19,750	15,927	12,105	0	19,750	15,927	12,105
66	0	1,409	17,859	14,130	10,401	19,268	15,539	11,810	0	19,268	15,539	11,810
67	0	1,374	17,424	13,785	10,147	18,798	15,160	11,522	0	18,798	15,160	11,522
68	0	1,341	16,999	13,449	9,900	18,339	14,790	11,241	0	18,339	14,790	11,241
69	0	1,308	16,584	13,121	9,658	17,892	14,429	10,967	0	17,892	14,429	10,967
70	0	1,276	16,179	12,801	9,423	17,456	14,077	10,699	0	17,456	14,077	10,699
71	0	1,245	15,785	12,489	9,193	17,030	13,734	10,438	0	17,030	13,734	10,438
72	0	1,215	15,400	12,184	8,969	16,615	13,399	10,184	0	16,615	13,399	10,184
73	0	1,185	15,024	11,887	8,750	16,209	13,072	9,935	0	16,209	13,072	9,935
74	0	1,156	14,658	11,597	8,537	15,814	12,753	9,693	0	15,814	12,753	9,693
75	0	1,128	14,300	11,314	8,328	15,428	12,442	9,456	0	15,428	12,442	9,456
76	0	1,101	13,951	11,038	8,125	15,052	12,139	9,226	0	15,052	12,139	9,226
77	0	1,074	13,611	10,769	7,927	14,685	11,843	9,001	0	14,685	11,843	9,001
78	0	1,047	13,279	10,507	7,734	14,327	11,554	8,781	0	14,327	11,554	8,781
79	0	1,022	12,955	10,250	7,545	13,977	11,272	8,567	0	13,977	11,272	8,567
80	0	997	12,639	10,000	7,361	13,636	10,997	8,358	0	13,636	10,997	8,358
81	0	973	12,331	9,756	7,182	13,304	10,729	8,154	0	13,304	10,729	8,154
82	0	949	12,030	9,518	7,006	12,979	10,467	7,955	0	12,979	10,467	7,955
83	0	926	11,737	9,286	6,836	12,663	10,212	7,761	0	12,663	10,212	7,761
84	0	903	11,451	9,060	6,669	12,354	9,963	7,572	0	12,354	9,963	7,572
85	0	881	11,171	8,839	6,506	12,053	9,720	7,387	0	12,053	9,720	7,387
86	0	860	10,899	8,623	6,347	11,759	9,483	7,207	0	11,759	9,483	7,207
87	0	839	10,633	8,413	6,193	11,472	9,252	7,031	0	11,472	9,252	7,031
88	0	818	10,374	8,208	6,042	11,192	9,026	6,860	0	11,192	9,026	6,860
89	0	798	10,121	8,007	5,894	10,919	8,806	6,693	0	10,919	8,806	6,693
90	0	779	9,874	7,812	5,751	10,653	8,591	6,529	0	10,653	8,591	6,529
91	0	760	9,633	7,622	5,610	10,393	8,382	6,370	0	10,393	8,382	6,370
92	0	741	9,398	7,436	5,473	10,139	8,177	6,215	0	10,139	8,177	6,215
93	0	723	9,169	7,254	5,340	9,892	7,978	6,063	0	9,892	7,978	6,063
94	0	706	8,945	7,077	5,210	9,651	7,783	5,915	0	9,651	7,783	5,915
95	0	688	8,727	6,905	5,083	9,415	7,593	5,771	0	9,415	7,593	5,771
96	0	672	8,514	6,736	4,959	9,186	7,408	5,630	0	9,186	7,408	5,630
97	0	655	8,307	6,572	4,838	8,962	7,227	5,493	0	8,962	7,227	5,493
98	0	639	8,104	6,412	4,720	8,743	7,051	5,359	0	8,743	7,051	5,359
99	0	624	7,906	6,255	4,605	8,530	6,879	5,228	0	8,530	6,879	5,228
100	0	608	7,713	6,103	4,492	8,322	6,711	5,101	0	8,322	6,711	5,101

Benefits (100 year)

Reduction in elephant damage (tangible only)									
-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
490,950	981,901	1,472,851	1,963,802	2,454,752	2,945,702	3,436,653	3,927,603	4,418,554	4,909,504

Present values using declining rates

14,960	29,920	44,881	59,841	74,801	89,761	104,721	119,681	134,642	149,602
14,454	28,909	43,363	57,817	72,271	86,726	101,180	115,634	130,088	144,543
13,965	27,931	41,896	55,862	69,827	83,793	97,758	111,724	125,689	139,655
13,493	26,986	40,480	53,973	67,466	80,959	94,453	107,946	121,439	134,932
13,037	26,074	39,111	52,148	65,185	78,222	91,258	104,295	117,332	130,369
12,596	25,192	37,788	50,384	62,980	75,576	88,172	100,768	113,365	125,961
12,170	24,340	36,510	48,680	60,851	73,021	85,191	97,361	109,531	121,701
11,759	23,517	35,276	47,034	58,793	70,551	82,310	94,068	105,827	117,586
11,361	22,722	34,083	45,444	56,805	68,166	79,526	90,887	102,248	113,609
10,977	21,953	32,930	43,907	54,884	65,860	76,837	87,814	98,791	109,767
10,606	21,211	31,817	42,422	53,028	63,633	74,239	84,844	95,450	106,055
10,247	20,494	30,741	40,988	51,235	61,481	71,728	81,975	92,222	102,469
9,900	19,801	29,701	39,602	49,502	59,402	69,303	79,203	89,104	99,004
9,566	19,131	28,697	38,262	47,828	57,394	66,959	76,525	86,090	95,656
9,242	18,484	27,726	36,968	46,211	55,453	64,695	73,937	83,179	92,421
8,930	17,859	26,789	35,718	44,648	53,578	62,507	71,437	80,366	89,296
8,628	17,255	25,883	34,510	43,138	51,766	60,393	69,021	77,649	86,276
8,336	16,672	25,008	33,343	41,679	50,015	58,351	66,687	75,023	83,359
8,054	16,108	24,162	32,216	40,270	48,324	56,378	64,432	72,486	80,540
7,782	15,563	23,345	31,126	38,908	46,690	54,471	62,253	70,035	77,816
7,518	15,037	22,555	30,074	37,592	45,111	52,629	60,148	67,666	75,185
7,264	14,528	21,793	29,057	36,321	43,585	50,850	58,114	65,378	72,642
7,019	14,037	21,056	28,074	35,093	42,111	49,130	56,149	63,167	70,186
6,781	13,562	20,344	27,125	33,906	40,687	47,469	54,250	61,031	67,812
6,552	13,104	19,656	26,208	32,760	39,311	45,863	52,415	58,967	65,519
6,330	12,661	18,991	25,321	31,652	37,982	44,312	50,643	56,973	63,304
6,116	12,233	18,349	24,465	30,581	36,698	42,814	48,930	55,047	61,163
5,909	11,819	17,728	23,638	29,547	35,457	41,366	47,276	53,185	59,094
5,710	11,419	17,129	22,838	28,548	34,258	39,967	45,677	51,387	57,096
5,517	11,033	16,550	22,066	27,583	33,099	38,616	44,132	49,649	55,165
5,330	10,660	15,990	21,320	26,650	31,980	37,310	42,640	47,970	53,300
5,150	10,299	15,449	20,599	25,749	30,898	36,048	41,198	46,348	51,497
4,976	9,951	14,927	19,902	24,878	29,854	34,829	39,805	44,780	49,756
4,807	9,615	14,422	19,229	24,037	28,844	33,651	38,459	43,266	48,073
4,645	9,290	13,934	18,579	23,224	27,869	32,513	37,158	41,803	46,448
4,488	8,975	13,463	17,951	22,439	26,926	31,414	35,902	40,389	44,877
4,336	8,672	13,008	17,344	21,680	26,016	30,352	34,688	39,024	43,359
4,189	8,379	12,568	16,757	20,947	25,136	29,325	33,515	37,704	41,893
4,048	8,095	12,143	16,191	20,238	24,286	28,334	32,381	36,429	40,477
3,911	7,822	11,732	15,643	19,554	23,465	27,375	31,286	35,197	39,108
3,779	7,557	11,336	15,114	18,893	22,671	26,450	30,228	34,007	37,785
3,651	7,302	10,952	14,603	18,254	21,905	25,555	29,206	32,857	36,508
3,527	7,055	10,582	14,109	17,636	21,164	24,691	28,218	31,746	35,273
3,408	6,816	10,224	13,632	17,040	20,448	23,856	27,264	30,672	34,080
3,293	6,586	9,878	13,171	16,464	19,757	23,049	26,342	29,635	32,928
3,181	6,363	9,544	12,726	15,907	19,089	22,270	25,451	28,633	31,814
3,074	6,148	9,222	12,295	15,369	18,443	21,517	24,591	27,665	30,738
2,970	5,940	8,910	11,880	14,849	17,819	20,789	23,759	26,729	29,699
2,869	5,739	8,608	11,478	14,347	17,217	20,086	22,956	25,825	28,695
2,772	5,545	8,317	11,090	13,862	16,635	19,407	22,179	24,952	27,724
4,395	8,790	13,185	17,580	21,975	26,370	30,765	35,160	39,555	43,950
4,288	8,576	12,863	17,151	21,439	25,727	30,015	34,303	38,590	42,878
4,183	8,366	12,550	16,733	20,916	25,099	29,283	33,466	37,649	41,832
4,081	8,162	12,244	16,325	20,406	24,487	28,568	32,650	36,731	40,812
3,982	7,963	11,945	15,927	19,908	23,890	27,872	31,853	35,835	39,817
3,885	7,769	11,654	15,538	19,423	23,307	27,192	31,076	34,961	38,845
3,790	7,580	11,369	15,159	18,949	22,739	26,529	30,318	34,108	37,898
3,697	7,395	11,092	14,789	18,487	22,184	25,882	29,579	33,276	36,974
3,607	7,214	10,822	14,429	18,036	21,643	25,250	28,858	32,465	36,072
3,519	7,038	10,558	14,077	17,596	21,115	24,634	28,154	31,673	35,192
3,433	6,867	10,300	13,733	17,167	20,600	24,034	27,467	30,900	34,334
3,350	6,699	10,049	13,399	16,748	20,098	23,447	26,797	30,147	33,496
3,268	6,536	9,804	13,072	16,340	19,608	22,876	26,143	29,411	32,679
3,188	6,376	9,565	12,753	15,941	19,129	22,318	25,506	28,694	31,882
3,110	6,221	9,331	12,442	15,552	18,663	21,773	24,884	27,994	31,105
3,035	6,069	9,104	12,138	15,173	18,208	21,242	24,277	27,311	30,346
2,961	5,921	8,882	11,842	14,803	17,764	20,724	23,685	26,645	29,606
2,888	5,777	8,665	11,554	14,442	17,330	20,219	23,107	25,995	28,884
2,818	5,636	8,454	11,272	14,090	16,908	19,726	22,543	25,361	28,179
2,749	5,498	8,248	10,997	13,746	16,495	19,244	21,994	24,743	27,492
2,682	5,364	8,046	10,729	13,411	16,093	18,775	21,457	24,139	26,821
2,617	5,233	7,850	10,467	13,084	15,700	18,317	20,934	23,551	26,167
2,553	5,106	7,659	10,212	12,765	15,317	17,870	20,423	22,976	25,529
2,491	4,981	7,472	9,963	12,453	14,944	17,434	19,925	22,416	24,906
2,430	4,860	7,290	9,720	12,149	14,579	17,009	19,439	21,869	24,299
2,371	4,741	7,112	9,483	11,853	14,224	16,594	18,965	21,336	23,706
2,313	4,626	6,938	9,251	11,564	13,877	16,190	18,502	20,815	23,128
2,256	4,513	6,769	9,026	11,282	13,538	15,795	18,051	20,308	22,564
2,201	4,403	6,604	8,805	11,007	13,208	15,410	17,611	19,812	22,014
2,148	4,295	6,443	8,591	10,738	12,886	15,034	17,181	19,329	21,477
2,095	4,191	6,286	8,381	10,476	12,572	14,667	16,762	18,858	20,953
2,044	4,088	6,133	8,177	10,221	12,265	14,309	16,353	18,398	20,442
1,994	3,989	5,983	7,977	9,972	11,966	13,960	15,955	17,949	19,943
1,946	3,891	5,837	7,783	9,728	11,674	13,620	15,565	17,511	19,457
1,898	3,796	5,695	7,593	9,491	11,389	13,288	15,186	17,084	18,982
1,852	3,704	5,556	7,408	9,260	11,112	12,964	14,815	16,667	18,519
1,807	3,614	5,420	7,227	9,034	10,841	12,647	14,454	16,261	18,068
1,763	3,525	5,288	7,051	8,813	10,576	12,339	14,102	15,864	17,627
1,720	3,439	5,159	6,879	8,599	10,318	12,038	13,758	15,477	17,197
1,678	3,356	5,033	6,711	8,389	10,067	11,744	13,422	15,100	16,778
1,637	3,274	4,911	6,547	8,184	9,821	11,458	13,095	14,732	16,368
1,597	3,194	4,791	6,388	7,985	9,581	11,178	12,775	14,372	15,969
1,558	3,116	4,674	6,232	7,790	9,348	10,906	12,464	14,022	15,580
1,520	3,040	4,560	6,080	7,600	9,120	10,640	12,160	13,680	15,200
1,483	2,966	4,449	5,932	7,414	8,897	10,380	11,863	13,346	14,829
1,447	2,893	4,340	5,787	7,234	8,680	10,127	11,574	13,021	14,467
1,411	2,823	4,234	5,646	7,057	8,469	9,880	11,292	12,703	14,114
1,377	2,754	4,131	5,508	6,885	8,262	9,639	11,016	12,393	13,770
1,343	2,687	4,030	5,374	6,717	8,061	9,404	10,747	12,091	13,434
1,311	2,621	3,932	5,243	6,553	7,864	9,175	10,485	11,796	13,107

