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Designing conservation-incentives for Tanzania's ecological corridors

cost-effectiveness and behavioral determinants

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"God is not unjust; he will not forget your work and the love you have shown him as you have helped his people and continue to help them". (**Hebrews 6:10).**

Abstract

The global forest resources assessments show that the world lost about 420 million hectares of forest between 1990 and 2020, mainly due to deforestation. Between 2010 and 2020, Africa experienced the highest annual net forest loss, averaging 3.9 million hectares per year. Deforestation contributes to greenhouse gas emissions, biodiversity loss, and threats to livelihoods. In Tanzania, deforestation is attributed to agricultural expansion and is particularly pronounced in ecologically sensitive areas such as ecological corridors.

Conservation policies to mitigate degradation have shown mixed results worldwide, but some instruments (e.g., payment for ecosystem services) are yet to be tested in the Tanzanian context. The success of instruments, however, depends not only on its design, but also the context to which they are applied. This dissertation evaluates the effectiveness of Payment for Ecosystem Services (PES) in conserving ecological corridors in Tanzania. It further investigates the role of landownership heterogeneity and intrinsic motivation factors (here: personal values) in shaping PES performance. Tanzania's ecological corridors, which are ecologically valuable yet heavily threatened by agricultural expansion, provide an ideal case study.

The first empirical chapter provides site-specific evidence and establishes a foundation to support the relevance of PES for conservation. This chapter employs a holistic approach, using decision analysis to estimate the costs and benefits of conserving ecological corridors for biodiversity and for farmers and the government. The findings indicate that biodiversity improves with increased conservation (through landscape connectivity). However, there is no evidence to suggest that the conservation-based benefits for households outweigh their costs. On a landscape level, the government, representing society, appears to gain greater conservation-based benefits than costs, highlighting the importance of government compensating farmers for their financial losses.

The second chapter tests two PES designs—fixed payment and fixed payment with an agglomeration bonus—using lab-in-the-field experiments that incorporate asymmetric landownership. Both designs demonstrated potential for conservation, and landownership asymmetry does not necessarily hinder collective action, a critical factor for conservation success. This resilience may be attributed to the strength of pre-existing social norms.

The third chapter examines how personal values (biospheric and egoistic) influence conservation behavior and PES performance. Biospheric values were found to promote conservation behavior, while egoistic values hindered it. PES designs had minimal impact on altering conservation behavior among participants with strong biospheric values compared to the average treatment effect. This suggests that PES may be cost-inefficient in communities with predominantly biospheric values.

The results of this dissertation generally suggest promising potential for PES in conserving ecological corridors in Tanzania. Nevertheless, it is important for policymakers to validate these findings in real-world contexts to ensure robust evidence.

Zusammenfassung

Die globalen Waldressourcenbewertungen zeigen, dass die Welt zwischen 1990 und 2020 etwa 420 Millionen Hektar Wald verloren hat, hauptsächlich durch Abholzung. Zwischen 2010 und 2020 verzeichnete Afrika den höchsten jährlichen Nettoverlust an Waldflächen, mit durchschnittlich 3,9 Millionen Hektar pro Jahr. Die Abholzung trägt zu Treibhausgasemissionen, dem Verlust der Biodiversität und Bedrohungen für Lebensgrundlagen bei. In Tansania wird die Entwaldung auf landwirtschaftliche Expansion zurückgeführt und ist besonders in ökologisch sensiblen Gebieten wie ökologischen Korridoren ausgeprägt.

Erhaltungspolitiken zur Minderung der Degradation haben weltweit gemischte Ergebnisse gezeigt, jedoch wurden einige Instrumente (z. B. Zahlungen für Ökosystemdienstleistungen) im tansanischen Kontext noch nicht getestet. Der Erfolg dieser Instrumente hängt jedoch nicht nur von ihrem Design ab, sondern auch von dem Kontext, in dem sie angewendet werden. Diese Dissertation bewertet die Effektivität von Zahlungen für Ökosystemdienstleistungen (PES) bei der Erhaltung ökologischer Korridore in Tansania. Sie untersucht außerdem die Rolle der Heterogenität im Landbesitz und intrinsischer Motivationsfaktoren (hier: persönliche Werte) bei der Gestaltung der PES-Leistung. Die ökologischen Korridore Tansanias, die ökologisch wertvoll, aber stark durch landwirtschaftliche Expansion bedroht sind, bieten eine ideale Fallstudie.

Das erste empirische Kapitel liefert ortsspezifische Beweise und schafft eine Grundlage, um die Relevanz von PES für den Naturschutz zu unterstützen. Dieses Kapitel verfolgt einen ganzheitlichen Ansatz, indem es Entscheidungsanalysen verwendet, um die Kosten und Nutzen der Erhaltung ökologischer Korridore sowohl für die Biodiversität als auch für Haushalte und die Regierung abzuschätzen. Die Ergebnisse zeigen, dass die Biodiversität mit verstärktem Naturschutz (durch Landschaftsvernetzung) verbessert wird. Es gibt jedoch keine Hinweise darauf, dass die naturschutzbedingten Vorteile für Haushalte ihre Kosten überwiegen. Auf Landschaftsebene scheint die Regierung, die die Gesellschaft repräsentiert, größere naturschutzbedingte Vorteile als Kosten zu erzielen, was die Bedeutung einer Entschädigung der Landwirte für ihre finanziellen Verluste durch die Regierung unterstreicht.

Das zweite Kapitel testet zwei PES-Designs – feste Zahlungen und feste Zahlungen mit einem Agglomerationsbonus – mithilfe von Laborexperimenten im Feld, die asymmetrischen Landbesitz einbeziehen. Beide Designs zeigten Potenzial für den Naturschutz, und asymmetrischer Landbesitz behindert nicht unbedingt kollektives Handeln, ein entscheidender Faktor für den Erfolg des Naturschutzes. Diese Widerstandsfähigkeit könnte auf die Stärke bestehender sozialer Normen zurückzuführen sein.

Das dritte Kapitel untersucht, wie persönliche Werte (biosphärische und egoistische) das Naturschutzverhalten und die PES-Leistung beeinflussen. Es wurde festgestellt, dass biosphärische Werte das Naturschutzverhalten fördern, während egoistische Werte es behindern. PES-Designs hatten nur geringe Auswirkungen auf die Veränderung des Naturschutzverhaltens bei Teilnehmern mit starken biosphärischen Werten im Vergleich zum durchschnittlichen Behandlungseffekt. Dies deutet darauf hin, dass PES in Gemeinschaften mit überwiegend biosphärischen Werten möglicherweise kosteneffizient ist.

Die Ergebnisse dieser Dissertation zeigen insgesamt vielversprechendes Potenzial von PES für die Erhaltung ökologischer Korridore in Tansania. Dennoch ist es wichtig, dass politische Entscheidungsträger diese Ergebnisse in realen Kontexten validieren, um robuste Nachweise zu gewährleisten.

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List of Abbreviations

AB	Agglomeration Bonus
AVE	Average Variance Extracted
BE	Budget Efficiency
BKG	Baga-Kisimagonja Ecological Corridor
CBD	Convention on Biodiversity Conservation
CBNRM	Community Based Natural Resource Management
CG	Control Group
DA	Decision Analysis
EAM	Eastern Arc Mountains
EVPI	Expected Value of Perfect Information
FAO	Food And Agriculture Organization of The United Nations
FFE	Framed Field Experiment
GoT	Government of Tanzania
HC	High Connectivity
HWC	Human-Wildlife Conflict
IIWC	Igando-Igawa Wildlife Corridor
IPCC	Intergovernmental Panel on Climate Change
IRD	Individual Relative Deprivation
LC	Low Connectivity
LDC	Least Developed Country
MC	Medium Connectivity
MNRT	Ministry of Natural Resource and Tourism
NGO	Non-Governmental Organization
NPV	Net Present Value
NTFP	Non-Timber Forest Product
PA	Protected Area
PES	Payment for Ecosystem Service
PLS	Partial Least Square

PV	Personal Values
PY	Fixed Payment
REDD+	Reducing Emissions from Deforestation and Degradation
SDG	Sustainable Development Goal
SSA	Sub-Saharan Africa
STEP	Southern Tanzania Elephant Program
TAFORI	Tanzania Forest Research Institute
TAWIRI	Tanzania Wildlife Research Institute
TFCG	Tanzania Forest Conservation Group
TG	Treatment Group
TZS	Tanzania Shillings
UNFCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USD	United States of America Dollar
VIP	Variable Importance in Projection
VLFR	Village Land Forest Reserve
VoI	Value of Information
WCS	Wildlife Conservation Society
WMA	Wildlife Management Area
ZEF	Center for Development Research

Achievements

All chapters of this dissertation were presented on several occasions, either orally or by poster. The second chapter was presented in the LANDSCAPE conference held in Berlin from 17th to 19th September 2024. The same chapter was presented as a poster at the international Conference organized by the Center for Development Research (ZEF) on Sustainable Solutions, Shared Futures: Development Research for the 21st Century from 30th September to 2nd October 2024. The third chapter was presented at the 25th International Conference on Environmental Economics, Policy, and International Environmental Relations at Prague University of Economics and Business, Prague, Czech Republic from 23rd to 24th November, 2024. The fourth chapter was presented at the 14th International Scientific Conference organized by Tanzania Wildlife Research Institute (TAWIRI) in Arusha, Tanzania from 6th to 8th December, 2024. Finaly the preliminary result for extended analysis of chapter three and four was presented at the Global Land Programme (GLP) Open Science Meeting (OSM) in Oaxaca, Mexico from 4th to 8th November, 2024.

PUBLICATIONS

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Chapter 1: Introduction and motivation

1.1 Background

The global decline in biodiversity has reached alarming levels (Convention on Biological Diversity (CBD), 2022). The global forest resources assessments shows that the world has lost about 420 million hectares—an area larger than India—between 1990 and 2020, mainly through deforestation (Food and Agriculture Organization (FAO), 2020)). This decline is projected to continue, affecting a wide range of social and economic dimensions across the globe (Pörtner et al., 2021). There is substantial evidence about the impacts of biodiversity loss on global warming (IPCC, 2023), lives and livelihoods of people (Ofori Acheampong et al., 2022) and economic growth (Balboni et al., 2023). These effects, however, have shown to affect, in particular, communities in the least developed countries (LDCs) (IPCC, 2023). LDCs are more vulnerable because their communities often depend substantially and directly on ecological assets (e.g., non-timber forest products) for their livelihoods (Coulibaly et al., 2020), while economically disadvantaged to bear higher cost of climate change adaptations (IPCC, 2023).

The global community has taken various initiatives to address the effect of biodiversity loss and climate change. A good example is the CBD, which has shown a road map by setting conservation targets, including to protect 30% of land and sea by 2030 (CBD, 2022). Biodiversity conservation is vital in achieving the goal of limiting global warming to below 2°C by 2050, set by the United Nations Framework Convention on Climate Change (UNFCCC) (UNFCCC, 2015). Unlike developed countries, Least Developed Countries (LDCs) have greater potential to contribute to biodiversity conservation for mitigation of climate change, potentially in a more cost-effective manner due to their extensive natural tropical ecosystems (Hou-Jones et al., 2021; UNFCCC, 2015). This could be, for example, through avoiding deforestation or enhancing ecological restorations in degraded landscapes (Shukla, 2010). Compensation for these efforts in LDCs (e.g., through trading of carbon credits) would be a way to offset opportunity costs to forest users and supporting livelihoods (Hultman et al., 2020; Streck, 2021).

Despite the importance of tropical ecosystems in LDCs for biodiversity conservation and mitigation of climate change, deforestation in Sub-Saharan African (SSA) has increased in the last decade (FAO, 2020). One of the leading drivers of such deforestation is agriculture (Fritz et al., 2022; Curtis et al., 2018; Masolele et al., 2024). This is also the case for Tanzania, where agriculture has been the main economic activity for over 65 percent of population (URT, 2021). However, the magnitude of expansion is spatially heterogenous, and most likely higher in ecologically sensitive landscapes such as in ecological corridors. This is because of reliability to access of ecosystem services (e.g., water flows and pollination) in ecological corridors supporting agricultural productivity (Balana et al., 2012; Kaboré et al., 2024).

Ecological corridors which connect protected areas such as National parks and Forest reserves have been increasingly degraded in many areas across SSA (Gregory et al., 2021; Li et al., 2023). The latest assessment of ecological corridors done by the GoT (URT, 2022) shows that degradation of ecological corridors in Tanzania has increased substantially compared to an assessment from 2009 done by Jones et al. (2009). The degradation is likely to accelerate with population growth and rising food demands, potentially increasing encroachment to protected areas. A degradation may be further reinforced by policies that motivate agricultural expansions, e.g., subsidies (Chibwana et al., 2013). This effect may be critical for regions with higher agronomic and agroecological values, but weaker conservation enforcement.

Conservation of ecological corridors is thus important for connectivity and subsequently ecosystem flow. Such conservation generally comes along with costs to landowners (e.g., opportunity costs of conservation) and government (e.g., through mobilization of farmers to conserve). However, in an ecosystem with higher potential of ecological outcomes (e.g., wildlife resources and carbon credits), existing ecosystems-based markets (e.g., tourism and carbon markets) may help to offset such costs (Dong et al., 2024); otherwise, alternative mechanism to motivate conservation behavior by farmers may be necessary, possibly through conservation incentives such as PES (Wunder et al., 2020). Although there is success evidence of PES on conservation globally (Wunder et al., 2020), unintended outcomes (e.g., conservation failure) have also been widely reported (Rode et al., 2015). The reasons for conservation failures include poor PES design and the inability to adequately align the scheme with various contextual factors and behavioral determinants of landholders (Pascual et al., 2014; Wunder et al., 2020).

A well-designed PES should not only be conservation effective, but also fair and cost-efficient (Leimona et al., 2015). Designing such a PES scheme is, however, a more complex and knowledge-intensive task compared to many conventional conservation policies (Engel, 2015). This complexity may be attributed to several reasons, including the interplay effect between PES and behavior. This means that not only can PES affect behavior, but behavior may also influence the effectiveness of PES (Bopp et al., 2019). Like many other countries in Sub-Saharan Africa (SSA), Tanzania has limited experience with PES, particularly in restoring degraded landscapes. However, it holds greater conservation potential than many other countries in the region and is likely to adopt PES mechanisms for conservation in the near future (Myers et al., 2000). Thus, the need for ex-ante assessments of different designs and in consideration of local contextual factor and behavioral determinants are important to inform potential outcomes before implementation.

1.2 Context and framing of research

Despite the existence of various conservation measures and policies for conservation of biodiversity worldwide, few have been tested in Tanzanian context. The most common measure is protected area (Noe et al., 2022). While protected areas (PAs) remain the most recognized tool used for biodiversity conservation globally, there is a concern that they may not be sufficient to conserve biodiversity (Gizachew et al., 2020). This is due to several reasons, including limited integration of local communities in governance of PAs (Andrade & Rhodes, 2012; Nyanghura & Abdallah, 2023). The spatial design of protected areas in Tanzania also contributed to ecosystem fragmentation, as many are structurally and functionally disconnected (Gizachew et al., 2020). To effectively and efficiently support biodiversity conservation, protected areas must be integrated and spatially interconnected (Gizachew et al., 2020). Integration can be through engaging local communities in conservation efforts (e.g., decision making process), while disconnection problem can be addressed by conserving landscapes that are vital for connectivity (e.g., ecological corridors).

To address the issue of community engagement in conservation of biodiversity, Tanzania adopted a Community-based Natural Resource Management (CBNRM) policy in the 1990's to secure ecological assets in unprotected areas. This policy was largely implemented in a communal or village land implicitly supporting landscape connectivity where applicable (Allen et al., 2022). CBNRM is claimed to be relatively cost-effective and could optimize ecological objective and socio-economic demands of communities (Noe et al., 2022). Up to 2019, more than 1091 village land forest reserves (VLFRs) and 38 wildlife management areas (WMA) were at different stages of gazettement (Keane et al., 2019). These community conservation areas showed some success in preserving biodiversity outside the core protected areas and somewhat supporting connectivity, however, there is concern that most of them were set in relatively less agro-ecological potentials (Blomley & Iddi, 2009), making it challenging to incentivize income generation e.g., through eco-tourism investments and carbon markets (Kimario et al., 2020). Even within the few CBNRM that appear to generate considerable revenue, the distribution of benefits remains challenging (Kimario et al., 2020). The benefits primarily appeared to serve the public (e.g., through the construction of schools) and sometimes be channeled to the elite, leaving the majority of individuals who bear sizable conservation costs marginalized (Keane et al., 2019).

Heterogeneity in individual conservation costs impedes collective conservation efforts, threatening the success of the community conservancy approach (Gatiso et al., 2018). This challenge is compounded by farmers' preference for benefit schemes aimed at individuals or households rather than those providing communal benefits (Kegamba et al., 2022). There is evidence that gazetted VLFRs and WMAs may continue to exist legally (de jure), but they are unlikely to be conservation effective (de facto), as many are currently increasingly being converted into cropland (Andrew, 2018). Researchers are, however, optimistic that CBNRM could still play a role in conservation within the Tanzanian context (Kegamba et al., 2022). Nevertheless, its effectiveness may depend on revisiting its design, particularly in terms of distributional equity and institutional arrangements (Kegamba et al., 2022).

In 2018, the Tanzanian Government introduced a wildlife conservation regulation aimed at securing ecological corridors as part of an additional conservation initiative (URT, 2018). The introduction of this regulation was motivated by increasing ecological fragmentation, despite ongoing efforts to conserve community lands through CBNRM (URT, 2022). Changes in the spatial distribution of ecological assets, such as wildlife, also influenced this decision. For instance, evidence from species distribution studies in Tanzania shows that privately owned agricultural lands often support significant wildlife populations, sometimes surpassing those found in protected areas and community conserved land (Msuha et al., 2012; Sachedina Nelson, 2010). The regulation was meant to persuade farmers to voluntarily retire their own farmlands for conservation without financial compensation. A non-payment voluntary policy option is advocated by the government, because it is relative less expensive for the government to implement than compensation-based policies (Santangeli et al., 2016). The GoT (through the regulation) appears to rely on the potentials of ecosystem-based benefits (e.g., eco-tourism, beekeeping and butterfly farming) together with the concern of public benefits (e.g., climate regulation) as a motivation to incentivize conservation by farmers.

Ideally, these ecosystem-based benefits can serve as conservation incentives, especially in regions where they have the potential to offset associated costs (Dong et al., 2024). To enhance these benefits, conservation efforts should target a specific ecosystem where additionality (e.g., of ecosystem-based benefits) can be realized (Cisneros et al., 2022; Nguyen et al., 2022). This could be, for instance, concentrating conservation efforts in ecosystem of highest conservation potential, but highly degraded (Cisneros et al., 2022). Given the diversity of ecosystem goods and services provided by ecological corridors in Tanzania—such as wildlife-based versus forest-based corridors—it is clear that the ecological outcomes and associated co-benefits of conservation are likely to vary. For example, a woodland ecosystem rich in wildlife may offer greater eco-tourism potential than rainforest ecosystem, which may be more effective in carbon sequestration (Meyer et al., 2021; Sayer et al., 2004).

Targeting a specific ecosystem alone may not be sufficient to guarantee sufficient ecosystem flows without an innovative conservation strategy. A handful of studies (e.g., Albers et al., 2018; Fooks et al., 2016; Goldman, 2009; Liang et al., 2018) have shown that coordinated conservation efforts are crucial for sustaining ecosystem flows. This suggests that to enhance ecosystem flows, conservation decisions must be coordinated to yield a larger and contiguous landscape (Nguyen et al., 2022). These efforts can be done by landowners under the support of the government (e.g., by mobilizing farmers and setting appropriate institutions). The key question is whether coordinated conservation efforts by landowners and the government are rationally justifiable. This can be explored through a systematic cost-benefit analysis, as highlighted by numerous studies in the literature review by Wainaina et al. (2020). However, most of such cost-benefit analysis studies often overlook potential risks. A good example of risks is extreme weather events such as droughts (Li et al., 2023), their occurrence can introduce uncertainty into conservation initiatives. Moreover, it remains unclear how such assessments perform under (i) different ecosystems (ii) within ecosystem, but across different level of landscape connectivity, and (iii) when the distribution of costs and benefits varies between farmers (through households) and the government.

In the view of mitigating potential uncertainties of conservation outcomes, and for the reasons of equity, fairness and political acceptability, it is important for farmers to be compensated for their conservation decisions (Börner et al., 2010; Ezzine-de-Blas et al., 2016; Wunder et al., 2020). This is particularly relevant when conservation decisions are associated with individual costs, but provide public benefits. Compensation can be done through the adoption of payment for ecosystem services (PES) schemes (Wunder, 2005). PES is a conditional voluntary scheme which allows user and buyers to engage in a transaction of ecosystem services. In many cases, the government takes the role of ecosystem service buyer (Matzdorf et al., 2013), but private organization or individuals can also be involved in transactions.

PES is relatively new in Tanzania as compared to many Latin America countries where they share the same tropical ecosystem. PES was firstly introduced in Tanzania in 2008 as a pilot through a Reducing Emissions from Deforestation and Degradation (REDD+) program, (Burgess et al., 2010). However, REDD+ in Tanzania have largely focused on the standing forests (i.e., already preserved forest) and so, this literally incentivizes limiting the loss (e.g., through reducing deforestation). There are, however, limited PES programs in Tanzania that are precisely directed to the conservation of degraded ecosystems (e.g., ecological corridors). At least, recently there was a one payment program to local farmers for restoration of the Nyerere-Selous-Udzungwa corridor, with funding from conservation NGO namely Southern Tanzania Elephant Program (STEP) (STEP, 2023). However, this was done without a clear PES design that is specifically customized to incentivize landscape connectivity. Landscape connectivity requires coordinated conservation efforts to ensure continuous conserved habitats and, therefore, the design of incentives should be crafted to support such coordination among farmers (Banerjee et al., 2012; Drechsler et al., 2010; Nguyen et al., 2022).

Payments can be made to individuals or groups, such as communities (Gatiso et al., 2018). Evidence from Tanzania indicates that farmers prefer individual payments over group payments (Kegamba et al., 2022) because they directly reward personal contributions or actions (Gatiso et al., 2018). A common payment design is the fixed payment per area, where compensation is based on the amount of land conserved. Although there is evidence that fixed payment (PY) can enhance conservation success (Wunder et al., 2020), it has often been criticized for resulting to fragmented patches of conserved parcels, which are less beneficial for connectivity and so to the ecosystem flows (Parkhurst et al., 2002; Nguyen et al., 2022). But, addition of bonus “agglomeration bonus” (AB) has shown to support landscape connectivity (Kuhfuss et al., 2022; Rakotonarivo et al., 2021; Rudolf et al., 2022). Agglomeration bonus is one of the coordinated based payment schemes that can support collective and coordinated actions among farmers (Nguyen et al., 2022; Parkhurst & Shogren, 2007, 2008). This is because of the inherent conditionality set to incentivize coordination efforts (Nguyen et al., 2022).

The agglomeration bonus has largely been tested in lab experiments using students as participants, making its results lack contextual relevance (Nguyen et al., 2022). There is, however, a limited understanding of the conservation effectiveness of AB in field settings particularly in SSA. Furthermore, like many other modalities of PES, performance of PY and PY+AB may be hampered by local contextual factors such as distributive (fairness in distribution of resources), procedural (involvement and inclusivity in resource allocation) and recognitional (acknowledgement or integration of social values) (Pascual et al., 2014). Distribution of land ownership has shown to influence participation in PES programs (Johnson et al., 2018). At the landscape scale, where coordinated conservation efforts are crucial, unequal landholdings can hinder the effectiveness of conservation incentives, regardless of their design. This may occur when small landowners perceive themselves as disadvantaged compared to larger landowners, which may limit their contribution in collective efforts (Smith et al., 2020). Therefore, assessing the effectiveness of PY and PY + AB under such conditions prior to implementation is critical to minimize potential uncertainties.

While economic incentives are necessary, there is a growing literature that shows conservation decisions of local farmers depend not only on extrinsic (here: financial incentives) but also intrinsic motives (Wegner, 2016; Cetas & Yasué, 2017). The interaction between the two have shown to yield unintentional outcomes such as crowding-out effect (Rode et al., 2015). Proponents of non-monetary motivations argue that intrinsic motivation drivers may have a longer-lasting conservation effect than PES, whose conservation effect may only last for the duration of the contract (Maca-Millán et al., 2021). Nonetheless, even within the time frame of the contract, these intrinsic factors have shown to affect conservation and cost-effectiveness of PES differently (Bopp et al., 2019). For example, PES is likely to have limited additionality when intrinsic motivations in favor of pro-conservation behavior are relatively higher (Polomé, 2016), making it less cost-ineffective to introduce PES. However, positive conservation effect of PES should be expected when intrinsic motivation is in favor of pro-self behavior (Sargisson et al., 2020).

Overlooking intrinsic motivational factors in the design of PES programs is likely to intensify the adverse selection problem (Wunder et al., 2020). This problem occurs when payments are provided to participants (in this case, farmers) who would have engaged in pro-conservation behaviors without compensation or with only minimal payment (Bopp et al., 2019). Biospheric and egoistic values represent examples of pro-conservation and pro-self motivational drivers, respectively (Davis et al., 2023; Russo et al., 2022). Understanding the distribution of these values among farmers in Tanzania's ecological corridors and how they shape performance of PES is crucial. This understanding is particularly important for addressing the issue of adverse selection, which frequently undermines the cost-effectiveness and efficiency of PES programs (Wunder et al., 2020).

1.3 Research objectives and contributions to the literature

The overarching research objective of this dissertation was to assess the conservation effectiveness of conservation incentives in conservation of ecological corridors of Tanzania. This dissertation builds on the scientific literature on conservation incentives for biodiversity conservation (Ezzine-de-Blas et al., 2016; Samii et al., 2014; Wunder et al., 2020) as well as intrinsic determinants of conservation (Blas, 2021; Cetas & Yasué, 2017; Palmer et al., 2020; Wegner, 2016) and provides empirical evidence based on an ex-ante analysis. The main research objective is sub-divided into three specific research objectives that are addressed in three separate chapters. Each chapter contributes to the environmental and ecological economics literature through cost-benefit analysis of conserving ecological corridors and designs of conservation incentives. The methods employed in the analytical chapters can be applied to a wide variety of countries and regions as well as different research questions.

The first research objective is to estimate the ecological and economic impacts of increasing landscape connectivity in ecological corridors of Tanzania. This objective was addressed under assumption that decision of farmers to conserve contiguously is voluntary, but government do not compensate for the costs associated to such decisions. This way, this objective contributes to conservation literature on costs and benefit of conservation under different levels of landscape connectivity and to the main affected actors of conservation, namely households and government. Here the conservation incentives to actors were assumed to be the co-benefits that may be accrued as a result of increasing landscape connectivity. Specific objectives under this objective are; to estimate (i) the impact of increasing landscape connectivity on biodiversity (elephant population and forest stock) (ii) the costs and benefits of increasing landscape connectivity to household and government, and (iii) the economic viability of increasing landscape connectivity to household and government.

The second research objective is to assess the conservation effectiveness of different PES design (fixed payment and fixed payments with agglomeration bonus) on the conservation of ecological corridors of Tanzania under asymmetric landownership. This was done under assumption that decision of farmers to conserve is voluntary, but the government can compensate for the costs of such decisions. This objective contributes to a literature on performance of payment for ecosystem services (PES) and specifically considering asymmetric in land ownership as one of the important local contextual factors which may hamper the effectiveness of PES. Specific objectives addressed under this objective are (i) to assess the effect of conditional financial incentives on conservation and (ii) to compare conservation effectiveness between small farmers in equal and unequal settings of farmland distributions.

The third research objective aims to assess the effect of intrinsic motivation on performance of PES design (fixed payment and fixed payments with agglomeration bonus). Here, the interest was to extend the second objective by exploring the effect of intrinsic motivational drivers (biospheric and egoistic values) on conservation and how they shape the effectiveness of PES. Through this objective, I contribute to the literatures on intrinsic or behavioral determinants of conservation decisions and its interaction effect with PES. Four specific objectives addressed here are to assess; (i) effect of biospheric values on conservation behavior (ii) effect of egoistic values on conservation behavior (iii) the effect of conditional incentive scheme on conservation behavior when biospheric values are high and (iv) the effect of conditional incentive scheme on conservation behavior when the egoistic values are high.

Furthermore, preliminary results are included in a supplementary material (see Appendix for extended analysis) of what could, alternatively, be considered as a separate chapter. These results basically extend analysis of the two previous objectives by estimating the effect of PES policies on conservation considering potential risks. The risks accounted for include mismanagement of funding, social conflicts and probability of opinion leaders to influence others to reject policy options. These results are not discussed.

1.4 Study area

The objectives of this dissertation were addressed using the context of two ecological corridors of Tanzania, namely Igando-Igawa Wildlife corridor (IIWC) and Bagakisimagonja forest corridors (BKG) (Figure.1.1). The IIWC corridor has an area of about 900 km^2, connecting Ruaha National Park and Mpanga Kipengere Game Reserve. The IIWC is important for the movement of wildlife population between the two PAs. The area is mainly covered by dry woodland (Massawe, 2010). African elephant (*Loxodonta africana*) is the most common wild animal in the corridor reacting to changes in connectivity due to their migration behavior. The altitude of the corridor ranges between 1030 to 1382 meters above sea level and receives rainfall half the year, from late November to May, with an average annual rainfall ranging from 800 mm to 1500 mm (Massawe, 2010). Crop farming is the main economic activity in the corridor where maize and rice are the most cultivated crops. Farmers in the corridor also practice beekeeping on a small scale. A recent assessment of ecological corridors in Tanzania indicates that in 2022 agriculture covered about 75% of the total IIWC area, making it the second most threatened corridor out of all 61 across Tanzania (MNRT, 2022).

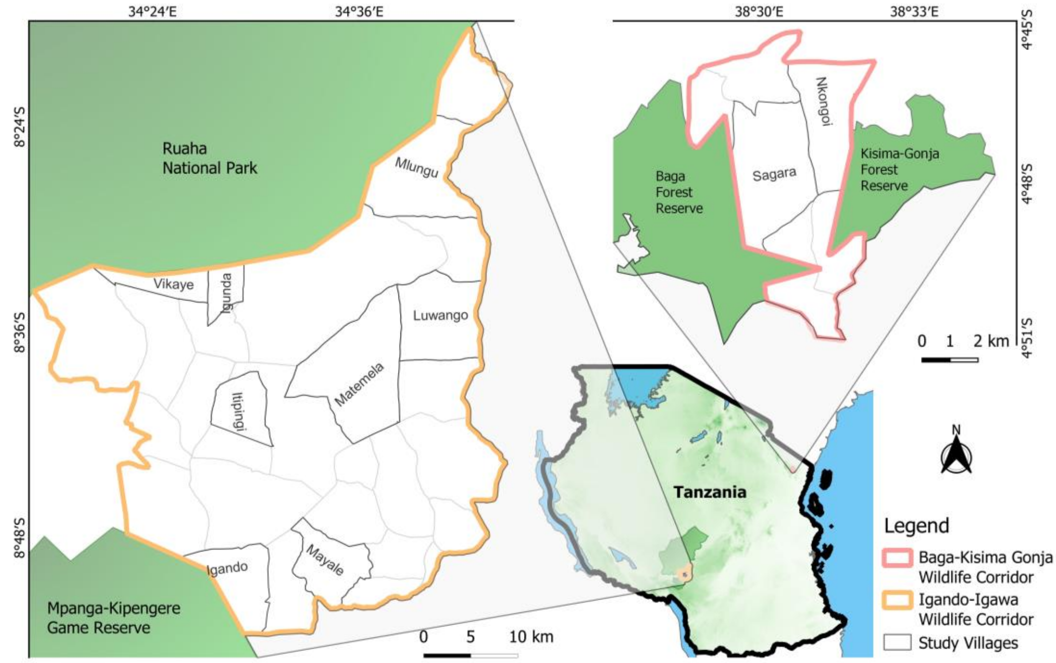

Figure 1.1: Map of the study area showing the two ecological corridors (IIWC and BKG) and the 10 villages within those corridors, where farmers participated in the experiment

The BKG corridor is relatively small (23 km^2), located in the North eastern part of Tanzania. It has an elevation range between 1300 to 1910 m. The monthly rainfall is below 50 mm with mean annual rainfall of 1300mm (Munishi & Shear, 2004). The corridor connects Baga and Kisima Gonja forest reserves in the Eastern Arc Mountains (EAM). EAM is known as a globally important biodiversity hotspot and outstanding ecoregion (Hoffman et al., 2016). About 25 percent of land cover is characterized as coastal mosaic and 13 percent Afro-montane rain forest (MNRT, 2022). Unlike IIWC, crop farming in BKG is mainly based on intercropping and crop rotation, e.g., combining maize with bean or groundnut. Small-scale agroforestry is also practiced to reduce the dependence of farmers on natural forest products (e.g., fuelwood). For the last decade, butterfly farming has been one of the most lucrative farming approaches in the ecosystem due to export of its pupa (Cooper & Gordon, 2022; Rich et al., 2014). About fifty-six percent of forest cover is estimated to be converted to cropland (MNRT, 2022).

Agricultural expansion in the two ecological corridors is likely to exacerbate forest and habitat fragmentation, disconnecting the ecological functioning of the entire ecosystem, subsequently reducing the flow of ecosystem services and the migration of species. Restoring the ecological corridors will require farmers to choose to conserve their farmlands contiguously. As previously mentioned, the key question is how to motivate farmers to voluntarily retire their farmland. This can be explored by testing various designs and modalities of conservation incentives that promote and strengthen pro-conservation behavior.

By studying these two ecological corridors, we are contributing to the body of literature from a comparative perspective between wildlife-based and forest-based ecological corridors. The two ecological corridors serve the common purpose of structurally and functionally connecting protected areas, but differ in terms of type and magnitude of ecosystem goods or service it can offer. For example, carbon sequestration may be a prominent service in forest-based, rather than in wildlife-based ecological corridor where there is physical destruction of vegetations by wildlife such as elephants (Sayer et al., 2004). However, the latter may have more potential for eco-tourism, which is largely wildlife based (Meyer et al., 2021).

1.5 Structure and organization of the dissertation

This dissertation explores the effectiveness of conservation incentives on conservation of ecological corridors along with cost benefits analysis of landscape connectivity. The ex-ante assessment of these policies is important to mitigate unforeseen uncertainties and unintended outcomes. Different local contextual factors, both extrinsic and intrinsic, may hamper conservation incentives to realize conservation outcomes. This dissertation is organized in five chapters. The first chapter provides a general background and motivation for the dissertation. Chapter 2 focuses on the ecological and economic impacts of increasing landscape connectivity. Effectiveness of financial incentives schemes under asymmetric landownership is addressed in chapter 3. Chapter 4 examines the effect of intrinsic motivation drivers on conservation and its effect on performance of PES. Chapter five concludes and offers policy implications.

The scope of this dissertation provides empirical evidence related to the sustainable development goals (SDG 15: life on land). It further contributes to development of the current plan of the Tanzanian National Development Vision 2050 by informing policy makers on appropriate conservation incentives that could optimize natural resource utilization and standard of living to farmers.

Chapter 2: Ecological and economic impacts of increasing landscape connectivity in Tanzania's ecological corridors

Abstract

Ecological corridors facilitate the flow of ecosystem goods (e.g., wildlife movement) and services (e.g., carbon sequestration) between protected areas, benefiting farmers and governments through carbon markets or eco-tourism. However, unregulated farming activities in Tanzania's ecological corridors threaten these benefits. Conservation efforts must focus on improving landscape connectivity for example, by encouraging farmers to conserve their owned farmland in a coordinated way. But these efforts come along with costs on both farmers (e.g., opportunity and transaction costs) and governments (e.g., mobilization and enforcement costs). Additionally, outcomes of conservation may not be certain due to risks such as droughts. Farmers and governments need to be ecologically and economically conscious in their conservation decisions. This study aims to estimate the ecological and economic impacts of different levels of landscape connectivity in the Igando-Igawa Wildlife Corridor (IIWC) and the Baga-Kisimagonja Forest Corridor (BKG) in Tanzania. Using the decision analysis approach, we estimated ecological (forest stock and elephant populations) and economic (conservation costs, benefits and net-present value) outcomes under low, medium, and high landscape connectivity scenarios. The impact was proxied as a change in outcomes, using low connectivity as counterfactual. Results from Monte Carlo simulations show that increasing connectivity to medium or higher level enhances forest stock in both corridors and elephant movement in IIWC. The annual conservation costs for households and governments are generally two to three times higher in IIWC than in BKG. While the government can benefit from increased landscape connectivity, the potential for household-level benefits was limited. Policymakers should consider payment-based policies to compensate farmers for conservation efforts.

Keywords: Ecological connectivity, Costs, Benefits, Risks, Net-present value, Decision analysis

2.1 Introduction

Biodiversity loss remains a significant challenge despite global efforts to mitigate it. Various conservation measures are currently implemented to meet global biodiversity targets including the 30x30 goal set by the Convention on Biological Diversity (CBD), which is to protect 30% of land and sea by 2030 (CBD, 2022). This goal is to ensure the protection especially of "…areas of particular importance for biodiversity and ecosystem functions and services,." and that they are "…managed through ecologically representative, well-connected and equitably governed systems of protected areas…" (CBD, 2010). Additionally, countries have committed to restore more than 350 million hectares of landscape globally by 2030 under the Bonn Challenge (Stanturf et al., 2019).

Biodiversity conservation in Sub-Saharan Africa (SSA) is often conflicting with agricultural activities (Jellason et al., 2021). This conflict is escalating as the economic gains from agriculture increasingly outweigh the public benefits of biodiversity conservation, resulting in land degradation (Albers et al., 2018). There is a considerable risk that land degradation can have a negative impact on livelihoods in the long run, both locally and beyond (Nkonya et al., 2016). This could happen through a diminished ability of nature to provide essential ecosystem goods and services, such as habitats for pollinators and regulated water flows, both of which are crucial for direct human consumption and the sustaining broader production systems (Millennium Ecosystem Assessment, 2005). Restoration of degraded ecosystems would enhance such flows, fostering long-term synergies between socioeconomic and ecological development (de Groot et al., 2010; Dong et al., 2024). The flow of ecosystem goods and services, however, depend on landscape connectivity (Elisa et al., 2024). Landscape-level restoration is most desirable and has shown to be cost-effective (Banerjee et al., 2021) compared to isolated restoration efforts which often results in fragmented ecological outcomes (Parkhurst et al., 2002).

Landscape restoration typically demands coordinated conservation efforts, including conservation decisions that could be made by landholders (Banerjee et al., 2017). Such coordinated efforts augment additional costs (e.g., transaction costs) related to coordination (Banerjee et al., 2017) beyond opportunity costs to farmers. Moreover, the government may incur costs, such as expenses for mobilizing farmers and enforcing compliance in the restored landscape. These costs and ecosystem-based benefits are, however, context-specific (e.g., varying between ecosystems). Still, even within the same ecosystem, different levels of conservation and landscape connectivity may result in varying costs and benefits. Understanding these dynamics is important in designing restoration policies that are conservation- and cost-effective. This study aims to broadly examine the ex-ante ecological and economic impacts of enhancing landscape connectivity.

One of the landscapes where the impact of landscape connectivity can be studied is ecological corridors. Ecological corridors have been suggested by ecologists and conservationists as priority areas for restoration due to the substantial benefits they can provide for biodiversity conservation through improved landscape connectivity (Goldman, 2009; Gregory et al., 2021; Elisa et al., 2024). Ecological corridors allow the flow of ecosystem goods and services, such as water and nutrients, as well as the movement of animals and pollinators between protected areas such as national parks and forest reserves (Windle et al., 2009). They also provide climate change mitigation and adaptation opportunities e.g. in terms of higher carbon mitigation (Burger, 2000; Sayer et al., 2004). For example, as shown by Li et al. (2023), they provide a buffer to drought effects threatening the survival of wildlife. Furthermore, corridors can also facilitate the exchange of nutrients between connected protected areas, supporting carbon sinks in the ecosystem (O'Brien et al., 2023). Beyond ecological outcomes, ecological benefits can further support social welfare for the local population within and outside the ecological corridors. For example, higher landscape connectivity has been shown to enhance the migration of wildlife populations, which could, in turn, boost eco-tourism opportunities (Burger, 2000; Haddad et al., 2014; Liang et al., 2018). Ecosystem goods and services from restored ecological corridors support environmentally friendly livelihoods, such as beekeeping (DeFries et al., 2007) and butterfly farming (Anderson & Saidi, 2011; Morgan-Brown et al., 2010). Additionally, carbon trading, derived from carbon storage, can benefit the local economy while contributing to global efforts to mitigate climate change (Koh et al., 2021).

Depending on the local context, restoration can be facilitated through natural regeneration, afforestation, or reforestation, among others (Ma et al., 2020; Mansourian & Berrahmouni, 2021). Natural regeneration is regarded as the most cost-effective restoration intervention and has been highlighted as a viable option in a low-income region such as Sub-Saharan Africa (SSA) (Chazdon & Guariguata, 2016; Holl & Aide, 2011). But natural regeneration cannot occur in farmlands—land use change from cropland to conserved land is necessary. One approach to restoring degraded ecosystems currently advocated by scientists is through the persuasion of landowners to retire their farmland, and, more so, in a contiguous or coordinated manner to support connectivity (Bareille et al., 2023; Kuhfuss et al., 2022; Nguyen et al., 2022). This could be supported by voluntary policies (Dayer et al., 2018), either with conditional payments to compensate farmers (Wunder et al., 2020) or without payments (Santangeli et al., 2016). The latter option seems to be preferred by many governments in low-income countries, partly because of a limited conservation budget (URT, 2018). But regardless of policy options, countries should be conscious of the use of public funding, while ensuring their conservation decisions are ecologically and economically effective (Giudice & Börner, 2021). This would include a detailed analysis of current and projected ecological outcomes and costs such as expenses of mobilizing farmers, establishing and enforcing regulations, and the costs of controlling human-wildlife conflicts (Yergeau et al., 2017).

While government decisions play a critical role in establishing landscape connectivity in ecological corridors, they are not sufficient on their own, as the government's primary responsibility is the formulation and implementation of policies. However, the farmers' willingness to conserve their privately owned farmlands has been found to be the most important factor for land restoration and effective policy implementation (Dayer et al., 2018). Since the retirement of agricultural land for conservation purposes leads to substantial opportunity costs from foregone agricultural rents (Schaub et al., 2023), studies have found that usually, only a few farmers are willing to retire their land (Yang et al., 2020). Limited retirements may, in turn, exacerbate interactions between remaining farms and nearby biodiversity which would further increase conservation costs e.g., human-wildlife conflicts (HWC). Under scenario of large and contiguous conservation, however, we would expect HWC to be lower compared to situations where only a small or moderate share of farmlands are conserved (Haddad et al., 2014) but opportunity costs may still be larger, particularly for agricultural productive landscapes. Furthermore, social costs (e.g., social conflicts) may arise if only a limited number of areas are conserved. This may occur due to the negative externalities of biodiversity from conserved lands affecting nearby farmlands (e.g., crop raiding), as noted by Yang et al. (2020). Other costs, even if farmers make coordinated conservation decisions, include coordination costs (e.g., costs of bargaining, negotiation, or communications—see Banerjee et al., 2017), which are likely to increase if many farmers are involved in the coordination process (Banerjee et al., 2012).

These costs endured by farmers could, generally, be compensated by returns from establishing conservation-compatible livelihoods as alternative sources of income (He & Jiao, 2023). Such expected returns together with the intrinsic motivation for conservation may induce some levels of contiguous conservation decisions. Nevertheless, since conservation may also be perceived differently (e.g., as land grabbing) and given that participation is voluntary, it is reasonable to expect varying coordinated conservation decisions, which could result in different levels of conservation and landscape connectivity. However, these variations are expected to be context-specific, depending on the potentiality of the area and perceived conservation values or motives. For instance, in the context of SSA, wildlife-rich ecosystems are more likely to benefit from eco-tourism (Meyer et al., 2021; Manrai et al., 2020), whereas forest-based landscapes offer greater potential for carbon sequestration (Burger, 2000; Sayer et al., 2004), as the impact of wildlife, such as elephants, on vegetation destruction is relatively limited (Mwambeo & Maitho, 2015). Moreover, stakeholders often have differing perceptions of environmental resources: while farmers may view wildlife negatively due to issues like crop damage or livestock predation, governments typically prioritize conservation for the broader public good, assigning higher value to environmental assets.

Farmers and the government need to carefully consider the potential impacts of their conservation decisions on ecological and socioeconomic outcomes. Yet, predicting the outcomes of conservation decisions in social-ecological systems is challenging because these systems are shaped and driven by complex relationships among multiple factors (e.g., socioeconomic and demographic factors, local contextual factors, intrinsic motivations, management approach, and national and international regulations (Gonçalves et al., 2020; Preiser et al., 2021; Rode et al., 2015). The underlying complexity can foster uncertainty for farmers and governments when identifying and quantifying costs and benefits. Uncertainty can further be reinforced by potential risks. A good example of risk is the occurrence of droughts, which have been shown to negatively affect forest condition (Corlett, 2016), the amount of carbon sequestrated (Costanza & Terando, 2019), farmer livelihoods, and the country's economy at large (Lottering et al., 2021). A global market crisis could also lower market opportunities for ecosystem goods and services, such as eco-tourism and carbon trading. Such crises can emanate from global financial instability, pandemics, or conflicts (e.g., civil wars).

Such risks and uncertainties are often ignored in deterministic empirical models e.g. traditional cost-benefit analysis (see Naidoo & Ricketts, 2006 and Wainaina et al., 2020). This could be due to data scarcity, poor data quality, or prohibitive costs of data acquisition (Landuyt et al., 2014). Consequently, it undermines appropriate decisions by farmers and governments. These challenges, however, can be effectively addressed through the field of Decision Analysis. Relevant factors (e.g. costs, benefits, and potential risks) in decision-making can be measured, estimated, or valued, even in the face of uncertainty (Howard, 1966; Hubbard, 2014). Unlike conventional economic analysis, Decision Analysis leverages expert judgment to provide more accurate measures and estimates when alternative information is not available. This approach is particularly advantageous for societies in low-income countries that face higher risks and uncertainties (Bateman et al., 2003). By embracing holistic methods, Decision Analysis allows for a thorough identification and quantification of costs and benefits within the specific context of the decision. Additionally, resulting stochastic models of complex systems allow for the estimation of the value of information, which helps determine whether acquiring additional information on model values would enhance the certainty of a decision recommendation.

Decision Analysis has been applied to analyze complex decision options in a wide range of topics, such as the restoration of irrigation reservoirs (Lanzanova et al., 2019), upscaling of agro-climate services (Luu et al., 2022), the evaluation of policies for agricultural development (Do et al., 2020; Fernandez et al., 2021), and biodiversity conservation (Dalyander et al., 2016; Hemming et al., 2022; Mattsson et al., 2019; Nascimento et al., 2020; Nicol et al., 2016; Tamba et al., 2021; Thorne et al., 2015). Our study is similar to Tamba et al. (2021) who used decision analysis (stochastic impact evaluation) to estimate the costs and benefits of different forest restoration interventions in Ethiopia. We are extending Tamba's work in three ways. Firstly, our study considers restoration costs and benefits across various levels of landscape connectivity— with the assumption that biomass accumulation (e.g. carbon as one of the conservation benefits) may be affected by connectivity (Guessan et al., 2019). We also account for variations of these costs and benefits between wildlife and forest-based ecological landscapes. Second, our study is counterfactual-based: we set a status quo level of connectivity as a benchmark scenario— an important aspect in the impact evaluation of a conservation intervention. Third, we only focus on natural regeneration as a cost-effective restoration intervention, the most promising approach in lower-middle-income countries like Tanzania, where government budgets to finance supportive restoration programs (e.g. reforestation or afforestation) are limited (Berghöfer et al., 2017). Finally, our study disaggregates the costs, benefits, and economic viability estimates for households and the government who are likely to be affected by conservation initiatives differently.

Given the policy background and the possibility of influencing farmers' and governments' decisions at the landscape level, we set out to model the costs and benefits of contiguous conservation decisions to advise local farmers and governments who will be in a position to take action based on the results. The specific objectives of our study are to estimate (i) the impact of increasing landscape connectivity on biodiversity in Tanzania, using the local elephant population as an indicator in wildlife-based corridors and the basal area of mixed natural trees as a proxy for forest stock; (ii) the costs and benefits of increasing landscape connectivity to households and the government; and (iii) the economic viability of increasing landscape connectivity to households and the government. We responded to these objectives using a case study of the Igando-Igawa wildlife corridor and the Baga-Kisimagonja forest corridor in Tanzania. The findings of this study are relevant for guiding farmers and members of the government to make informed conservation decisions. The results will also be helpful for conservation organizations interested in supporting conservation efforts to make informed investments.

2.2 Materials and methods

2.3 Decision modeling

We used a Decision analysis (DA) framework (Figure 2.2), to simulate our outcomes and applied it as an iterative five-step process that integrates information from the literature and expert opinions. While steps one to three primarily focus on data gathering, we analyzed them in step four. Step five is carried out depending on the clarity of the simulation results. The DA is one of the holistic approaches used in modeling complex interactions and integrating potential risks under imperfect information (Hubbard, 2014). This is an appropriate approach in our case, where data (e.g. costs) is scarce and the realization of outcomes (e.g. ecosystem goods and services) is bounded by risks (e.g., drought).

Step one: Literature review and conceptualization

At the beginning of our decision analysis, we conducted a literature review to understand the conservation challenges in the two ecological corridors and to explore how decision science could be applied in the given socio-ecological contexts. We specifically focused on conservation-related literature in the region (e.g., Caro et al., 2009; Giliba et al., 2023; Hariohay & Røskaft, 2015; Hilty et al., 2020; Mashalla & Ringo, 2015), conservation policies and regulations (e.g., United Republic of Tanzania (URT), 2018, 2011, 2012) government reports (e.g., Ministry of Natural Resources and Tourism (MNRT), 2022; URT, 2022a, 2022b), and decision analysis literature (e.g., Do et al., 2020; Hemming et al., 2022; Hubbard, 2014; Luedeling et al., 2015; Tamba et al., 2021; Whitney et al., 2018). Based on the gathered information, we developed a draft version of the Decision Analysis (DA) conceptual model. The decision was framed as to whether the decision to conserve the ecological corridor will be able to enhance ecological and socioeconomic benefits under different scenarios of landscape connectivity. Conservation was defined as (i) halting crop farming activities and (ii) ensuring that such cessation is coordinated. We assumed that coordinated conservation decisions are essential for achieving landscape connectivity and identified scenarios of landscape connectivity as low, medium, and high, following Mestre et al. (2017). The scenarios are meant to describe the proportion of farmlands conserved in a coordinated manner.

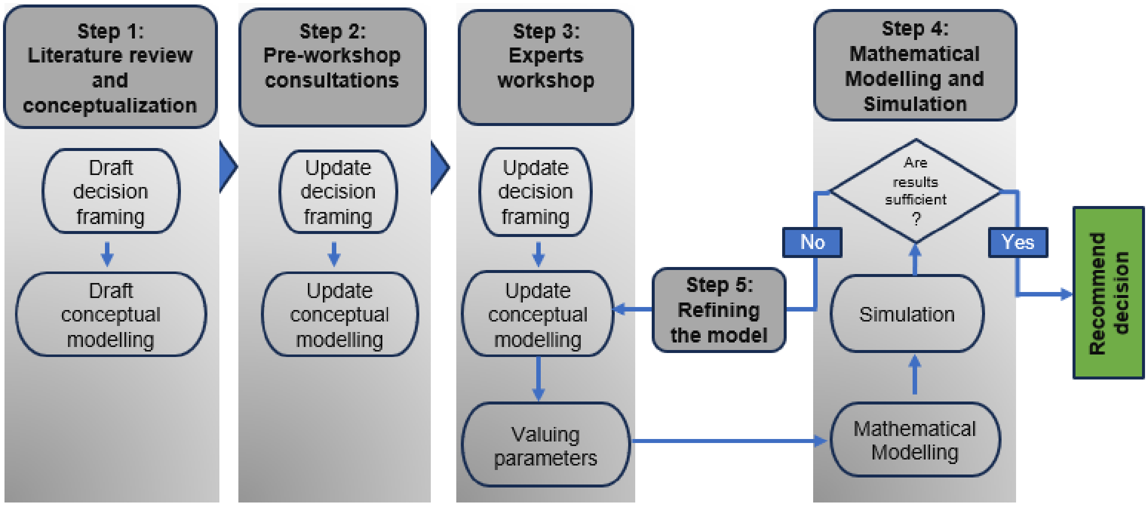

Figure 2.2: Sequence of methodological activities in the decision modeling (adapted from Tamba et al., 2021).

Step 2: Pre-workshop consultations

The draft of our conceptual model was presented during a pre-workshop consultation meeting with experts in Tanzania. This took place as part of a side event at the Tanzania Wildlife Research Institute (TAWIRI) scientific conference in December 2023. The discussion served three main objectives: first, to introduce researchers and scientists to decision analysis (DA) in conservation within the Tanzanian context, where, to our knowledge, DA had not been previously applied. Second, to gather participants' suggestions on the model's relevance to ecological restoration and discuss potential refinements, such as adding more variables to the model. Third, to invite potential experts to participate in the main stakeholder workshop, which was held subsequently (see Step 3).

The discussions during the side event were very helpful in gathering expert insights for the Tanzanian context and for preparing the expert workshop. Participants unanimously agreed on the relevance of the decision to conserve farmlands to restore ecological corridors. However, it was noted that efforts to support coordinated conservation efforts, particularly in privately owned farmland, would be relatively new in Tanzania. Consequently, stakeholders, such as farmers and the government, may face uncertainties about the costs and benefits of engaging in such conservation interventions. Additionally, participants recommended considering managing retired farmlands through community conservation programs instead of strictly protected areas (e.g. forest reserves). This management system was seen to be realistic, supporting decentralization of power, and enhancing the legitimacy and cost-effectiveness of conservation efforts (Kegamba et al., 2022). Furthermore, the participants identified experts, organizations, or groups to be invited to the workshop that could influence, be affected by, or have an interest in ecological restoration efforts (Reed et al., 2009). Local farmers and government representatives were considered as the key experts as was also pointed out by Elisa et al. (2024). However, the definition of government appeared ambiguous as Tanzania has two main levels of government: the local government which includes the village and district government, and the central or national government (Kegamba et al., 2022). However, since the roles between government levels overlap considerably, it was difficult to separate them. For example, the development and enforcement of local regulations for community conservation programs cannot be exclusively done by the village government—district and, sometimes, central governments must be involved (Kijazi et al., 2017). As such, it was agreed to define government in general terms.

Step 3: Experts workshop

In February 2024, we conducted a three-day workshop with experts. The experts included representatives of local farmers from two ecological corridors (IIWC and BKG), natural and agricultural officers of the Mbarali and Bumbuli district councils, a local conservation NGO (Tanzania Forest Conservation Group), and representatives from the Tanzanian Forest Research Institute (TAFORI) and the TAWIRI. Conservation officers from Ruaha National Park, the Mpanga-Kipengele game reserve, and the Baga and Kisima Gonja forest reserves were also present. During the workshop, we introduced the participants to decision analysis and its application in ecological restoration. We also presented an updated draft of the conceptual impact model we developed based on literature and inputs from the pre-workshop consultations. Together we revised the conceptual model, including the costs and benefits of pursuing conservation decisions, which systematically follows the structured processes of Whitney et al. (2018) and Martin et al. (2012). In three sub-groups of four to five members, each participant was first asked to individually reflect on potential decisions for the restoration of ecological corridors as well as scenarios of landscape connectivity. The individual results were then shared with a neighbor and discussed with the entire sub-group. A consensus was recorded as the final decision for each sub-group. Participants could replicate the proposed decision and scenarios from a draft conceptual model or improve as they deemed reasonable. We then asked participants in their sub-groups to prepare a conceptual model that could be applicable in both ecological corridors. Each sub-group presented their results in a plenary session. During the discussion, the three conceptual models, one from each sub-group, were merged into one common impact pathway (Figure. 2.3).

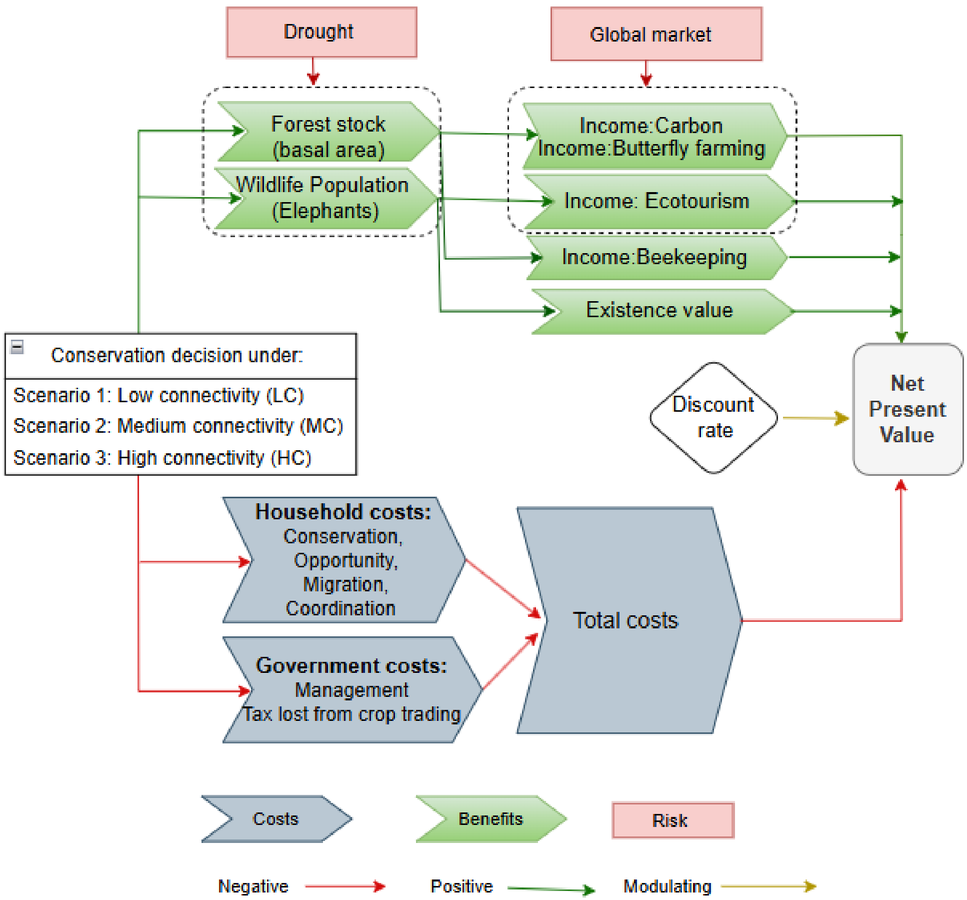

Figure 2.3: Conceptual model of cost-benefit analysis of coordinated conservation decision under three scenarios of landscape connectivity in ecological corridors of Igando-Igawa and Baga-Kisima gonja.

Before we elicit values for the model's parameters (i.e. parameterization), we used a procedure outlined by Whitney et al. (2018) to calibrate experts. The objective of the calibration was to assess the uncertainties in experts' estimation and to train participants to reduce their uncertainties and biases in judgments (Hubbard, 2014). After calibration training, we asked participants to provide estimates for all the variables in the impact pathway model. The estimates were expressed as a range, representing the lower and upper bounds, within which the expert is 90% confident the true value resides. This was done for two ecological corridors separately leading to two datasets of the same variables but different values.

Scenarios of landscape connectivity

We asked experts to decide which connectivity scenarios would be reasonable assumptions to occur as a result of conservation efforts. They reached a consensus on three levels of scenarios: low, medium, and high landscape connectivity. Experts described low landscape connectivity as the scenario where contiguously conserved farmland parcels do not exceed 40 percent[1] of the total farmland, while medium connectivity would range from 41 to 80 percent. Landscapes with more than 80 percent of farmlands conserved contiguously would represent high connectivity.

We assumed that the conservation of the entire landscape of the corridor may not be reasonable or desirable because some portions of the landscape are relatively less beneficial for connectivity compared to others. As such, the experts estimated the proportion of the landscape that is mostly important to support connectivity. This could be, for example, the common migratory route used by elephants—we called this the "best path". According to experts, the best path accounts for approximately 40 to 50 percent of the total farmlands in the Igando-Igawa wildlife corridor (IIWC). Thus, this target restricts area where the conservation of farmland is most desirable for connectivity. For the forest-based corridor (i.e. Baga-Kisima Gonja (BKG)), the best path was considered for the landscape that is necessary for efficient carbon sequestration, movement of pollinators (e.g. bees, butterfly) and primates (e.g. colobus monkey) of which this was estimated to account for 60 to 70 percent of the total farmland.

[1] The earlier model proposed by researchers defined the low scenario as farmland parcels that are conserved contiguously and which do not exceed 25 percent of the total farmlands in the corridor. However, this was updated to 40 percent because of the growing elephant population in the ecosystem which requires a larger landscape to migrate (Southern Tanzania Elephant Program and Wildlife Connection, 2016).

Risks

The experts identified two main risks[2] affecting the decisions' outcome, namely droughts and global financial crises. The former was noted to influence a number of potential conservation benefits, such as wildlife population and forest growth similar to Guldemond et al. (2022) and Wato et al. (2016). A global market crisis could impact tourism development and butterfly farming because both depend on foreign markets (Anderson & Saidi, 2011). The two risks were estimated by experts as a probability of occurrence and a range of potential losses they could cause to the outcomes. The probability of a global market crisis was estimated by considering its potential determinants such as pandemics, financial recessions, and social conflicts. This was supplemented from relevant literature, such as Greenwood et al. (2022) and Varghese (2023). The estimated probability of drought to occur falls within the range reported by Rojas et al. (2011). As in Tamba et al. (2021), we estimated the risk scaler ($Risk_{scaler}$) as a product of the probability of a risk to occur ($Probability_{risk\_occur}$) and the loss related to the respective risk ($Impact_{risk}$) using equation 2.1.

$$Risk_{scaler} = Probability_{risk\_occur} \times Impact_{risk} \tag{2.1}$$

Costs

We quantified costs to farmers and the government using all available information. Information sources included literature as well as government documents and published statistics. In cases where data was not available, we used expert knowledge to describe uncertainty distributions about the possible values.

Farmers' costs include conservation costs ($Cons_{costs}$), which include crop loss from wildlife raiding, wildlife-induced livestock loss, human injuries, and property damages. These costs were estimated by experts and complemented by relevant literature in the country (see Kegamba et al., 2024; Green et al., 2018; Woodroffe et al., 2005; Kideghesho, 2008; Mashalla & Ringo, 2015). We included opportunity costs ($Oppt_{costs}$) accounting for time spent guarding farms against animal crop raiding from Manoa et al. (2021) and foregone crop farm rent based on expert knowledge and from Nuru et al. (2014). These costs can be described as

[2]Diseases (for plants and wildlife) and wild fires were also mentioned by two stakeholders but after the discussion, experts decided to drop because of their very limited chance to occur in the study sites.

environmental shocks, which may induce the migration of rural farmers (Salerno et al., 2024). We included the likelihood of a farmer migrating due to such shocks and possible migration costs ($Migr_{cost}$), considering permanent migration (often household migration) and temporary migration (frequently individual migration) from experts' estimates. We also included the transaction costs of coordination ($Trans_{costs\_\mathrm{coord}}$). This involves expenses a farmer may incur for bargaining, consultation, and communications in coordination of collective conservation decisions—estimated by experts and complemented by Banerjee et al. (2017).

Government costs included the potential government revenue loss from taxes that could have been collected through the trade of agricultural products if crop farming ($Tax\_crop\_trade_{lost}$) and livestock keeping ($Tax\_lvsk\_trade_{lost}$) persisted. We included the costs of poaching as an average trophy value lost from URT, (2012)—for the number of animals poached per year ($Anim\_lost_{poach}$). Government costs to console farmers ($Consol_{cost}$) affected by wild animals (e.g. through crop-raiding) were estimated by experts and supplemented by Runyoro et al. (2019). Finally, the management costs[3] ($Mngnt_{cost}$) of the corridor, which entails enforcement (e.g., patrolling), administration (stationaries, office space, and meetings), and monitoring expenses (outlays for field trips by evaluation experts) were added using estimates by researchers in the region (see Nyanghura & Abdallah, 2023, Nyamoga, 2016; Wenborn et al., 2022). The total costs of households and government are modeled in equations 2.2 and 2.3 respectively as follows:

$$TC_{hh} = Cons_{costs} + Oppt_{costs} + Migr_{cost} + Trans_{costs\_\mathrm{coord}} \tag{2.2}$$

Where, TC_{hh} is the total costs of conservation per year (in USD) for the household. Other variables in the right-hand side of the equation are as explained in the text.

$$TC_{gov} = Tax\_crop\_trade_{lost} + Tax\_lvsk\_trade_{lost} + Anim\_lost_{poach} + Consol_{cost} + Mngnt_{cost} \tag{2.3}$$

[3] We did not include the costs of establishing the regulations and land use plan because these costs will likely be the same for every scenario of landscape connectivity.

Where, TC_{gov} is the total costs of conservation per year (in USD) for the government. Other variables in the right-hand side of the equation are as explained in the text.