Benefits (100 year)

Reduction in elephant damage (tangible + intangible)											
-10%	-20%	-25%	-30%	-40%	-50%	-60%	-70%	-75%	-80%	-90%	-100%
981,901	1,963,802	2,454,752	2,945,702	3,927,603	4,909,504	5,891,405	6,873,306	7,364,256	7,855,207	8,837,107	9,819,008

Present values using declining rates

29,920	59,841	74,801	89,761	119,681	149,602	179,522	209,442	224,403	239,363	269,283	299,203
28,909	57,817	72,271	86,726	115,634	144,543	173,451	202,360	216,814	231,268	260,177	289,085
27,931	55,862	69,827	83,793	111,724	139,655	167,586	195,517	209,482	223,448	251,379	279,310
26,986	53,973	67,466	80,959	107,946	134,932	161,919	188,905	202,398	215,891	242,878	269,864
26,074	52,148	65,185	78,222	104,295	130,369	156,443	182,517	195,554	208,591	234,665	260,738
25,192	50,384	62,980	75,576	100,768	125,961	151,153	176,345	188,941	201,537	226,729	251,921
24,340	48,680	60,851	73,021	97,361	121,701	146,041	170,381	182,552	194,722	219,062	243,402
23,517	47,034	58,793	70,551	94,068	117,586	141,103	164,620	176,378	188,137	211,654	235,171
22,722	45,444	56,805	68,166	90,887	113,609	136,331	159,053	170,414	181,775	204,497	227,219
21,953	43,907	54,884	65,860	87,814	109,767	131,721	153,674	164,651	175,628	197,581	219,535
21,211	42,422	53,028	63,633	84,844	106,055	127,267	148,478	159,083	169,689	190,900	212,111
20,494	40,988	51,235	61,481	81,975	102,469	122,963	143,457	153,704	163,950	184,444	204,938
19,801	39,602	49,502	59,402	79,203	99,004	118,805	138,605	148,506	158,406	178,207	198,008
19,131	38,262	47,828	57,394	76,525	95,656	114,787	133,918	143,484	153,050	172,181	191,312
18,484	36,968	46,211	55,453	73,937	92,421	110,905	129,390	138,632	147,874	166,358	184,842
17,859	35,718	44,648	53,578	71,437	89,296	107,155	125,014	133,944	142,873	160,733	178,592
17,255	34,510	43,138	51,766	69,021	86,276	103,531	120,787	129,414	138,042	155,297	172,552
16,672	33,343	41,679	50,015	66,687	83,359	100,030	116,702	125,038	133,374	150,046	166,717
16,108	32,216	40,270	48,324	64,432	80,540	96,648	112,756	120,810	128,864	144,972	161,079
15,563	31,126	38,908	46,690	62,253	77,816	93,379	108,943	116,724	124,506	140,069	155,632
15,037	30,074	37,592	45,111	60,148	75,185	90,222	105,259	112,777	120,296	135,332	150,369
14,528	29,057	36,321	43,585	58,114	72,642	87,171	101,699	108,963	116,228	130,756	145,284
14,037	28,074	35,093	42,111	56,149	70,186	84,223	98,260	105,279	112,297	126,334	140,371
13,562	27,125	33,906	40,687	54,250	67,812	81,375	94,937	101,718	108,500	122,062	135,625
13,104	26,208	32,760	39,311	52,415	65,519	78,623	91,727	98,279	104,831	117,934	131,038
12,661	25,321	31,652	37,982	50,643	63,304	75,964	88,625	94,955	101,286	113,946	126,607
12,233	24,465	30,581	36,698	48,930	61,163	73,395	85,628	91,744	97,860	110,093	122,326
11,819	23,638	29,547	35,457	47,276	59,094	70,913	82,732	88,642	94,551	106,370	118,189
11,419	22,838	28,548	34,258	45,677	57,096	68,515	79,935	85,644	91,354	102,773	114,192
11,033	22,066	27,583	33,099	44,132	55,165	66,198	77,231	82,748	88,265	99,298	110,331
10,660	21,320	26,650	31,980	42,640	53,300	63,960	74,620	79,950	85,280	95,940	106,600
10,299	20,599	25,749	30,898	41,198	51,497	61,797	72,096	77,246	82,396	92,695	102,995
9,951	19,902	24,878	29,854	39,805	49,756	59,707	69,658	74,634	79,610	89,561	99,512
9,615	19,229	24,037	28,844	38,459	48,073	57,688	67,303	72,110	76,917	86,532	96,147
9,290	18,579	23,224	27,869	37,158	46,448	55,737	65,027	69,672	74,316	83,606	92,895
8,975	17,951	22,439	26,926	35,902	44,877	53,852	62,828	67,316	71,803	80,779	89,754
8,672	17,344	21,680	26,016	34,688	43,359	52,031	60,703	65,039	69,375	78,047	86,719
8,379	16,757	20,947	25,136	33,515	41,893	50,272	58,650	62,840	67,029	75,408	83,786
8,095	16,191	20,238	24,286	32,381	40,477	48,572	56,667	60,715	64,762	72,858	80,953
7,822	15,643	19,554	23,465	31,286	39,108	46,929	54,751	58,662	62,572	70,394	78,216
7,557	15,114	18,893	22,671	30,228	37,785	45,342	52,899	56,678	60,456	68,013	75,571
7,302	14,603	18,254	21,905	29,206	36,508	43,809	51,111	54,761	58,412	65,714	73,015
7,055	14,109	17,636	21,164	28,218	35,273	42,328	49,382	52,909	56,437	63,491	70,546
6,816	13,632	17,040	20,448	27,264	34,080	40,896	47,712	51,120	54,528	61,344	68,160
6,586	13,171	16,464	19,757	26,342	32,928	39,513	46,099	49,392	52,684	59,270	65,855
6,363	12,726	15,907	19,089	25,451	31,814	38,177	44,540	47,721	50,903	57,266	63,628
6,148	12,295	15,369	18,443	24,591	30,738	36,886	43,034	46,108	49,181	55,329	61,477
5,940	11,880	14,849	17,819	23,759	29,699	35,639	41,578	44,548	47,518	53,458	59,398
5,739	11,478	14,347	17,217	22,956	28,695	34,433	40,172	43,042	45,911	51,650	57,389
5,545	11,090	13,862	16,635	22,179	27,724	33,269	38,814	41,586	44,359	49,904	55,448
8,790	17,580	21,975	26,370	35,160	43,950	52,740	61,530	65,925	70,320	79,110	87,900
8,576	17,151	21,439	25,727	34,303	42,878	51,454	60,029	64,317	68,605	77,181	85,756
8,366	16,733	20,916	25,099	33,466	41,832	50,199	58,565	62,748	66,932	75,298	83,665
8,162	16,325	20,406	24,487	32,650	40,812	48,974	57,137	61,218	65,299	73,462	81,624
7,963	15,927	19,908	23,890	31,853	39,817	47,780	55,743	59,725	63,707	71,670	79,633
7,769	15,538	19,423	23,307	31,076	38,845	46,615	54,384	58,268	62,153	69,922	77,691
7,580	15,159	18,949	22,739	30,318	37,898	45,478	53,057	56,847	60,637	68,216	75,796
7,395	14,789	18,487	22,184	29,579	36,974	44,368	51,763	55,461	59,158	66,553	73,947
7,214	14,429	18,036	21,643	28,858	36,072	43,286	50,501	54,108	57,715	64,929	72,144
7,038	14,077	17,596	21,115	28,154	35,192	42,230	49,269	52,788	56,307	63,346	70,384
6,867	13,733	17,167	20,600	27,467	34,334	41,200	48,067	51,501	54,934	61,801	68,667
6,699	13,399	16,748	20,098	26,797	33,496	40,196	46,895	50,244	53,594	60,293	66,993
6,536	13,072	16,340	19,608	26,143	32,679	39,215	45,751	49,019	52,287	58,823	65,359
6,376	12,753	15,941	19,129	25,506	31,882	38,259	44,635	47,823	51,012	57,388	63,765
6,221	12,442	15,552	18,663	24,884	31,105	37,326	43,547	46,657	49,767	55,988	62,209
6,069	12,138	15,173	18,208	24,277	30,346	36,415	42,484	45,519	48,554	54,623	60,692
5,921	11,842	14,803	17,764	23,685	29,606	35,527	41,448	44,409	47,369	53,291	59,212
5,777	11,554	14,442	17,330	23,107	28,884	34,661	40,437	43,326	46,214	51,991	57,768
5,636	11,272	14,090	16,908	22,543	28,179	33,815	39,451	42,269	45,087	50,723	56,359
5,498	10,997	13,746	16,495	21,994	27,492	32,990	38,489	41,238	43,987	49,486	54,984
5,364	10,729	13,411	16,093	21,457	26,821	32,186	37,550	40,232	42,914	48,279	53,643
5,233	10,467	13,084	15,700	20,934	26,167	31,401	36,634	39,251	41,868	47,101	52,335
5,106	10,212	12,765	15,317	20,423	25,529	30,635	35,741	38,294	40,846	45,952	51,058
4,981	9,963	12,453	14,944	19,925	24,906	29,888	34,869	37,360	39,850	44,832	49,813
4,860	9,720	12,149	14,579	19,439	24,299	29,159	34,018	36,448	38,878	43,738	48,598
4,741	9,483	11,853	14,224	18,965	23,706	28,448	33,189	35,559	37,930	42,671	47,413
4,626	9,251	11,564	13,877	18,502	23,128	27,754	32,379	34,692	37,005	41,631	46,256
4,513	9,026	11,282	13,538	18,051	22,564	27,077	31,590	33,846	36,102	40,615	45,128
4,403	8,805	11,007	13,208	17,611	22,014	26,416	30,819	33,020	35,222	39,625	44,027
4,295	8,591	10,738	12,886	17,181	21,477	25,772	30,067	32,215	34,363	38,658	42,953
4,191	8,381	10,476	12,572	16,762	20,953	25,143	29,334	31,429	33,525	37,715	41,906
4,088	8,177	10,221	12,265	16,353	20,442	24,530	28,619	30,663	32,707	36,795	40,884
3,989	7,977	9,972	11,966	15,955	19,943	23,932	27,921	29,915	31,909	35,898	39,887
3,891	7,783	9,728	11,674	15,565	19,457	23,348	27,240	29,185	31,131	35,022	38,914
3,796	7,593	9,491	11,389	15,186	18,982	22,779	26,575	28,473	30,372	34,168	37,965
3,704	7,408	9,260	11,112	14,815	18,519	22,223	25,927	27,779	29,631	33,335	37,039
3,614	7,227	9,034	10,841	14,454	18,068	21,681	25,295	27,101	28,908	32,522	36,135
3,525	7,051	8,813	10,576	14,102	17,627	21,152	24,678	26,440	28,203	31,728	35,254
3,439	6,879	8,599	10,318	13,758	17,197	20,636	24,076	25,796	27,515	30,955	34,394
3,356	6,711	8,389	10,067	13,422	16,778	20,133	23,489	25,166	26,844	30,200	33,555
3,274	6,547	8,184	9,821	13,095	16,368	19,642	22,916	24,553	26,189	29,463	32,737
3,194	6,388	7,985	9,581	12,775	15,969	19,163	22,357	23,954	25,551	28,744	31,938
3,116	6,232	7,790	9,348	12,464	15,580	18,696	21,811	23,369	24,927	28,043	31,159
3,040	6,080	7,600	9,120	12,160	15,200	18,240	21,280	22,799	24,319	27,359	30,399
2,966	5,932	7,414	8,897	11,863	14,829	17,795	20,760	22,243	23,726	26,692	29,658
2,893	5,787	7,234	8,680	11,574	14,467	17,361	20,254	21,701	23,148	26,041	28,934
2,823	5,646	7,057	8,469	11,292	14,114	16,937	19,760	21,172	22,583	25,406	28,229
2,754	5,508	6,885	8,262	11,016	13,770	16,524	19,278	20,655	22,032	24,786	27,540
2,687	5,374	6,717	8,061	10,747	13,434	16,121	18,808	20,151	21,495	24,182	26,869
2,621	5,243	6,553	7,864	10,485	13,107	15,728	18,349	19,660	20,971	23,592	26,213