Benefits

To derive environmental and socioeconomic benefits, we estimated the forest stock and wildlife population as primary biodiversity benefits of landscape connectivity. We measured the forest stock using basal area[4] and wildlife, using the elephants as the main indicator of migratory species in IIWC. The basal area at the baseline (i.e. year 1 of conservation) and rate of change over time were obtained from literature that assessed the dynamics of natural forest regeneration in abandoned or fallow farmland. We relied on estimates from studies in Miombo woodlands of sub-Saharan Africa to represent IIWC (see Kalaba, 2013), and in Afro-montane forest to represent BKG (see Mathew et al., 2016 and Mwampamba, 2009). The baseline population of elephants and the rate of change over time was estimated by experts and complemented by Mduma et al. (2010) and Southern Tanzania Elephant Program and Wildlife Connection, (2016). Both basal area (Basal_area) and elephant population ($Elephant\_popl$) estimates were adjusted to account for the potential loss due to the occurrence of drought as an important risk using equations 2.4 and 2.5, respectively.

$$Basal\_area_{risk\_adjusted} = Basal\_area_{non-adjusted} \times (1 - Risk_{scaler}) \tag{2.4}$$

$$Elephant\_popl_{risk\_adjusted} = Elephant\_popl_{non-adjusted} \times (1 - Risk_{scaler}) \tag{2.5}$$

We proceeded by quantifying the monetary values for the possible benefits of forest stock and elephant population in the two corridors. We distinguished between benefits to households and benefits for the government. One of the ways farmers benefit from conservation is through ecosystem services that support livelihood activities. For example, cage-based butterfly farming—a lucrative business in the Eastern Arc Mountain of Tanzania. The practice depends on landscape connectivity for a sustainable source of butterfly breeding (Morgan-Brown et al., 2010). Thus, net benefits accrued from potential livelihood activities

[4] Basal area is a standard forest metric that uses individual stem cross-sectional area to quantify stem density and stand volume (Newton, 2007). The basal area is a good predictor for biomass and carbon since it integrates the effect of both the number and size of trees and therefore appropriate for comparing re-growth across sites (Clark and Clark, 2000)

$(Benefit_{livhd})$ were modeled as household benefits associated with landscape connectivity. Household income from tourism $(Benefit_{trsm\_hh})$ such as employment opportunities was modeled separately from other livelihood activities. We also include the net benefits of crop farming $(Benefit_{crop})$ per hectare for farmers who decide not to conserve and net income from livestock keeping $(Benefit_{lvsk})$. Lastly, we included the existence or bequest value of elephants $(Benefit_{elpnt\_hh})$ from farmers' perspectives. Here, our estimate was based on contingent valuation literature of African elephants from SSA (see Laws et al., 2020; Muchapondwa et al., 2008; Newton et al., 2012; Ngouhouo Poufoun et al., 2016). The total benefit per year for the households was then modeled as follows:

$$TB_{hh} = Benefit_{livhd} + Benefit_{trsm\_hh} + Benefit_{crop} + Benefit_{lvsk} + Benefit_{elpnt\_hh} \quad (2.6)$$

Where, TB_{hh} is the total benefits for the household per year (in USD). Other variables on the right-hand side of equation 2.6 are explained in the text. $Benefit_{livhd}$ includes net benefits of two livelihood activities: beekeeping, which was common in the two study areas, and butterfly farming[5] which was reported in BKG (Mansourian et al., 2019; Mkonda & He, 2017). Specific risks accounted for each benefit in parentheses are as follows: $Benefit_{livhd}$ (drought and global market crisis), $Benefit_{trsm\_hh}$ (global market crisis) and $Benefit_{crop}$ (drought). These benefits were risk-unadjusted using equation 2.7.

$$Benefit_{risk\_adjusted} = Benefit_{non\_adjusted} \times (1 - Risk_{scaler}) \quad (2.7)$$

We modeled the government benefits from four categories: ecotourism, carbon markets, taxes collected from trading crops and livestock, and the trophy value of elephants. For tourism $(Benefit_{trsm\_gov})$ we relied on reports from the nearby community-based conservancy, such as Idodi-Pawaga, Mbarang'andu, and Kisangule (see Community Wildlife Management Areas Consortium, 2019) to estimate potential tourism revenue at baseline and projection of future trends in IIWC. The same approach was used in BKG by using eco-tourism

[5] Butterfly farming is one of the lucrative businesses with growing export demands from Africa. Though butterfly farming was recently banned in Tanzania, experts are optimistic that it will be reopened in the near future. Therefore, experts used previous experience to estimate the net benefits at the household level.

benefits from the Mazumbai government forest reserve, with an adjusted coefficient suggested by experts. The adjustment was necessary because Mazumbai is mainly a research forest, which may have a different tourism potential than the community-based tourism that is envisaged. Specifically, we accounted for earnings from hunting and photographic tourism, and values of tourism-based community projects (e.g. building of dispensaries, schools, etc.) supported by tourism earnings from connected protected areas.

Carbon value ($Benefit_{crbn}$) was estimated as a product of carbon stock per year and a range of prevailing carbon prices adopted for the Reducing Emissions from Deforestation and Forest Degradation (REDD+) market (Abatable, 2022). The carbon stock (stem) dynamics were estimated using the knowledge from experts which was complemented by findings from studies that assess carbon sequestration over time in abandoned or fallow farmland in Miombo woodland to represent IIWC (see Williams et al., 2008) and in Afromontane forest to represent BKG (see Mathew et al., 2016 and Mwampamba, 2009). We also consider the potential government revenues, particularly taxes collected through the trade of crop yield produced from non-conserved farms ($Benefit_{tax-crop}$) and livestock ($Benefit_{tax-lvsk}$). Finally, we used the trophy value of elephants $\left(Benefit_{elpnt\_gov}\right)$ as a perceived value of elephants by the government (URT, 2012). The annual total benefit of conservation to the government is then given by equation 2.8.

$$TB_{gov} = Benefit_{trsm\_gov} + Benefit_{crbn} + Benefit_{tax-crop} + Benefit_{tax-lvstk} + Benefit_{elpnt\_gov} \quad (2.8)$$

Where, TB_{gov} is the annual total benefits for the government (in USD). Other variables on the right-hand side of the equation are as explained previously. $Benefit_{trsm\_gov}$ was adjusted for possible losses from the global market crisis while $Benefit_{crbn}$ was adjusted for both the global market crisis and drought risks using equation 2.7.

Both costs and benefits were firstly estimated at baseline (i.e. at year one of conservation) and the rate of change over time was given by experts under each scenario. The estimates were given at either the corridor, household, or farm level, depending on the confidence of the experts during estimation. For analysis purposes, the costs and benefits related to farmers were extrapolated per household and per year. Those related to the government were presented per hectare conserved per year and per landscape per year.

Time horizon

We chose a 30-year timeframe based on the understanding that the natural regeneration of forests and wildlife is a time-consuming process (Underwood et al., 2008). This is supported by studies conducted in Mozambique, Tanzania, and Zambia, which have shown that basal area and carbon stocks gradually increase when abandoned farmlands are left undisturbed for forest regeneration, reaching a recovery point within two to four decades (Williams et al., 2008; Kalaba et al., 2013; McNicol et al., 2015). However, some literature shows that this can extend beyond five decades (Guessan et al., 2019). Variation in time of recovery may be attributed to land management before recovery e.g., farming that retained trees has a faster recovery process, whereas intense use of agro-chemicals or tillage may slow recovery (Mwampamba & Schwartz, 2011). Additionally, 30 years aligns with the half-life of an elephant, making it an ideal timeframe to consider for population change.

Step 4: Mathematical modeling and simulation: biodiversity, costs, and benefits

We transformed the impact pathway (Figure. 2.1) into a mathematical model in the R programming language (R Core Team, 2020). Then, we presented the distribution of the outcomes (basal area and elephant population) at status quo (i.e. under LC scenario). We do the same for total costs and benefits per household, government per hectare, and per landscape. However, given that our core interest is to estimate the effect of increasing landscape connectivity using LC as a counterfactual, we subtracted the outcomes under LC from MC and HC using equation 2.9. Such difference constituted a measure of impact of landscape connectivity.

$$Change_{s\prime,c}^{Outcomes} = Outcomes_{s\prime,c} - Outcomes_{LC,c} \tag{2.9}$$

Where, $Change_{s\prime,c}^{Outcomes}$ represents the difference in outcomes between scenarios $s' \ (HC\ or\ MC)$ and LC in the respective corridor $c\ (IIWC\ or\ BKG)$. $Outcomes_{s\prime,c}$ represents outcomes determined in equations 2.2, 2.3, 2.4, 2.5, 2.6, and 2.8 for

HC and MC scenarios and $Outcomes_{LC,c}$ represents the outcomes from the same equations for LC scenario.

Then, we run a simulation of $Change_{s\prime,c}^{Outcomes}$ using the datasets of two ecological corridors separately. We do this by using Monte Carlo simulations with 10,000 alterations for each year, over 30 years of conservation intervention.

Step 4: Mathematical modeling and simulation: net present values

To estimate the NPV, we first quantified the expected net benefits by subtracting the aggregate costs from aggregate benefits for each scenario s $(LC, MC\ or\ HC)$ using equation 2.10 and then discounted the net benefit to find the NPV (equation 2.11).

$$Net\_benefit_{s,c} = TB_{s,c} - TC_{s,c} \quad (2.10)$$

Where, s represents all the scenarios (i.e. LC, MC or HC) and c is as explained in equation 2.9.

$$NPV_{s,c} = \frac{Net\_benefit_{s,c}}{(1+r)^t} \quad (2.11)$$

where NPV = Net present value, r = discount rate[6], and t = year

We presented the NPV at status quo (i.e. under low connectivity— $NPV_{LC,c}$). Then, we determine the change in NPV between high and low landscape connectivity and between medium and low landscape connectivity by subtracting the NPV under LC from NPV under MC and HC as follows:

$$Change_{s\prime,c}^{NPV} = NPV_{s\prime,c} - NPV_{LC,c} \quad (2.12)$$

Where, $Change_{s\prime,c}^{NPV}$ represents change in NPV for s' = MC (i.e., MC-LC) or HC (i.e., HC-LC).

As we did to $Change_{s\prime,c}^{Outcomes}$, we run a simulation of $Change_{s\prime,c}^{NPV}$ using the datasets of two ecological corridors separately. We do this using Monte Carlo simulations with 10,000 alterations and for 30 years of conservation intervention. The simulation provides the

[6] We used a discount rate ranging from 4 to 21 percent as in Green et al. (2018).

probability distributions of each outcome. We presented these distributions[7] comparing two ecological corridors (IIWC and BKG). Furthermore, we estimated the probability of gain as a proportion of positive values within the distribution of change in NPV.

Sensitivity analysis

We also performed a sensitivity analysis by implementing Partial Least Square (PLS) regression analysis and Expected Value of Perfect Information (EVPI). PLS is appropriate in a situation where there is partial information about the determinants of the outcome—and that is when a large set of predictors is included in the model (Abdi, 2003). This is the case in our study where all the input variables (about 143) are included in the model to determine the Variable Importance in Projection (VIP) score similar to several other related studies (for example, see Do et al., 2020; Lanzanova et al., 2019; Sain et al., 2017; Tamba et al., 2021). A variable with a VIP score of more than one is considered to have a substantial effect on the outcome (Cocchi et al., 2018). Finally, we assessed the Value of information (VoI) by estimating the Expected Value of Perfect Information (EVPI). EVPI was computed to determine the variables with information gaps. These are variables for which more information could improve confidence regarding the decision outcome (i.e. change the recommendation from one option to another).

Step 5: Refining the model

Model refinement is essential when the simulation results do not lead to a clear recommendation. In such instances, variables with higher EPVI should be updated with additional data. This information can be sourced from existing literature or through further consultations with experts. However, most of our simulation outcomes were conclusive, and the VoI results indicated minimal benefit in pursuing collection of further information.

[7] We consistently show the distribution of 5 to 95 percent quantile to avoid the effect of the observed extreme outliers.

2.4 Results

2.4.1 Biodiversity, conservation costs, and benefits under a low landscape connectivity scenario

Simulated outcomes at a low connectivity scenario show that the median forest stock per year (proxied by basal area) was 1.40 m^2/ha [0.8 to 2.0] in IIWC and 3.67 m^2/ha [1.39 to 6.02] in BKG (Figure 2A.1 in the Appendix). Figure 2A.1c (in the Appendix) shows the elephant population in the IIWC ranges from 234 to 274 per year. The median costs of conservation incurred by a household per year were USD 233 [50 to 1585] and USD 109 [25 to 517] in IIWC and BKG respectively (Figure 2A.2. in the Appendix). The benefits per household per year were around USD 1273 [226 to 6416] in IIWC and USD 573 [195 to 2430] in BKG (Figure 2A.5. in the Appendix).

We estimated the government costs of conservation and benefits per hectare of farmland conserved (i.e., per unit value) and per total landscape conserved contiguously (i.e., absolute value per landscape). The median government costs per hectare per year were around USD 10 [2.57 to 197.17] in IIWC and USD 62 [18 to 764] in BKG (Figure 2A.3 in the Appendix). The absolute cost was USD 20,605 [10062 to 69,704] in IIWC which is three times higher than in BKG (Figure 2A.4 in the Appendix). The annual government benefits per hectare conserved were estimated to be USD 1,709 [431 to 21265] in IIWC and USD 564 [103 to 2050] in BKG (Figure 2A.6 in the Appendix). At the landscape level, the annual median benefits were USD 3,452,522 [2,172,884 to 5,790,109] and USD 46,622 [3,487 to 352,991] in IIWC and BKG respectively (Figure 2A.7 in the Appendix).

2.4.2 The effect of an increase in landscape connectivity on biodiversity

Our results show that an increase in landscape connectivity from the low to the high-level scenario augments the basal area per year by a median of 0 to 10.6 m^2/ha in IIWC and by 0 to 15 m^2/ha in BKG for a period of 30 years (see Fig. 2.4b and d). This is equivalent to an average of 5.1 m^2/ha/year and 7.1m^2/ha/year respectively. Medium landscape connectivity enhances the basal area per year by approximately a median of 0 to 4.6 m^2/ha and 0 to 10 m^2/ha in IIWC and BKG, respectively (Fig. 2.4a and c), making it a relatively less conservation-effective scenario compared to high connectivity.

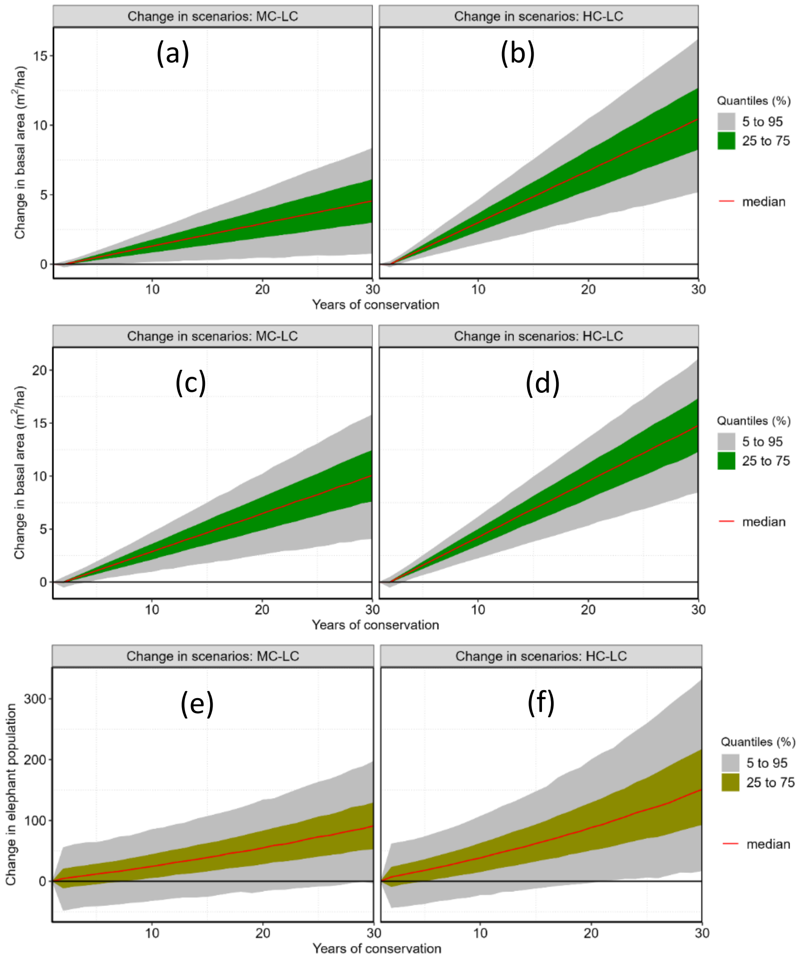

Figure 2.4: Change in biodiversity as a result of an increase in landscape connectivity from low to medium (MC – LC) and from low to high (HC-LC). (a) and (b) show such change of basal area in IIWC. (b) and (c) show the same change in BKG. (d) and (e) represents the change of the elephant population in IIWC.

High landscape connectivity also supports more migration of animals in IIWC, increasing the elephant population by around 60 elephants per year [0 to 146] compared to a low connectivity scenario (Fig. 2.4 e). This increase represents about 20 more elephants per year compared to when connectivity is increased to a medium level.

2.4.3 Change in annual costs of conservation for households and the government due to increase in landscape connectivity

The simulation results show the annual costs of conservation per household in both ecological corridors consistently rise with increasing landscape connectivity. Specifically, higher landscape connectivity results in a median increase of USD 782 and USD 251 per household in IIWC and BKG, respectively (Fig. 2.5 a and b). This is equivalent to three and two times higher than the household costs in the low connectivity scenario. Medium landscape connectivity, on the other hand, increases the costs by approximately 2.5 times in IIWC and 1.5 times in BKG compared to the low connectivity scenario.

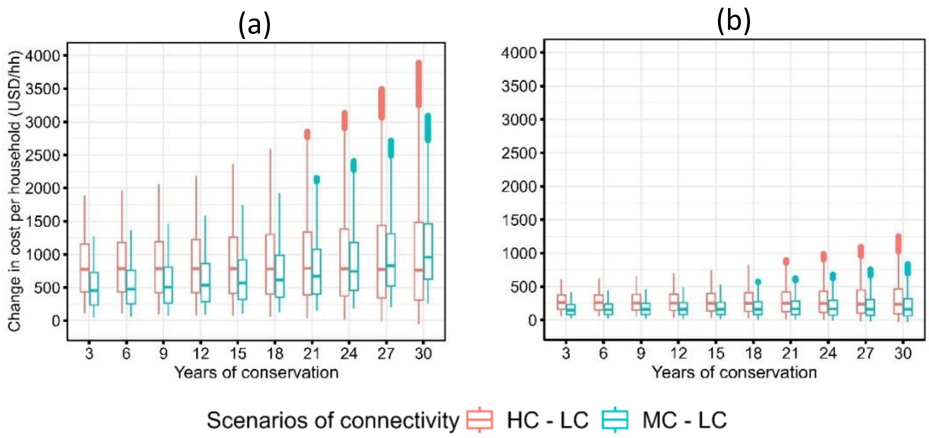

Figure 2.5: Change in annual cost per household as a result of increase in landscape connectivity from LC to MC (MC-LC) and from LC to HC (HC-LC) scenarios in IIWC (a) and BKG (b).

The increase in landscape connectivity to medium and high scenarios in IIWC reduces the annual government costs per hectare by a median of USD 6 (60%) and USD 8 (80%), respectively (Figure. 2.6a). However, the total government costs (at landscape) increase to a median of USD 15,964 [USD 931 to USD 210,523] and USD 12,256 [—USD 26,786 to USD 69,947] when landscape connectivity is raised to medium and high connectivity scenarios, respectively (Figure. 2.6b).

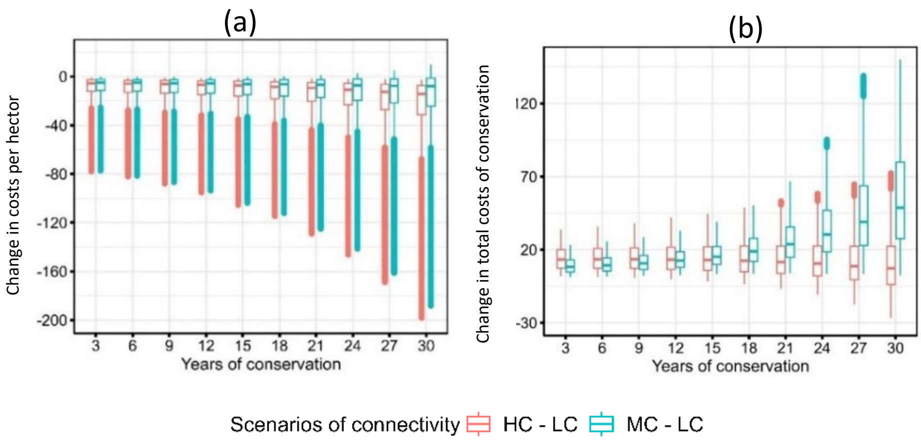

Figure 2.6: Change in annual government cost due to increased landscape connectivity from LC to MC (MC-LC) and LC to HC (HC-LC) scenarios in IIWC. (a) shows the change in government costs per hectare (USD/ha) and (b) shows the change in absolute government costs for landscape conserved (thousand USD).

A similar trend was observed in BKG, where the costs per hectare of conserved farmland decreased by approximately USD 43 (70%) and USD 46 (74%) under medium and high connectivity scenarios, respectively. However, total government costs at the landscape level grew at a rate approximately five to six times lower than the increase observed in IIWC. Specifically, these costs were around USD 2,807 (ranging from USD 864 to USD 7,011) and USD 4,933 (ranging from USD 2,483 to USD 10,643) for the medium and high connectivity scenarios, respectively.

2.4.4 Change in annual benefits of conservation for households and the government under each scenario of landscape connectivity

Our findings indicate that the annual benefits per household under the medium and high connectivity scenarios were lower than those under the low connectivity scenario. This is consistently reflected by the negative differences between household benefits under high and low connectivity (HC - LC) and under medium and low connectivity (MC - LC) in IIWC (Figure 2.7a). While there appears to be potential for increased household benefits at BKG in future years due to improved connectivity (see Figure 2.7b), the median benefits are generally lower by 78 USD under the medium connectivity scenario and 108 USD under the high connectivity scenario compared to the low connectivity scenario (Figure 2.7b).

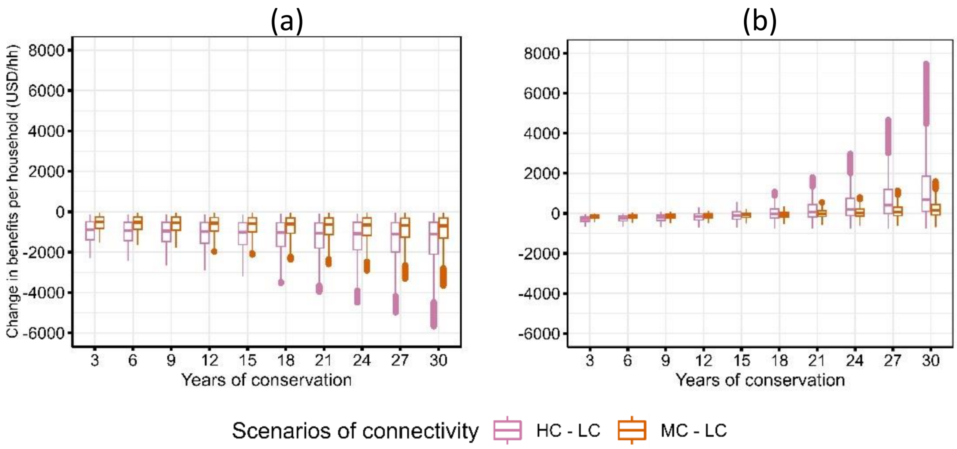

Figure 2.7: Change in annual household benefits as a result of an increase in landscape connectivity from LC to MC (MC-LC) and from LC to HC (HC-LC) scenarios in IIWC (a) and BKG (b).

Similar to household benefits, we observed a downward trend in annual government benefits per hectare in IIWC (Figure. 2.8a). Higher connectivity was associated with a decrease in government benefits by 1,268 USD/ha while medium connectivity was found to lower the benefits by 1,179 USD/ha (Figure. 2.8a). A similar decreasing trend was noted in BKG, but by a relatively small magnitude of USD 21 USD/ha and USD 64 USD/ha as connectivity increases to higher and medium respectively.

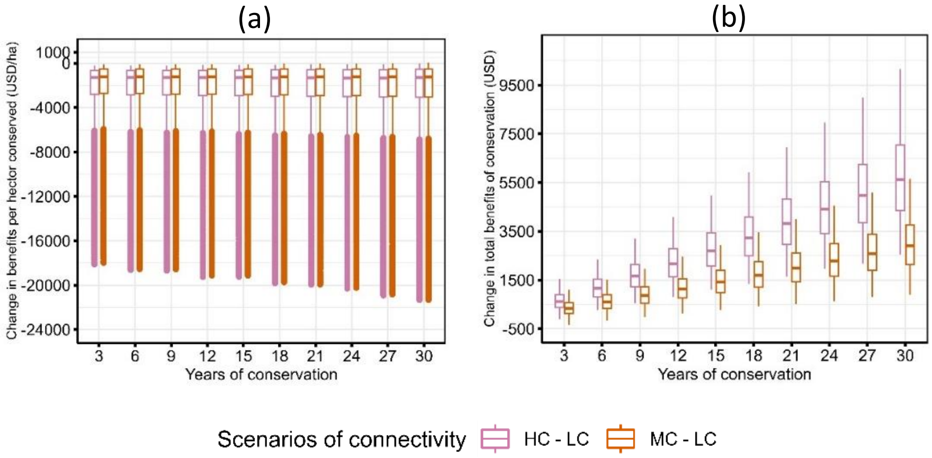

Figure 2.8: Change in annual government benefits due to an increase in landscape connectivity from LC to MC (MC-LC) and from LC to HC (HC-LC) scenarios in IIWC. (a) shows the change in government benefits per hectare, and (b) shows the change in total government benefits at landscape level.

As anticipated, the annual conservation benefits accrued by the government in IIWC and BKG at the landscape level remained consistently positive throughout the simulation period as landscape connectivity increased to medium and high levels. The difference in annual benefits between high connectivity (HC) and low connectivity (LC) was more pronounced than between medium connectivity (MC) and LC. In IIWC, these differences were estimated at a median of USD 2.61 million (HC-LC) and USD 1.32 million (MC-LC) (Figure 2.8b), while in BKG, the differences were relatively small—approximately USD 0.32 million (HC-LC) and USD 0.15 million (MC-LC).

2.4.5 Net present value

Figure 2.9 depicts the changes in Net Present Value (NPV) associated with increased landscape connectivity, comparing transitions from low to medium and low to high connectivity scenarios. The analysis shows that increasing connectivity to a high-level scenario reduces the NPV per household by a median of USD 21,228 in IIWC and USD 3,734 in BKG. Similarly, transitioning to a medium-level connectivity scenario decreases the NPV by a median of USD 13,393 in IIWC and USD 2,569 in BKG.

For government investments per hectare, the NPV remained consistently negative under all scenario changes in IIWC. However, in BKG, 73 percent of simulations appeared to yield a positive NPV when connectivity increased from low to high, with the highest NPV reaching USD 6,450 per hectare (Figure 2.9 d). On the contrary, the same Figure 2.9 d shows that increasing connectivity from low to medium reduced the NPV per hectare by a median of USD 60, with a 53 percent probability of negative NPV.

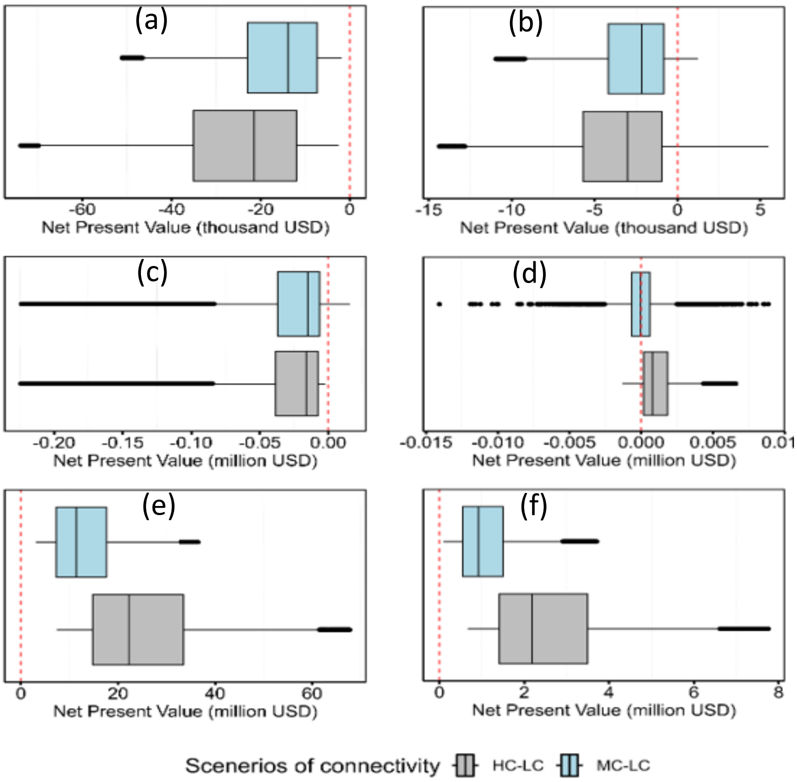

Figure 2.9: Net present value differences between low and medium landscape connectivity (MC-LC) and between low and high connectivity (HC-LC) scenarios. (a) and (b) represent such difference per household in IIWC and BKG respectively. (c) and (d) represent the same difference for government (per hectare) in IIWC and BKG respectively. (e) and (f) represent the same difference for government (per landscape) in IIWC and BKG respectively.

As anticipated, we observed a consistent positive change in Net Present Value (NPV) for government investments at the landscape level. Figures 2.9e and f illustrate this trend, showing increases of USD 22.2 million in IIWC and USD 2.4 million in BKG as connectivity improves from low to high scenario level. Similarly, medium connectivity enhances NPV by approximately half the increase observed under high connectivity.

2.5 Sensitivity analysis

2.5.1 Estimation of variable importance in projection

Our sensitivity analysis, conducted using Partial Least Square (PLS) regression, yielded Variable Importance in Projection (VIP) scores that, generally, ranged from 0 to 7.2 (Table. 2.1). As in Luu et al. (2022), we chose a VIP threshold of 1 to determine the variables that substantially affected outcomes (NPV difference between HC and LC and between MC and LC) for households (Models 1 to 4). We further separate our analysis and present the results for the difference in government NPV per hectare (Models 5 to 8) and per landscape (Models 9 to 12).

We found that medium and high connectivity scenarios negatively influenced the NPV per household, while low connectivity and discount rates positively correlated with NPV consistently (Models 1 to 4). The net benefits of crop farming per hectare and the rate of change of net benefits over time consistently correlated negatively to NPV per household, but only in IIWC (Models 1 to 2).

The NPV for the government investment per hectare was influenced by 16 factors and in different ways between the two ecological corridors. As in household models, discount rates and low connectivity were positively correlated to NPV (Models 5 to 8). Amount of stem carbon accumulated per hectare per year (ton/ha/year) for conserved farmland showed a mixed effect on the NPV. Under the high connectivity scenario, it was found to be negatively correlated to NPV in IIWC, but positive in BKG (Models 5 and 7). Yet, under medium connectivity, it appeared to lower the NPV while increasing under low connectivity in BKG (Models 7 and 8). Other sensitive variables are the price of carbon per ton, rate of change of wildlife poaching per year, tourism income per year lost due to global market risks, costs of controlling HWC, wildlife lost due to drought, and the rate of change of consolation expenses incurred by the government. Others are monitoring costs and the number of households in the ecological corridor.

At the landscape level, the government investment was consistently negatively influenced by low connectivity and discount rates (Models 5 to 8). Medium and high connectivity was positively linked to NPV (Models 6 and 8). Carbon-related variables, such as stem carbon at baseline, accumulated stem carbon stock per year, and price of carbon per ton, were also associated with a positive change in NPV (Models 9 to 12).

Table 2.1: Partial Least Square results showing the Variable Importance in Projection (VIP) for the variables to which the model was most sensitive in IIWC and BKG. The dependent variables are NPV differences for higher and lower connectivity (HC - LC) and medium and lower connectivity (MC - LC) for the respective corridors. Models 1 to 4 present the VIP variables for the NPV estimated per household. Model 5 to 8 represent the VIP variables for government NPV estimated per hectare. Models 9 to 12 presents the VIP variables for the NPV estimated for the government at the landscape level.

Variables	Description of the variables	VIP-Scores											
		Household				Government_per_hectare				Government_landscape			
		IIWC		BKG		IIWC		BKG		IIWC		BKG	
		HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Net_benefits_crop_farm	Net benefits of crop farming per hectare per year (USD/Ha/year)	- 6.9	- 6.1										
Change_net_benfits_farm	Change in net benefits of crop farming per hectare per year (%)	- 3.1	- 2.8										
Discount_rate	Discount rate (%)	4.5	4.5	7.2	5.9	1.8	1.8		1.8	- 6.1	- 4.7	- 5.3	- 4.4
Low_connectivity	Proportion of landscape conserved contiguously equivalent to less than 40% of the total farmlands in the corridor	2.2	3.1	3.2	4.1	4.8	4.8	2.7	2.6		- 1.9	- 1.3	- 2.7
Medium_connectivity	Proportion of landscape conserved contiguously equivalent to more than 40% but less than 80% of the total farmlands in the corridor		-2.9		-3.9						2.2		2.1
High_connectivity	Proportion of landscape conserved contiguously equivalent to more than 80% of the total farmlands in the corridor	- 1.0		-1.2						3.4		3.3	
Exchange_rate	Exchange rate from TZS to USD	1.2	1.1	1.8	1.4					- 1.2			
Households_own_farm_best_path	Number of households owns farmland in areas of high agro-ecological value (best path)			3.2	2.6								
Stem_carbon_baseline	Amount of stem carbon hectare (ton/ha) for a conserved farmland in year one										1.2		
Stem_carbon_acumultion_HC	Amount of stem carbon accumulated per hectare per year (ton/ha/year) for a conserved farmland under high connectivity scenario					- 1.0		3.3		2.2	3.2	2.2	
Stem_carbon_acumultion_MC	Amount of stem carbon accumulated per hectare per year (ton/ha/year) for a conserved farmland under medium connectivity scenario							- 3.0	-2.7				2.1
Stem_carbon_acumultion_LC	Amount of stem carbon accumulated per hectare per year (ton/ha/year) for a conserved farmland under low connectivity scenario							1.6	3.6				
Price of carbon per ton	Market price of carbon per ton (USD/ton)					- 1.7	- 1.7			1.8	2.2	2.4	2.1

Variables	Description of the variables	VIP-Scores											
		Household				Government_per_hectare				Government_landscape			
		IIWC		BKG		IIWC		BKG		IIWC		BKG	
		HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Change_wildlife_poached_HC	Rate (in %) of change of poaching per year per under high connectivity scenario					- 1.4	- 1.4						
Tourism_income_lost_global_market_risk	Income from tourism (in USD) that is lost due to global market risk.					1.3	1.3						
Cost_control_human_wildlife_conflict_MC	Costs (in USD) of controlling human wildlife conflicts per year under medium connectivity scenario					- 1.2	- 1.2						
Cost_control_human_wildlife_conflict_HC	Costs (in USD) of controlling human wildlife conflicts per year under high connectivity scenario					-1.1	-1.1						
Wildife_lost_drought	Proportion of wildlife lost (in %) when drought occur					1.1	1.1						
Change_cost_consolation_HC	Rate (in %) of change of consolation expenses with time under high landscape connectivity scenario.					1.0	1.0						
Monitoring_costs_HC	Monitoring costs per year (USD) under high landscape connectivity scenario							- 1.2	- 1.2				
Monitoring_costs_MC	Monitoring costs per year (USD) under medium landscape connectivity scenario							1.2	1.1				
Monitoring_costs_LC	Monitoring costs per year (USD) under low landscape connectivity scenario							1.1	1.0				
Number_households_corridor	Number of households in the ecological corridor at year one of conservation							- 1.1	-1.1				

2.5.2 Estimation of expected value of perfect Information

Table 2.2 presents the expected value of perfect information (EVPI). One variable “low connectivity," was found to have a positive EVPI for household model estimates (Model 1 to 4). The EVPI for this variable was approximately USD 1, USD 200, USD 1, and USD 200 for Models 1 through 4, respectively.

Twelve variables showed positive EVPI for the government per hectare models (Models 5 to 8). The variables with the highest EVPI were the amount of stem carbon accumulated per hectare per year (under medium and low connectivity scenarios) and monitoring costs per year (under low connectivity). The information value for these variables ranged from approximately USD 16,000 to USD 50,000. Other variables with positive EVPI, but below USD 8,000, included net benefits of crop farming per hectare, low connectivity, discount rates, rate of change in projects funded by tourism, monitoring costs (under low and medium connectivity), number of rangers (under high connectivity), farm size, rate of change in consolation expenses (under medium connectivity), government tax from crop yield trading, and the price of carbon per ton.

For government NPV at the landscape level (Models 9 to 12), two variables exhibited positive EVPI: low connectivity and the amount of stem carbon accumulated per hectare per year. While additional information on these variables could reduce uncertainties in outcomes, we determined that the EVPI values were too low to justify further investment in data collection.

Table 2.2: Expected Value of Perfect Information (EVPI) for variables with non-zero values. Models 1 to 4 show the EVPI for the household model in IIWC and BKG. Models 5 to 8 display the EVPI for the government model (per hectare estimates), while Models 9 to 12 present the EVPI for the government model (per landscape estimates) within the same ecological corridors.

Variables	Description of the variables	**EVPI in thousand USD**											
		Household				**Government_per_hectare**				**Government_landscape**			
		IIWC		**BKG**		**IIWC**		**BKG**		**IIWC**		**BKG**	
		HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC	HC-LC	MC-LC
		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Net_benefits_crop_farm	Net benefits of crop farming hectare (USD/ha/year)												
Low_connectivity	Proportion of landscape conserved contiguously equivalent to less than 40% of the total farmlands in the corridor	0.0	0.2	0.0	0.2	0.03	0.1				0.05		6.8
Medium_connectivity	Proportion of landscape conserved contiguously equivalent to more than 40% but less than 80% of the total farmlands in the corridor					0.4	0.4						
Discount_rate	Discount rate (%)							1.1	1.2				
Stem_carbon_acumulted_MC	Amount of stem carbon accumulated hectare(ton/ha/year) for a conserved farmland under medium connectivity scenario							49.6	49.3		8.3		
Stem_carbon_acumulted_LC	Amount of stem carbon accumulated hectare(ton/ha/year) for a conserved farmland under low connectivity scenario							15.6	16.0				
Rate_change_tourism_project	Rate of change (in %) of projects funded by the tourism funds					0.4	0.3						
Monitoring_costs_LC	Monitoring costs per year (USD) under low landscape connectivity scenario					25.8	26.7						
Monitoring_costs_MC	Monitoring costs per year (USD) under medium landscape connectivity scenario					1.9	2.0						
Monitoring_costs_HC	Monitoring costs per year (USD) under high landscape connectivity scenario					0.1	0.1						
Number_rangers_HC	Number of rangers employed in a landscape per year					0.2	0.1	0.01	0.02				
Farm_size_high_agro_ecological_value	Farm size (in ha) of high agronomic and ecological value in the corridor					7.6	7.8						
Rate_change_consol_costs_MC	Rate (in %) of change of consolation expenses with time under medium landscape connectivity scenario.					1.5	1.6						
Gov_tax_traded_crops	Government taxes collected from trading of crop yields							0.2	0.2				
Price_carbon_ton	Market price of carbon per ton (USD/ton)							0.01	0.02				

2.6 Discussion

2.6.1 Landscape connectivity and biodiversity growth

Biodiversity is a fundamental resource for socioeconomic development, and landscape connectivity has been shown to support biodiversity growth and development. This study assessed the impact of landscape connectivity on forest stock and elephant population in forest-based ecological corridor and wildlife-based ecological corridor of Tanzania and further analyzed the economic viability of such connectivity. The economic viability was estimated from two relevant perspectives: local farmers and the government.

The simulation results confirm our prediction that increasing landscape connectivity to medium and high levels enhances forest stock in both ecological corridors and boosts the elephant population in IIWC. We, however, observed a higher basal area in BKG in all landscape connectivity scenarios compared to IIWC. This can be explained by three possible reasons. First, BKG is situated within the Afro-montane ecosystem, defined by its moist and humid climate, facilitating rapid natural regeneration when farmlands are abandoned for conservation (Hishe et al., 2021). These ecological conditions also promote resilience and stability against climate shocks like drought. This is unlike IIWC, which features dry woodlands with lower precipitation, which could support a slower natural regeneration. Second, the type and nature of crop farming before farmland retirement may also contribute to the differences observed. Thus, the agroforestry systems practiced in BKG may contribute to enhancing soil conditions, structure, and microclimate, facilitating quicker natural regeneration (Mwampamba & Schwartz, 2011). The lower basal areas in IIWC may be attributed to the vegetation destruction caused by elephants, as presented by Mwambeo & Maitho, (2015) and further corroborated by Meyer et al. (2021) who showed limited woodland cover in wildlife-based ecosystems. The increase in the elephant population in IIWC is partly supported by Meyer et al. (2021) who showed the association of wildlife-based conservancy and an increase in the elephant population in Namibia.

2.6.2 Costs of conservation to households and government

Our simulation models showed that aggregate conservation costs per household in both ecological corridors were about two to three times higher under medium and high landscape connectivity scenarios respectively compared to the low connectivity scenario. This means that low connectivity remains the least cost-effective option and is more likely to be preferred by rational farmers. The rise in aggregate conservation costs per household was two times higher (under medium connectivity) and three times higher (under higher connectivity) in IIWC compared to BKG. This indicates that households in the IIWC corridor are likely to be more affected by conservation than those in the BKG corridor. This discrepancy between IIWC and BKG was probably due to additional costs from wildlife, such as elephants in a former ecosystem, which are not present in the latter ecosystem. Furthermore, it could be due to lower household density (~10 households/km² in IIWC compared to ~60 households/km² in BKG). A lower household density may also be intensified by potential human migration to avoid environmental shocks (e.g., wildlife-related injuries) as connectivity increases, which increases cost intensity for the remaining households (Salerno et al., 2024).

The rise in absolute costs incurred by the government at the landscape level can be attributed to an increase in management expenses. This is because expanding conserved landscapes requires more costs, e.g., rangers for patrolling and additional time or experts for monitoring. However, when the increase in absolute expenses is proportionally less than the increase in conserved area, the cost per unit area declines. This is what we observed—a decrease in government costs per hectare as landscape connectivity increases. Our findings on costs per hectare at medium and high connectivity were approximately 0.5 to 0.8 times smaller than the lower connectivity scenario. This is somewhat comparable to the results of Frazee et al. (2003) who showed that increasing the conservation area can – owed to economies of scale – reduce operational costs of conservation per hectare by 1.2 times compared to previously conserved landscape.

2.6.3 Benefits of conservation to households and the government

Our findings regarding farmers' conservation benefits per household showed decreased benefits as landscape connectivity increases. This was expected and likely attributed to a loss of agricultural rent, once farming ceased due to conservation. This is the case where agricultural rent is relatively higher than alternative land use such as ecotourism and other income-generating enterprises, such as traditional beekeeping (Naidoo & Ricketts, 2006; Wainaina et al., 2020). The loss of benefits was relatively smaller under high landscape connectivity compared to medium connectivity, suggesting the potential for alternative land uses (e.g., tourism) to offset some opportunity costs, though only to a limited share. In BKG, where a greater diversity of livelihood alternatives exists, a larger share of opportunity costs can be compensated.

A consistent increase in absolute government benefits as landscape connectivity increases implies that the government should expect additionality with greater connectivity. However, this additionality was comparable irrespective of the ecological corridor: benefits increased by approximately 33 percent from lower to medium scenario and by 76 percent from lower to higher scenario. These increments may be attributed to the enhanced benefits associated with increased basal area and elephant populations, as previously mentioned. For instance, income can be generated through carbon trading, linked to carbon accumulation from a growing basal area (Yang & Li, 2018) and through tourism fueled by a rising elephant population (Meyer et al., 2021).

2.6.4 NPV for households

Our simulations show that the increase in landscape connectivity lowers the NPV per household. This suggests that it is relatively less beneficial for a rational farmer to engage in landscape conservation, at least voluntarily without payment. These findings align with a broad range of cost-benefit analyses in conservation literature in SSA, which demonstrate that farmers' decisions to conserve result in net losses (Balana et al., 2012; Wainaina et al., 2020), thereby discouraging conservation decisions.

As expected, the outcome (difference in NPV) was most sensitive to our estimates of low landscape connectivity. This suggests that households are likely to benefit under low connectivity compared to when connectivity increases. The positive relationship between NPV and the discount rate indicates that the profitability of conservation aligns with households' preferences for present benefits over future ones, as also observed by Balana et al. (2012). Net benefits of crop farming per hectare and their changes over time were found to negatively correlate with household NPV in IIWC as connectivity increases. This suggests that a decline in agricultural income imposes significant costs on households, which conservation benefits alone cannot fully offset (see also Green et al., 2018). This finding aligns with Balana et al. (2012) and Kaboré et al. (2024), who demonstrated that converting cropland to forests reduces the NPV for households. Lower household NPV with increased conservation area could also be attributed to a potential increase in negative conservation externalities on the remaining non-conserved farms (e.g., crop raiding) as in Yang et al. (2020).

2.6.5 NPV for government

Our model consistently revealed negative median NPV per hectare for government investments in IIWC. In contrast, BKG showed over a 50% chance of positive NPV, but only under high connectivity scenario. This suggests that government investments in IIWC connectivity are not economically viable, whereas investments in BKG could be profitable under high connectivity. The profitability of BKG is likely influenced by the presence of diverse conservation-supportive livelihoods, such as butterfly farming and beekeeping. Furthermore, BKG's lower opportunity costs of conservation (e.g., foregone crop farming rents) compared to IIWC make it easier to offset through alternative land uses.

Government NPV at the landscape level increased under medium and high connectivity scenarios for both ecological corridors, with higher gains observed in high connectivity scenario. This indicates greater economic viability when over 80% of the landscape is conserved contiguously. The positive viability is likely attributed to the lower costs of community conservancy approaches, as assumed in this study, compared to centralized protected areas. This aligns with findings by Giudice & Börner (2021) and Nyamoga (2016), who reported reduced implementation and monitoring costs in decentralized conservation management.

Carbon-related variables, such as stem carbon at baseline, accumulated stem carbon stock per year, and price of carbon per ton, were identified as important variables explaining the positive NPV. This suggests that measures to enhance carbon storage – for example, through exclosure of the conserved landscape – can support more government benefits while minimizing management costs (see also Tamba et al., 2021). Our findings are supported by Balana et al. (2012), who demonstrated that the net present value is volatile to changes in biomass production in the Tigray region of northern Ethiopia. Our sensitivity analysis indicates that NPV is likely to be positive as the unit price of carbon increases. This is consistent with findings by Nuru et al. (2014) and Yang & Li (2018), who observed a positive association between carbon market prices and profitability of conserving African forests.

2.6.6 Implications for conservation actors and policymakers

This study provides valuable insights for policymakers and conservationists, especially regarding the conservation of ecological corridors in Tanzania. Our findings suggest a clear increase in forest stock and elephant populations as connectivity increases. This provides a compelling justification for investing in the conservation of ecological corridors, with a reasonable certainty of realizing ecological outcomes. However, such investments should prioritize high landscape connectivity over lower connectivity scenario. Additionally, policymakers may need to account for multiple ecological outcomes associated with connectivity, such as soil conservation, nutrient recycling, and micro-climate regulation. Although these outcomes were not explicitly addressed in this study, they can be inferred from evidence in similar studies, such as Dong et al. (2024).

While ecological outcomes deserve priority in decision making, the socioeconomic aspects of local farmers are equally critical. Due to socio-ecological complexity, achieving ecological outcomes is less likely if the social dimensions of local farmers are undermined. For instance, although the government currently promotes voluntary conservation policies (i.e., voluntary retirement of farmland), it is often difficult to isolate farmers' decisions from various underlying motives e.g., peer pressure, influence from opinion leaders, or the desire for personal recognition. Such underlying motives may have varied social impacts in the long run, potentially complicating conservation efforts. This is particularly relevant in cases where conserved landscapes are placed under partial or strict exclosure, denying access to ecological resources (e.g., non-timber forest products) (Tamba et al., 2021). Under such challenging conditions, farmers may regret their decisions and attempt to reclaim their lands, leading to social conflicts.

Thus, to ensure fairness and equity for farmers, as well as the sustainability of conservation interventions, exclosure would lead policymakers to consider adopting payment for ecosystem services (PES) policies to compensate farmers for their losses. This policy direction would help justify confinement of the conserved landscape, restricting access to facilitate rapid self-regeneration of ecological assets.

PES has proven to be a successful policy tool for conservation in many tropical ecosystems (Wunder et al., 2020) including in the conservation of degraded landscapes (Dong et al., 2024). However, selecting the specific design and modality of PES from the diverse options available in the PES portfolio requires systematic and context-specific investigation. For instance, it is crucial for payment modalities to reflect the actual opportunity costs of conservation while also improving distributional outcomes (Börner et al., 2016a).

Additionally, behavioral considerations, (e.g., crowding effect), contextual factors, and intrinsic determinants of PES are non-trivial (Rode et al., 2015; Palmer et al., 2020). These factors must be addressed alongside land ownership, governance structure, and social connectedness among farmers (Wunder et al., 2020).

The next key policy question is how the financing of such conservation interventions can be possible through PES, particularly in low-income countries like Tanzania. Although our study does not explicitly assess conservation financing, we offer some policy-provoking insights. One potential source of funding is income generated from ecotourism in protected areas, including those connected by ecological corridors. For instance, the government of Tanzania generated approximately 3.4 billion USD in 2023 from eco-tourism, primarily in protected areas (United Republic of Tanzania, 2023). This represents substantial income, a portion of which could be re-invested in the conservation of ecological corridors as part of the investments in protected area development.

The integration of ecological corridors into protected area management and budgeting is critical due to its importance in sustaining connected protected areas (Frazee et al., 2003). To facilitate such financing, the government of Tanzania may need to grant protected area authorities a *de-facto* financial autonomy by allowing them to retain their revenue collections for biodiversity development projects within the country. Furthermore, leveraging carbon credits from the rich carbon stocks within protected areas could be another effective option to enhance financing for ecological conservation, as also suggested by Koh et al. (2021).

The second key funding source is conservation NGOs and international community, which have already made substantial contributions to financing conservation efforts in low-income countries like Tanzania (Levine, 2002). However, it is imperative that such support is tied to the conservation of degraded ecosystems (e.g., restoration of ecological corridors) rather than solely the preservation of already conserved landscapes (e.g., payment to reduce deforestation in conserved forests).

Third, our results for BKG suggest that household benefits may increase in the long run as connectivity increases to medium or high scenarios. Although the observed increase in benefits was generally smaller than the rise in costs, it highlights the potential for additional income that could help offset some of the farmers' expenses, such as lost agricultural rent. The increase in benefits could be attributed to butterfly farming in tropical forests, driven by the high demand of butterflies in international markets (Morgan-Brown et al., 2010). This presents an opportunity for the government of Tanzania to support butterfly farming by creating and enhancing a conducive environment for its production and improving access to markets. Similar support could be extended to other products, such as honey from local beekeepers.

The government may also need to consider subsidizing these eco-friendly enterprises, particularly those operating in ecologically sensitive landscapes, to better align net gains with conservation efforts. Previous studies on integrated conservation and development programs have shown that conservation co-benefits can compensate for opportunity costs over the long term (e.g., Blom et al., 2010).

Given the high opportunity costs of conservation, it is evident that conservation success cannot be fully achieved without addressing agricultural policies that are ecologically unproductive. Our findings on the sensitivity of NPV to opportunity costs (net benefits of crop farming) illuminate the need to de-incentivize agricultural development in ecologically sensitive landscapes. Failing to do so risks an increase in agricultural rent per hectare, which could further exacerbate land and ecosystem degradation at large. Such an increase in rent may further inflate the conservation budget (e.g., through higher compensation) if conservation interventions are delayed. This is corroborated by Nkonya et al. (2016), who concluded that the costs of inaction in addressing land degradation are higher than the costs of conservation and are likely to become even more expensive in the future.

2.7 Limitations of the study

This study has its limitations, which we acknowledge as key areas for further research. First, our study did not account for potential leakage or spill-over effects of landscape connectivity. Leakage effects might occur, for instance, through increased deforestation outside conserved landscapes, particularly when farmers face limited alternative income sources due to farmland retirement and when enforcement outside conserved areas is inadequate. Conversely, landscape connectivity could generate spill-over effects, such as increased agricultural production in adjacent farmlands, as demonstrated by Yang et al. (2020). If this positive effect is significant, it could potentially result in a rebound effect, where increased agricultural productivity may drive the expansion of farmlands, leading to further deforestation. An empirical assessment of the likelihood and magnitude of these effects would be valuable for policymakers to better understand the broader implications of landscape connectivity.

Secondly, our modeling considered a limited range of ecosystem goods and services and their interactions in yielding benefits. For instance, while we assumed that an increase in the elephant population might lower carbon stocks, it could alternatively support carbon storage indirectly through their ecological roles in seed dispersal, nutrient recycling, and their influence on forest structure. For example, a decline in elephant populations would reduce seed dispersal, a vital process for the regeneration of forests. Furthermore, limited forest damage by elephants could increase stem density, often of less biomass, and reduce the recruitment of large trees, which often have high wood density and, thus, decrease carbon stocks (Berzaghi et al., 2019). Further research could estimate a more comprehensive NPV by including a broader range of ecosystem services (e.g., provisioning and regulating) and explicitly modeling their interaction effects.

Finally, we acknowledge that our study defined landscape connectivity using only one dimension—specifically, the proportion of landscape conserved contiguously—without considering different configurations of landscape connectivity. Variations in the configuration of landscape connectivity, even with the same conserved proportions, could lead to different connectivity effects. Exploring these different configurations would be an interesting extension of our study.

2.8 Conclusions

We concluded that increased landscape connectivity supports the augmentation of ecological assets, specifically forest stock and elephant populations. The increase in forest stock (measured by basal area) from low to medium- and high-level scenarios was relatively greater in BKG than in IIWC. In IIWC, the elephant population increased by 20 individuals compared to the increase attributed to medium landscape connectivity.

Farmers appeared to gain more benefits than costs under the low connectivity scenario, with relatively higher estimates in IIWC than in BKG. However, further increases in landscape connectivity to medium and high scenarios led to a notable reduction in NPV (i.e., negative change in NPV). Thus, it is unlikely for a rational farmer to engage in landscape connectivity programs without compensation. Our sensitivity analyses revealed that this observed negative NPV change is largely driven by increased opportunity costs (i.e. rent from crop farming). This indicates that ongoing government reforms to enhance agricultural development in the country are likely to exacerbate conservation costs in ecological corridors if restoring landscape connectivity is postponed.

The estimates for government NPV per hectare were not sufficiently clear to draw definitive conclusions. However, at the landscape level, our estimates clearly indicated that aggregate costs increased at a lower rate than aggregate benefits, resulting in a positive NPV. This trend was observed when landscape connectivity consistently increased to medium and high scenarios in both ecological corridors. The positive change in NPV resulting from increased connectivity was relatively greater in IIWC than in BKG, likely due to significant differences in landscape size between the two ecological corridors.

Our conclusions are based on a holistic analysis approach which accounted for potential risks. Thus, the recommendations and policy implications identified in this study are deemed robust for policymakers to make informed decisions. This study reinforces earlier findings (e.g., Tamba et al. 2021) that decision analysis can be instrumental in addressing partial information and system complexity to support decision-making processes. This is achieved by presenting a distribution of plausible decision outcomes through simulations of ranges and probability estimates (e.g., costs, benefits and risks) derived from experts.

Chapter 3: Incentives for biodiversity conservation under asymmetric land ownership

Abstract

The effectiveness of biodiversity conservation initiatives depends on their ability to maintain and restore the integrity and connectivity of ecological systems. Payments for environmental services (PES) can encourage farmers to set aside land for conservation, but landscape connectivity requires coordination among land users. Fairness in the distribution of payoffs has been shown to affect conservation efforts in response to PES, but the sources of inequality in payment allocation mechanisms can be manifold. Here we focus on the performance of conservation incentives under alternative payment modalities and levels of inequality in land ownership. We applied lab-in-the-field experiment with 384 Tanzanian farmers from two ecological corridors. Groups of participants were endowed with either equal or unequal amounts of hypothetical farmland and subsequently exposed to two treatments, namely a fixed individual payment and a fixed payment with an agglomeration bonus. Both payment modalities had positive effects on conservation, but we find no strong evidence for impact of asymmetries in landownership on conservation decisions. Overall, our results suggest that conditional payments can be effective even when land with high conservation value is unequally distributed in ecological corridors.

Keywords: Payment, Agglomeration bonus, Conservation, Landscape connectivity, Ecological corridor, Framed field experiment

3.1 Introduction

Despite considerable efforts, biodiversity continues to decline at an unprecedented rate, which increasingly threatens planetary health and human wellbeing (Diaz et al., 2019). Ecological or wildlife corridors are a key element in strategies towards achieving the recently adopted goal of the Convention on Biological Diversity (CBD) to protect 30% of land globally by 2030 (Convention on Biological Diversity, 2022). The effectiveness of ecological corridors for biodiversity conservation depends on whether protection enhances landscape connectivity (Mtui et al., 2017). Landscape connectivity plays an important role for the conservation of biodiversity by facilitating wildlife movements. The relevance of connectivity varies based on the dispersal range of specific species. For example, large mammals with high dispersal ranges, such as elephants *(Loxodonta africana*), benefit more from connectivity across landscapes than small species such as the large blue butterfly *(Maculinea teleius*), which can survive on small and more isolated patches (George et al., 2013; Kiffner et al., 2022). Higher levels of landscape connectivity are generally beneficial for multiple migratory species and also enhance flows of other ecosystem services such as pollination and nutrient cycles (Mitchell et al., 2013). However, these corridors often cut through privately owned farmland. Allocating agricultural land for conservation, therefore, comes with opportunity costs for farmers via reduced agricultural production and farm income as well as related risks of food insecurity.

To encourage voluntary conservation actions, many countries are experimenting with conditional incentive schemes, such as Payment for Ecosystem Services (PES). Many such schemes, however, were shown to underperform in terms of conservation effectiveness (Wunder et al., 2020). Both participation and compliance in PES schemes are driven by complex interactions between aspects of incentive design and local contextual factors, including monetary and non-monetary behavioural motives (Howley & Ocean, 2020). Research about the relevance of these motives and their consequences for behavioural change remains inconclusive (Cortés-Capano et al., 2021).

Conservation incentives can be designed to affect individual and collective decision making. Most existing PES schemes rely on fixed individual area-based payments (Ngoma et al., 2020; Hayes et al., 2019; Gatiso et al., 2018; Ezzine-de-Blas et al., 2016). Individual payments are often preferred over other payment modalities for reasons of administrative simplicity and perceived fairness, but varying levels of performance in terms of cost-effectiveness have been documented in the literature (Samii et al., 2014; Snilsveit et al., 2019; Wunder et al., 2020). Impact variability has been attributed to economic factors, such as variation in conservation opportunity costs, but also to variations in cultural and socio-political contexts as noted by Gatiso et al. (2018). The size of the payment and pre-existing intrinsic conservation motives matter according to studies that document varying levels of participation in schemes that only partially compensate for opportunity costs (see Vorlaufer et al., 2017 and Rudolf et al., 2022). Incentive design and resulting payment modalities thus represent an important entry point for understanding PES effectiveness (see for example Gatiso et al., 2018, Wunder et al., 2020, Nguyen et al., 2022).

In the context of biodiversity conservation, fixed individual payments can be suboptimal if they lead to isolated patches of conserved land with little benefits for landscape connectivity (Parkhurst et al., 2002). In order to promote landscape connectivity, Parkhurst et al. (2002) proposed an agglomeration bonus (AB). The AB can be offered as a supplement to a fixed individual payment to encourage land users towards conserving connected fragments of land (Parkhurst & Shogren, 2008, 2007; Parkhurst et al., 2002). Following Parkhurst et al. (2002), the AB comes with a coordination problem: it resembles a classic coordination game with two potential Nash equilibria (Clark et al., 2001), where land users have to cooperate to achieve the pareto optimal conservation outcome that maximizes pay-offs. The performance of an AB was explored under laboratory conditions, for example, with and without communication (Warziniack et al., 2007), with different group sizes (Banerjee et al., 2012), with different information flows (Banerjee, 2018), and under varying transactions costs (Banerjee et al., 2017). The findings from Warziniack et al. (2007) showed that communication facilitates coordination and increases conservation efforts. This was corroborated by Andersson et al., (2018) in a framed field experiment and a multi-country analysis including Tanzania.

In an observational study, Huber et al. (2021) showed that spatial factors affect the uptake of agglomeration payment schemes in a Swiss mountain region. Rudolf et al. (2022) compared the effect of threshold and agglomeration payments on environmental benefits generated by Indonesian oil palm farmers in a field experiment. Both studies confirm the potential of AB to increase landscape connectivity, but Liu et al. (2019) report mixed evidence as to the effectiveness of AB to induce bidding patterns in favour of landscape connectivity based on auction experiments in rural China. This empirical finding confirms the theoretical prediction that ABs do not necessarily induce optimal coordination among farmers (Clark et al., 2001). Even if farmers agree on a mutually beneficial conservation strategy, e.g. during the communication phase, coordination failure may occur if trust is insufficient or the pay-off distribution violates local equity norms (Loft et al., 2019, 2020). Thus, differences in results across this small number of studies is likely due to variation in local context factors, including, for example, distributive (fairness in distribution of resources), procedural (involvement and inclusivity in resource allocation), and recognitional (acknowledgement or integration of social values, norms, local knowledge and rights) inequality, or varying levels of trust (Pascual et al., 2014). In lab experiments, these factors were shown to be strong enough to determine levels of collective actions among social actors and therefore warrant further research in a lab-in-the-field setting (Cardella & Roomets, 2022; Wichardt, 2012; Rode, 2010).

Importantly, poor performance of incentive schemes has been attributed to distributional asymmetries under which payments may compromise conservation impacts (Lliso et al., 2021; Duong & de Groot, 2018; Loft et al., 2017; Wegner, 2016), for example by reinforcing social differentiation (To et al., 2012). Loft et al. (2020) confirmed this notion in an experiment with Vietnamese farmers, where participants, who were disadvantaged by unequal payments, exerted significantly less conservation effort than participants, who received the same payment under the equal payment distribution.

Asymmetry in access to or ownership of land can be a key underlying payment distribution mechanism in PES (Jones et al., 2020; Andersson et al., 2018) and has so far not been systematically considered in the experimental literature on incentive-based conservation. Smallholders may have limited bargaining power in collective negotiation processes and will naturally receive lower absolute transfers if land size is the main payment allocation mechanism in a conservation scheme (Vorlaufer et al., 2017; Börner et al., 2016a). Inequality in land endowments may also have negative effects on cooperation by decreasing levels of trust or willingness to coordinate or engage in negotiations among social actors (Andersson & Agrawal, 2011; Gangadharan et al., 2017). A potential underlying mechanism leading to such outcomes is relative deprivation. Relative deprivation was shown to be associated with limited pro-social behaviour due to perceived unfairness (Qu et al., 2023; Skylark & Callan, 2021; Zhang et al., 2016) and may thus lead to sub-optimal participation in collective efforts towards conservation (Loft et al., 2020).

Few studies have examined how land size heterogeneity may affect the performance of PES programs. Narloch et al. (2012) conducted a public good game with farmers from Peru and Bolivia under heterogeneous land ownership. They found no evidence for individual payments to be less effective for disadvantaged participants, but did not explore payment designs that required coordination between individual participants. Using an investment game, Vorlaufer et al. (2017) compared the effectiveness of redistributive and flat-payment on conservation and social equity under land size heterogeneity in Indonesia. The redistributive scheme in favour of small landowners was found to improve the overall conservation outcome. Here the underlying mechanism was considered to be a difference in conservation opportunity costs, but a counterfactual scenario with homogeneous land distribution was not explored.

Here, our main contribution lies in systematically comparing the conservation decisions of smallholders under condition of symmetric (equal) versus asymmetric (unequal) land ownership. We do so under two alternative treatments and control conditions. The two treatment conditions differ in terms of potential maximum net benefits derived by smallholders versus large landholders under asymmetric land ownership. This allows us to test for relative deprivation and, consequently, coordination failure as a potential underlying mechanism explaining differences in the conservation response of smallholders under the two treatments and (land) distributional settings (see Section 2.0 for more details).

We find that both treatments effectively induce the intended conservation behaviour. Smallholders in the subgroup with unequal land distribution were marginally less willing to conserve than smallholders in the subgroup with equal land distribution, but this difference was not statistically significant. We also discuss efficiency considerations.

The remainder of the paper is organized as follows. In section 3.2, we describe the study area context and experimental design along with our hypotheses. We also document the data collection process and all analytical steps. In sections 3.3 and 3.4, we report and discuss our results. Conclusions are offered in section 3.5.

3.2 Study area, methods, and data

3.2.1 Study area

Tanzania is one of the world's most biodiverse countries (Myers et al., 2000), with most of its biodiversity confined within small and fragmented protected areas (Mtui et al., 2017). The conservation of ecological corridors is recognized as important by the government of Tanzania (Kiffner et al., 2022) and supported by community-based natural resource management. However, these efforts lag behind expectations, likely due to high conservation opportunity costs for local communities (Milupi, 2017; Moyo et al., 2016). In addition, forced displacement and relocation of farmers in various ecological corridors, such as Darema, the Ihefu wetland, and the Kilombero floodplain, were met with harsh criticism by national and international organizations (Cernea & Maldonado, 2018). The Tanzanian government will therefore be reluctant to impose the creation of new wildlife corridors (as planned in a corresponding wildlife conservation regulation passed in 2018, see United Republic of Tanzania (2018)) in a top-down manner. The wildlife conservation regulation foresaw consultations with local governments and villagers in order to seek consent for voluntary farmland retirement without any financial compensation. Yet, as Tanzania's rural population grows, voluntary farmland retirement becomes increasingly unlikely. Cost-effectively designed conservation incentives could thus become a feasible alternative to expand the existing network of wildlife corridors. Financial incentives to encourage conservation have rarely been employed in the Tanzanian context. We are, however, aware of at least one planned donor-based intervention project compensating farmers that decide to retire land for conservation in the Nyerere-Selous-Udzungwa corridor, where biodiversity is highly threatened by agricultural expansion (MNRT, 2022).

3.2.2 Experimental design

Framed or lab-in-the-field experiments have become a valuable tool for conservation planning (Cinner, 2018) and can help address knowledge gaps related to human behaviour in applied policy research (Nelson et al., 2018). To avoid the problematic connotation of the term "experiment" in the context of working with humans, we used the term "conservation game" in all communications with local partners and farmers, in line with Rudolf et al. (2022). Subsequently, we thus often refer to our framed field experiment as a conservation game. The game was framed around the decision between conservation or farming (business-as-usual) individually owned parcels of land. It involved a total of 384 farmers, who were randomly divided into two equal subgroups of 192 participants. In each subgroup, multiple teams of four players were randomly assigned to either Treatment (TG) or Control (CG) groups. Thus, each subgroup consisted of a total of 24 teams in TG, as well and the CG. One subgroup was endowed with an equal number of parcels (labelled "equal" in Figure 3.1a) and another subgroup was endowed with an unequal number of parcels (labelled "unequal" in Figure 3.1b).

In the "equal" subgroup, each farmer was allocated two hypothetical land parcels: one with low (L) and one with high (H) agronomic and ecological value. In the "unequal"[1]

[1] Our framing of land inequality was based on heterogeneity in farm size instead of focusing on disparities in land quality. This framing was designed in line with the prevalent action-based PES schemes, which primarily aim to conserve a vast and diverse range of land, including the restoration of degraded ecosystems (Gibbons et al., 2011).

subgroup, two players were allocated four rather than two parcels (i.e., 2Hs and 2Ls) to reflect a reality in which smallholders are neighbours of large farmers. This endowment reflects variation in the size of farms in the study regions, for which prior research informed that over 80% of farmers own an average of about 2 hectares and 17% own around 4 hectares (David et al., 2022). This choice later proved to be adequate also for our specific sample, where the farm sizes of participants average 1.1 ha in the second quartile and 2.6 ha in third quartile. The landscape configurations (Figure 3.1a and 3.1b) are pre-defined, such that each player has two neighbours and H parcels are contiguous to each other at the centre. The arrangement of H parcels thus mimics a connected landscape with high ecological value that the regulator aims to conserve. Both treatment and control groups in each subgroup played three consecutive rounds that corresponds to the treatments. The first round served as a baseline treatment involving conservation sensitization. The first and second treatments implemented in the TG came with an individual payment and the individual payment plus an agglomeration bonus, respectively. The CG continued with the baseline treatment in all three rounds (see the "*The baseline stage*" to "*Treatment two*" sections below). In all three rounds, players could decide whether to conserve or farm any of their parcels, i.e., 1152 observations of land use decisions (see more details in section 3.4.4 in the Appendix).

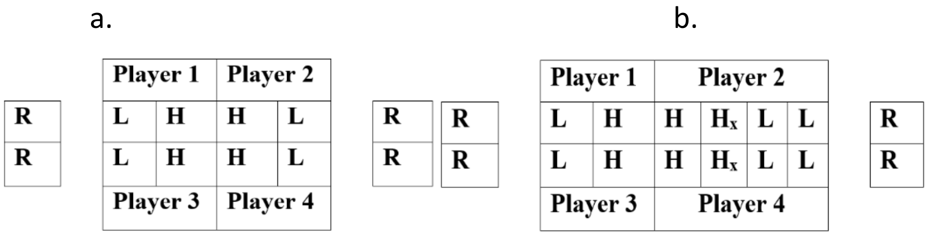

Figure 3.1a: Spatial configuration of farmland illustrating equal distribution of farmlands (Equal), location of each player and farmland owned. Figure 3.1b. Spatial configuration of farmland illustrating unequal distribution of farmlands (Unequal), location of each player and farmland owned. H and Hx represents farmland parcel with higher agronomic and ecological value and L represent farmland parcel with relatively lower agronomic and ecological value. R represents land parcels framed as a potential farmland that is reserved for future use; this land could be utilized for subsistence or as a safety net.