Benefits (100 year)

ESV	Reduction in elephant damage (tangible only) + ESV									
	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
20,728,236	21,219,186	21,710,136	22,201,087	22,692,037	23,182,988	23,673,938	24,164,889	24,655,839	25,146,789	25,637,740

Present values using declining rates

0	14,960	29,920	44,881	59,841	74,801	89,761	104,721	119,681	134,642	149,602
0	14,454	28,909	43,363	57,817	72,271	86,726	101,180	115,634	130,088	144,543
29,514	43,479	57,444	71,410	85,375	99,341	113,306	127,272	141,237	155,203	169,168
53,689	67,182	80,675	94,168	107,662	121,155	134,648	148,141	161,634	175,128	188,621
76,195	89,232	102,269	115,306	128,343	141,380	154,417	167,454	180,490	193,527	206,564
97,118	109,714	122,310	134,906	147,502	160,098	172,694	185,290	197,886	210,482	223,079
116,539	128,709	140,879	153,049	165,219	177,389	189,559	201,729	213,899	226,069	238,240
134,535	146,293	158,052	169,810	181,569	193,327	205,086	216,844	228,603	240,362	252,120
151,180	162,541	173,902	185,263	196,624	207,985	219,346	230,707	242,068	253,429	264,790
166,546	177,523	188,500	199,477	210,453	221,430	232,407	243,384	254,360	265,337	276,314
180,700	191,306	201,911	212,517	223,122	233,728	244,334	254,939	265,545	276,150	286,756
193,706	203,953	214,200	224,447	234,694	244,941	255,188	265,435	275,682	285,929	296,175
205,626	215,527	225,427	235,328	245,228	255,128	265,029	274,929	284,829	294,730	304,630
216,519	226,084	235,650	245,215	254,781	264,347	273,912	283,478	293,043	302,609	312,174
226,439	235,681	244,923	254,165	263,407	272,650	281,892	291,134	300,376	309,618	318,860
235,441	244,370	253,300	262,230	271,159	280,089	289,018	297,948	306,877	315,807	324,737
243,575	252,203	260,830	269,458	278,085	286,713	295,341	303,968	312,596	321,223	329,851
250,890	259,225	267,561	275,897	284,233	292,569	300,905	309,241	317,577	325,912	334,248
257,431	265,485	273,539	281,593	289,647	297,701	305,755	313,809	321,863	329,917	337,971
263,243	271,025	278,806	286,588	294,370	302,151	309,933	317,715	325,496	333,278	341,059
268,368	275,886	283,405	290,923	298,442	305,960	313,479	320,997	328,516	336,034	343,553
272,845	280,109	287,373	294,638	301,902	309,166	316,430	323,694	330,959	338,223	345,487
276,712	283,731	290,749	297,768	304,787	311,805	318,824	325,842	332,861	339,879	346,898
280,006	286,787	293,568	300,350	307,131	313,912	320,693	327,475	334,256	341,037	347,818
282,761	289,313	295,864	302,416	308,968	315,520	322,072	328,624	335,176	341,728	348,280
285,009	291,339	297,669	304,000	310,330	316,660	322,991	329,321	335,651	341,982	348,312
286,781	292,898	299,014	305,130	311,246	317,363	323,479	329,595	335,712	341,828	347,944
288,108	294,018	299,927	305,837	311,746	317,655	323,565	329,474	335,384	341,293	347,203
289,017	294,727	300,437	306,146	311,856	317,565	323,275	328,985	334,694	340,404	346,114
289,536	295,052	300,569	306,085	311,602	317,118	322,635	328,151	333,668	339,184	344,701
289,688	295,018	300,348	305,678	311,008	316,338	321,668	326,998	332,328	337,658	342,988
289,500	294,649	299,799	304,949	310,099	315,248	320,398	325,548	330,697	335,847	340,997
288,992	293,968	298,943	303,919	308,895	313,870	318,846	323,821	328,797	333,773	338,748
288,188	292,996	297,803	302,610	307,418	312,225	317,032	321,840	326,647	331,454	336,262
287,108	291,753	296,398	301,042	305,687	310,332	314,977	319,622	324,266	328,911	333,556
285,772	290,259	294,747	299,235	303,722	308,210	312,698	317,185	321,673	326,161	330,649
284,197	288,533	292,869	297,205	301,541	305,877	310,213	314,549	318,885	323,220	327,556
282,402	286,591	290,781	294,970	299,159	303,349	307,538	311,727	315,917	320,106	324,295
280,404	284,451	288,499	292,547	296,594	300,642	304,690	308,737	312,785	316,833	320,880
278,217	282,128	286,039	289,950	293,861	297,771	301,682	305,593	309,504	313,414	317,325
275,858	279,637	283,415	287,194	290,973	294,751	298,530	302,308	306,087	309,865	313,644
272,436	276,087	279,738	283,389	287,039	290,690	294,341	297,992	301,642	305,293	308,944
263,224	266,751	270,278	273,806	277,333	280,860	284,387	287,915	291,442	294,969	298,497
254,322	257,730	261,138	264,546	267,954	271,362	274,770	278,178	281,586	284,995	288,403
245,722	249,015	252,308	255,600	258,893	262,186	265,479	268,771	272,064	275,357	278,650
237,413	240,594	243,775	246,957	250,138	253,320	256,501	259,683	262,864	266,045	269,227
229,384	232,458	235,532	238,606	241,680	244,753	247,827	250,901	253,975	257,049	260,123
221,627	224,597	227,567	230,537	233,507	236,477	239,447	242,416	245,386	248,356	251,326
214,133	217,002	219,872	222,741	225,610	228,480	231,349	234,219	237,088	239,958	242,827
206,891	209,664	212,436	215,209	217,981	220,754	223,526	226,298	229,071	231,843	234,616
327,977	332,372	336,767	341,162	345,557	349,952	354,347	358,742	363,137	367,532	371,927
319,977	324,265	328,553	332,841	337,128	341,416	345,704	349,992	354,280	358,567	362,855
312,173	316,356	320,539	324,723	328,906	333,089	337,272	341,455	345,639	349,822	354,005
304,559	308,640	312,721	316,802	320,884	324,965	329,046	333,127	337,208	341,290	345,371
297,131	301,112	305,094	309,076	313,057	317,039	321,021	325,002	328,984	332,966	336,947
289,884	293,768	297,653	301,537	305,422	309,306	313,191	317,075	320,960	324,844	328,729
282,813	286,603	290,393	294,183	297,972	301,762	305,552	309,342	313,132	316,921	320,711
275,915	279,613	283,310	287,007	290,705	294,402	298,100	301,797	305,494	309,192	312,889
269,186	272,793	276,400	280,007	283,614	287,222	290,829	294,436	298,043	301,650	305,258
262,620	266,139	269,659	273,178	276,697	280,216	283,735	287,255	290,774	294,293	297,812
256,215	259,648	263,082	266,515	269,948	273,382	276,815	280,248	283,682	287,115	290,549
249,966	253,315	256,665	260,015	263,364	266,714	270,063	273,413	276,763	280,112	283,462
243,869	247,137	250,405	253,673	256,941	260,209	263,477	266,744	270,012	273,280	276,548
237,921	241,109	244,297	247,486	250,674	253,862	257,050	260,238	263,427	266,615	269,803
232,118	235,228	238,339	241,449	244,560	247,670	250,781	253,891	257,002	260,112	263,223
226,457	229,491	232,526	235,560	238,595	241,630	244,664	247,699	250,733	253,768	256,803
220,933	223,894	226,854	229,815	232,776	235,736	238,697	241,657	244,618	247,578	250,539
215,545	218,433	221,321	224,210	227,098	229,986	232,875	235,763	238,652	241,540	244,428
210,287	213,105	215,923	218,741	221,559	224,377	227,195	230,013	232,831	235,649	238,467
205,158	207,908	210,657	213,406	216,155	218,904	221,654	224,403	227,152	229,901	232,650
200,155	202,837	205,519	208,201	210,883	213,565	216,247	218,930	221,612	224,294	226,976
195,273	197,889	200,506	203,123	205,740	208,356	210,973	213,590	216,207	218,823	221,440
190,510	193,063	195,616	198,169	200,722	203,275	205,827	208,380	210,933	213,486	216,039
185,863	188,354	190,845	193,335	195,826	198,317	200,807	203,298	205,789	208,279	210,770
181,330	183,760	186,190	188,620	191,050	193,480	195,910	198,339	200,769	203,199	205,629
176,907	179,278	181,649	184,019	186,390	188,761	191,131	193,502	195,872	198,243	200,614
172,593	174,905	177,218	179,531	181,844	184,157	186,469	188,782	191,095	193,408	195,721
168,383	170,639	172,896	175,152	177,409	179,665	181,921	184,178	186,434	188,691	190,947
164,276	166,478	168,679	170,880	173,082	175,283	177,484	179,686	181,887	184,088	186,290
160,269	162,417	164,565	166,712	168,860	171,008	173,155	175,303	177,451	179,598	181,746
156,360	158,456	160,551	162,646	164,742	166,837	168,932	171,027	173,123	175,218	177,313
152,547	154,591	156,635	158,679	160,723	162,768	164,812	166,856	168,900	170,944	172,989
148,826	150,820	152,815	154,809	156,803	158,798	160,792	162,786	164,781	166,775	168,769
145,196	147,142	149,088	151,033	152,979	154,925	156,870	158,816	160,762	162,707	164,653
141,655	143,553	145,451	147,350	149,248	151,146	153,044	154,942	156,841	158,739	160,637
138,200	140,052	141,904	143,756	145,608	147,459	149,311	151,163	153,015	154,867	156,719
134,829	136,636	138,443	140,249	142,056	143,863	145,670	147,476	149,283	151,090	152,897
131,541	133,303	135,066	136,829	138,591	140,354	142,117	143,879	145,642	147,405	149,168
128,332	130,052	131,772	133,491	135,211	136,931	138,650	140,370	142,090	143,810	145,529
125,202	126,880	128,558	130,236	131,913	133,591	135,269	136,947	138,624	140,302	141,980
122,149	123,785	125,422	127,059	128,696	130,333	131,970	133,606	135,243	136,880	138,517
119,169	120,766	122,363	123,960	125,557	127,154	128,751	130,348	131,945	133,542	135,138
116,263	117,821	119,379	120,937	122,495	124,053	125,611	127,168	128,726	130,284	131,842
113,427	114,947	116,467	117,987	119,507	121,027	122,547	124,067	125,587	127,107	128,627
110,661	112,143	113,626	115,109	116,592	118,075	119,558	121,041	122,524	124,007	125,489
107,961	109,408	110,855	112,302	113,748	115,195	116,642	118,089	119,535	120,982	122,429
105,328	106,740	108,151	109,563	110,974	112,385	113,797	115,208	116,620	118,031	119,443
102,759	104,136	105,513	106,890	108,267	109,644	111,021	112,398	113,775	115,152	116,529
100,253	101,596	102,940	104,283	105,627	106,970	108,314	109,657	111,000	112,344	113,687
97,808	99,118	100,429	101,740	103,050	104,361	105,672	106,982	108,293	109,604	110,914