Based on each decision, public benefits and private payoffs were calculated according to a previously explained procedure. The private payoff reflects the agricultural revenue of non-retired parcels. The revenues were determined as product of maize yielded for each parcel and hypothetical market price of maize. We set L parcels to yield 2 bags of maize where one bag was equivalent to TZS 500[2]. Thus, farming one L parcel yielded TZS 1000 (≈ USD 0.43) and farming an H parcel implied a TZS 2000 (≈ USD 0.86)[3] private payoff. We framed the environmental benefits that accrue if parcels are retired as an (external) public good to be twice as high as the private return (i.e., TZS 2000 for each retired L parcel and TZS 4000 (≈ USD 1.72) for each retired H parcel). Additionally, public environmental benefits of TZS 1000 were generated for each border of a retired H parcel that is shared with another conserved H parcel. Equation (3.1) illustrates how total environmental benefits are calculated:

$$\pi_{i,t}^{C}=[2000C_L+4000C_H]+[1000B_H] \tag{3.1}$$

where $\pi_{i,t}^{C}$ represents public environmental benefits for farmer *i* in round t, C_L is the number of conserved L parcels, C_H is number of conserved H parcels. B_H is the number of a shared borders between conserved H parcels.

Hence, conservation benefits outweighed private benefits motivating government intervention. Participants were informed that the public payoff will contribute to conservation via a donation to an organization that supports habitat restoration in wildlife corridors. The public payoff thus reflects public environmental benefits (in terms of monetary value) accrued as a result of a farmer's decision to conserve in the game (see also Sandbrook et al., 2015). We donated the accumulated public payoffs from the experiment to a local conservation NGO in Tanzania (Tanzania Forest Conservation Group). The name of the NGO was not disclosed to the participants to avoid reputational bias.

[2] The price of maize was framed to account for a possibility of a farmer to be compensated for the real-time spent in the game. Maize was selected because of its dominance over other crops in many rural areas of Tanzania including the study sites.
[3] A currency conversion of TZS 1 to USD 0.00043 of 15th April 2022 taken from OANDA was adopted (https://shorturl.at/fsuEO)

To determine the actual amount a farmer would receive at the end of a post-experiment survey and the donation we would give to a conservation NGO, one out of three game rounds was selected randomly. A corresponding personal payoff was added to a fixed participation fee of TZS 2500 (≈ USD 1.075) for each participant. The public payoffs in terms of conservation benefits obtained in the selected round were donated to the Tanzania Forest Conservation Group (TFCG). On average farmers received TZS 5,592 (≈ USD 2.4), which is equivalent to 2.5 to 3 hours wage rate in the studied villages. A total of TZS 1,359,500 (≈ USD 584) was donated to TFCG. The experiment together with hypothesis and pre-analysis plan were pre-registered in Open Science Framework before actual data collection (Nyanghura et al., 2022). "*The baseline stage*" to "*Treatment two*" sections below summarize the treatments and how participants were assigned to the respective groups in each round. A detailed documentation of the treatment plan and overall game procedure is provided in section 3.4.4 in the Appendix.

The baseline stage

In the baseline **(T0),** all participants were exposed to a "cheap talk" on the environmental benefits of conservation in order to reduce the effect of hypothetical bias related to the experimental framing (Penn & Hu, 2019). In our cheap talk, a colored visual poster was used to highlight how conservation contributes to ecosystem service provision, such as habitat for wildlife, climate regulation, and pollination. This was equally relevant to reduce heterogeneity regarding the perceived biodiversity conservation value (e.g. due to different levels of knowledge about biodiversity conservation and ecosystem services). Furthermore, we emphasized that all decisions are voluntary, independent and communicated privately to create environment for fair decision making. Similar to the experiment by Parkhurst & Shogren (2007) players in each team were permitted to engage in non-binding communication without time constraints. Communication mimics a real-world experience, where farmers are likely to interact when an intervention is introduced. After the communication phase, each player made a private decision on whether to keep farming or retire one or more of the parcels for conservation.

Treatment one: Conditional payment (PY)

In the second round, the CG repeated the baseline game and the TG was offered an individual conditional payment (**T1)** equivalent to TZS 1000 for any parcel that is retired for conservation. Other settings in terms of communication, public payoff and constant participation fee remained the same as in the baseline stage. Under T1, large farmers in the unequal subgroup could obtain proportionally larger absolute transfers. But, since payments are merely compensatory, net benefits from participation in the conservation scheme were always the same (i.e. zero) for large and small farmers. A comparison between small farmers in the equal subgroup and small farmers in the unequal subgroup under T1 thus explores whether relative deprivation is triggered merely by a potential difference in the size of transfers (see hypothesis 2 below).

Treatment two: Combined payment and agglomeration bonus (PY + AB)

In the third round, the CG repeated the baseline game and the TG was offered an agglomeration bonus (T2) adding TZS 750 (≈ USD 0.32) as a private payoff to the conditional payment for each retired H parcel bordering another retired H parcel, regardless of ownership. As such, the size of the AB was 75% of the uniform payment for a single shared border and 150% for two shared borders. This decision was made for T2 to result in a coordination game with two alternative Nash equilibria, where the pareto optimal outcome overcompensates players for opportunity costs and potentially also transaction costs as in Fooks et al. (2016) and Banerjee et al. (2017). This design also resulted in different maximum levels of overcompensation for large and small farmers in the “unequal” group, which enabled us to test for potential behavioural responses to relative deprivation. Our design resulted in a smaller difference between the uniform treatment and the AB than used in some earlier studies (e.g., Banerjee et al. (2017), but pre-tests indicated that the difference was sufficient to induce the expected behavioural response. Other settings in terms of communication, public payoff and constant participation fee remained the same as in the baseline stage. More details on treatment design are provided in section 3.1 in the Appendix).

3.3 Hypotheses

We designed our experiment to test hypotheses about farm-level decision-making behaviour under two different incentive designs and conditions of equal versus unequal land distribution. Baseline environmental benefits per participant are calculated as in equation 3.1. Private payoffs are:

$$\pi_{i,t}^{p} = [1000F_L + 2000F_H] \tag{3.2}$$

Where $\pi_{i,t}^{p}$ represents personal benefits (framed as private payoff) contributed by the decision of farmer i in round t. F_L and F_H are the numbers of L and H parcels under cultivation.

Assuming profit maximization, farmer i must be expected to cultivate all parcels (i.e., max $\pi_{i,t}^{p}$ with $\pi_{i,t}^{c}$ = 0 unless there are intrinsic conservation motivations[4] (Van Hecken et al., 2019; Zabala et al., 2017). Such intrinsic motivations may be mobilized, for example, by traditional knowledge, education, and environmental awareness raising.

Conservation incentives can reinforce intrinsic conservation motivations as they fully or partially compensate for opportunity costs (Huber et al., 2021). Let N_c represent the total number of parcels conserved by farmer i in round t (i.e., N_c=C_L+ C_H) Then, equation (3.3) represents private profit under T1. Equation (3.4) extends equation (3.3) to include an agglomeration bonus (T2).

$$\pi_{i,t}^{p} = [1000F_L + 2000F_H + 1000N_c] \tag{3.3}$$

$$\pi_{i,t}^{p} = [1000F_L + 2000F_H + 1000N_c] + 750B_H \tag{3.4}$$

Both treatments at least compensate farmers for conserving L parcels. This motivates our first hypothesis:

[4] We measured intrinsic motivations, but focus here on testing our pre-registered hypotheses on average treatment effects.

H1. Conditional financial incentives enhance conservation[5]

Note, however, that the individual payment only partially covers the opportunity costs for the retirement of H parcels, but fully compensates for the conservation of L parcels. Conserving H parcels under T1 would thus require some intrinsic conservation motives. Under T2 the fixed payment is augmented by the AB, which can eventually come to overcompensate individual players for conservation opportunity costs. Maximum compensation, however, requires coordination with neighbours, i.e. players have to trust that neighbours will behave reciprocally. This makes T2 inherently different from T1. Maximum landscape connectivity requires all H parcels to be conserved and therefore hinges on coordination. However, large landholders in the unequal group can achieve higher levels of pay-offs (and landscape connectivity) than smallholders without coordination. We therefore focus in our analyses on the individual behavioural outcomes of smallholders in the equal versus unequal groups.

Deviations from rational behaviour could moderate the effectiveness of conservation incentives (Howley & Ocean, 2020). According to the theory of relative deprivation (Runciman, 1966), the belief that one is worse off, inferior, or relatively resource deprived compared to others, may reduce pro-social and cooperative behaviour. In our experiment, small farmers in the unequal subgroup know that their counterparts hold larger areas of land and thus are able to obtain higher revenues from agriculture or conservation payments. Under T1 large landholders receive higher absolute payments than small farmers, but they never have higher net benefits, because payments are designed such that they can only cover partial opportunity costs on average. Under T2, however, large land holders can obtain larger absolute net benefits than smallholders This allows us to test whether relative deprivation has a relevant effect on the response of smallholders comparing their behaviour under asymmetric and symmetric land ownership (i) without any payment (relative resource deprivation), (ii) with fixed compensation payments (relative deprivation due to potentially unequal compensatory

[5] This hypothesis was not preregistered. The final experimental design did not allow us to rigorously test for motivational crowding effects as planned in the pre-registration."

transfer levels) and (iii) with potential compensation beyond opportunity costs (relative deprivation due to unequal levels of overcompensation). We hypothesize:

H2. Small farmers conserve less in subgroups with large farmers (unequal land distribution) than in subgroups with equally sized farmers (equal land distribution)

3.3.1 Data collection and setting of experiment

We collected data from farmers in eight villages out of twenty-two within the Igando-Igawa Wildlife corridor (IIWC) and two out of four in Baga-Kisima Gonja (BKG). The selection of villages was not random, but influenced by accessibility and our goal to capture spatial variation in population densities. A total of 384 farmers, who were household heads or spouses, were selected randomly from a respective village register and invited to participate in the experiment and post-experiment survey (see section 3.4.1 in the Appendix for detailed sample selection process). The sample size is informed by a power calculation (see details in section 3.4.1 in the Appendix). Eighty four percent (84%) of invited participants showed-up for the experiment. Participants who did not show up, were replaced with other farmers with the help of village leaders. Two participants terminated their engagement in the course of the post-survey due to time constraints, but the collected information was still useful and missing data were substituted by averaging over the group peers[6]. We conducted the actual experiment between April and May 2022 in the selected villages (Figure 1.1). Before the experiment, we conducted a pre-test in February 2022 in two villages in IIWC, Manienga and Igava. In each village, the experiment started once eight participants arrived with a general introduction of the research team and study. Written consent was sought before we assigned teams of four players randomly to four different groups (equal or unequal subgroups and treatment or control groups). Two farmers, who decided to offer verbal consent instead of written, were allowed to participate in the study. We organized four sessions per day (two in the morning and two in the evening) and every village was visited more than once. No information spillover effect was observed as a result of

[6] Results are robust to removing these two respondents from the analysis.

visiting each village more than once (see section 3.4.2 in the Appendix for detailed on testing for spillover effects).

3.4 Analysis

Our variable of interest is conservation measured in terms of environmental benefits ($\pi_{i,t}^{c}$ in equation (3.1)). Differences in environmental benefits in response to alternative treatments reflect variation in conservation effectiveness. Because of the zero truncation in the dependent variables, we estimated the treatment effect using a Tobit model and conducted a robustness check with a linear model and an ordered Probit model. Thus, we estimated hypothesis 1 and 2 using equations (3.5) and (3.6), respectively. Standard errors were clustered at individual level. We chose a between subject-design to minimize bias due to order effects. We implemented the experiment such that potential round effects are minimized, e.g., through avoiding giving feedback on player's earnings between decisions from respective rounds similar to Vorlaufer et al. (2017).

Budget efficiency (BE) is an outcome of interest for policy makers. BE was defined as environmental benefits generated per unit of budget spent at individual level. Budget efficiency was computed for payment spent (PY) using within-subject analysis, controlling for round effect (equation 3.7). We do the same for payment plus agglomeration bonus spent (PY + AB) using equation 3.8.

Our independent variables of interest included treatments (payment = T1 and payment + agglomeration bonus = T2), and land equality versus inequality subgroups (LD), which were all measured as binary.

$$\pi_{i,t}^{c} = \beta_0 + \beta_1 Treat + \beta_2 X_i + \beta_3 ENUM_j + \beta_4 COR + \varepsilon_{ij} \quad (3.5)$$

$$\pi_{i,t}^{c} = \beta_0 + \beta_1 LD + \beta_2 Treat + \beta_3 Treat^{*}LD + \beta_4 X_i + \beta_5 ENUM_j + \beta_6 COR + \varepsilon_{ij} \quad (3.6)$$

$$BE_{PY} = \frac{(TEB_{TG,t=2} - TEB_{TG,t=1}) - (TEB_{CG,t=2} - TEB_{CG,t=1})}{Total_{PY}} \quad (3.7)$$

$$BE_{PY+AB} = \frac{(TEB_{TG,t=3} - TEB_{TG,t=1}) - (TEB_{CG,t=3} - TEB_{CG,t=1})}{Total_{PY+AB}} \qquad (3.8)$$

Where $Treat$ ($T1$ = Payment and $T2$ = Payment + Agglomeration bonus) are included as dummy variables, with "$T0$ = No incentive" in control group as a reference. X_i is a vector of individual-specific covariates and $X_j$is a vector of group-specific covariates: these variables and their relevance are explained in the next section below. LD identifies the land ownership subgroup (Equal = 1, Unequal = 0). $ENUM_j$ controls for enumerator effects and COR controls for corridor effects (see next section below). TEB refers to average total environmental benefits at individual level, TG and CG are treated and control groups, respectively.

Control variables

In equation 3.5 and 3.6 we controlled for individual-specific covariates (X_i). These variables are defined in Table 3A.III in the Appendix. The variables include socio-economic and demographic characteristics (age, gender, education, household income, family size and total farmland owned by household), which are likely to influence decisions (see Chen et al., 2009; Hayo & Vollan, 2012). As trust may affect coordination among participants (Rakotonarivo et al., 2021), we controlled for self-reported existing levels of trust among participants towards other community members following the construct in Rudolf (2020). Further, as highlighted by Hayo & Vollan (2012), farmers are likely to bring real-world knowledge and experience to the game. As the real-world variation in decision-making power over land among our study participants is likely to matter (García-Morán & Yates, 2022), we included a corresponding control variable along with a measure of past dispossession experiences following Liu et al. (2019). Moreover, social and environmental relatedness may play a role in conservation decisions, e.g. through a reputation effect (Handberg & Angelsen, 2019). As in Handberg & Angelsen (2019), we controlled for the presence of friends and family members in each group. Environmental relatedness was measured by the extent to which a participant was already involved in conservation activities. Finally, we included corridor fixed effects to address unobserved confounding factors at corridor level and enumerator fixed effects to account for variations in enumeration styles.

3.5 Results

3.5.1 Sample characteristics and internal validity

Sixty-one percent of the total participants were male. On average, participants were aged 44 years with 7 years of schooling and 8.8 acres (3.6 ha) of farmland (Table 3A. IV in the Appendix). Eighty-nine percent of participants were either main decision makers in their household or hold a significant share of power in decision making with regards to land. Eleven percent had no decision-making power (i.e., decisions are made for example by children, members of clan etc.,). Table 3A. IV in the Appendix also shows that most covariates are balanced across experimental groups, allowing us to attribute experimental outcomes to treatment effects. The distribution of decisions (Figure 3A.III in the Appendix) is skewed towards “N” indicating that most participants opted for no conservation in the baseline, in particular in the control group. We further checked for internal validity by comparing the public environmental benefits between control and treated groups in the baseline. The differences are insignificant in the equal subgroup (Mann-Whitney U test: $p = 0.35$) and significant in the unequal subgroup (Mann-Whitney U test: $p = 0.05$). To determine the source of this difference we regressed baseline environmental benefits (separately for treated and control group) on individual-specific variables, village, and enumerator fixed effects, and the time at which the game was conducted (i.e., morning vs evening session). One village exhibited somewhat lower average environmental benefits in the control group ($p < 0.1$) than in the treated group and one enumerator dummy had a significant effect in treatment group ($p < 0.01$) (Table 3A. IX in the Appendix). Given balance in other characteristics, we attribute the isolated village and enumerator effect to chance (Morgan & Rubin, 2012).

3.5.2 Full sample average treatment effects on environmental benefits

On average, participants in the control subgroup with equal land ownership contributed 1.83[1.38, 2.29], 2.00 [1.51, 2.49], and 2.01[1.56, 2.46][7] worth of public environmental benefits over three rounds, respectively (Figure 3.3a). This contribution is significantly lower (Mann-Whitney U test: $p < 0.01$) than in the control subgroup with unequal land ownership (2.0 [1.21, 2.79], 2.35 [1.55, 3.16], and 2.0 [1.27, 2.73]) (Figure 3.3b). Within both subgroups (equal and unequal), public benefits contributed by control group participants were statistically similar (Kruskal-Walli's test: $p = 0.797$ and 0.629, respectively), but consistently different from zero (Mann-Whitney U test: $p <0.01$). Hence, participants were willing to contribute to biodiversity conservation even without policy support.

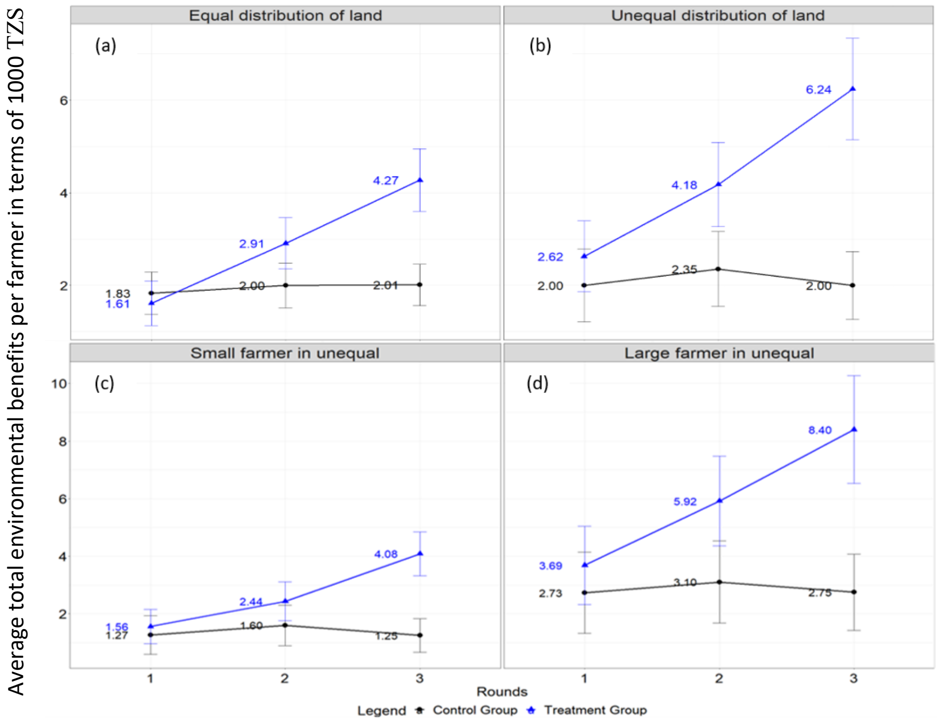

Figure 3.2: Average total environmental benefits per farmer comparing (a) equal land participants (b) unequal land participants as well as (c) small farmers in unequal and (d) large farmers in unequal.

The public environmental benefits contributed by the treated participants in the equal and unequal subgroups increase in response to each treatment. Figure 3.3 shows that

[7] 95% confidence intervals in brackets

the highest environmental benefits contributed under T1 was 4.18[3.26, 5.09] (second round) and 6.24 [5.15, 7.33] under T2 (third round), both under unequal land ownership. These estimates, however, are far lower than the maximum potential average environmental benefit of TZS 12.5[8] under unequal setting.

We estimated the treatment effects on environmental benefits for T1 and T2 using between-subject analysis (equation 3.5) and for the responses of round 2 and 3 respectively (Table 3.1). Our findings appear to be unaffected by potential learning bias (see results from testing for round effects in the control group in Table 3A. VIII in the Appendix). Both treatments significantly increase environmental benefits. Table 3.1 shows that T1 enhanced environmental benefits by approximately TZS 3 (Tobit model), while T2 increased environmental benefits by around TZS 5 (Tobit model). Model 2 confirms the robustness of results in model 1 using linear regression (see extension results in Table 3A.V in the Appendix).

Table 3.1: Full sample treatment effects on environmental benefits.

Variables	Tobit model (1)	Linear model (2)
Payment		
T1: PY (Dummy: 1 = TG, 0 = CG)	2.60***	1.32***
	(0.56)	(0.36)
Observations	384	384
R^2	0.05	0.17
Payment + Agglomeration bonus		
T2: PY+ AB (Dummy: 1 = TG, 0 = CG)	4.86***	3.21***
	(0.59)	(0.38)
Observations	384	384
R^2	0.07	0.28

*Note: Dependent variable is scaled by 1000 for easy interpretation of results. In each model specification we controlled for individual-specific covariates, enumerators' fixed effect and corridor fixed effects. Standard errors (in brackets) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01*

[8] The maximum conservation level for a small farmer is TZS 8 and TZS 17 for a large farmer. Thus, at full conservation level we expect an average total environmental benefit of TZS 12.5 in the unequal setting.

3.5.3 Treatment effects on small farmers in the equal versus unequal subgroups

To test our main hypothesis 2, we compared average total environmental benefits contributed by small farmers in the subgroup with equally sized farms (equal) and small farmers in the subgroup paired with large farmers (unequal, see Figure 3.3a and 3.3c). As expected, treated small farmers in the unequal subgroup conserved less on average (1.56 [0.97, 2.16], 2.44 [1.77, 3.11] and 4.08 [3.32, 4.85] in first, second and third rounds, respectively) compared to farmers in the equal subgroup (1.61[1.14, 2.09], 2.91[2.35, 3.46] and 4.27[3.60, 4.95]). This pattern consistently reflects control group behavior as mentioned earlier. Before testing whether the observed difference between equal and unequal is statistically significant, we checked whether our experiment induced perceptions of unfairness among participants in the unequal subgroup (Loft et al., 2020). This was important, because we predicted that higher individual relative deprivation (IRD, measured by perceived unfairness in distribution of experimental land) (Jia, 2022; Smith et al., 2012) among the less endowed farmers will stifle willingness to conserve. Indeed, small farmers in the unequal subgroup significantly perceived the land ownership distribution as less fair (fairness rating = 3.84 in the unequal versus 9.68 in the equal subgroup, Mann-Whitney U test: $p < 0.01$). We use this fairness gap as a measure of IRD (i.e., relative less fairness rating means high relative land deprivations). Details on how we measured IRD are documented in section 3.3 in the Appendix).

In fact, small farmers in the equal subgroup conserved more than small farmers in the unequal subgroup in all three rounds of the game, though the difference was small (see model 1, 4 and 7 in Table 3.2). The effect of T1 was significant for small farmers in the equal subgroup 2.71[1.57, 3.86] and insignificant in the unequal subgroup 1.26 [0.43, 2.95], respectively (model 2 and 3). T2 enhanced environmental benefits significantly by around TZS 4 worth of environmental benefits in each subgroup of equal and unequal (model 5 and 6). Results using the ordered Probit model are equivalent (see robustness check in Table 3A.VII in the Appendix).

Table 3.2: Treatment effects on environmental benefits among small farmers in the equal versus unequal subgroups.

Variables	First round	Second round (T1)			Third round (T2)		
	Equal & Unequal (1)	Equal (2)	Unequal (3)	Equal & Unequal (4)	Equal (5)	Unequal (6)	Equal & Unequal (7)
Equal/unequal subgroups (LD) (Dummy: 1 = Equal, 0 = Unequal)	0.70 (0.52)			0.42 (1.07)			0.22 (1.08)
T1: PY (Dummy: 1 = TG, 0 = CG)		2.71*** (0.58)	1.26 (0.86)	1.51 * (0.89)			
T1*LD				0.56 (1.07)			
T2: PY + AB (Dummy: 1 = TG, 0 = CG)					3.69*** (0.63)	4.18*** (0.80)	4.86*** (0.89)
T2*LD							-1.77 (1.10)
Observation	288	192	96	288	192	96	288
Pseudo R^2	0.02	0.07	0.59	0.05	0.07	0.61	0.07

Note: Dependent variable is scaled by 1000 for easy interpretation of results. For T1 and T2 we report results first separately for the equal and unequal subgroups and then for both groups jointly. In each model specification, we controlled for individual-specific covariates, enumerators' fixed effect and corridor fixed effects. Standard errors (in brackets) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

3.5.4 Budget efficiency

Beyond conservation effectiveness budget efficiency (i.e., additional environmental benefits per unit of spending) is an important decision criterion for policy makers. In Table 3.4 we report average total environmental benefits generated, the corresponding expenditure for compensation payments and the budget efficiency estimated based on equation 3.7 and 3.8. The results shows that efficiency of T1 is 1.16 in the equal and 0.67 in the unequal subgroup, while efficiency of T2 is 1.39 in the equal and 1.57 in the unequal subgroup. However, statistically there are no significant differences between the budget efficiency estimates in the equal and the unequal subgroups (a Mann-Whitney U tests yielded p-values of 0.24 and 0.36 for T1 and T2, respectively).

Table 3.3: Average total environmental benefits and respective total budget used to compensate small farmers.

Group and treatments	Equal			Unequal		
	TEB (TZS)	TC (TZS)	BE	TEB (TZS)	TC (TZS)	BE
Treatment group						
T2: PY + AB	4.27 (3.37)	1.78 (1.45)	1.39	4.08 (2.70)	1.60 (1.10)	1.57
T1: PY	2.91 (2.78)	0.97 (0.70)	1.16	2.44 (2.37)	0.81 (0.64)	0.67
T0: No incentive	1.61 (2.39)	0		1.56 (2.11)	0	
TOTAL _TG	**8.79**	**2.75**		**8.08**	**2.41**	
Control group						
T0_3: No incentive	2.01 (2.25)	0		1.25 (2.07)	0	
T0_2: No incentive	2.00 (2.43)	0		1.60 (2.49)	0	
T0_1: No incentive	1.83 (2.28)	0		1.27 (2.37)	0	
TOTAL_CG	**5.84**	**0**		**4.12**	**0**	

Note: TEB is the average total environmental benefits contributed by individual. TC represents respective average total compensation (i.e., equivalent to PY and PY+AB) and BE represents budget efficiency. Both TEB and TC are scaled by 1000 for easy interpretation of results. The number in front of T0 represents respective rounds. In brackets are standard deviations.

3.6 Discussion

We ran a pre-registered and incentivized lab-in-the-field experiment to study how Tanzanian farmers respond to conservation payments. Our main goal was to systematically compare conservation decisions in response to varying incentive regimes under asymmetric land ownership (Hypothesis 2). Comparing conservation decisions under T1 and T2 allowed us to further test whether payments that reward large farmers proportionally more than smallholders (T2) perform different in terms of conservation effectiveness than payments that just about compensate for conservation opportunity costs (T1). We found no robust evidence confirming hypothesis 2 under any of the two treatments. It thus seems that asymmetric landownership in our experimental setting had no tangible effect on conservation behaviour regardless of whether the payment allocation mechanism required coordination between players with unequal landholdings or whether it implied varying levels of net benefits derived from setting aside arable land.

We can think of at least two explanations for this null-result. First, asymmetric landownership in our experiment was induced by randomization. In the real world, heterogeneous distributions of land are often the result of historical processes and that may involve power imbalances and illegal land appropriation (Anseeuw & Baldinelli, 2020). Thus, relative deprivation and resentments resulting from such historical processes may have much stronger impacts on the behavioural response to conservation incentives than we were able to produce in our experimental setup. Still, participants in the unequal subgroup did clearly perceive the distribution of land as unfair suggesting that our experiment did activate the hypothesized mechanism. However, IRD scores did not differ between the treatment and control groups in the unequal subgroup, so our treatments did not reinforce the perception of unfairness. Moreover, the farmers in our sample are exposed to substantial variation in landownership also in the real world with land endowments in an interquartile range of 0.6 to 3.7 ha. Any real-world differences in landownership, however, would have been balanced in our experiment and individual difficulties in separating the framed (hypothetical) from the actual land endowment could have blurred the effect of the mechanism on the outcome (Hayo & Vollan, 2012).

Second, recent work on measuring IRD (e.g. Jia, 2022) suggests that unfairness is necessary but not sufficient to hamper pro-social behaviour. Strong pre-existing social ties between participants along with cooperative norms may have contributed to coordination and cooperation success in the game. As in many developing countries, farm-households in Tanzania depend on each other in various ways (Rapsomanikis, 2015). For example, small farmers often rely on large farmers for credits, ox-plough services, and exchange of labour. These mutual dependences strengthen social cohesion and often come along with social norms that villagers seek to preserve. Different from many other African countries, social values and norms in Tanzanian villages are sometimes still rooted in socialist ideology, which was introduced in late 1960s. This conjecture is supported by Naime et al. (2022), who pointed out that inequality is less likely to represent a critical cooperation constraint in the areas with a history of collective action.

Like Handberg & Angelsen (2015), we find that farmers conserve even without monetary incentives. This could be either the result of intrinsic conservation motives including "warm glow" (Shan et al., 2023) or due to remaining hypothetic bias. Our participants knew that, there is a farmland reserve (R) for subsistence production. This somewhat reduces the risk that intrinsic conservation motivations are neutralized by concern over food insecurity. It is however challenging to eliminate hypothetical bias in the experimental setting (Harrison & List, 2004). Instead, we tried to reduce bias by offering real monetary payoffs. In the presence of warm glow, however, the difference between private and environmental payoffs matters even in the baseline scenario without conservation incentives. In the real world, we would thus expect baseline conservation be lower than in our experiment, if farmers perceived environmental benefits of conservation as being lower than twice the private payoff.

Our treatments, T1 (individual payment) and T2 (agglomeration bonus requiring coordination among participants), resulted in significant additional conservation efforts. This finding is in line with several PES studies (e.g., Jones et al., 2020; Kagata et al., 2018; Jayachandran et al., 2017), who found a relatively high effectiveness of conditional financial incentives for conservation in Sub-Saharan Africa. T1 induced more conservation than we would have expected under profit maximization, i.e. some participants conserved H parcels, for which opportunity costs exceeded payments. However, average environmental benefits under T2 were notably below the optimum (i.e., TZS 8 and 12.5 for equal and unequal subgroups respectively under full conservation). While the effect observed under T1 suggests the presence of intrinsic conservation motives, suboptimal environmental benefits under T2 could be due to the required additional coordination effort and, relatedly, pre-existing levels of reputation, trust, and social norms among participants (see Liu et al., 2019; Raymond, 2006; Ostrom & Ahn, 2003). These results may also be affected by game design, because the potential effectiveness of AB depends (1) on the spatial auto-correlation of both conservation opportunity costs as well as the potential environmental benefits of conservation, and (2), on the degree of connectivity and corresponding payoff needed for the AB to cover conservation opportunity costs. In our game design, we did not allow for spatial heterogeneity to affect decisions on H parcel conservation, because this would have made the experiment too complex for the lab-in-the-field setting. Allowing for heterogeneity, for example, in conservation opportunity costs, we would have expected to see higher than observed levels of conservation (and connectivity) for spatial configurations in which the AB covers opportunity costs for less than two connections with neighbouring conserved H parcels.

Our analyses of budget efficiency for each of the two treatments partly confirm earlier work, for example by Drechsler et al. (2010) and Parkhurst & Shogren (2008) who found that coordination-based incentives are relatively more efficient than individual incentives. Both studies rely on an experimental setup and quantify cooperation in terms of contiguously conserved parcels in a hypothetical landscape. We note, however, that our experiment was not designed specifically to compare payment modalities in terms of budget efficiency.

3.7 Conclusions

With the discussion above in mind, we carefully conclude that asymmetries in land endowment must not necessarily preclude the effective design and implementation of conservation incentives in ecological corridors. Local contextual conditions can be such that farmers' willingness to contribute to a public environmental good, individually or in coordination, remains unaffected by land distribution even if it affects individual net payoffs from participation. Practitioners must nonetheless pay attention to historical reasons for heterogeneous landownership and consider social safeguards if conservation threatens to reinforce historically grown inequalities. This may involve compensations for the psychological costs of relative deprivation (Callan et al., 2011; Smith et al., 2018) via redistributive schemes to promote synergies between social equity and conservation outcomes (Vorlaufer et al., 2017).

The role of historical land allocation mechanisms in driving the effectiveness of conservation payments could be more systematically explored in future experimental studies. For example, different framings could be used across subgroups to motivate unequal land endowments or heterogeneous land ownership could be the result of non-cooperation in early rounds of a repeated game. Non-cooperation in a collective payment scheme could then be introduced as a punishment option in subsequent rounds of the game. Further, we do not analyze the content of communication between participants as e.g. in Banerjee et al. (2017), which could provide valuable insights in future research. But also adding additional aspects of reality to the experimental design, e.g. spatial variation or asymmetry in opportunity costs across players, could in principle affect behavioral outcomes and should be explored in future research.

Given the hypothetical nature of our experiment, we cannot derive specific recommendations for policy action in our two Tanzanian study regions. For example, given the local history of top-down regulatory conservation measures, there seems to be relatively little scope for additional voluntary conservation even if our baseline results suggest otherwise. However, the observed treatment effects are broadly in line with those of well-designed incentive-based conservation programs in the real world (see for example Wunder et al., 2020). Our standardized treatment effect (Cohen's d) ranges from 0.38 for T1 to 0.83 for T2 which is above the average of around 0.2 in the studies reviewed by Wunder et al. (2020). This implies that conditional payments could come to be a promising complementary conservation strategy in our study area.

Chapter 4: Motivational drivers and the effectiveness of conservation incentives

Abstract

The debate about how external incentives (e.g., payments for ecosystem services) and internal motivations (e.g., intrinsic values) interact in producing conservation outcomes is still unresolved. This paper examines the role of personal values (biospheric and egoistic) as intrinsic motivational drivers for conservation and their potential to affect conditional payments to enhance conservation behavior. We used a lab-in-the-field experiment with rural farmers in two ecological corridors of Tanzania to assess their conservation behavior under two payment modalities, namely a fixed individual payment and a fixed individual payment with an agglomeration bonus. In addition, a post-experiment survey was conducted to determine the levels of personal value endorsement for each individual participant. We consistently found that biospheric values increased conservation behavior, while egoistic values decreased it. The positive effect of biospheric values was higher than the negative effect of egoistic values. Both payments do not seem to affect the conservation behavior of farmers with high biospheric value endorsement. Heterogeneity in personal values thus likely has economic implications for the design of real-world PES schemes. Our results suggest that educational investments in training future generations of farmers with strong pro-environmental values can reduce future pressure on the environment and the costs of associated policy action. Areas for further research are discussed.

Keywords: ecological corridors, payment for ecosystem services, biospheric, egoistic, lab-in-the-field experiment

4.1 Introduction

Human-induced activities, including unregulated farming practices and deforestation, are the primary cause of the alarming biodiversity decline (Convention on Biological Diversity, 2022), particularly in areas with high levels of biodiversity and ecological corridors where they disrupt ecological connectivity (Gregory et al., 2021). Ecological corridors are landscapes that structurally and functionally link protected areas, making them fundamental hotspots for targeted interventions, such as restoration activities to maintain ecosystem service flows (Beita et al., 2021). To promote restoration of corridors, many countries have launched policies to encourage conservation behavior of farmers, including monetary and non-monetary incentives. Non-monetary incentives are important for the argument that behavioral shifts of farmers are not only driven by rationality but also by intrinsic motivation[9], among other factors (Bopp et al., 2019). Farmers' conservation decisions are further entangled with social dilemmas, where individual interests might conflict with societal goals (Dawes & Messick, 2000), making it challenging to predict farmers' behavior under a given policy option without understanding individual motivations.

Numerous attempts to explain intrinsic determinants of conservation behavior have been made in the last decades using different proxies of intrinsic motivational drivers of decision makers (Cetas & Yasué, 2017). For example, Bopp et al. (2019) and Sommerville et al. (2010) concluded that farmers' attitudes toward conservation constitute an important intrinsic motivational driver for conservation behavior. Luu et al. (2024) also underscore the role of farmers' attitudes in spreading and delivery of agro-climate services, which are necessary for development of conservation agriculture. Similarly, Blas (2021) highlights the importance of self-determination drivers, such as individuals' autonomy (the power to make their own decisions), sense of competence (confidence in achieving goals), and relatedness (feeling of social and environmental

[9] A general definition of motivation is "to be moved to do something" (Ryan & Deci, 2000). Thus, borrowing from the environmental psychology literature, motivation is defined as a reason to engage in behavior that benefits the environment. This behavior is often manifested through decisions and/or actions (Steg et al., 2014).

connectedness), in promoting conservation behavior. Accounting for such intrinsic motivational drivers in conservation strategies and programs has shown to be successful in supporting both social and ecological goals (Moros et al., 2019; Cetas & Yasué, 2017).

A further proxy of intrinsic motivational drivers are the personal values, as suggested by Schwartz (1992). Both biospheric (valuing the environment) and egoistic (valuing personal resources) value orientations are among the personal values of relevance in environmental domains (Davis et al., 2023; Russo et al., 2022). These values have been studied by Lange et al. (2022), Suama et al. (2019), and Contzen et al. (2021), among other scholars, to understand pro-conservation behavior. Unlike other intrinsic motivational drivers, personal values are theoretically considered stable over time, prompting scholars (e.g., Ignell et al., 2019; Russo et al., 2022) to argue that personal values are key for long-lasting efforts to conserve biodiversity. Furthermore, there is evidence showing value orientations explain more variance in pro-environmental behavior than self-determined motivational drivers (de Groot & Steg, 2010). We thus focus on personal values in this study.

Research on the conservation roles of personal values, largely presented in the psychological literature, shows that individuals with strong biospheric value are more likely to be intrinsically motivated to engage in pro-environmental behavior (Fornara et al., 2020; Kim et al., 2023; Matzek & Wilson, 2021). The opposite is true for individuals with strong egoistic values, who are often unlikely to engage in pro-environmental behavior (Marshall et al., 2019) unless with support for extrinsic factors (de Groot & Steg, 2010). However, some studies also found biospheric values to be unrelated to conservation behavior (Kollmuss & Agyeman, 2002; Rhead et al., 2018), for example, when the conservation action is too effortful, costly, or culturally incompatible (Steg et al., 2014). In the same vein, some literature (e.g., Kollmuss & Agyeman, 2002; De Dominicis et al., 2017) has shown that strong egoistic farmers may act pro-environmentally, even without external motivation. This may occur, for example, when environmental problems affect farmers personally, such as through their health or financial wellbeing (Matzek & Wilson, 2021). Different results have also been observed across socio-demographic characteristics, such as age, income, and gender (see Sargisson et al., 2020), the level of farmers' reliance on environmental assets (Steg et al., 2014), and in diverse cultural settings (Ignell et al., 2019; Milfont et al., 2006). These differences underscore the importance of acknowledging variations in personal values across regional and cultural contexts as a key to leveraging pro-conservation behavior in the design of environmental policies.

Despite the relevance of intrinsic motivation for farmers' behavior, policymakers still seem to favor conditional economic incentives, such as payments for ecosystem services (PES), as a tool for biodiversity conservation (Powlen & Jones, 2019). Most of these incentive schemes rely on an individual fixed payment per area (PY) design (Ngoma et al., 2020). This design has faced numerous criticisms. One concern is that it can result poorly unconnected conservation areas that provide limited overall conservation benefits due to the fragmentation it can cause (Parkhurst et al., 2002). Parkhurst et al. (2002) proposed an agglomeration bonus (AB) to promote connectivity, which requires coordinated decisions among farmers. This payment would supplement the fixed payment (i.e., PY + AB) and encourage farmers to systematically retire or conserve connected fragments of land (Parkhurst & Shogren, 2008, 2007; Parkhurst et al., 2002). Recently, Nyanghura et al. (2024) examined the effectiveness of PY and PY + AB on conservation of two ecological corridors of Tanzania using a lab-in-the-field experiment. Both payment modalities appeared to motivate conservation behavior substantially.

Incentive design is closely linked to cost-efficiency, i.e. the relationship between conservation outcomes and the total costs of implementing a conservation scheme (Martin et al., 2014). One way that inefficiency can occur is when the pre-existing intrinsic motivations of farmers favor conservation, which can lead to overpayment (Greiner & Gregg, 2011). For example, if a farmer already has a strong internal motivation to conserve land (e.g., due to higher biospheric values), the additional benefits of payments may be limited, making the scheme less efficient. Thus, external motivations (such as PES) and intrinsic motivation variables (here, personal values) may not only have a significant influence on farmers' decisions, but may also mutually influence each other, resulting in a complex interplay between these variables that shapes conservation behavior. Bopp et al. (2019) found limited evidence for the need of subsidies when the conservation attitude of farmers to adopt sustainable conservation agriculture is relatively high. Further interactions have been discussed in the view of the crowding effect of PES, which can either undermine or reinforce intrinsic conservation motivation (Rode et al., 2015). However, the crowding effect on personal values may be limited due to their inherent resistance to change. Instead, pre-existing personal values could affect the effectiveness of introduced PES. Here, our proposition is closely related to Polomé (2016), who showed limited effects of economic incentives to motivate private forest owners to adopt biodiversity-related protection programs when intrinsic conservation motives (attachment to the forest and mastery of forest practices) are constant. Polomé's study, however, did not focus on the underlying personal values.

Here we thus systematically assessed the role of intrinsic motivational factors, expressed through personal values, for conservation behavior and on how they shape PES effectiveness, using a case study of two ecological corridors in Tanzania. Understanding the interplay between PES and personal values is relevant because international and national funds are increasingly used to pay farmers and communities to support pro-environmental behaviors, of which the question of efficiency is critical (Chu et al., 2019). In the following section, we formulate a set of hypotheses to be tested through an on-site behavioral experiment with farmers. Section 2 outlines the context of the study area, the data collection procedure, and the analytical approach. Our findings are presented in Section 3, followed by a discussion in Section 4. Section 5 concludes with policy recommendations.

4.1.1 Formulation of hypotheses

The effect of personal values on conservation behavior is described by the theory of basic human values proposed by Schwartz (1992). The theory postulates that individuals' decisions are motivated by the values they hold, but also emphasizes the complementary and conflicting nature of these values. Of the ten values proposed by Schwartz (1992), biospheric values are the most associated with conservation behavior, as they explain one's concern for the environment or nature. Several scholars have demonstrated a strong correlation between biospheric value orientation and pro-conservation behavior (Bouman et al., 2018; Marshall et al., 2019; Shi et al., 2019; Wang et al., 2021). This motivates our first hypothesis as follows:

H1: Biospheric values enhance conservation decisions and related environmental benefits

Engaging in pro-environmental actions often has negative consequences for individuals (e.g., increased financial costs and reduced personal comfort) (Sargisson et al., 2020). Consequently, egoistically motivated individuals would be less likely to participate in conservation efforts, given their preference for prioritizing personal income. According to Schwartz (1992) and other recent research (e.g., Marshall et al., 2019; Nkaizirwa et al., 2022), egoistic values are associated with anti-conservation behavior. Therefore, our second hypothesis is framed as follows:

H2: Egoistic values discourage conservation decisions and related environmental benefits

Furthermore, the existing literature on incentive systems and behavior suggests that conditional monetary incentives can motivate farmers to adopt pro-conservation behavior when intrinsic motivation is low (Bopp et al., 2019; d'Adda, 2010). However, this effect is most likely to manifest when the intrinsic motivational factor is already positively aligned with pro-conservation behavior. However, when farmers are strongly motivated by stable conservation commitments, such as constant intrinsic motivation or social norms, external influences like financial incentives tend to result in limited conservation success (Greiner & Gregg, 2011; Polomé, 2016). This is similar to biospheric values which positively correlate with pro-conservation behavior but often remain stable over time. With a strong biospheric value orientation, the effectiveness of PES is likely to be undermined. Consequently, intervention with an incentive scheme may not be justifiable for farmers, who already have a high level of biospheric values. Against this background, the following third hypothesis emerges:

H3: Conditional incentive schemes are less likely to produce additional environmental benefits when the biospheric values are high

Self-interest motives can be effectively reinforced by conditional payments (Bopp et al., 2019; Steg et al., 2014). This is due to the benefits that farmers receive from compensation. Subsequently, individuals are inclined to prioritize self-centered actions with higher personal gains rather than uncompensated conservation behavior. Thus, individuals who are more egoistic should be more likely to conserve to augment their financial savings and circumvent the inconveniences and potential risks associated with farming. This background results in our fourth hypothesis as follows:

H4: Conditional incentive schemes are more likely to enhance environmental benefits when the egoistic values are high

4.2 Methods, study area and data

4.2.1 Study area

Our study was conducted in 8 out of 22 villages in IIWC and in 2 out of 4 villages in BKG (Figure 1.1). These villages were selected to represent the spatial distribution and population density within their respective corridors. In each village, farmers were represented by the heads of households or their spouses, and were randomly selected from village registers. The total sample size was 384 farmers, determined by power analysis. Land tenure was mostly informal: over 80% of participants in both landscapes did not hold legal land titles but claimed legitimate ownership of their farmlands. The average landholding size was 2.8 acres per household in BKG and 11.5 acres in IIWC. Land ownership was unequally distributed among households, with greater inequality in IIWC (Gini = 0.635) compared to BKG (Gini = 0.455). Crop farming was the dominant livelihood activity in both corridors, with over 87% of farmers practicing crop farming, both for subsistence and as a primary source of income. Common crops include rice, maize, beans, and various horticultural crops, especially in BKG.

4.2.2 Data collection

We collected our data from a conservation game (i.e., lab-in-the-field experiment) that was conducted with farmers in the two corridors. The game was followed by a questionnaire that we filled out together with the farmers. In the game, farmers were randomly assigned to a team of four players. Each team was then randomly assigned to subgroups with either equal or unequal land size distribution and to either a treatment (TG) or a control group (CG). In the equal subgroups, each farmer received two hypothetical land parcels. In the unequal subgroups, two participants received two pieces of hypothetical land while the other two received four parcels. Participants who received two parcels were defined as small farmers, and those who received four parcels were defined as large farmers.

During the game, we introduced three treatments at the group level (i.e., groups of four players) for three consecutive rounds. The first treatment (baseline) was a cheap talk about the importance of conservation to maintain ecosystems. The second treatment was a conditional payment (a fixed payment (T1)), and the third treatment was a fixed payment plus an agglomeration bonus (T2) – the latter two treatments (T1 and T2) were assigned only to treatment groups. Control groups repeated the baseline treatment for the next two rounds.

In each round, each participant voluntarily and independently decided for each parcel whether to conserve or continue farming. The decisions had real-world implications in terms of private financial rewards and environmental payoffs, which were reflected in a donation to a local environmental NGO. The total environmental benefit contributed by each individual decision corresponded to the payoff value, ranging from TZS 0 to TZS 8000 (USD 3.44) for a small farmer and up to TZS 17,000 (USD 7.31) for a large farmer. A detailed procedure for the game is presented in the supplementary material to this article (see Section 3.4.4 of the Appendix).

We conducted a survey with each player after the game (see Section 3.4.5 of the Appendix) to elicit information about the endorsement of personal values to farmers and other potentially confounding factors (Table 4.1). We measured personal values using the universal values scale as proposed by Schwartz (1992) and as applied in several psychological studies (e.g., Ignell et al., 2019; Wang et al., 2021; Yasir et al., 2021). Since these values are latent variables, it was necessary to assess them based on indicators following a theoretical construct item. We assessed the biospheric values based on four questions related to each respondent's affinity with nature, commitment to environmental protection, respect for the earth, and efforts to prevent pollution. The egoistic values were assessed based on the extent to which the farmers assessed their own social power, authority, wealth, ambition, and influence. Each participant was presented with a list of statements related to these values and was asked to use a 9-point Likert scale (from −1 *opposed to my values* to 0 *not important* to 7 *of supreme importance*) to express the importance of each statement as a guiding principle in their lives. Collected control variables included socio-economic characteristics of the respondents, such as age, gender, household income, family size, marital status, and farmland size ownership, which might also have had an impact on the personal values of respondents and their conservation behavior.

It is important to note that the game was designed to induce coordinated decisions among players to achieve higher environmental benefits, e.g., in the form of the agglomeration bonus. Nevertheless, each player decided to conserve or to continue farming privately. Therefore, it is reasonable to assume that a respondent's decision may have been influenced by the level of trust in the co-players (Liu et al., 2019). Furthermore, social relatedness might also have played a role in the decision outcomes, as exemplified by the reputation effect (Handberg & Angelsen, 2019). This effect comes into play when a player is aware of a peer's values and motivations regarding conservation and farming. Therefore, we included a variable reflecting trust within each group of players using a 10-point Likert scale and a dummy variable indicating the presence of relatives or friends within a group. As emphasized by Hayo & Vollan (2012), farmers are likely to bring real-world experiences to decision games like ours. We therefore also included questions about the participants' authority and decision-making power regarding the land use and at the household level (such as selling to, purchasing from, or gifting to others).

After dropping outliers, our dataset included responses from 381 out of 384 farmers. Of the 381 farmers, 191 were assigned to the equal subgroup and 190 to the unequal subgroup. A total of 192 farmers participated in the treatment group and 189 in the control group. Since each player participated in three rounds, the full sample contains 1143 observations.

4.2.3 Empirical approach

We began by examining whether self-reported values identified after the experiment were affected by the experiment. To do this, we regressed self-reported personal values on dichotomous dummy variables (treated vs. control, equal vs. unequal, and whether a participant was a small or large farmer in a game) and control variables (Table 4.1) using linear regression as modeled in Equation 4.1.

$$PV_i = \alpha + \varphi Treat_i + \partial LD_i + \Theta Farm_i + \vartheta X_i + \sigma ENUM_i + \rho COR_i + \varepsilon_i \qquad (4.1),$$

where PV_i represents personal values (i.e., biospheric and egoistic) endorsed by individual i, and $Treat_i$ ($T1$ = Payment and $T2$ = Payment + Agglomeration bonus) was included as a dummy variable, with "$T0$ = no incentive" in the control group as a reference. LD_i represents a dummy variable for whether the participant was assigned to an equal or unequal subgroup. $Farm_i$ indicates whether a farmer was assigned as a small or large farmer in the game. X_i is a vector of subject specific covariates (socio-demographic characteristics) and other control variables as listed in Table 4.1. $ENUM_i$ is a set of $j-1$ dummy variables controlling for enumerator effects, and COR_i is a dummy variable controlling for the corridor effect.

We proceeded by estimating the effect of personal values on environmental benefits (i.e., testing H1 and H2) using Equation 4.2.

$$\pi_{i,t}^{PCB} = \alpha + \gamma PV_i + \varphi Treat_{i,t} + \partial LD_i + \vartheta X_i + \sigma ENUM_i + \rho COR_i + \mu Round_t + \varepsilon_i \quad (4.2),$$

where $\pi_{i,t}^{PCB}$ refers to the proportion of total environmental benefits contributed by individual i's decision in round t. This was our dependent variable. The variable "$Round_t$" controls for round effects (t = 1, 2, and 3). The rest of the variables are defined as in Equation 4.1. We used a Tobit regression model for our estimation because the dependent variable was zero truncated.

Finally, we tested H3 and H4 using Equation 4.3.

$$\pi_{i,t}^{PCB} = \alpha + \gamma PV_i + \varphi Treat_{i,t} + \partial LD_i + \theta Treat_{i,t} * PV_i + \vartheta X_i + \sigma ENUM_i + \rho COR_i + \varepsilon_i \qquad (4.3)$$

Here, we extended Equation 4.2 to allow interaction between the respective treatments and personal values (i.e., $Treat_{i,t} * PV_i$). The coefficient on this interaction term represents the effect of the incentive (here: treatments) under different intrinsic motivational factors (here: personal values). Our estimation was done with a sample of 1143 observations.

4.3 Results

4.3.1 Descriptive statistics

On average, the participants were 43 years old and had attended school for 7 years. The majority were men (61%), and the average household family size was 6, with an average farm size of 8.78 acres. The average proportion of environmental benefits contributed by the farmer was equivalent to TZS 0.28 (USD 0.00012) (Table 4.1). On average, the biospheric values were endorsed at a level of 4.98 out of 7 and the egoistic values at 4.28 out of 7 (Table 4.1). A specific variation of personal values endorsed by different categories of socio-economic characteristics is presented in Table 4A.1 in the Appendix.

The variation of personal values endorsed by participants across the different experimental groups (treatment vs. control group, equal vs. unequal, and small vs. large farmers in the game) is presented in Figure 4.2. We found that the level of personal values endorsed by treatment and control participants was comparable: the score was around 5 (biospheric) and 4 (egoistic), as shown in Figure 4.2a.

Table 4.1: Descriptive statistics of the main variables used in the model estimation.

Variables	Description	Mean	SD
A. Environmental benefits	Proportion of the total environmental benefits (in TZS) contributed by each individual for all rounds of the game.	0.28	0.34
B. Personal values			
Biospheric [−1:7]	Care for the environment: measured as the average from the Likert scale score of four items: unity with nature, environmental protection, respect for the earth, and pollution prevention.	4.98	1.54
Egoistic [−1:7]	Care for self-interest: measured as the average from the Likert scale score of four items: social power, authority, wealth, and influence.	4.28	1.78
C. Socio-economic and demographic characteristics			
Age	Age of respondents in years	43.4	13.24
Educ	Years of schooling	6.80	2.46
HHI	Household income of the last year in TZS presented in 1,000,000s	2.59	3.05
Gender	Sex of the respondents (Dummy: 1 = Male, 0 = Female)	0.61	0.49
Famil_size	Number of people who sleep in the same household on a regular basis	6.00	2.95
Marital_status	Whether respondent is married or not (Dummy: 1 = Married, 0 = Not married)	0.89	0.31
Farm_own	Farm size owned by household in acres	8.78	14.73
D. Other control variables			
Trust [0;10]	Respondents had to answer this question: Generally speaking, most people in the community are trusted (Likert scale: 0 = fully disagree, 10 = fully agree).	6.95	2.14
Decision_land	The authority of the subject with regards to decisions related to land (use, purchase, selling, reallocation, etc.) at household level (Dummy: 1 = subject is the main decision maker or has shared power in land decisions, 0 = subject has no power in decisions)	0.89	0.31
Relat_friend	Whether a farmer had a relative or friend in the same experiment group (Dummy: 1 = Yes, 0 = No)	0.23	0.42

Note: 1TZS is equivalent to approximately 0.00043 USD (https://rb.gy/p6dr3s)

On average, participants in the equal subgroup endorsed biospheric values at 5.15 and egoistic values at 4.81 (Figure 4.2b). In comparison, those in the unequal subgroup had average scores of 4.77 for biospheric values and 3.78 for egoistic values (Figure 4.2b). The differences between the subgroups for each value were not statistically significant.

However, difference between the egoistic values endorsed by the equal and unequal subgroups was statistically significant (Mann-Whitney U test: $p<0.01$). Both small and large farmers in the game reported relatively higher biospheric than egoistic values (Figure 4.2c).

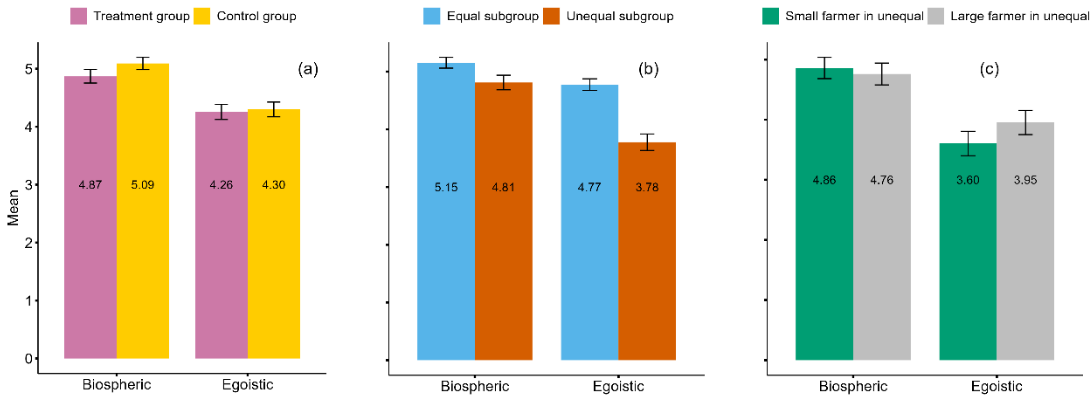

Figure 4.1: Average personal values endorsed by farmers across different experimental groups.

4.3.2 Reliability, validity, and consistency of the measurement items used to measure personal values

Before the empirical model estimation, we assessed the reliability, validity, and consistency of the personal values indicators. We determined the reliability by estimating factor loadings (Table 4.2) and found that most indicators surpassed the recommended threshold of a 0.7 factor loading, as suggested by Fornell & Larcker (1981). This indicates that the respective indicator constructs account for more than 50% of the variance, thus showing acceptable indicator reliability.

To validate the accuracy of construct measurement, we computed convergent validity using the average variance extracted (AVE) method, similar to Sánchez-García et al. (2021). The AVE estimates reflect the degree to which the construct converges to explain the variance of its indicators. Our AVE estimates exceeded 0.5 for each indicator, affirming that all indicators adequately explain the variance (Zahedi et al., 2019). To assess the internal consistency of each indicator construct, we used Cronbach's alpha (α) (Table 4.2). All alpha estimates exceeded the recommended threshold of 0.6 as proposed by Martinez-Conesa et al. (2017), indicating a high level of internal consistency in measuring the constructs of the model.

Table 4.2: Test for reliability, convergent validity, and consistency of personal values' measurement items.

Measurement item	Mean	SD	FL	AVE	alpha
Biospheric values				0.744	0.88
Unity with nature	4.889	1.825	0.848		
Environmental protection	5.314	1.628	0.900		
Respect for the earth	4.374	2.050	0.841		
Prevent pollution	5.343	1.667	0.860		
Egoistic values				0.588	0.815
Social power	3.151	2.726	0.778		
Authority	2.997	2.579	0.783		
Wealth	5.275	2.253	0.771		
Ambition	5.916	1.528	0.759		
Influence	4.047	2.443	0.743		

Note: SD = standard deviation, FL = factor loading, AVE = average variance extracted.

4.3.3 The effect of experimental elements on personal values

Our results from Equation 4.1 show that none of the experimental elements significantly affected the personal values elicited during the post-experiment survey (Table 4.3).

Table 4.3: The effect of experimental variables on personal values.

Variables	Dependent variables are personal values	
	Biospheric	Egoistic
Treatment/Control: (Treatment = 1)	0.161	0.067
	(0.151)	(0.170)
Equal/Unequal: (Equal = 1)	0.304	0.102
	(0.257)	(0.290)
Small/Large farmer: (Small = 1)	−0.185	0.300
	(0.209)	(0.235)
Socio-economic and demographic characteristics (Table 4.1)	Yes	Yes
Other control variables (Table 4.1)	Yes	Yes
Corridor-fixed effect	Yes	Yes
Enumerator-fixed effect	Yes	Yes
N	381	381
R^2	0.206	0.240

Standard errors (in parentheses) are clustered at the individual level. *p<0.1, **p<0.05, ***p<0.01. See the detailed table in the Appendix (Table 4A.2).

4.3.4 The effect of personal values on environmental benefits

The results of Equation 4.2 indicate that personal values had a significant effect on environmental benefits, supporting H1 and H2 (Table 4.4). We found that biospheric values enhanced environmental benefits by 11%, while egoistic values lowered environmental benefits by around 4% (Model 1). This effect remained consistent when we controlled for socio-economic variables specified in Table 4.1 (Model 2) and when experimental elements were added (Model 3).

Table 4: The effect of personal values on environmental benefits.

Variables	(1)	(2)	(3)
Biospheric	0.109***	0.104***	0.087***
	(0.013)	(0.013)	(0.013)
Egoistic	−0.043***	−0.046***	−0.063***
	(0.010)	(0.010)	(0.010)
Socio-economic and demographic characteristics + other control variables		Yes	Yes
Experimental variables			Yes
N	1143	1143	1143
Pseudo R^2	0.043	0.071	0.142

Standard errors (in parentheses) are clustered at the individual level. *p<0.1, **p<0.05, ***p<0.01.

4.3.5 How do personal values shape the treatments effect toward environmental benefits?

We tested H3 and H4, assessing how personal values shape the performance of conditional incentives, by estimating interaction effects of treatments and personal values. We present our results from the sample analysis (1143 observations) in Table 4.5. The results show that none of the interaction terms were significant. A similar pattern of results was observed when we re-estimated the interaction term using the second and third round dataset (the rounds that received treatments with 762 observations)—see the results in Table 4A.5 in the Appendix. Our results suggest that higher biospheric and egoistic scores weaken the effect of treatments in inducing conservation decisions. Thus, our findings confirm H3 while providing limited evidence in support of H4.

Table 4.4: The interaction effect of incentives and personal values (full sample of 1143 observations).

Variables	Full sample			
	(1)	(2)	(3)	(4)
Treatment/Control: (Treatment = 1)	0.239***	0.305**	0.204**	0.279**
	(0.033)	(0.125)	(0.085)	(0.130)
Biospheric	0.087***	0.094***	0.087***	0.097***
	(0.013)	(0.018)	(0.013)	(0.019)
Egoistic	−0.063***	−0.063***	−0.067***	−0.071***
	(0.010)	(0.010)	(0.014)	(0.015)
Treatment × Biospheric		−0.013		−0.020
		(0.023)		(0.025)
Treatment × Egoistic			0.008	0.015
			(0.018)	(0.020)
Socio-economic and demographic characteristics (Table 4.1))	Yes	Yes	Yes	Yes
Other control variables (Table 4.1)	Yes	Yes	Yes	Yes
Equal/Unequal: (Equal = 1)	Yes	Yes	Yes	Yes
Small/Large farmer: (Small = 1)	Yes	Yes	Yes	Yes
Rounds of the game (Ref = round 1)	Yes	Yes	Yes	Yes
Corridor-fixed effect	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes
N	1143	1143	1143	1143
Pseudo R^2	0.142	0.143	0.143	0.143

Standard errors (in parentheses) are clustered at the individual level. *p<0.1, **p<0.05, ***p<0.01. See the detailed results in the Appendix (Table 4A.4).

We extend our analysis to the subsample level by estimating the interaction (treatments and personal values) in equal and unequal subgroups separately, although we had no specific hypothesis for this. Our decision to perform this analysis was motivated by prior expectations regarding the treatment effect under different distributions of land ownership as an important local contextual factor (see Nyanghura et al., 2024). In summary, Nyanghura et al. used a lab-in-the-field experiment to estimate the average treatment effect (T1 and T2) on conservation under two subgroups of participants: equal (symmetric landowners in the experiment) and unequal (asymmetric landowners in the experiment). The study found no strong evidence of a difference in treatment effect between the two subgroups. Here, we extended the analysis to examine the interaction of treatments and personal values among subsamples of the same two subgroups. Our subsample analysis revealed a significant interaction effect, where both treatments (T1 and T2) reduce environmental benefits significantly ($p<0.05$) by 12 and 22%, respectively, when the biospheric values were high (see Table 4.6, Model 2, Part I and II, respectively). However, this effect was observed in the equal subgroup and not in the unequal subgroup (see Model 5). Surprisingly, T1 and T2 also reduce environmental benefits significantly ($p<0.01$) by 13% and 21%, respectively, when the egoistic values were high in the equal subgroup (Table 4.6, Model 3), similar to what we observed for the high biospheric values. More surprisingly, this effect was inconsistent compared to the unequal subgroup, where both treatments increase environmental benefits substantially ($p<0.05$) by about 7% when the egoistic value was high (Model 6). A further subsample analysis between small and large farmers in the unequal subgroup shows that the positive effect was indeed driven by the small farmers (Table 4A.8 in the Appendix) and not by the large farmers (Table 4A.9 in the Appendix). This suggests heterogeneity between different categories of landowners, even if they endorse the same egoistic motive.

Table 4.5: The interaction effect of incentives and personal values for equal and unequal subgroups.

Part I: Effect of T1	Equal subgroup			Unequal subgroup		
	(1)	(2)	(3)	(4)	(5)	(6)
T1: PY	0.333***	0.966**	0.967***	0.246***	0.045	−0.026
	(0.072)	(0.334)	(0.281)	(0.074)	(0.241)	(0.143)
Biospheric	0.099**	0.159***	0.091**	0.070**	0.048	0.071**
	(0.031)	(0.046)	(0.029)	(0.026)	(0.038)	(0.025)
Egoistic	−0.046	−0.054*	0.016	−0.066**	−0.066**	−0.108***
	(0.029)	(0.029)	(0.038)	(0.021)	(0.021)	(0.029)
T1 × Biospheric		−0.119**			0.040	
		(0.060)			(0.044)	
T1 × Egoistic			−0.129**			0.074**
			(0.056)			(0.031)
Small/Large farmer: (small = 1)	No	No	No	Yes	Yes	Yes
Socio-economic and demographic characteristics (Table 4.1)	Yes	Yes	Yes	Yes	Yes	Yes
Other control variables (Table 4.1)	Yes	Yes	Yes	Yes	Yes	Yes
Corridor-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	191	191	191	190	190	190
Pseudo R^2	0.234	0.252	0.257	0.217	0.221	0.235
Part II: Effect of T2	Equal subgroup			Unequal subgroup		
	(1)	(2)	(3)	(4)	(5)	(6)
T2: PY + AB	0.449***	1.629***	1.510***	0.542***	0.285	0.270*
	(0.078)	(0.396)	(0.300)	(0.072)	(0.231)	(0.151)
Biospheric	0.105**	0.218***	0.090*	0.059*	0.031	0.061*
	(0.038)	(0.048)	(0.037)	(0.026)	(0.036)	(0.025)
Egoistic	−0.033	−0.050	0.068*	−0.070**	−0.069**	−0.112***
	(0.032)	(0.032)	(0.038)	(0.022)	(0.022)	(0.031)
T2 × Biospheric		−0.220**			0.051	
		(0.070)			(0.042)	
T2 × Egoistic			−0.214**			0.075**
			(0.060)			(0.036)
Small/Large farmer: (small = 1)	No	No	No	Yes	Yes	Yes
Socio-economic and demographic characteristics (Table 4.1)	Yes	Yes	Yes	Yes	Yes	Yes
Other control variables (Table 4.1)	Yes	Yes	Yes	Yes	Yes	Yes
Corridor-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
N	191	191	191	190	190	190
Pseudo R^2	0.203	0.239	0.244	0.299	0.304	0.314

*Standard errors (in parentheses) are clustered at the individual level. *p<0.1, **p<0.05, ***p<0.01. See the detailed results in the Appendix (Table 4 A.6 and 7).*

4.4 Discussion

The objective of this study was to ascertain the influence of personal values on conservation behavior and to examine how these values influence the effect of conditional payments on conservation behavior. By incorporating psychological factors (in this case, personal values) into the analysis, we broadened the scope of the neoclassical approach to explaining farmers' behavior.