Benefits (100 year)

Reduction in elephant damage (tangible + intangible) + ESV										
0%	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
20,728,236	21,710,136	22,692,037	23,673,938	24,655,839	25,637,740	26,619,641	27,601,541	28,583,442	29,565,343	30,547,244

Present values using declining rates

0	29,920	59,841	89,761	119,681	149,602	179,522	209,442	239,363	269,283	299,203
0	28,909	57,817	86,726	115,634	144,543	173,451	202,360	231,268	260,177	289,085
29,514	57,444	85,375	113,306	141,237	169,168	197,099	225,030	252,961	280,892	308,823
53,689	80,675	107,662	134,648	161,634	188,621	215,607	242,594	269,580	296,567	323,553
76,195	102,269	128,343	154,417	180,490	206,564	232,638	258,712	284,786	310,860	336,934
97,118	122,310	147,502	172,694	197,886	223,079	248,271	273,463	298,655	323,847	349,039
116,539	140,879	165,219	189,559	213,899	238,240	262,580	286,920	311,260	335,600	359,941
134,535	158,052	181,569	205,086	228,603	252,120	275,637	299,154	322,672	346,189	369,706
151,180	173,902	196,624	219,346	242,068	264,790	287,511	310,233	332,955	355,677	378,399
166,546	188,500	210,453	232,407	254,360	276,314	298,267	320,221	342,174	364,128	386,081
180,700	201,911	223,122	244,334	265,545	286,756	307,967	329,178	350,389	371,600	392,811
193,706	214,200	234,694	255,188	275,682	296,175	316,669	337,163	357,657	378,151	398,644
205,626	225,427	245,228	265,029	284,829	304,630	324,431	344,232	364,033	383,833	403,634
216,519	235,650	254,781	273,912	293,043	312,174	331,306	350,437	369,568	388,699	407,830
226,439	244,923	263,407	281,892	300,376	318,860	337,344	355,829	374,313	392,797	411,281
235,441	253,300	271,159	289,018	306,877	324,737	342,596	360,455	378,314	396,173	414,032
243,575	260,830	278,085	295,341	312,596	329,851	347,106	364,362	381,617	398,872	416,127
250,890	267,561	284,233	300,905	317,577	334,248	350,920	367,592	384,263	400,935	417,607
257,431	273,539	289,647	305,755	321,863	337,971	354,079	370,187	386,295	402,403	418,511
263,243	278,806	294,370	309,933	325,496	341,059	356,623	372,186	387,749	403,312	418,876
268,368	283,405	298,442	313,479	328,516	343,553	358,590	373,626	388,663	403,700	418,737
272,845	287,373	301,902	316,430	330,959	345,487	360,016	374,544	389,072	403,601	418,129
276,712	290,749	304,787	318,824	332,861	346,898	360,935	374,972	389,009	403,047	417,084
280,006	293,568	307,131	320,693	334,256	347,818	361,381	374,943	388,506	402,068	415,631
282,761	295,864	308,968	322,072	335,176	348,280	361,384	374,487	387,591	400,695	413,799
285,009	297,669	310,330	322,991	335,651	348,312	360,973	373,634	386,294	398,955	411,616
286,781	299,014	311,246	323,479	335,712	347,944	360,177	372,409	384,642	396,874	409,107
288,108	299,927	311,746	323,565	335,384	347,203	359,022	370,841	382,659	394,478	406,297
289,017	300,437	311,856	323,275	334,694	346,114	357,533	368,952	380,371	391,790	403,210
289,536	300,569	311,602	322,635	333,668	344,701	355,734	366,767	377,800	388,833	399,866
289,688	300,348	311,008	321,668	332,328	342,988	353,648	364,308	374,968	385,628	396,288
289,500	299,799	310,099	320,398	330,697	340,997	351,296	361,596	371,895	382,195	392,494
288,992	298,943	308,895	318,846	328,797	338,748	348,699	358,651	368,602	378,553	388,504
288,188	297,803	307,418	317,032	326,647	336,262	345,876	355,491	365,106	374,720	384,335
287,108	296,398	305,687	314,977	324,266	333,556	342,845	352,135	361,425	370,714	380,004
285,772	294,747	303,722	312,698	321,673	330,649	339,624	348,599	357,575	366,550	375,526
284,197	292,869	301,541	310,213	318,885	327,556	336,228	344,900	353,572	362,244	370,916
282,402	290,781	299,159	307,538	315,917	324,295	332,674	341,053	349,431	357,810	366,189
280,404	288,499	296,594	304,690	312,785	320,880	328,976	337,071	345,166	353,261	361,357
278,217	286,039	293,861	301,682	309,504	317,325	325,147	332,968	340,790	348,611	356,433
275,858	283,415	290,973	298,530	306,087	313,644	321,201	328,758	336,315	343,872	351,429
272,436	279,738	287,039	294,341	301,642	308,944	316,245	323,547	330,848	338,150	345,451
263,224	270,278	277,333	284,387	291,442	298,497	305,551	312,606	319,660	326,715	333,770
254,322	261,138	267,954	274,770	281,586	288,403	295,219	302,035	308,851	315,667	322,483
245,722	252,308	258,893	265,479	272,064	278,650	285,235	291,821	298,406	304,992	311,577
237,413	243,775	250,138	256,501	262,864	269,227	275,590	281,953	288,315	294,678	301,041
229,384	235,532	241,680	247,827	253,975	260,123	266,270	272,418	278,566	284,713	290,861
221,627	227,567	233,507	239,447	245,386	251,326	257,266	263,206	269,145	275,085	281,025
214,133	219,872	225,610	231,349	237,088	242,827	248,566	254,305	260,044	265,783	271,522
206,891	212,436	217,981	223,526	229,071	234,616	240,160	245,705	251,250	256,795	262,340
327,977	336,767	345,557	354,347	363,137	371,927	380,717	389,507	398,297	407,087	415,877
319,977	328,553	337,128	345,704	354,280	362,855	371,431	380,007	388,582	397,158	405,733
312,173	320,539	328,906	337,272	345,639	354,005	362,372	370,738	379,105	387,471	395,837
304,559	312,721	320,884	329,046	337,208	345,371	353,533	361,696	369,858	378,020	386,183
297,131	305,094	313,057	321,021	328,984	336,947	344,911	352,874	360,837	368,800	376,764
289,884	297,653	305,422	313,191	320,960	328,729	336,498	344,267	352,036	359,805	367,574
282,813	290,393	297,972	305,552	313,132	320,711	328,291	335,870	343,450	351,030	358,609
275,915	283,310	290,705	298,100	305,494	312,889	320,284	327,678	335,073	342,468	349,863
269,186	276,400	283,614	290,829	298,043	305,258	312,472	319,686	326,901	334,115	341,329
262,620	269,659	276,697	283,735	290,774	297,812	304,851	311,889	318,927	325,966	333,004
256,215	263,082	269,948	276,815	283,682	290,549	297,415	304,282	311,149	318,016	324,882
249,966	256,665	263,364	270,063	276,763	283,462	290,161	296,860	303,560	310,259	316,958
243,869	250,405	256,941	263,477	270,012	276,548	283,084	289,620	296,156	302,692	309,228
237,921	244,297	250,674	257,050	263,427	269,803	276,180	282,556	288,933	295,309	301,685
232,118	238,339	244,560	250,781	257,002	263,223	269,444	275,664	281,885	288,106	294,327
226,457	232,526	238,595	244,664	250,733	256,803	262,872	268,941	275,010	281,079	287,149
220,933	226,854	232,776	238,697	244,618	250,539	256,460	262,381	268,303	274,224	280,145
215,545	221,321	227,098	232,875	238,652	244,428	250,205	255,982	261,759	267,535	273,312
210,287	215,923	221,559	227,195	232,831	238,467	244,103	249,738	255,374	261,010	266,646
205,158	210,657	216,155	221,654	227,152	232,650	238,149	243,647	249,146	254,644	260,142
200,155	205,519	210,883	216,247	221,612	226,976	232,340	237,705	243,069	248,433	253,797
195,273	200,506	205,740	210,973	216,207	221,440	226,673	231,907	237,140	242,374	247,607
190,510	195,616	200,722	205,827	210,933	216,039	221,145	226,251	231,356	236,462	241,568
185,863	190,845	195,826	200,807	205,789	210,770	215,751	220,732	225,714	230,695	235,676
181,330	186,190	191,050	195,910	200,769	205,629	210,489	215,349	220,208	225,068	229,928
176,907	181,649	186,390	191,131	195,872	200,614	205,355	210,096	214,837	219,579	224,320
172,593	177,218	181,844	186,469	191,095	195,721	200,346	204,972	209,598	214,223	218,849
168,383	172,896	177,409	181,921	186,434	190,947	195,460	199,973	204,485	208,998	213,511
164,276	168,679	173,082	177,484	181,887	186,290	190,693	195,095	199,498	203,901	208,303
160,269	164,565	168,860	173,155	177,451	181,746	186,041	190,337	194,632	198,928	203,223
156,360	160,551	164,742	168,932	173,123	177,313	181,504	185,694	189,885	194,076	198,266
152,547	156,635	160,723	164,812	168,900	172,989	177,077	181,165	185,254	189,342	193,430
148,826	152,815	156,803	160,792	164,781	168,769	172,758	176,747	180,735	184,724	188,713
145,196	149,088	152,979	156,870	160,762	164,653	168,544	172,436	176,327	180,219	184,110
141,655	145,451	149,248	153,044	156,841	160,637	164,434	168,230	172,026	175,823	179,619
138,200	141,904	145,608	149,311	153,015	156,719	160,423	164,127	167,831	171,535	175,238
134,829	138,443	142,056	145,670	149,283	152,897	156,510	160,124	163,737	167,351	170,964
131,541	135,066	138,591	142,117	145,642	149,168	152,693	156,218	159,744	163,269	166,794
128,332	131,772	135,211	138,650	142,090	145,529	148,969	152,408	155,847	159,287	162,726
125,202	128,558	131,913	135,269	138,624	141,980	145,335	148,691	152,046	155,402	158,757
122,149	125,422	128,696	131,970	135,243	138,517	141,791	145,064	148,338	151,612	154,885
119,169	122,363	125,557	128,751	131,945	135,138	138,332	141,526	144,720	147,914	151,108
116,263	119,379	122,495	125,611	128,726	131,842	134,958	138,074	141,190	144,306	147,422
113,427	116,467	119,507	122,547	125,587	128,627	131,667	134,707	137,746	140,786	143,826
110,661	113,626	116,592	119,558	122,524	125,489	128,455	131,421	134,387	137,353	140,318
107,961	110,855	113,748	116,642	119,535	122,429	125,322	128,216	131,109	134,003	136,896
105,328	108,151	110,974	113,797	116,620	119,443	122,266	125,088	127,911	130,734	133,557
102,759	105,513	108,267	111,021	113,775	116,529	119,283	122,037	124,792	127,546	130,300
100,253	102,940	105,627	108,314	111,000	113,687	116,374	119,061	121,748	124,435	127,122
97,808	100,429	103,050	105,672	108,293	110,914	113,536	116,157	118,778	121,400	124,021

Benefits (100 year)

Elephant pop growth effect			
+0.001%	+0.002%	+0.003%	+0.004%
1,434,732	3,013,844	4,306,550	5,743,637

Present values using declining rates

0	0	0	0
0	0	0	0
0	0	0	0
1,053	2,211	3,159	4,211
2,044	4,292	6,132	8,176
2,976	6,250	8,928	11,904
3,852	8,088	11,555	15,407
4,673	9,814	14,020	18,694
5,443	11,431	16,331	21,775
6,164	12,945	18,494	24,659
6,838	14,361	20,516	27,356
7,467	15,682	22,404	29,873
8,054	16,913	24,163	32,219
8,599	18,059	25,800	34,402
9,106	19,123	27,320	36,429
9,575	20,109	28,729	38,307
10,009	21,021	30,031	40,044
10,409	21,862	31,233	41,647
10,778	22,635	32,338	43,121
11,115	23,344	33,352	44,472
11,424	23,993	34,278	45,708
11,705	24,583	35,121	46,832
11,960	25,118	35,886	47,852
12,189	25,600	36,575	48,771
12,395	26,033	37,193	49,596
12,578	26,418	37,743	50,330
12,740	26,758	38,229	50,978
12,882	27,055	38,654	51,545
13,004	27,312	39,022	52,035
13,108	27,531	39,334	52,452
13,195	27,713	39,595	52,800
13,265	27,861	39,806	53,082
13,320	27,976	39,971	53,303
13,360	28,061	40,092	53,465
13,387	28,117	40,172	53,571
13,400	28,145	40,213	53,625
13,401	28,147	40,216	53,630
13,390	28,125	40,185	53,589
13,369	28,080	40,121	53,504
13,337	28,014	40,026	53,378
13,296	27,927	39,903	53,213
13,246	27,821	39,752	53,012
13,187	27,698	39,575	52,777
13,120	27,558	39,375	52,511
13,046	27,402	39,153	52,214
12,964	27,231	38,909	51,890
12,877	27,048	38,647	51,540
12,783	26,851	38,366	51,166
12,684	26,643	38,069	50,769
12,579	26,423	37,755	50,352
20,460	42,978	61,410	81,899
20,472	43,002	61,444	81,946
20,475	43,008	61,454	81,958
20,469	42,997	61,438	81,938
20,456	42,969	61,399	81,886
20,435	42,926	61,337	81,804
20,407	42,867	61,254	81,693
20,372	42,794	61,149	81,554
20,330	42,707	61,025	81,389
20,282	42,606	60,881	81,198
20,228	42,493	60,719	80,982
20,168	42,367	60,540	80,743
20,103	42,229	60,344	80,482
20,032	42,081	60,131	80,199
19,956	41,921	59,904	79,896
19,875	41,751	59,661	79,573
19,789	41,572	59,405	79,231
19,699	41,383	59,135	78,872
19,605	41,185	58,853	78,496
19,507	40,979	58,558	78,103
19,404	40,764	58,252	77,695
19,299	40,542	57,935	77,273
19,189	40,313	57,608	76,837
19,077	40,077	57,271	76,387
18,961	39,834	56,924	75,926
18,843	39,585	56,569	75,452
18,721	39,331	56,205	74,967
18,597	39,071	55,834	74,472
18,471	38,805	55,455	73,967
18,342	38,535	55,069	73,453
18,211	38,260	54,676	72,930
18,079	37,981	54,278	72,399
17,944	37,698	53,874	71,860
17,807	37,411	53,464	71,314
17,669	37,121	53,049	70,761
17,529	36,828	52,630	70,202
17,388	36,531	52,207	69,638
17,245	36,232	51,779	69,068
17,102	35,930	51,348	68,493
16,957	35,626	50,914	67,914
16,811	35,320	50,477	67,331
16,664	35,012	50,037	66,745
16,517	34,702	49,594	66,155
16,369	34,391	49,150	65,562
16,220	34,078	48,703	64,967
16,070	33,765	48,255	64,370
15,920	33,450	47,805	63,770
15,770	33,134	47,355	63,169
15,620	32,818	46,903	62,567
15,469	32,502	46,451	61,964

Direct costs

Summary

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Meetings and Workshops	29,830	25,915	25,915	18,915	18,915	**119,490**
Construction	0	149,808	30,000	10,000	10,000	**199,808**
Corridor Protection	0	22,400	19,776	20,369	20,980	**83,525**
Operational expenses	22,200	22,866	23,551	24,258	24,986	**117,861**
Staff costs	90,000	114,300	117,729	121,261	124,899	**568,189**
Community Livelihoods Projects	80,000	80,000	55,000	40,000	40,000	**295,000**
Capital Items	60,580	0	0	0	0	**60,580**
Research and Monitoring	7,400	7,622	7,850	8,086	8,328	**39,286**
Consultancy Fees	42,000	27,810	28,645	18,113	40,493	**157,061**
Crossing structures construction	0	408,000	0	0	0	**408,000**
Total	**332,010**	**858,721**	**308,466**	**261,002**	**288,601**	**2,048,800**

Summary (Iacona [2018] categories)

	Year 1	Year 2	Year 3	Year 4	Year 5	Total
Labor	87,230	102,737	83,541	62,370	63,223	**399,101**
Capital	90,580	591,008	55,000	35,000	35,000	**806,588**
Consumables	64,200	50,676	52,196	42,371	65,479	**274,922**
Overhead	90,000	114,300	117,729	121,261	124,899	**568,189**
Total	**332,010**	**858,721**	**308,466**	**261,002**	**288,601**	**2,048,800**

Opportunity costs

Area

						Expected ellie damage			
Corridor area	434	acres							
Sole	67	acres	15%	27	ha	0.00	$/ha	0	$ total
Mang'ula A	162	acres	37%	66	ha	0.00	$/ha	0	$ total
Kanyenja	204	acres	47%	83	ha	20.27	$/ha	1,676	$ total

Opportunity cost (US$)

Profitability scenario	Sole	Mang'ula	Kanyenja	Total
High	14,383	34,741	43,677	92,800
Medium	11,434	27,618	34,722	73,773
Low	8,485	20,495	25,767	54,746

Opportunity cost (US$) - ex. Elephant damage

Sole	Mang'ula	Kanyenja	Total
14,383	34,741	42,001	91,124
11,434	27,618	33,046	72,098
8,485	20,495	24,091	53,071

Current planting within corridor area

Crops

			Revenue			Profit						Profit/acre		
English	Swahili	Acres planted	TSH / acre	USD / acre	Total USD / year	High (%)	Medium (%)	Low (%)	High (USD)	Medium (USD)	Low (USD)	High (USD)	Medium (USD)	Low (USD)
Miwa	Sugarcane	95	2,638,153	1,138	108,107	45%	35%	25%	49,163	38,353	27,542	517	404	290
				Total:	108,107				49,163	38,353	27,542			

Trees

English	Swahili	Number planted	TSH / tree	USD / tree	Productive	Harvests per year	USD / tree / year	Total USD / year	High (%)	Medium (%)	Low (%)	High (USD)	Medium (USD)	Low (USD)
Mianzi	Bamboo	1,392	30,000	13	yes	0.33	4.31	6,003	53%	43%	33%	3,188	2,588	1,988
Michikichi	Palm oil	464	190,000	82	yes	1.00	81.93	38,021	53%	43%	33%	20,193	16,391	12,589
Mwembe	Mango	421	182,000	78	yes	1.00	78.48	33,048	53%	43%	33%	17,552	14,247	10,943
Mgomba	Bananas	387	29,000	13	yes	1.00	12.51	4,836	53%	43%	33%	2,568	2,085	1,601
Mpira	Rubber	17	20,000	9	yes	1.00	8.62	148	53%	43%	33%	79	64	49
Msonobari	Pine	9	70,000	30	yes	0.10	3.02	26	53%	43%	33%	14	11	9
Mti mbao ngumu	Hardwoods	9	45,000	19	yes	0.05	0.97	8	53%	43%	33%	4	4	3
Mstapheri	Custard appl	9	19,000	8	yes	1.00	8.19	70	53%	43%	33%	37	30	23
Mkama	Fence tree	610	5,000	2	no	-	-	-	-	-	-	-	-	-
Mti kivuli	Shade trees	112	20,000	9	no	-	-	-	-	-	-	-	-	-
Mjohoro	Cassia	9	30,000	13	no	-	-	-	-	-	-	-	-	-
Mwarobaini	Neem	9	25,000	11	no	-	-	-	-	-	-	-	-	-
					Total:			82,161				43,637	35,421	27,205

Profitability assumptions

Profitability assumptions

Literature estimates

Mean	43%
Max	83%
Q3	67%
Median	40%
Q1	20%
Min	3%
Sugarcane mean	35%
All crops mean	43%