Our findings indicate a consistent positive effect of biospheric values on conservation behavior. This suggests that individuals with strong biospheric values are willing to forego some private returns to the benefit of nature. Our findings align with those of other studies that have evaluated the impact of personal values on conservation behavior and in diverse environmental contexts. For example, research has demonstrated a positive correlation between biospheric values and individuals' actions toward the conservation of biodiversity, even in the absence of direct benefits from ecosystem services in return (Fornara et al., 2020; Matzek & Wilson, 2021). Furthermore, Soyez (2012) demonstrated that individuals with elevated biospheric values are more likely to consume organic food products. Additionally, Perlaviciute & Steg (2015) posited that consumers with robust biospheric value orientations are more likely to purchase renewable energy equipment. In Tanzania, secondary students who endorsed biospheric values demonstrated a substantial level of conservation behavior (Nkaizirwa et al., 2022).

As anticipated, our results demonstrate a negative and significant impact of egoistic values on conservation behavior. This is because egoistic values often lead to the pursuit of personal gains rather than public benefits, which often entail ecological costs. Our findings are consistent with those of previous studies that examined the relationship between egoistic values and pro-conservation behavior (e.g., Perlaviciute & Steg, 2015; Bouman et al., 2018; Oh et al., 2021). Notwithstanding, our findings indicate a below-average conservation response among egoistic farmers, irrespective of the intervention (here: compensation through T1 and T2). One reason may lie in the stability of personal values. This stability is more pronounced in adulthood (as is the case for all our participants) than in childhood, when values are considered to be in their nascent stages of formation (Ignell et al., 2019). This is supported by the study of Sargisson et al. (2020), who showed that adults are more likely to express stable egoistic behavior than children.

The effect size of the two personal values is also worth noting. Although all observed values showed a statistically significant conservation benefit, the large positive effect size of the biospheric values relative to the negative effect caused by the egoistic values suggests that biospheric values trump egoistic values. This observation somewhat explains the recent findings of Nyanghura et al. (2024), in the same study areas, which showed a sizable willingness of farmers to retire their personal farmland for conservation, even without compensatory payments. Greiner & Gregg (2011) also found Australian farmers to boast higher intrinsic motivational scores in favor of conservation behavior than for self-interest.

Our PES treatments did little to alter conservation behavior for participants with high biospheric values compared to the average treatment effect (Table 4.5). Still, it may not be necessary to fully compensate farmers with high intrinsic conservation motives for their opportunity costs to achieve the same conservation levels than on farms headed by individuals with average intrinsic motivation levels. This finding offers a complementary explanation for why some studies observe high participation rates in conservation schemes with low actual payments, which has also been attributed to adverse selection (see, Bopp et al., 2019, and Wunder et al., 2020).

However, neither participant with high egoistic values exhibited stronger responses to PES incentives than farmers with average motivation scores (Table 4.5). On average we thus do not find any evidence for personal motivations to mediate PES impacts. Still, higher payment levels might be needed to induce highly egoistic farmers to conserve the same amount of land than farmers with average motivational scores.

When looking at equal and unequal groups separately, we found small but statistically significant interactions between treatments and motivational scores (Table 4.6). In the equal subgroup, for example, these interaction effects are of similar size as the average effects of the motivational scores indicating that motivations matter less in the presence of PES than under the control condition without conservation payments. This finding, even if only present in the subgroup analysis, suggests that conservation payments could, under some conditions, offset the effects of intrinsic motivations lending weak support to the idea of motivational crowding (Rode et al., 2015).

Future research may expand on our study to explore the role of other personal values, such as altruism and hedonism. This would require a larger sample size and, crucially, the ability to deconstruct prevailing or centrally endorsed values from the other existing values to see the possible effect of complementarity or conflicting amongst them. As our study employed self-reported measures for evaluating personal values, it is not possible to completely rule out the possibility of response error due to social desirability bias. Therefore, it may be necessary to use other measures, such as peer reporting, in future studies to offset this bias. Additionally, examining the generational dynamics of personal values, including the transformation across generations (children, young adults, and elders), would be a thought-provoking and innovative extension of the current study.

Finally, it would be beneficial for future studies to test the suitability of treatment effects in a wider range of social and spatial contexts to ensure the robustness of the findings for national-based policy recommendations. Such an extension should also investigate the conditions under which different groups of farmers (e.g., small and large landowners) may be motivated to conserve biodiversity. Since our study derived the outcome variables from a lab-in-the-field experiment, we cannot entirely rule out potential biases related to our experimental design. For instance, farmers who were either not interested in or had negative experiences with conservation NGOs might not have opted to retire their farmland for conservation, as this decision would have resulted in a donation to a conservation NGO. Future research could explore how farmers' decisions to retire farmland for conservation might differ when donations are directed to various organizations (e.g., government vs. non-government conservation organizations).

4.5 Conclusions and policy recommendations

This study offers two conclusions, followed by potential policy suggestions and areas for further studies. First, our findings underscore the relevance of personal values, specifically those related to the environment (biospheric) and those related to the individual (egoistic). The positive effect of the biospheric values on conservation and the negative effect of the egoistic values suggests that policymakers should acknowledge the pre-existence of personal values and their effect on conservation efforts. It is crucial for policymakers to focus their conservation strategies on reinforcing the human-environment relationship supporting biospheric values. To achieve this, interventions might include investing in conservation education for future generations, such as children in schools, who are at the formative stage of value development (Ignell et al., 2019). For current generation, it may be necessary to enhance the dissemination of conservation information, for instance, through advertisements. Formation and strengthening of the biospheric values are vital for enhancing the cost-effectiveness and efficiency of conservation policies, such as PES (Steg et al., 2014). Investing in the education and training of future farmers with strong pro-environmental values would most likely be a viable option to strengthen pro-environmental behavior and thereby reduce the costs of PES related policy measures.

Second, our findings on interaction effects between conservation incentives and motivational indicators suggest that payments can, under some conditions, offset the effect of intrinsic conservation motives (i.e. motivational crowding out) or boost willingness to conserve for rather self-interested individuals (i.e. motivational crowding in). These motivational PES impact channels must remain on the radar of incentive-based conservation program developers.

Chapter 5: Conclusions and policy recommendations

5.1 Conclusions

The main objective of this dissertation was to assess the effectiveness of conservation incentives for conservation of ecological corridors of Tanzania. This objective was framed on the premises that protection of biodiversity requires appropriate design of incentive schemes to safeguard ecological assets in a privately owned landscape. Payment for ecosystem services is one of such policy options of which its performance in biodiversity conservation remained inconclusive (Wunder et al., 2020), with local contextual factors and intrinsic motivation proving to be the underlying determinants of such mixed conclusions (Kuhfuss et al., 2022). Many of these results are, however, derived from tropical regions with substantial natural forest (e.g., in Latin America) and which have long experience of PES schemes (see for example (Börner et al., 2017; Börner et al., 2016b; Jones et al., 2020; Wunder et al., 2020). Like many African countries, Tanzania lags behind, with limited experience of PES, particularly in conservation of ecological corridors. As population grows, along with land demands and economic growth, it is very likely that the government of Tanzania may need to adopt PES policies in future as a pathway to just, fair and equitable conservation strategies. Thus, ex-ante analysis of such policies is important to inform policy makers on potential outcomes beforehand.

Before exploring the effectiveness of PES, it was vital to first understand whether payment is necessary in the studied ecological corridors. Thus, I first assessed the ecological and economic implications of conservation, particularly landscape connectivity to farmers and the government. The results show that increasing conservation “through landscape connectivity” has positive effects on biodiversity. However, additional ecosystem goods and services from such connectivity and associated co-benefits do not offset farmers costs if they decide to conserve their privately owned farmlands. The study found, however, evidence of potential societal benefits from ecosystem goods and services (e.g., through trading of carbon credits and revenues from tourism) at landscape level, rendering conservation economically viable for the government, while it was not for the households. This finding serves as the foundation for defining the objectives of the subsequent chapters, particularly focusing on the modalities of government payments to compensate local farmers for their conservation decisions.

To understand the effect of different PES design on conservation of ecological corridor, chapter 3 analyzed the effectiveness of fixed payment and fixed payment with agglomeration bonus in enhancing conservation of ecological corridors. These two PES modalities were tested under asymmetric land ownership as an important local contextual factor which was hypothesized to lower collective conservation efforts. Theoretically, landownership heterogeneity could be one of underlying factors for social disparity, that would undermine collective conservation action. Using a pre-registered lab-in-the-field experiment with local farmers, the study found that both modalities of PES enhance conservation. However, we found no evidence to support the effect of asymmetric in land endowment in lowering conservation efforts. Lack of evidence suggests strong collective norms amongst community. This may be linked to the history of collective actions initiated approximately four decades ago in rural Tanzania during the implementation of socialism policies, which farmers appear to have maintained as lasting norms.

Performance of PES can also be affected by intrinsic motivational factors. One of these intrinsic factors is personal values, such as biospheric and egoistic. In chapter 4, the study investigates the effect of biospheric and egoistic values on conservation of ecological corridors and how these values shape the performance of PES. Using the combination of lab-in-the-field experiment and social survey, the study found that high biospheric values are positively associated to higher conservation while egoistic values lower conservation efforts. The positive effect of biospheric values was comparatively higher than the decreasing effect of egoistic value. Both modalities of payments appeared to have limited effect on conservation when biospheric values are higher. This suggests that heterogeneity in biospheric values is likely to have economic implications for the design of real-world PES schemes.

5.2 Policy implications and recommendations

The conclusions draw from this study offers some potential suggestions that are imperative for conservation of biodiversity and policy action in Tanzania. As in many cases, investing in conservation is reinforced by different dimensions, including potential of additionality and cost-effectiveness of intervention. Selecting appropriate landscape for conservation is, thus important: a landscape with larger costs of conservation (including opportunity costs) and relatively more degraded may be given a conservation priority with expectation of additionality to occur (Cisneros et al., 2022). Thus, relatively higher costs of conservation per hectare observed in IIWC than in BKG illuminate the need for policy makers to prioritize conservation efforts in the former than the latter. At a landscape level, conservation efforts in IIWC may also benefit from economies of scale, as the area is approximately 40 times bigger than the BKG. The distribution of NPV for conservation investment by the government and household implies that the government should think of adopting compensating local farmers who are net-losers of conservation. Such compensations should take a form of payment per area conserved and for the affected households. As argued by Gatiso et al. (2018), the individual specific payment scheme is more effective than group or community payment as it accounts for heterogeneity in costs of conservation. It is important, however, to note that, while this study focuses on returns for the government investment in conservation, ideally positive return, would be expected for any other investing organizations (e.g., conservation NGO).

PES may not lead to effective conservation outcomes unless it is carefully designed to align with the unique characteristics of the context and tailored to achieve specific desired results. This dissertation suggests that fixed payments per area and those with agglomeration bonuses can effectively support conservation, particularly the latter, which proved more efficient for preserving ecological corridors. While recommending the implementation of these schemes may be difficult due to potential bias and concerns about external validity (see section 5.3), this study provides an entry point for collecting sufficient evidence for more robust recommendations.

The level of payment needed to incentivize conservation is often contingent to the pre-existing intrinsic motivation such as biospheric and egoistic values. As mentioned before, these motivations often determine additionality and cost-effectiveness of specific payment. The conclusion of this dissertation regarding the role of personal values suggests that the government prioritizing the reinforcement of existing biospheric values among farmers would be the first best option. Such reinforcement could be, for example, through a framing and dissemination of conservation information (e.g., through extension programs or advertisements) that are specifically tailored to activate biospheric values. The framing of advertisements should be clear, easily understandable, and widely distributed to farmers, delivering a message that is both compelling and emotionally engaging. By appealing to the emotional responses of farmers, the effectiveness of regulatory advertisements can be enhanced, thereby facilitating environmental conservation. Furthermore, the activation of biospheric value may be employed to reinforce the environmental conservation curriculum in primary and secondary schools, where children are in the critical stage of personal value formation (Ignell et al., 2019).

For equity, fairness and just reasons, policy makers may need to opt for payment policy as a second-best option. However, the level of payment can be heterogenous based on distribution of personal values. For example, highly biospheric farmers may need to be compensated relatively less to mitigate the effect of adverse selection and supporting the additionality. Identification of such optimal payment level need further research.

5.3 Limitations and areas of future research

Scientific literature indicates that results of cost-benefit analysis in conservation often depend on the specific variables of costs and benefits included and assumptions applied. Findings from chapter two of this dissertation and corresponding conclusion are based on the limited ecosystem based-benefits mentioned by stakeholders (e.g., earnings from carbon, tourism, bees and butterfly). Future study may extend this by incorporating a wider range of ecosystem goods and services (e.g., nutrient cycling, flooding regulations and many other non-timber forest products) in decision analysis modeling.

The findings from lab-in-the-field experiment (chapters 3 and 4) are largely generated based on hypothetical case. Although the experiment was framed to mimic real world and local context, in many cases, it is challenging for experimental studies to control for heterogeneity of many influencing attributes. Thus, there is limited possibility for the results to be free from hypothetical biases and less confident claim for the external validity (Handberg & Angelsen, 2015; List, 2011). For example, the experiment was framed to assume a systematic spatial configuration of farmlands, which may not perfectly describe the layout of farmlands on the ground. Local contextual factors are also manifold and sometimes may be correlated amongst each other: asymmetric in land distribution assumed in this dissertation is just one, but historical procedure for acquiring such land and recognition related to landholding may also be peculiar. The effect of such contextual elements and their interactions on conservation behavior are worth addressing systematically to understand the potential of PES under wide range of contextual factors.

Contextual factors may also take a form of intrinsic motivation variables. While in this dissertation we focus on the biospheric and egoistic values, other personal values such as altruistic and hedonic has not been tested in specific sites. Intrinsic motivation drivers can further be extended to include autonomy, sense of competence and relatedness, as explained by the self-determination theory as in Blas (2021). Extension of this study to account for a wider intrinsic motivation, their interaction with extrinsic contextual factors and how they shape PES effectiveness is critical for a robust conclusion and policy action.

There is enormous evidence that conservation incentives like PES, regardless of the design, may be ineffective if implemented independently (Börner et al., 2016b; Jones et al., 2020; Wunder et al., 2020). Thus, the need for the PES to be complemented by other policies and instruments such as monitoring and enforcement is of high importance to reinforce the conditionalities of scheme (Börner et al., 2016b). This dissertation only focused on PES. It is evident that for a country like Tanzania, where PES is relatively new, it may not be conservation or cost-effective in absence of mechanism to enforce its compliance. The question of what compliance mechanism is locally appropriate, who set it, and how it is enforced are pertinent in explaining conservation effectiveness of specific PES. It would, thus be of interest for future study to investigate a site-specific effectiveness of PES under different compliance mechanisms and enforcement levels, and when such enforcement is exercised by local communities versus external actors (e.g., government) or a combination of both. This is relevant e.g., for the conservation of ecological corridors of Tanzania, where the government through a wildlife corridor regulation (URT, 2018) seems to be flexible on the modalities of managing the corridor once conserved (e.g., being part of protected areas, partial protected area or community conservancy), representing different compliance mechanism and enforcement levels.

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Appendices

Appendix Chapter 2

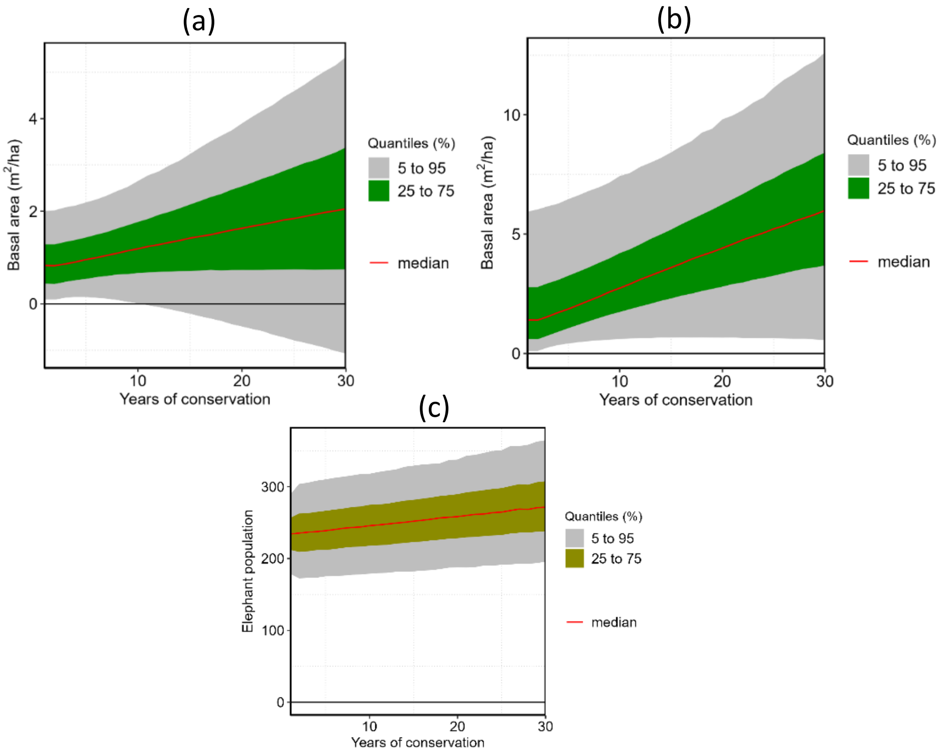

Figure 2A.1. Basal area (m^2/ha) under low landscape connectivity scenario in IIWC (a) and in BKG (b). Figure 2A.1 (c) represents elephant population under low landscape connectivity scenario in IIWC.

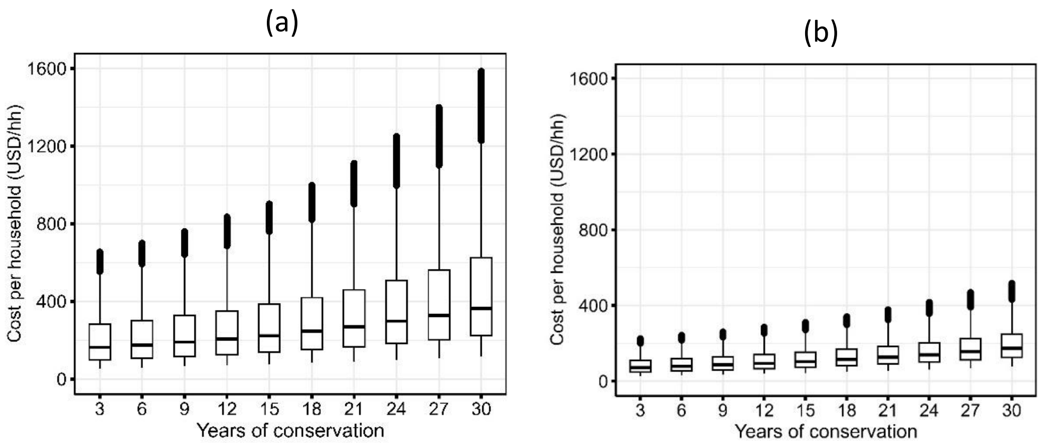

Figure 2A.2. Annual farmers cost per household (USD/hh) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

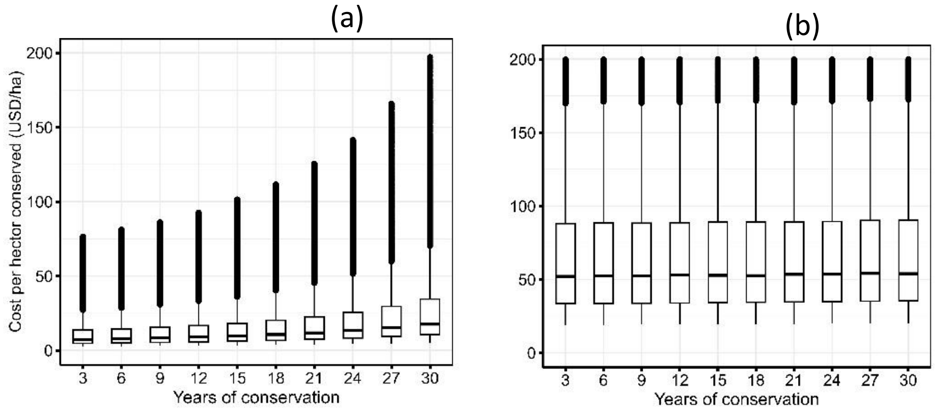

Figure 2A.3. Annual government cost per hectare (USD/ha) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

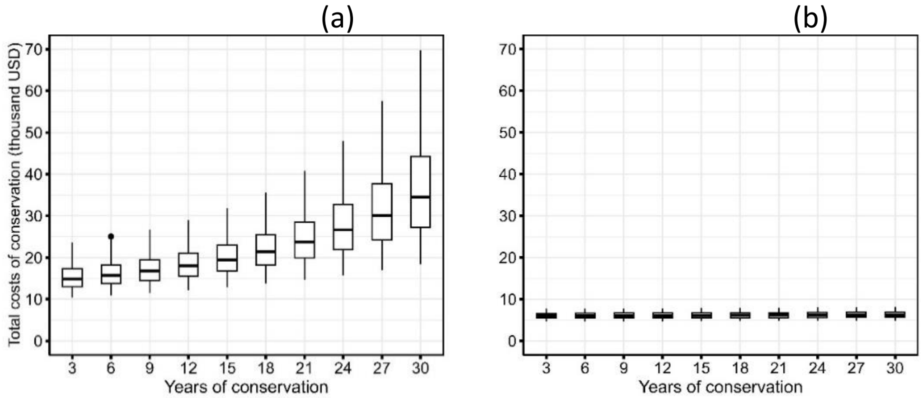

Figure 2A.4. Annual total government cost of conservation (USD/ha) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

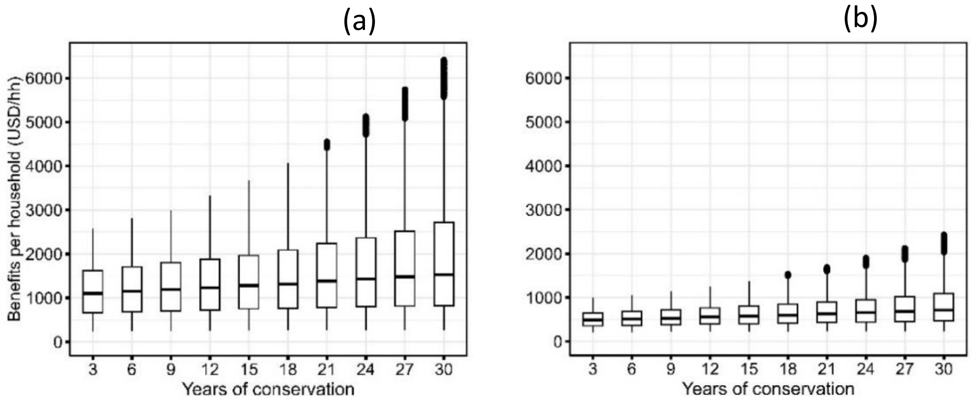

Figure 2A.5. Annual farmer's benefits per household (USD/hh) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

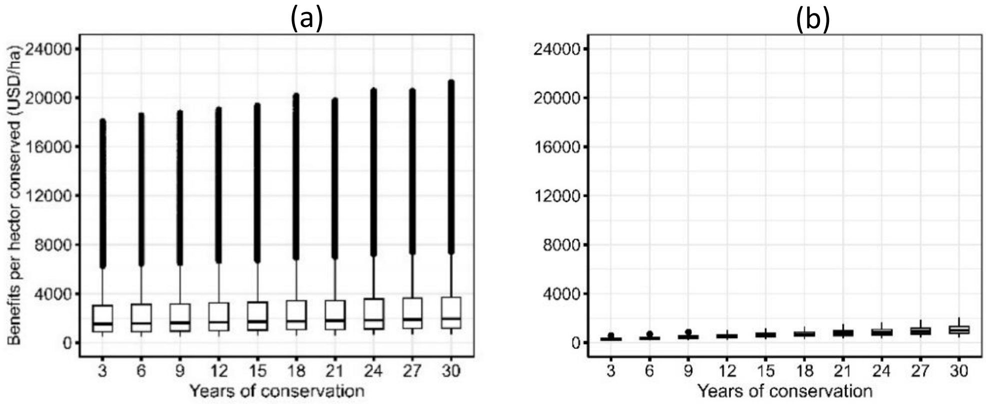

Figure 2A.6. Annual government benefits per hectare (USD/ha) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

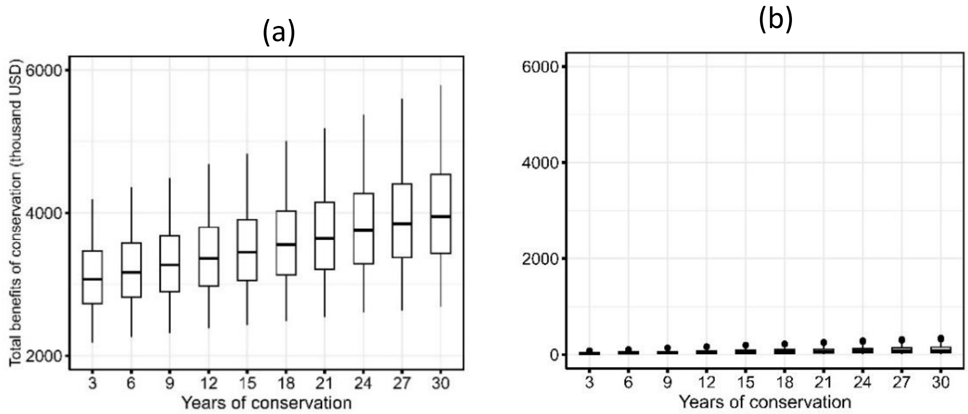

Figure 2A.7. Annual total government benefits (USD) under low landscape connectivity scenario in IIWC (a) and in BKG (b).

Appendix Chapter 3

3.0 Supplementary methods

3.1 Experimental design: selection of treatments

Our selection of treatments for the framed field experiment was policy relevant and informed by literature and current conservation practice in Tanzania. According to Mahulu et al. (2019), conservation awareness raising and sensitization constitutes a common strategy used to motivate farmers to conserve, particularly in buffer zones of protected areas and ecological corridors. We therefore frame our baseline treatment (T0) to mimic the existing sensitization practice on the ground. While sensitization has shown to enhance pro-conservation behaviour (Wilfred et al., 2019), it may not be sufficient to trigger this behaviour if land users face substantial opportunity costs. Hence, monetary conservation incentives are often proposed to compensate for conservation costs (Gómez-Baggethun et al., 2010).

We framed our incentives to account for personal gains from crop farming and environmental gains as a public benefit associated with conservation decisions. Public benefits comprise rival and non-rival non-excludible ecosystem services. Framing of conservation incentives in experiments is generally challenging and requires abstraction from real world complexities for ease of understanding (Sauer & Wossink, 2013). We set public environmental gains from conservation to be twice as high as personal gains from farming to justify policy intervention. A fixed individual payment (T1) was defined that just about compensates for opportunity costs as in Reeling et al. (2019). As fixed individual payments may not specifically encourage the conservation of contiguous landscapes, we also introduced an agglomeration bonus (AB) as a second treatment (T2) as proposed by Parkhurst et al.(2002). We set the AB such that it can overcompensate opportunity costs when farmers optimally coordinate their conservation decisions. Overcompensation can account for transaction costs of coordination as suggested by Banerjee et al. (2017), but it also leads to varying net benefits under asymmetric land ownership.

3.2 Experimental design: asymmetric land ownership

Our design of asymmetric land ownership reflects actual inequalities in the distribution of land in rural Tanzania (Wineman & Liverpool-Tasie, 2017). To mimic existence of small and large farmers in a community, we created one "unequal subgroup" of game participants to be compared to an "equal subgroup". Our prediction was that small farmers in the subgroups with large farmers (unequal subgroup) will make less optimal conservation decisions than small farmers in the subgroups with equally sized (equal subgroup) due to relative deprivation (see next section). Our analysis thus focused on the behavioural response of small farmers and not large farmers.

3.3 Relative deprivation

Relative deprivation refers to an individual's cognitive evaluation of a (disadvantageous) situation compared to others and can result in feelings of anger and resentment (Smith & Huo, 2014). The adverse consequences of relative deprivation can include antisocial behaviour reflected in individuals' actions and decisions (Skylark & Callan, 2021). Relative deprivation can occur in individuals or groups and can be measured subjectively or objectively (Runciman, 1966). Our experiment is framed to account for the key dimensions of individual relative deprivation (IRD) as proposed by Smith et al. (2012). The first IRD dimension is social comparison, which our experiment allows when participants learn about the distribution of land ownership in their subgroup. Small farmers in the unequal subgroup will immediately see that they own less land than their neighbours. The second dimension is cognitive evaluation, which refers to the perception of farmers about their disadvantageous situation derived from social comparison. We used a fairness rating to measure this dimension in both subgroups. The third dimension is emotional experience, where disadvantage may lead to anger and resentment. Though recent studies (e.g. Jia, 2022) treated this third dimension as independent, we assumed that the emotional reaction is the outcome of perceived unfairness. Therefore, our measure of relative deprivation was centred on cognitive valuation based on social comparison similar to previous psychological literature (e.g. Abrams & Grant, 2012 and Zhang & Tao, 2013). Adopting this methodological construct, we use the perceived (subjective) fairness gap between small farmers in the equal and the unequal subgroups as a measure of IRD.

3.4 Data collection

3.4.1 Selection of studied corridors, villages, and households

Selection of corridors

The study was conducted in two ecological corridors, the Igando-Igawa Wildlife Corridor (IIWC) and the Baga-Kisima Gonja (BKG) corridor. These corridors were selected given their ecological relevance and high levels of threat to their ecosystems. According to the Tanzania wildlife corridors assessment, prioritization, and action plan (2022-2026) prepared by the Ministry of Natural Resources and Tourism (MNRT, 2022), the IIWC is the second most threatened corridor out of all 61 corridors in Tanzania. Until 2021, about 75% of the corridor was converted to agricultural land. The corridor connects Ruaha National Park and Mpanga-Kipengere Game Reserve, which are among the most important tourist destinations in Southern-region of Tanzania. The IIWC is an important landscape that facilitates the movement of wildlife population beyond the scope of the corridor. Furthermore, the corridor links different water catchment areas from the uplands and the Great Ruaha River to the lower land. The Great Ruaha River is fundamental for the conservation of the Ruaha National Park and the main source of water for the generation of hydropower in Tanzania (England, 2019). BKG is a small corridor of 23 square kilometers, located in the North-Eastern region of Tanzania. The corridor connects Baga and Kisima Gonja forest reserves in Eastern Arc Mountains (EAM), a globally important biodiversity hotspot (Hoffman et al. 2016). BKG is the third most threatened corridor by agricultural activities in Tanzania, witnessing a 56 percent conversion of its land into crop-farming (MNRT, 2022). According to the same source, the corridor is among the most important habitats hosting a high number of IUCN Red List species, with 25 percent of land cover being costal mosaic and 13 percent Afro-montane rain forest.

Crop farming is the dominant livelihood activity in the two corridors. Over 87 percent of farmers in IIWC and 98 percent in BKG practice crop-farming for both subsistence agriculture and as a primary source of income. The common crops grown include maize, rice, beans and horticultural crops particularly in BKG. On average, household own an average farmland size of 11.5 acres in IIWC and 2.8 acres in BKG. Landless households make up 13 and 18 percent of the total number of households sampled in IIWC and BKG, respectively. The Gini coefficient suggests that farmlands are unequally distributed – more so in IIWC (Gini = 0.635) than in BKG (Gini = 0.455). Ongoing and expanding agricultural activities are likely to exacerbate forest and habitat fragmentation, disconnecting the ecological functioning of the entire ecosystem and ultimately reducing the flow of ecosystem services, which are vital for the wellbeing of the local population and beyond.

Selection of villages

Eight villages out of 22 from IIWC were involved in this study. These are Igando, Mayale, Mlungu, Itipingi, Igunda, Luwango, Matemela and Vikaye. Seventeen of these villages fall under the jurisdiction of Mbarali district and remaining five under Wanging'ombe district (see Table 3A.I). From BKG, two villages (Nkogoi and Sagara) were selected out of four; all villages are located in Lushoto district. The selection of villages was not random, but influenced by accessibility and our goal to capture spatial variation in population densities.

Table 3A.I: Selected villages and their characteristics[10]

Name of the selected village	District	Population (Pop)	Area of the village (km^2)	Number of households in the village (Hh)	Household density (Hh/km^2)	Population density (Pop/km^2)	Hh represented in a sample (%)
Matemela	Mbarali	3,919	84.4	579	6.9	46.4	8.29
Luwango	Mbarali	1,912	78.7	471	6.0	24.3	6.79
Mlungu	Mbarali	1,989	69.7	402	5.8	28.5	7.96
Igando	Mbarali	960	51.9	310	6.0	18.5	10.32
Mayale	Mbarali	1,005	39.1	317	8.1	25.7	10.09
Itipingi	Wanging'ombe	1,018	35.7	371	10.4	28.5	8.63
Vikaye	Mbarali	2,168	30.1	513	17.0	72.0	9.36
Igunda	Wanging'ombe	929	31.2	399	12.8	29.8	8.02
Nkongoi	Lushoto	2,087	8.1	512	63.2	257.7	9.38
Sagara	Lushoto	2,193	10.9	598	54.9	201.2	8.03

Selection of households

We used households as the unit of analysis in this study. This was because land is usually considered a household rather than individual asset. The sample size (number of households) per village was informed by power analysis. In this power analysis we used effect sizes reported by two related studies that estimated the conservation effect of fixed payments and or agglomeration bonus Reeling et al., 2019), a power of 0.8 and significance level of 0.05, to determine the sample size. These studies reported effect sizes of 0.573 and 0.239 respectively. Thus, we adopted a minimum effect size of 0.2, which gave us a sample size of 32 assuming using a fixed linear model (Figure 3A.I). We considered this sample size as a minimum number of households per village. Where possible we exceeded this limit and in total 384 farmers participated in the game followed by an interview.