Paper	Crop	Location	Margin
Sugarcane			
Mushi & Ngaruko (2015)	Sugarcane (tr	Tanzania (Kilc	39%
Chongela (2015)	Sugarcane	Tanzania (Mo	18%
Herrmann (2017)	Sugarcane	Tanzania	67%
Juma (2019)	Sugarcane	Tanzania	18%
Other			
Chongela (2015)	Rice	Tanzania (Mo	3%
Kinyau et al (2013)	Rice	Tanzania (Mo	28%
Kuboja & Temu (2013)	Tobacco	Tanzania	37%
Kuboja & Temu (2013)	Groundnuts	Tanzania	68%
Herrmann (2017)	Rice	Tanzania	67%
Herrmann (2017)	Maize	Tanzania	83%
Asfaw et al (2012)	Pigeonpea (b	Tanzania	41%
Asfaw et al (2012)	Pigeonpea (ir	Tanzania	48%

Mutabazi et al (2013)
Average returns to land (US$/acre)
Various crops, multiple sites in Tanzania

Mean	492
Median	212

Human-elephant conflict benefits

Potential elephant damage reduction benefits vs. 2020 baseline (USD)

		Avoided elephant damage due to installed corridor									
Group	2020 $	-10%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
Total	154,838	15,484	30,968	46,451	61,935	77,419	92,903	108,386	123,870	139,354	154,838
Corridor	25,993	2,599	5,199	7,798	10,397	12,996	15,596	18,195	20,794	23,393	25,993
Non-corridor	128,845	12,885	25,769	38,654	51,538	64,423	77,307	90,192	103,076	115,961	128,845
Corridor %	17%										

Elephant damage by village, 2019-20 (original)

								# of reported damage incidents			Total damage value (USD)				Average incidents per month				
Village	Corridor village?	Valley side	Population	Number of households	Area (km2)	Pop per km2	HH per km2	2019	2020	Total	2019	2020	Total	Av value per incident (USD)	2019	2020	Overall	2020 damage ($) per km2	2020 damage ($) per household
Katurukila	no	East	2,786	745	13	214	57	29	88	117	3,294	48,162	51,456	440	2	7	5	3,705	65
Magombera	no	East	949	256	7	136	37	162	120	282	7,093	43,767	50,860	180	14	10	12	6,252	171
Kanyenja	yes	East	1,743	479	23	76	21	162	334	496	17,354	26,962	44,316	89	14	28	21	1,172	56
Msolwa Station	no	East	8,285	2,063	17	487	121	18	59	77	4,961	2,038	6,999	91	2	5	3	120	1
Mkula	no	West	1,844	490	6	307	82	2	2	4	174	223	397	99	0	0	0	37	0
Mang'ula A	yes	West	3,060	705	5	612	141	0	0	0	0	0	0	..	0	0	0	0	0
Mang'ula B	no	West	5,418	1,309	7	774	187	20	4	24	723	193	916	38	2	0	1	28	0
Mwaya	no	West	10,366	2,581	9	1,152	287	4	0	4	7	0	7	2	0	0	0	0	0
Sole	yes	West	2,020	478	4	505	120	2	0	2	4,179	0	4,179	2,089	0	0	0	0	0
Sonjo	no	West	2,020	478	5	404	96	0	0	0	0	0	0	..	0	0	0	0	0
Msalise	no	East	1,825	429	17	107	25	2	0	2	131	0	131	66	0	0	0	0	0
							Total:	401	607	1,008	37,916	121,345	159,260	344					
							Subtotals												
							Corridor	164	334	498	21,533	26,962	48,495	1,089					
							Non-corridor	237	273	510	16,383	94,383	110,766	131					
							Corridor	41%	55%	49%	57%	22%	30%						
							Non-corridor	59%	45%	51%	43%	78%	70%						
							East	373	601	974	32,833	120,928	153,762	173					
							West	28	6	34	5,082	416	5,499	557					
							East	93%	99%	97%	87%	100%	97%						
							West	7%	1%	3%	13%	0%	3%						

Assumption: While west side villages don't have LEMs, damage is routinely reported to STEP's HEC Officer, who covers these villages.

No data is reported for Msalise in 2020. Instead, likely elephant damage is modelled below.

Elephant damage by village, 2019-20 (modelled data for Msalise)

Assume comparable damage per household to neighbouring Katurukila, Magombera, & Kanyenja

Average damage/household in neighbouring villages (2020):	80	USD
Average incidents/household in neighbouring villages (2020):	0.37	incidents
Assumed Msalise damage in 2020 (USD):	34,462	
Assumed Msalise incidents in 2020:	157	

								# of reported damage incidents			Total damage value (USD)				Average incidents per month					
Village	Corridor village?	Valley side	Population	Number of households	Area (km2)	Pop per km2	HH per km2	2019	2020	Total	2019	2020	Total	Av value per incident (USD)	2019	2020	Overall	2020 damage ($) per km2	2020 damage ($) per ha	2020 damage ($) per household
Katurukila	no	East	2,786	745	13	214	57	29	88	117	3,294	48,162	51,456	440	2	7	5	3,705	37.0	65
Magombera	no	East	949	256	7	136	37	162	120	282	7,093	43,767	50,860	180	14	10	12	6,252	62.5	171
Kanyenja	yes	East	1,743	479	23	76	21	162	334	496	17,354	26,962	44,316	89	14	28	21	1,172	11.7	56
Msolwa Station	no	East	8,285	2,063	17	487	121	18	59	77	4,961	2,038	6,999	91	2	5	3	120	1.2	1
Mkula	no	West	1,844	490	6	307	82	2	2	4	174	223	397	99	0	0	0	37	0.4	0
Mang'ula A	yes	West	3,060	705	5	612	141	0	0	0	0	0	0	..	0	0	0	0	0.0	0
Mang'ula B	no	West	5,418	1,309	7	774	187	20	4	24	723	193	916	38	2	0	1	28	0.3	0
Mwaya	no	West	10,366	2,581	9	1,152	287	4	0	4	7	0	7	2	0	0	0	0	0.0	0
Sole	yes	West	2,020	478	4	505	120	2	0	2	4,179	0	4,179	2,089	0	0	0	0	0.0	0
Sonjo	no	West	2,020	478	5	404	96	0	0	0	0	0	0	..	0	0	0	0	0.0	0
Msalise	no	East	1,825	429	17	107	25	-	157	-	-	34,462	-	219	0	0	0	2,027	20.3	80
							Total:		764			155,807		361						
							Subtotals													
							Corridor villages		334			26,962		1,089						
							Non-corridor villages		430			128,845		153						
							Corridor		44%			17%								
							Non-corridor		56%			83%								
							East		758			155,391		204						
							West		6			416		557						
							East		99%			100%								
							West		1%			0%								
							+10%					171,387								
							+20%					186,968								

Assumption: While west side villages don't have LEMs, damage is routinely reported to STEP's HEC Officer, who covers these villages.

No data is reported for Msalise in 2020. Instead, likely elephant damage is modelled below.

Corridor village benefit scaling

Removing corridor land from calculations to estimate potential HEC benefit on land remaining in agriculture

Village	Corridor ha	Total ha	Corridor %
Sole	27	400	7%
Mang'ula A	66	500	13%
Kanyenja	83	2,300	4%

		Potential avoided losses	
Village	Corridor village?	2020	Correct
Kanyenja	yes	26,962	25,993
Mang'ula A	yes	0	0
Sole	yes	0	0
Katurukila	no	48,162	48,162
Magombera	no	43,767	43,767
Mang'ula B	no	193	193
Mkula	no	223	223
Msalise	no	34,462	34,462
Msolwa Station	no	2,038	2,038
Mwaya	no	0	0
Sonjo	no	0	0

Corridor villages:	25,993
Landscape villages:	154,838

Ecosystem service value benefits

ESVD

Reference: Foundation for Sustainable Development (2021). Ecosystem Services Valuation Database 1.0, July 26 2022, https://esvd.net

ESVD summary statistics

The summary statistics show the mean standardised values for each selected biome and ecosystem service. To allow for comparison, values in the ESVD are standardised to a common set of units: International dollars/hectare/year in 2020 price levels. The number of value records used to compute mean values is indicated in parentheses. Additional summary statistics (median, standard deviation, minimum, maximum) can be viewed by hovering the mouse pointer over the results.

In most cases only a portion of the search results will be included in the calculation of summary statistics. These are value records that: i) Could be standardised to a common set of units (International dollars/hectare/year in 2020 price levels); ii) Refer to only 1 biome and 1 ecosystem service (i.e. records with multiple services or biomes are not included).

	2020 US$/ha/year		
Service	Cropland	Forest	Grassland
1. Food	6,594	71	3
2. Water		24	130
3. Raw materials	0	580	441
4. Genetic resources		410	
5. Medicinal resources		492	
6. Ornamental resources		0	
7. Air quality regulation	8	278	428
8. Climate regulation	0	805	498
9. Moderation of extreme events	2	82	
10. Regulation of water flows		175	43
11. Waste treatment		317	120
12. Erosion prevention		3,763	29
13. Maintenance of soil fertility	117	29	3,159
14. Pollination	566	303	
15. Biological control	565	14	
16. Maintenance of life cycles		1,422	
17. Maintenance of genetic diversity		147	123
18. Aesthetic information	0		743
19. Opportunities for recreation and tourism		52	384
20. Inspiration for culture, art and design	3	2	252
21. Spiritual experience			
22. Information for cognitive development		7	147
23. Existence, bequest values		200	0
Total	7,855	9,174	6,500
Total (ex-food)	**1,261**	**9,174**	**6,500**

Land type assumptions

Corridor area:	176	ha	
No corridor			
Cropland	100%		
Corridor			
Grassland	50%		
Forest	50%		
Restoration time			
Forests	40	years	*Philipson et al (2020): https://www.science.org/doi/10.1126/science.aay4490*
Grassland	30	years	*Mbaabu et al (2020): https://www.nature.com/articles/s41598-020-77126-7*

ESVs by year (2020 US$)

		Corridor									
		Forest				Grassland					
Year	No-corridor	Restoration %	US$/ha	Ha	Total US$	Restoration %	US$/ha	Ha	Total US$	Total	Net
1	221,545	0%	1,261	88	110,773	0%	1,261	88	110,773	221,545	0
2	221,545	0%	1,261	88	110,773	0%	1,261	88	110,773	221,545	0
3	221,545	3%	1,459	88	128,153	3%	1,435	88	126,114	254,268	32,722
4	221,545	5%	1,657	88	145,534	6%	1,566	88	137,620	283,154	61,609
5	221,545	8%	1,854	88	162,915	8%	1,697	88	149,126	312,041	90,496
6	221,545	10%	2,052	88	180,296	11%	1,828	88	160,632	340,928	119,383
7	221,545	13%	2,250	88	197,677	13%	1,959	88	172,138	369,815	148,270
8	221,545	15%	2,448	88	215,057	16%	2,090	88	183,644	398,702	177,156
9	221,545	18%	2,646	88	232,438	18%	2,221	88	195,150	427,589	206,043
10	221,545	20%	2,844	88	249,819	21%	2,352	88	206,657	456,475	234,930
11	221,545	23%	3,041	88	267,200	23%	2,483	88	218,163	485,362	263,817
12	221,545	25%	3,239	88	284,580	26%	2,614	88	229,669	514,249	292,704
13	221,545	28%	3,437	88	301,961	28%	2,745	88	241,175	543,136	321,591
14	221,545	30%	3,635	88	319,342	31%	2,876	88	252,681	572,023	350,477
15	221,545	33%	3,833	88	336,723	33%	3,007	88	264,187	600,910	379,364
16	221,545	35%	4,031	88	354,104	36%	3,138	88	275,693	629,796	408,251
17	221,545	38%	4,228	88	371,484	38%	3,269	88	287,199	658,683	437,138
18	221,545	40%	4,426	88	388,865	41%	3,400	88	298,705	687,570	466,025
19	221,545	43%	4,624	88	406,246	43%	3,531	88	310,211	716,457	494,912
20	221,545	45%	4,822	88	423,627	46%	3,662	88	321,717	745,344	523,798
21	221,545	48%	5,020	88	441,007	48%	3,793	88	333,223	774,231	552,685
22	221,545	50%	5,218	88	458,388	51%	3,924	88	344,729	803,117	581,572
23	221,545	53%	5,415	88	475,769	53%	4,055	88	356,235	832,004	610,459
24	221,545	55%	5,613	88	493,150	56%	4,186	88	367,741	860,891	639,346
25	221,545	58%	5,811	88	510,530	58%	4,317	88	379,247	889,778	668,233
26	221,545	60%	6,009	88	527,911	61%	4,448	88	390,753	918,665	697,119
27	221,545	63%	6,207	88	545,292	63%	4,579	88	402,260	947,552	726,006
28	221,545	65%	6,405	88	562,673	66%	4,710	88	413,766	976,438	754,893
29	221,545	68%	6,602	88	580,054	68%	4,841	88	425,272	1,005,325	783,780
30	221,545	70%	6,800	88	597,434	71%	4,972	88	436,778	1,034,212	812,667
31	221,545	73%	6,998	88	614,815	73%	5,103	88	448,284	1,063,099	841,554
32	221,545	75%	7,196	88	632,196	76%	5,234	88	459,790	1,091,986	870,440
33	221,545	78%	7,394	88	649,577	78%	5,365	88	471,296	1,120,873	899,327
34	221,545	80%	7,592	88	666,957	81%	5,495	88	482,802	1,149,759	928,214
35	221,545	83%	7,789	88	684,338	83%	5,626	88	494,308	1,178,646	957,101
36	221,545	85%	7,987	88	701,719	86%	5,757	88	505,814	1,207,533	985,988
37	221,545	88%	8,185	88	719,100	88%	5,888	88	517,320	1,236,420	1,014,875
38	221,545	90%	8,383	88	736,481	91%	6,019	88	528,826	1,265,307	1,043,761
39	221,545	93%	8,581	88	753,861	93%	6,150	88	540,332	1,294,194	1,072,648
40	221,545	95%	8,779	88	771,242	96%	6,281	88	551,838	1,323,080	1,101,535
41	221,545	98%	8,976	88	788,623	98%	6,412	88	563,344	1,351,967	1,130,422
42	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
43	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
44	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
45	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
46	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
47	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
48	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
49	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
50	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
51	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
52	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
53	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
54	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
55	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
56	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
57	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
58	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
59	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
60	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
61	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
62	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
63	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
64	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
65	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
66	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
67	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
68	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
69	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
70	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
71	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
72	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
73	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
74	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
75	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
76	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
77	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
78	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
79	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
80	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
81	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
82	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
83	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
84	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
85	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
86	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
87	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
88	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
89	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
90	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
91	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
92	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
93	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
94	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
95	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
96	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
97	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
98	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
99	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473
100	221,545	100%	9,174	88	806,004	100%	6,500	88	571,015	1,377,019	1,155,473

<< restoration starts in Y3

Elephant population benefits

Assumptions

Population size

	Current		Current density
Selous-Mikum	15,501	TAWIRI (2019)	0.5
Udzungwa	750	STEP (PC)	0.6

Carrying capacity

	Density (elepl	Area (sq mile)	Carrying capacity	Density (/km2	Area (km2)
Selous-Mikum	3.1	32,397	100,431	1.2	83,908
Udzungwa	3.1	1,336	4,142	1.2	3,460

Density = elephants per square mile (Armbruster & Lande, 1993)

Current % of carrying capacity: 15.54%

Elephant value

Value 7,366 2020 US$ / elephant / year

Current pop growth rate 7.000%

Selous-Mikumi (2014)	15,217	30
Selous-Mikumi (2018)	15,501	
		117,998
Implied rate	0.463%	
Max rate	7.0%	

Elephant deaths in the corridor area
(2020-22)

Deaths	6
100 year value	1,401,341

Elephant population effects by year

Total additional elephants:

@ 30:	1	10	15	16	20
@ 100:	25	52	74	78	99

Present value:

@ 30:	78,096	164,013	234,318	245,927	311,444
@ 100:	1,414,732	3,013,844	4,306,550	4,483,270	5,743,637

Additional growth due to corridor

	Baseline	0.001%	0.002%	0.003%	0.0031%	0.004%
1	16,251	16,251	16,251	16,251	16,251	16,251
2	16,326	16,326	16,326	16,326	16,326	16,326
3	16,402	16,402	16,402	16,402	16,402	16,402
4	16,478	16,478	16,478	16,478	16,478	16,479
5	16,554	16,555	16,555	16,555	16,555	16,556
6	16,631	16,631	16,632	16,633	16,633	16,633
7	16,708	16,709	16,709	16,710	16,710	16,711
8	16,785	16,786	16,787	16,788	16,788	16,789
9	16,863	16,864	16,865	16,866	16,866	16,867
10	16,941	16,943	16,944	16,945	16,945	16,946
11	17,020	17,021	17,023	17,024	17,024	17,025
12	17,099	17,100	17,102	17,103	17,104	17,105
13	17,178	17,180	17,182	17,183	17,183	17,185
14	17,258	17,259	17,262	17,263	17,263	17,265
15	17,338	17,340	17,342	17,344	17,344	17,346
16	17,418	17,420	17,423	17,425	17,425	17,427
17	17,499	17,501	17,504	17,506	17,506	17,508
18	17,580	17,582	17,585	17,588	17,588	17,590
19	17,661	17,664	17,667	17,670	17,670	17,672
20	17,743	17,746	17,749	17,752	17,752	17,755
21	17,825	17,828	17,832	17,835	17,835	17,838
22	17,908	17,911	17,915	17,918	17,918	17,921
23	17,991	17,994	17,998	18,001	18,002	18,005
24	18,074	18,078	18,082	18,085	18,086	18,089
25	18,158	18,162	18,166	18,170	18,170	18,174
26	18,242	18,246	18,251	18,255	18,255	18,259
27	18,326	18,331	18,336	18,340	18,340	18,344
28	18,411	18,416	18,421	18,425	18,426	18,430
29	18,497	18,502	18,507	18,511	18,512	18,516
30	18,582	18,587	18,593	18,597	18,598	18,602
31	18,669	18,674	18,679	18,684	18,685	18,689
32	18,755	18,760	18,766	18,771	18,772	18,777
33	18,842	18,848	18,854	18,859	18,860	18,864
34	18,929	18,935	18,942	18,947	18,947	18,953
35	19,017	19,023	19,030	19,035	19,036	19,041
36	19,105	19,111	19,118	19,124	19,125	19,130
37	19,194	19,200	19,207	19,213	19,214	19,220
38	19,283	19,289	19,297	19,303	19,304	19,309
39	19,372	19,379	19,386	19,393	19,394	19,400
40	19,462	19,469	19,477	19,483	19,484	19,490
41	19,552	19,559	19,567	19,574	19,575	19,581
42	19,642	19,650	19,658	19,665	19,666	19,673
43	19,733	19,741	19,750	19,757	19,758	19,765
44	19,825	19,833	19,842	19,849	19,850	19,857
45	19,917	19,925	19,934	19,942	19,943	19,950
46	20,009	20,018	20,027	20,035	20,036	20,043
47	20,102	20,111	20,120	20,128	20,129	20,137
48	20,195	20,204	20,214	20,222	20,223	20,231
49	20,288	20,298	20,308	20,316	20,317	20,326
50	20,382	20,392	20,402	20,411	20,412	20,421
51	20,477	20,487	20,497	20,506	20,507	20,516
52	20,572	20,582	20,593	20,602	20,603	20,612
53	20,667	20,677	20,689	20,698	20,699	20,708
54	20,763	20,773	20,785	20,794	20,796	20,805
55	20,859	20,870	20,882	20,891	20,893	20,902
56	20,956	20,967	20,979	20,989	20,990	21,000
57	21,053	21,064	21,077	21,087	21,088	21,098
58	21,150	21,162	21,175	21,185	21,187	21,197
59	21,248	21,260	21,273	21,284	21,285	21,296
60	21,347	21,359	21,372	21,383	21,385	21,395
61	21,446	21,458	21,472	21,483	21,484	21,495
62	21,545	21,558	21,572	21,583	21,585	21,596
63	21,645	21,658	21,672	21,684	21,685	21,697
64	21,745	21,758	21,773	21,785	21,786	21,798
65	21,846	21,859	21,874	21,886	21,888	21,900
66	21,947	21,961	21,976	21,988	21,990	22,002
67	22,049	22,063	22,078	22,091	22,093	22,105
68	22,151	22,165	22,181	22,194	22,196	22,208
69	22,254	22,268	22,284	22,298	22,299	22,312
70	22,357	22,372	22,388	22,402	22,403	22,416
71	22,460	22,476	22,492	22,506	22,508	22,521
72	22,564	22,580	22,597	22,611	22,613	22,627
73	22,669	22,685	22,702	22,716	22,718	22,732
74	22,774	22,790	22,808	22,822	22,824	22,839
75	22,880	22,896	22,914	22,929	22,931	22,945
76	22,986	23,002	23,021	23,036	23,038	23,052
77	23,092	23,109	23,128	23,143	23,145	23,160
78	23,199	23,216	23,235	23,251	23,253	23,268
79	23,307	23,324	23,344	23,360	23,362	23,377
80	23,415	23,433	23,452	23,468	23,471	23,486
81	23,523	23,541	23,561	23,578	23,580	23,596
82	23,632	23,651	23,671	23,688	23,690	23,706
83	23,742	23,760	23,781	23,798	23,801	23,817
84	23,852	23,871	23,892	23,909	23,912	23,928
85	23,962	23,983	24,003	24,021	24,023	24,040
86	24,073	24,093	24,115	24,133	24,135	24,153
87	24,185	24,205	24,227	24,245	24,248	24,266
88	24,297	24,317	24,340	24,358	24,361	24,379
89	24,409	24,430	24,453	24,472	24,475	24,493
90	24,522	24,544	24,567	24,586	24,589	24,607
91	24,636	24,658	24,681	24,701	24,703	24,722
92	24,750	24,772	24,796	24,816	24,818	24,838
93	24,865	24,887	24,912	24,932	24,934	24,954
94	24,980	25,003	25,028	25,048	25,051	25,071
95	25,096	25,119	25,144	25,165	25,168	25,188
96	25,212	25,235	25,261	25,282	25,285	25,306
97	25,329	25,353	25,379	25,400	25,403	25,424
98	25,446	25,470	25,497	25,519	25,522	25,543
99	25,564	25,589	25,616	25,638	25,641	25,662
100	25,683	25,707	25,735	25,757	25,760	25,782

Additional elephants due to corridor

	0.001%	0.002%	0.003%	0.0031%	0.004%
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	1	1
5	0	1	1	1	1
6	0	1	1	2	2
7	1	1	2	2	3
8	1	2	3	3	3
9	1	2	3	3	4
10	1	2	4	4	5
11	1	3	4	4	5
12	1	3	5	5	6
13	2	4	5	5	7
14	2	4	6	6	8
15	2	4	6	6	9
16	2	5	7	7	9
17	2	5	7	8	10
18	3	6	8	8	11
19	3	6	8	9	11
20	3	6	9	9	12
21	3	7	10	10	13
22	3	7	10	11	14
23	4	8	11	11	14
24	4	8	11	12	15
25	4	8	12	12	16
26	4	9	13	13	17
27	4	9	13	14	18
28	5	10	14	14	18
29	5	10	14	15	19
30	5	10	15	16	20
31	5	11	16	16	21
32	5	11	16	17	22
33	6	12	17	18	23
34	6	12	18	18	23
35	6	13	18	19	24
36	6	13	19	20	25
37	6	14	19	20	26
38	7	14	20	21	27
39	7	15	21	22	28
40	7	15	22	22	29
41	7	16	22	23	30
42	8	16	23	24	31
43	8	17	24	25	31
44	8	17	24	25	32
45	8	17	25	26	33
46	9	18	26	27	34
47	9	18	26	28	35
48	9	19	27	28	36
49	9	20	28	29	37
50	10	20	29	30	38
51	10	21	29	31	39
52	10	21	30	31	40
53	10	22	31	32	41
54	11	22	32	33	42
55	11	23	32	34	43
56	11	23	33	35	44
57	11	24	34	35	45
58	12	24	35	36	46
59	12	25	36	37	47
60	12	25	36	38	49
61	12	26	37	39	50
62	13	27	38	40	51
63	13	27	39	40	52
64	13	28	40	41	53
65	13	28	40	42	54
66	14	29	41	43	55
67	14	30	42	44	56
68	14	30	43	45	57
69	15	31	44	46	59
70	15	31	45	47	60
71	15	32	46	48	61
72	16	33	47	48	62
73	16	33	47	49	63
74	16	34	48	50	64
75	16	34	49	51	66
76	17	35	50	52	67
77	17	36	51	53	68
78	17	36	52	54	69
79	18	37	53	55	71
80	18	38	54	56	72
81	18	38	55	57	73
82	19	39	56	58	74
83	19	40	57	59	76
84	19	40	58	60	77
85	20	41	59	61	78
86	20	42	60	62	80
87	20	43	61	63	81
88	21	43	62	64	82
89	21	44	63	65	84
90	21	45	64	66	85
91	22	45	65	67	86
92	22	46	66	69	88
93	22	47	67	70	89
94	23	48	68	71	91
95	23	48	69	72	92
96	23	49	70	73	94
97	24	50	71	74	95
98	24	51	72	75	96
99	24	51	73	76	98
100	25	52	74	78	99

Additional value due to corridor

	0.001%	0.002%	0.003%	0.0031%	0.004%
1	$0	$0	$0	$0	$0
2	$0	$0	$0	$0	$0
3	$0	$0	$0	$0	$0
4	$0	$0	$0	$0	$0
5	1,208	2,537	3,625	3,773	4,833
6	2,428	5,098	7,283	7,581	9,710
7	3,658	7,682	10,971	11,421	14,633
8	4,900	10,291	14,701	15,304	19,602
9	6,154	12,923	18,462	19,219	24,616
10	7,419	15,580	22,257	23,170	29,677
11	8,695	18,261	26,087	27,157	34,784
12	9,984	20,966	29,953	31,181	39,938
13	11,284	23,697	33,854	35,242	45,140
14	12,596	26,452	37,790	39,340	50,389
15	13,919	29,232	41,762	43,475	55,686
16	15,255	32,038	45,770	47,647	61,031
17	16,603	34,869	49,815	51,858	66,424
18	17,963	37,725	53,896	56,107	71,867
19	19,336	40,608	58,015	60,394	77,358
20	20,720	43,516	62,170	64,720	82,899
21	22,117	46,451	66,363	69,084	88,491
22	23,527	49,411	70,593	73,488	94,132
23	24,949	52,399	74,861	77,931	99,824
24	26,384	55,413	79,168	82,414	105,567
25	27,832	58,453	83,512	86,937	111,361
26	29,292	61,521	87,896	91,501	117,207
27	30,766	64,616	92,318	96,105	123,104
28	32,253	67,739	96,780	100,749	129,055
29	33,753	70,889	101,281	105,435	135,058
30	35,265	74,067	105,822	110,162	141,115
31	36,791	77,273	110,403	114,931	147,225
32	38,331	80,507	115,024	119,742	153,386
33	39,884	83,770	119,686	124,595	159,603
34	41,451	87,061	124,388	129,491	165,875
35	43,031	90,380	129,132	134,429	172,202
36	44,625	93,729	133,917	139,411	178,584
37	46,233	97,107	138,744	144,436	185,022
38	47,855	100,514	143,613	149,504	191,516
39	49,491	103,951	148,524	154,617	198,066
40	51,142	107,418	153,478	159,774	204,673
41	52,806	110,914	158,475	164,976	211,337
42	54,485	114,441	163,514	170,222	218,059
43	56,178	117,998	168,597	175,514	224,839
44	57,886	121,586	173,724	180,851	231,677
45	59,608	125,204	178,895	186,234	238,574
46	61,345	128,854	184,110	191,664	245,530
47	63,097	132,534	189,370	197,139	252,546
48	64,864	136,246	194,675	202,662	259,622
49	66,646	139,990	200,025	208,233	266,758
50	68,443	143,765	205,420	213,848	273,955
51	70,255	147,573	210,861	219,513	281,213
52	72,083	151,412	216,349	225,226	288,533
53	73,926	155,285	221,883	230,987	295,915
54	75,784	159,190	227,464	236,797	303,359
55	77,658	163,127	233,091	242,656	310,866
56	79,548	167,098	238,767	248,564	318,436
57	81,454	171,103	244,490	254,522	326,070
58	83,376	175,141	250,261	260,530	333,769
59	85,314	179,213	256,080	266,588	341,532
60	87,268	183,318	261,948	272,697	349,359
61	89,239	187,458	267,865	278,857	357,253
62	91,225	191,633	273,831	285,068	365,212
63	93,229	195,842	279,847	291,332	373,238
64	95,249	200,087	285,914	297,647	381,330
65	97,285	204,366	292,030	304,014	389,490
66	99,339	208,681	298,197	310,435	397,717
67	101,409	213,032	304,415	316,908	406,012
68	103,497	217,418	310,685	323,435	414,376
69	105,601	221,841	317,006	330,016	422,810
70	107,723	226,300	323,379	336,651	431,313
71	109,863	230,795	329,805	343,341	439,885
72	112,020	235,328	336,284	350,085	448,528
73	114,194	239,897	342,815	356,885	457,242
74	116,387	244,505	349,400	363,741	466,027
75	118,597	249,149	356,039	370,652	474,886
76	120,825	253,832	362,732	377,620	483,814
77	123,072	258,552	369,480	384,645	492,816
78	125,336	263,311	376,282	391,727	501,892
79	127,619	268,108	383,140	398,866	511,041
80	129,921	272,945	390,053	406,064	520,265
81	132,241	277,821	397,022	413,319	529,563
82	134,579	282,736	404,048	420,634	538,937
83	136,937	287,691	411,130	428,007	548,387
84	139,314	292,685	418,270	435,440	557,913
85	141,709	297,720	425,467	442,933	567,515
86	144,124	302,795	432,722	450,486	577,195
87	146,559	307,911	440,035	458,099	586,953
88	149,012	313,068	447,407	465,774	596,789
89	151,486	318,266	454,838	473,510	606,704
90	153,979	323,506	462,328	481,308	616,698
91	156,492	328,788	469,878	489,169	626,772
92	159,025	334,111	477,488	497,092	636,927
93	161,578	339,477	485,159	505,078	647,162
94	164,151	344,886	492,891	513,127	657,479
95	166,745	350,337	500,684	521,241	667,878
96	169,359	355,832	508,539	529,419	678,359
97	171,994	361,370	516,456	537,661	688,924
98	174,650	366,952	524,436	545,969	699,572
99	177,327	372,578	532,479	554,343	710,305
100	180,025	378,249	540,585	562,782	721,122
101	182,744	383,964	548,756	571,288	732,024

Avoided deaths (2020-22)

	Gross	PV	Rate
1	44,196	41,701	3.5%
2	44,196	41,257	3.5%
3	44,196	39,862	3.5%
4	44,196	38,514	3.5%
5	44,196	37,212	3.5%
6	44,196	35,953	3.5%
7	44,196	34,738	3.5%
8	44,196	33,563	3.5%
9	44,196	32,428	3.5%
10	44,196	31,331	3.5%
11	44,196	30,272	3.5%
12	44,196	29,248	3.5%
13	44,196	28,259	3.5%
14	44,196	27,303	3.5%
15	44,196	26,380	3.5%
16	44,196	25,488	3.5%
17	44,196	24,626	3.5%
18	44,196	23,793	3.5%
19	44,196	22,989	3.5%
20	44,196	22,211	3.5%
21	44,196	21,460	3.5%
22	44,196	20,735	3.5%
23	44,196	20,033	3.5%
24	44,196	19,356	3.5%
25	44,196	18,701	3.5%
26	44,196	18,069	3.5%
27	44,196	17,458	3.5%
28	44,196	16,868	3.5%
29	44,196	16,297	3.5%
30	44,196	15,746	3.5%
31	44,196	15,214	3.5%
32	44,196	14,699	3.5%
33	44,196	14,202	3.5%
34	44,196	13,722	3.5%
35	44,196	13,258	3.5%
36	44,196	12,809	3.5%
37	44,196	12,376	3.5%
38	44,196	11,958	3.5%
39	44,196	11,553	3.5%
40	44,196	11,163	3.5%
41	44,196	10,785	3.5%
42	44,196	10,420	3.5%
43	44,196	10,068	3.5%
44	44,196	9,728	3.5%
45	44,196	9,399	3.5%
46	44,196	9,081	3.5%
47	44,196	8,774	3.5%
48	44,196	8,477	3.5%
49	44,196	8,190	3.5%
50	44,196	7,913	3.5%
51	44,196	12,545	2.5%
52	44,196	12,239	2.5%
53	44,196	11,940	2.5%
54	44,196	11,649	2.5%
55	44,196	11,365	2.5%
56	44,196	11,088	2.5%
57	44,196	10,817	2.5%
58	44,196	10,554	2.5%
59	44,196	10,296	2.5%
60	44,196	10,045	2.5%
61	44,196	9,800	2.5%
62	44,196	9,561	2.5%
63	44,196	9,326	2.5%
64	44,196	9,100	2.5%
65	44,196	8,878	2.5%
66	44,196	8,662	2.5%
67	44,196	8,451	2.5%
68	44,196	8,244	2.5%
69	44,196	8,043	2.5%
70	44,196	7,847	2.5%
71	44,196	7,656	2.5%
72	44,196	7,469	2.5%
73	44,196	7,287	2.5%
74	44,196	7,109	2.5%
75	44,196	6,936	2.5%
76	44,196	6,767	2.5%
77	44,196	6,602	2.5%
78	44,196	6,441	2.5%
79	44,196	6,283	2.5%
80	44,196	6,130	2.5%
81	44,196	5,981	2.5%
82	44,196	5,835	2.5%
83	44,196	5,692	2.5%
84	44,196	5,554	2.5%
85	44,196	5,418	2.5%
86	44,196	5,286	2.5%
87	44,196	5,157	2.5%
88	44,196	5,031	2.5%
89	44,196	4,909	2.5%
90	44,196	4,789	2.5%
91	44,196	4,672	2.5%
92	44,196	4,558	2.5%
93	44,196	4,447	2.5%
94	44,196	4,339	2.5%
95	44,196	4,233	2.5%
96	44,196	4,129	2.5%
97	44,196	4,029	2.5%
98	44,196	3,930	2.5%
99	44,196	3,835	2.5%
100	44,196	3,741	2.5%