[10] The area and population presented here are indicative. This was due to absence of clear and reliable dataset as a result of land boundary disputes in many villages. Nevertheless, we used the available information from the village offices which were collected between 2018 and 2020 through a national sanitation campaign programme. The programme aimed to identify and assess the status of toilets for each household in the village.

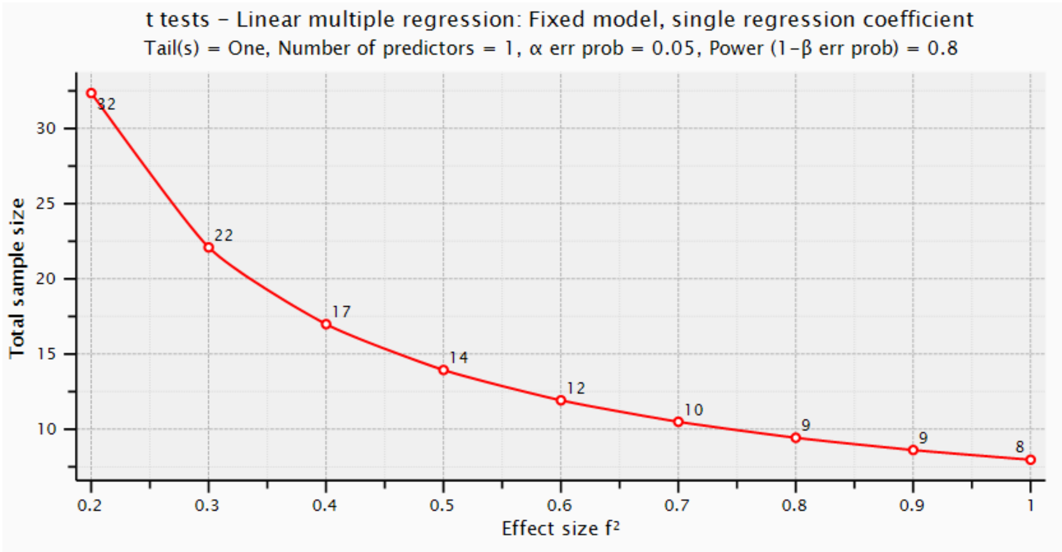

Figure 3A.I: Estimated sample size under different effect sizes

In each of the selected villages, households were randomly selected from the village register, one or two days before the game. We invited either the household head or the spouse through notification from village leaders. We conducted the actual experiment between April and May 2022 in the selected villages.

3.4.2 Schedule of experiment and potential information spillover effect

The experiment was conducted mainly in village offices or classrooms, with a few sessions held in farmers' houses. Four sessions were held each day, with two parallel sessions in the morning/afternoon and two in the afternoon/evening. Two enumerators facilitated each parallel session at different venues. The experiment was conducted on two consecutive days in six villages with relatively low population densities and for three consecutive days in four villages with relatively higher population densities (see Table 2A.I). Repetitions may have resulted in information spill-overs as higher population density increases the likelihood for farmers to communicate the games to others. To test for information spill-over effects, a linear model was used to explore whether lagged average environmental benefits at village level explain current day environmental benefits based on Lawley & Yang, (2015). The results in Table 2A. II show no significant effect of a one-day lagged environmental benefit π_{t-1}^{C} indicating information spill-over effects are unlikely to have affected our results. This result is supported by descriptive findings, with 98.7% of participants reporting that they had not discussed the game with anyone beforehand.

Table 3A. II: Effect of spill over

Variable	Treated + Control (1)	Treated (2)	Control (3)
π_{t-1}^{c}	0.20	-0.40	0.15
	(0.33)	(0.29)	(0.19)
Constant	0.37	4.29*	-0.44
	(1.78)	(2.14)	(0.89)
Village fixed effect	Yes	Yes	Yes
Observations	23	23	23
R^2	0.58	0.59	0.81

Standard errors in parentheses. *p<0.1, **p<0.05, ***p<0.01

3.4.3 Enumerators

The principal researcher and lead author was accompanied by three enumerators in the field, two of which had a background in agricultural economics and one in environmental sciences. All of them were fluent Swahili speakers and had prior experience working in the field. Before collecting actual data, the enumerators underwent one day of training to familiarize themselves with the experiment and survey protocols. This training was conducted a few weeks after the pre-test, and adjustments were made to the protocols accordingly. Due to resource constraints, only one enumerator was involved in the pre-test.

3.4.4 Experiment procedure

The description below narrates a detailed procedure of the game, from the general to specific instructions of each round of the game. In every step, we read the instructions in Swahili language slowly and aloud. Every farmer knows Swahili. Italicized text indicates instructions for enumerators, which were not read out loud.

A. General instructions

- Thank you for agreeing to be part of this research study with us today. It is part of a doctoral research project at Centre for Development Research (ZEF). The project is funded by the government of Germany through DAAD.
- In this research study you will play a game with other three co-players, who are village members; two of those co-players are your neighbour in the game. From these games you will **generate real money**. The games will be followed by an interview. The whole process will last for about two hours and 30 minutes.
- Depending on your decisions and the decisions of your neighbours, the monetary outcome can either yield in **personal benefits** for you and/or contribute to a **public environmental good**.
- After the interview, there will be a **lottery to select one game** in which your decision in that game will constitute the amount of real money you receive. **Corresponding public benefit in the selected game will be donated** to a conservation NGO. This means that you should always decide based on **your true preference**.
- Computation of personal and environmental benefits will be explained to you in each respective game. All decisions you make or answers you give during the game will remain private, confidential and anonymous.
    - You will be identified by your ID which is anonymous to your co-players. No communication will be allowed until you are told to do so. *Let player pick the ID randomly from the urn and remind them to treat it privately. Let them know that the ID identifies their position in the configuration (fig 3A. IIa for equal and fig 3A. IIb for unequal) (i.e., Player 1,2,3 or 4). Let players understand that the seating arrangement does not indicate neighbourhood (i.e., either of the two players are their neighbours, but they will not know who exactly)*.
    - *Let the experimenter/enumerator note the ID of each player and their sitting arrangement. This is important for one of the survey questions.*

B. Round 1 (Baseline)

- Consider the spatial configuration of the farmland where you are player 1,2,3 or 4 **with two acres of farmland like your right and left-side neighbour -** If you are a player within the unequal group, you are player 1,2,3 or 4 **with two or four acres of farmland like one of your right or left-side neighbours**. If you are part of the equal group, you are also player 1,2,3 or 4 but with two acres of farmland like both of your neighbours.
    - *The enumerator will display the land configuration sheet to subjects (fig 3A. IIa for equal and fig 3A. IIb for unequal – translated to posters, see example in Appendix 3II)*
    - *The land grid sheet will be pinned on the wall for the player to remember their position, endowment and neighbour's endowment throughout the experiment*.
- One acre (H parcel) gives you 4 bags of maize per year and another acre (L parcel) gives you 2 bags of maize per year. **The market price of one bag of maize is 500 TZS**. Each farmer makes 3000 TZS [6000 TZS for large farmer in unequal].
    - *To ensure that the subsistence life of farmers is not destructed, the players will be assured with one acre of land inside the village (shown as a side parcel "R") for a farmer who will decide to retire ALL of their land for conservation.*

	Player 1		Player 2		
R	L	H	H	L	R
R	L	H	H	L	R
	Player 3		Player 4		

Figure 3A. IIa: Land configuration for equal

	Player 1		Player 2				
R	L	H	H	H_x	L	L	R
R	L	H	H	H_x	L	L	R
	Player 3		Player 4				

Figure 3A. IIb: Land configuration for unequal

- You are asked to voluntarily retire your agricultural land for conservation or keep farming. Retirement means that **your parcel will not produce any agricultural benefits for yourself**. However, your decision to retire implies public **environmental**

benefits in terms of improved forest cover, climate regulation, increase in habitat for wildlife, pollinators and water flows as illustrated in the poster in Appendix 3II)

    - *The enumerator will display a poster, which shows a coloured-visual images of ecosystem service flows supported by conservation. The poster will be pinned on the wall, in front of the players and stay there for the rest of the experiment/game.*

- Public environmental benefits generated for retiring parcels are worth 4000 TZS for H and 2000 TZS for L parcel. Thus, each farmer generates a total of 6000 TZS [12000 TZS for large farmer under unequal] public benefit for not farming. This amount will be donated to a Tanzanian conservation NGO. As more public benefits are generated when you and your neighbours retire H parcels, **an addition of 1000 TZS can be generated for every H parcel that is retired and that borders to another retired H parcel**. This is because the retirement of both H parcel facilitates free movements of animals and pollinators, unblocking water flows from the streams and forest cover increase. Conservation NGOs will use the paid donation to support nature restoration programs, including tree planting.
- Your decision "not to retire" your farmland(s) for conservation will allow you to continue farming and therefore you will get private benefits of 4 bags of maize for H parcel (equivalent to TZS 2000) and 2 bags of maize for L parcel (equivalent to TZS 1000). These benefits will be given to you as real money.
    - Let's see examples of possible decisions and associated payoffs.
    - *The enumerator will provide four possible examples of decisions and associated personal and public benefit (Appendix 3III).*
    - *We told players that the decision to retire land is irreversible and that, land ownership rights will be shifted to the government.*
- Do you have any question or you need more clarification?
    - *The enumerator should respond to questions and clarifications accordingly.*
- Now let's do a test run. You will not get earnings for your decisions during this test run. This is only meant to familiarize you with and enhance your understanding of the game.

- *The enumerator should allow subjects to make one round of practice that will NOT count for the real earnings.*

- Now you are allowed to communicate. You are given unlimited time to discuss anything of your interests. When you are through with your discussion, one of you can raise up his/her hand.
  - *Enumerator insisted not to disclose their ID during the discussion*
  - *During discussion the experimenter will record the time of start and end time*
- **Remember, your personal earnings depend ONLY on your decision, but public benefits depend on your decision AND your neighbor's decision**.
- Which land parcel(s) are you willing to retire, if any?
  - *Enumerator will call the subject, one-by-one in a private place and ask for his/her willingness to retire for conservation*?
  - *Enumerator will record the decision of a player accordingly (N = if player is not willing to retire any land, L = if player is willing to retire one (any) L parcel, H = if is willing to retire H parcel, Hx = if is willing to retire Hx parcel, LH = if willing to retire any of L parcel and H parcel, LHx = if willing to retire any of L parcel and Hx parcel, LHHx = if willing to retire L and all H parcels, LLH = if willing to retire all L parcels and H parcel, LLHx = if willing to retire all L parcels and Hx parcel, LLHHx= if willing to retire all L parcels and all H parcels, LL= if willing to retire all L parcels and HHx= if willing to retire all H parcels.*

+++Thank you for your time: Round one is completed, welcome to round two+++

C. Round 2 (Fixed conservation payment)

- Now the government wants to reward you for conservation and will offer a conservation payment of 2 bags per retired acre. The subsidy will be converted to real money and given to you. **The markets price of one bag of maize is 500 TZS.**
  - ***All other procedures are the same as in round 1***
  - Remember to locate yourself as player 1, 2, 3 or 4 accordingly in the spatial land configuration of the farmland before you

   - *The enumerator will show the land configuration pinned in the wall.*
- Let's see examples of possible decisions and associated payoffs.
   - *The enumerator will provide four possible examples of decisions and associated personal and public benefit (Appendix 3IV).*

- **Remember, your personal earnings depend ONLY on your decision, but public benefits depend on your decision AND your neighbor's decision**.
- Which land parcel(s) are you willing to retire, if any?
   - *The enumerator will call the subject, one-by-one in a private place and ask for his/her willingness to retire land for conservation*?
   - *The enumerator will record the decision of a player accordingly (N = if player is not willing to retire any land, L = if player is willing to retire one (any) L parcel, H = if is willing to retire H parcel, Hx = if is willing to retire Hx parcel, LH = if willing to retire any of L parcel and H parcel, LHx = if willing to retire any of L parcel and Hx parcel, LHHx = if willing to retire L and all H parcels, LLH = if willing to retire all L parcels and H parcel, LLHx = if willing to retire all L parcels and Hx parcel, LLHHx= if willing to retire all L parcels and all H parcels, LL= if willing to retire all L parcels and HHx= if willing to retire all H parcels.*

++*Thank you for your time: Round two is now completed, welcome to round three*++

D. Round 3 (Fixed conservation payment + Agglomeration bonus)

- Now the government is interested to increase landscape connectivity through conservation of H parcels. As such, it is willing to reward you more by adding a bonus of 1.5 bags of maize on top of the fixed payment (2 bags of maize). **However, the bonus is offered for every border of a conserved H parcel bordering another retired H parcel. This implies that to get the bonus, it depends on both your decision and your neighbours' decisions.** The fixed payment and bonus will be converted to real money and given to you. **Remember the market price of one bag of maize is 500 TZS.**

- ***All other procedures are the same as in round 1***

- Remember to locate yourself as player 1, 2, 3 or 4 accordingly in the spatial land configuration of the farmland before you
    - *The enumerator will show the land configuration pinned on the wall.*
    - Let's see examples of possible decisions and associated payoffs.
    - *The enumerator will provide four possible examples of decisions and associated personal and public benefit (Appendix 3V).*
- **Remember, BOTH your personal earnings and public benefits depend on your decision AND your neighbor's decision**.
- Which land parcel(s) are you willing to retire, if any?
    - *The enumerator will call the subject, one-by-one in a private place and ask for his/her willingness to retire for conservation?*
    - *The enumerator will record the decision of a player accordingly (N = if player is not willing to retire any land, L = if player is willing to retire one (any) L parcel, H = if is willing to retire H parcel, Hx = if is willing to retire Hx parcel, LH = if willing to retire any of L parcel and H parcel, LHx = if willing to retire any of L parcel and Hx parcel, LHHx = if willing to retire L and all H parcels, LLH = if willing to retire all L parcels and H parcel, LLHx = if willing to retire all L parcels and Hx parcel, LLHHx= if willing to retire all L parcels and all H parcels, LL= if willing to retire all L parcels and HHx= if willing to retire all H parcels.*

+++Thank you for your time: Round three is now completed, now welcome for interview session+++

3.4.5 Survey

The post-experiment survey is documented below. All questions were coded in kobotoolbox and tablets were used to facilitate data collection.

Part One: Researcher, players' Information and location

1.1 Name of the researcher_________ Date____________________

1.2 Name of the corridor__________

1.3 Name of the village________ GPS coordinate *(taken at the village centre)* _______

1.4 Player's ID_____________ *(The ID should follow the following sequence: Player No, subgroup, group, village and date. Example: P1-LE-TG-Itipingi-2)*

1.5 To which group does the player belongs? Equal/Unequal _______________

1.6 To which group does the player belongs? Treatment Group (TG)/Control Group (CG)___________

1.7 To which group does the player belongs? Small farmer/ Large farmer_______________

Part two: Socio-economic and demographic characteristics

2.1 What is your age (in years) _________

2.2 Gender (Male/Female) ______________________________

2.3 What is your position in the household? ☐ Head of the household ☐ Spouse

2.4 How many years of formal schooling do you have? ___________________

2.5 What is the family size of your household ___________________________

2.6 What is your marital status

☐ Married ☐ Single ☐ Widow/widower

☐ Separated ☐ Divorced ☐ Other. Specify _______________

2.7 How long in years have you lived in this village________________________

2.8 What are your three most important occupations? *(List in order of time you spend (1st being the one which you spend relatively more time on it)*

☐ Crop farming ☐ Livestock keeping ☐ Formal employment

☐ Business ☐ Informal employment ☐ Other. Specify __

2.9 What type of farming do you practice?

☐ Rainfed ☐ Irrigation ☐ Rainfed and Irrigation

2.10 What type of farming do you practice?

☐ Subsistence farming ☐ Commercial farming ☐ Both subsistence and commercial

2.11 What are the sources of your household income and how much did you earn on average (in TZS) per year in the last five years for each source?

No.	Source of income	Specific source *(E.g., If crop farming, which crops do you cultivate)*	Annual average earnings (In TZS) in the past five years
1	Crop farming		
2	Livestock keeping		
3	Business		
4	Casual labour		
5	Formal employment		
6	Forest harvest		
7	Poaching		
8	Fishing		
9	Social protection		
10	Remittance		
11	Tourism activities		
12	Self-employment		
13	Rent-out of farmland		
14	Others (specify)		

2.12 What was your estimated total household income (in TZS) in the last year (2021)?

Part three: Land

3.1 Which form of land ownership and management describes you better?

☐ I own land in the village ☐ I rent land in the village ☐ I borrow land in the village

3.2 What is the total land (in acres) owned/rented/borrowed in the village? *(For rent or borrowing land report annual average acreage you rented or borrowed in the last five years)*

(a) Own land____________(b) Rent land__________(c) Borrow land _____

3.3 On average how much land (in acres) do you use for each specific land use?

(a) Crop farming only________________(d) Livestock grazing only_______

(b) Crop farming and livestock grazing_________(d) Settlement________

(c) Reserved for future_________________ (f) Other. Specify__________

3.4 For those who own land: How much of your land (in acres), on average, do you

(a) rent-out per year ______________(b) borrow-out per year_________

3.5 For those who own land: How much land (in acres) did you obtain in each of the following ways?

(a) Inherited___________ (d) Allocated by the village government________

(b) Purchasing__________ (e) Forest clearing in a no-man's land __________

(c) Given by relative or friends as gift ______________ (f) Other means_____

3.6 Which form of ownership do you have for owned land?

○ National tittle deed ○ Customary right of occupancy ○ No formal ownership

3.7 Who is the main decision maker with regards to land (e.g., purchase, selling, reallocation etc.) in your household?

☐ Head of the household ☐ Spouse ☐ Both head of household and spouse ☐ Other. Specify ______

3.8 Does the village still have unoccupied land? Yes/No/I don't know _______

3.9 Did you experience any land loss over the last 15 years (either through reallocation or expropriation) Yes/No_______

Part four: Perceived fairness on distribution of experimental land

4.1 **Equal:** Please rate the fairness of your endowment compared to others in the group; 0 (not fair at all), 10 (very fair)

4.2 **Small farmer in unequal:** Please rate the fairness of your endowment compared to those with four parcels in the group; 0 (not fair at all), 10 (very fair)

4.3 **Large farmer in unequal:** Please rate the fairness of your endowment compared to those with two parcels in the group; 0 (not fair at all), 10 (very fair)

Part five: Endorsement of personal values

5.1 To what extent the following (indicators of personal values in the table) are important 'as a guiding principle in your life: −1 (Opposed to the principles that guide you), 0 (Not important), 3 (Important), 6 (Very important), 7 (Supreme important)?

Indicators of personal values	**Likert scale**								
	-1	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
Unity with Nature									
Protecting the Environment:									
Respecting the Earth									
Preventing pollution									
Social power									
Authority									
Wealth									
Ambitious									
Influential									

Part six: Relatedness, trust and information spillover effect

6.1 Was there anyone in the game, who was your relative or friend? Yes/No_______

6.2 How would you rate your involvement in conservation activities (Not at all), 10 (Extremely involved)? ______ *(e.g., as a member of natural resource committee of the village, in conservation awareness, convincing others to protect resources, resource protection, attending conservation meeting etc)*

6.3 Generally speaking, do you trust most of people in the community, 0 (fully disagree) to 10 (fully agree).

6.4 Did you discuss anything related to the game with anyone before playing the game? Yes/No_______

Part seven: Lottery

7.1 *The participants randomly select one out of the three rounds through lottery. The enumerator records the selected round (i.e., first, second or third round). The personal earning and public payoffs are calculated accordingly and communicated to the participants. Each participants receives the accrued personal earning and sign a corresponding receipt.*

+++++Thank you for your time. This marks the end of our interview+++++

3.5 Pre-registration and ethical approval

All main hypotheses were pre-registered in Open Science Framework before data collection on 31st March 2022 (see pre-registration here (https://osf.io/rha5x). Ethical approval was obtained from the Centre for Development Research (ZEF) at the University of Bonn (Appendix 3VI). However, we deviated from the pre-registration in a couple of aspects. We did not test for pre-registered hypothesis one. This is because the final experimental design did not allow us to rigorously test for motivational crowding effects as planned in the pre-registration. Second, in our pre-analysis plan we propose a linear model as the main model. Given the nature of our dependent variable a Tobit model was more appropriate, but, as we show, our results were robust to using linear and ordered Probit specifications. Instead of testing all hypotheses at group level, we tested at individual level using clustered standard errors. This was necessary to account for possible within-subject correlation, which are likely to emerge because of communication. Finally, we decided not to test hypotheses 3a and 3b (in pre-registration) because of incomparable scales of landscape connectivity measures in the equal and unequal subgroups.

2.0 **Supplementary results**

Table 3A.III: Definition of control variables at individual and group level

Variables	Description of variables: Individual-specific covariates	Description of variables: Group-specific covariates
Social economic and demographic variables		
Age (Age)	Age of respondent in years	Average age (meanAge)
Education (Educ)	Years of schooling	Average years of schooling (meanEduc)
Household income (Hh_Income)	Household income of the last year in TZS presented in 1,000,000s	Average household income in TZS (meanHhIncome)
Gender (Sex)	Sex of the respondents (Dummy: 1 = Male, 0 = Female)	Number of females in the group (Number_Females)
Family size (Famil_size)	Number of people who sleep in the same household on a regular basis	Average family size (meanFamil_size)
Total farmland size owned by household in the village (Farm_Own)	Farm size owned by household in acres	Average farm size owned in acres (meanFarm_Own)
Trust	Respondent were to respond to this question: Generally speaking, most people in the community are trusted (Likert scale: 0 = fully disagree, 10 = fully agree).	Average trust (meanTrust)
Land dispossession		
Land loss in the past 15 years (LandLoss_15Yrs)	Whether a farmer experienced any land loss over the last 15 years either through reallocation or expropriation (Dummy: 1 = Yes, 0 = No)	Number of farmers in the group who lost their land in the past 15 years (Number_LandLoss15Yrs)
Authority of a farmer in land related decisions at household level		
Land decision maker (Decision_Land)	The authority of the subject with regards to decisions related to land (purchase, selling, reallocation etc) at household level (Dummy: 1 = subject is the main decision maker or has shared power in land decisions, 0 = subject has no power in decisions)	Number of subjects in the group who are either main decision makers or have shared power in land related decisions at household level (Number_DecisionLand)
Social and environmental relatedness		
Presence of relative or friend in experimental group (Relative_Friend)	Whether a farmer had relative or friend in the same experiment group (Dummy: 1 = Yes, 0 = No)	Number of relatives or friends in the group (Number_RelativeFriend)
Involvement of farmer in conservation activities (Involve_Conservation)	The extent to which farmer involved in conservation activities (Likert scale: 0 = Not at all, 10 = Extremely involved)	Average extent of involvement in conservation activities (meanInvolConser)

Table 3A. IV: Balancing variables for full sample and Equal and Unequal subgroups separately: Mean estimates

Variable	Full Sample	Equal and Unequal			Equal subgroup			Unequal subgroup		
		Equal	Unequal	*Mann-Whitney U test: p-values*	TG	CG	*Mann-Whitney U test: p-values*	TG	CG	*Mann-Whitney U test: p-values*
Social economic and demographic variables										
Age (Years)	44 (13.27)	43.90(13.4)	43.30(13.1)	*0.688*	44.0 (14.0)	43.7(13.0)	*0.951*	43.20(13.6)	43.30(12.8)	*0.827*
Education (Years)	7.0 (2.48)	6.83 (2.5)	6.79 (2.4)	*0.801*	7.05(2.22)	6.60 (2.81)	*0.501*	6.77 (2.42)	6.81(2.45)	*0.748*
Household income[18] (TZS) (x1,000,000)	2.6 (3.1)	0.3(3.0)	2.5 (3.1)	*0.069*	2.6 (2.9)	2.8 (3.2)	*0.786*	2.5 (2.9)	2.5 (3.3)	*0.466*
Gender (1 = Male)	0.61 (0.49)	0.62 (0.49)	0.60 (0.49)	*0.754*	0.65 (0.48)	0.59(0.49)	*0.459*	0.61 (0.49)	0.59 (0.49)	*0.769*
Family size (persons)	6 (2.95)	5.59 (2.81)	5.51 (3.09)	*0.381*	5.39 (2.47)	5.79(3.12)	*0.645*	5.27 (2.72)	5.75 (3.42)	*0.149*
Farmland size owned by household in the village (acres)	8.76 14.68)	9.62 (16.9)	7.91(12.0)	0.846	8.70 (17.2)	10.50(16.7)	0.536	7.77 (11.5)	8.05 (12.5)	0.562
Trust [0;10]	6.93 (2.16)	6.62 (1.96)	7.25 (2.29)	*0.001*	6.77 (1.72)	6.47 (2.18)	*0.409*	7.39 (2.17)	7.12 (2.40)	*0.591*
Land dispossession										
Land loss in the past 15 years (1 = Yes)	0.06 (0.24)	0.07(0.25)	0.06 (0.23)	*0.676*	0.08 (0.28)	0.05 (0.22)	*0.392*	0.05(0.22)	0.06 (0.24)	*0.759*

[18] Household income presented in 1,000,000s

Variable	Full Sample	Equal and Unequal			Equal subgroup			Unequal subgroup		
		Equal	**Unequal**	***Mann-Whitney U test: p-values***	**TG**	**CG**	***Mann-Whitney U test: p-values***	**TG**	**CG**	***Mann-Whitney U test: p-values***
Authority of subjects in land decisions										
Subject's authority in land decision (1 = subject has authority)	0.89 (0.32)	0.89 (0.32)	0.89 (0.31)	0.758	0.89 (0.31)	0.88 (0.33)	0.653	0.89 (0.65)	0.91 (0.66)	0.657
Social and environmental relatedness										
Presence of relative or friend in experimental group (1 = Yes)	0.23 (0.42)	0.26 (0.44)	0.21 (0.40)	0.277	0.24 (0.43)	0.27 (0.45)	0.622	0.23 (0.42)	0.19 (0.39)	0.479
Involvement in conservation activities [0;10]	2.77(3.16)	2.71 (3.08)	2.82 (3.25)	0.367	2.77 (3.07)	2.66 (3.11)	0.721	2.91 (3.42)	2.74 (3.08)	0.929

In brackets are standard deviations

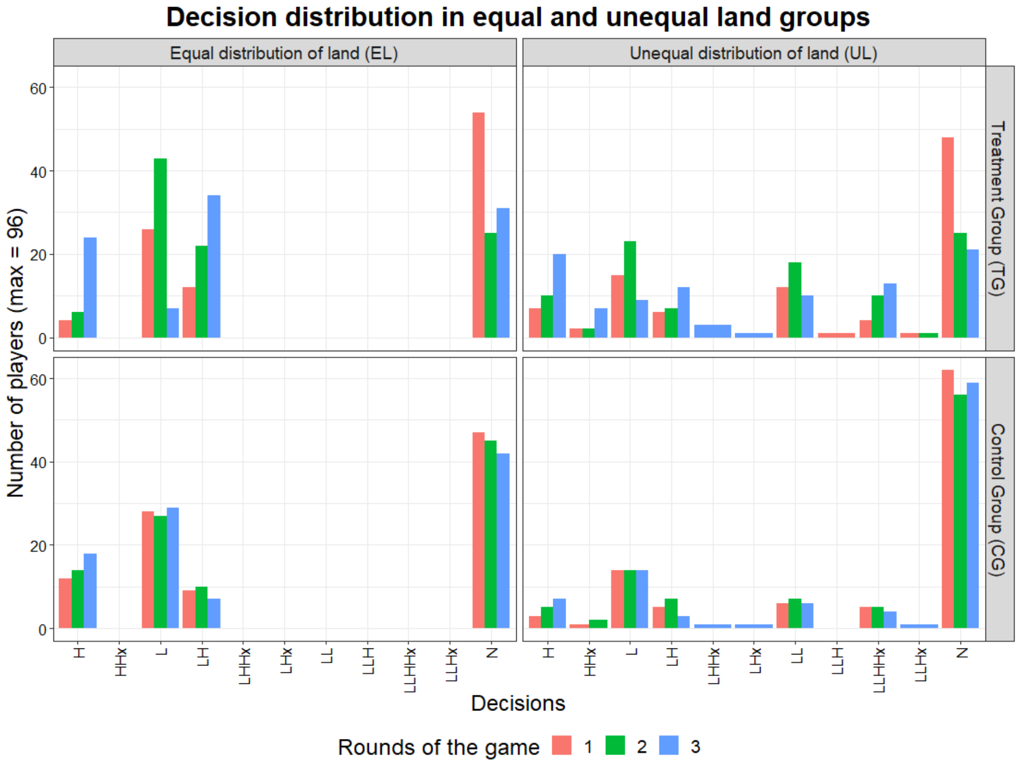

Figure 3A.III: Distribution of individual decisions in equal and unequal subgroups for three rounds. The abbreviations for decisions is as follows: N = if player is not willing to retire any land, L = if player is willing to retire one (any) L parcel, H = if is willing to retire H parcel, Hx = if is willing to retire Hx parcel, LH = if willing to retire any of L parcel and H parcel, LHx = if willing to retire any of L parcel and Hx parcel, LHHx = if willing to retire L and all H parcels, LLH = if willing to retire all L parcels and H parcel, LLHx = if willing to retire all L parcels and Hx parcel, LLHHx= if willing to retire all L parcels and all H parcels, LL= if willing to retire all L parcels and HHx= if willing to retire all H parcels.

Table 3A.V: Full sample treatment effects on environmental benefits

Variables	Tobit model		Linear model	
	(1)	(2)	(3)	(4)
T1: PY	2.60 ***		1.32***	
(Dummy: 1 = TG, 0 = CG)	(0.56)		(0.36)	
T2: PY + AB		4.86 ***		3.21***
(Dummy: 1 = TG, 0 = CG)		(0.59)		(0.38)
Age (Yrs)	-0.04*	-0.02	-0.03**	-0.01
	(0.02)	(0.03)	(0.01)	(0.02)
Educ (Yrs)	-0.06	0.12	-0.04	0.07
	(0.12)	(0.13)	(0.07)	(0.07)
Farm_Own (Acres)	-0.02	-0.04	-0.02	-0.03*
	(0.02)	(0.02)	(0.01)	(0.01)
Hh_Income (TZS)	-0.04	-0.10	-0.01	-0.06
	(0.09)	(0.10)	(0.05)	(0.05)
Gender (1 = Male)	2.44 ***	1.78 **	1.59***	1.22 **
	(0.62)	(0.69)	(0.38)	(0.42)
Famil_size (Persons)	-0.19**	-0.16	-0.12**	-0.10*
	(0.10)	(0.10)	(0.05)	(0.05)
Trust [0;10]	-0.05	-0.12	0.00	-0.04
	(0.12)	(0.13)	(0.07)	(0.08)
Type of farmer	-3.29***	-4.02 ***	-2.60***	-3.19***
(Dummy: 1 = Small farmer)	(0.85)	(0.87)	(0.61)	(0.62)
LandLoss_15Yrs	-1.53	-0.61	-0.80 *	-0.22
(1 = Yes)	(0.97)	(1.14)	(0.46)	(0.71)
Decision_Land	-1.42*	-0.75	-0.82	-0.36
(1 = Yes)	(0.86)	(0.91)	(0.54)	(0.59)
Relative_Friend	0.07	-0.32	-0.01	-0.18
(1 = Yes)	(0.63)	(0.72)	(0.42)	(0.46)
Involve_Conservation	0.15 *	0.16 *	0.11*	0.09
[0;10]	(0.09)	(0.09)	(0.06)	(0.07)
Constant	6.30 **	4.67 *	6.26***	5.41***
	(2.15)	(2.34)	(1.35)	(1.45)
Corridor-fixed effect	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes
Observation	384	384	384	384
R^2 Adj			0.17	0.28

Dependent variable is scaled by 1000 for easy interpretation of results. Standard errors in parentheses, clustered at individual level.

*p<0.1, **p<0.05, ***p<0.01*

Table 3A.VI: Treatment effects on environmental benefits among small farmers in the equal versus unequal subgroups

Variables	First round	Second round			Third round		
	Equal & Unequal	Equal	Unequal	Equal & Unequal	Equal	Unequal	Equal & Unequal
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Equal/unequal subgroups (LD) (Dummy: 1 = Equal, 0 = Unequal)	0.70 (1.09)			0.42 (1.07)			0.22 (1.08)
T1: PY (Dummy: 1 = TG, 0 = CG)		2.71*** (0.58)	1.26 (0.86)	1.51 * (0.89)			
T1*LD				0.56 (1.07)			
T2: PY+AB (Dummy: 1 = TG, 0 = CG)					3.69*** (0.63)	4.18*** (0.80)	4.86*** (0.89)
T2*LD							-1.77 (1.10)
Age (Yrs)	-0.02 (0.03)	-0.05 * (0.02)	0.06 (0.04)	-0.03 (0.02)	-0.02 (0.03)	0.04 (0.03)	-0.01 (0.02)
Educ (Yrs)	0.02 (0.13)	-0.21 * (0.11)	0.45* (0.22)	-0.07 (0.10)	-0.13 (0.12)	0.50 ** (0.19)	0.02 (0.11)
Farm_Own (Acres)	0.00 (0.02)	-0.01 (0.01)	-0.08 (0.06)	-0.01 (0.02)	-0.02 (0.02)	-0.04 (0.04)	-0.02 (0.02)
Hh_Income (TZS)	-0.13 (0.11)	0.00 (0.08)	0.18 (0.22)	-0.06 (0.08)	-0.03 (0.10)	0.07 (0.18)	-0.10 (0.08)
Gender (1 = Male)	0.49 (0.68)	1.51 * (0.60)	0.72 (0.91)	1.34 * (0.52)	1.30 * (0.70)	1.07 (0.93)	1.14* (0.57)
Famil_size (Persons)	0.02 (0.10)	-0.02 (0.09)	0.04 (0.21)	-0.03 (0.09)	0.01 (0.10)	-0.05 (0.17)	-0.03 (0.09)
Trust [0;10]	-0.14 (0.14)	-0.07 (0.13)	0.00 (0.17)	-0.05 (0.11)	-0.21 (0.16)	-0.08 (0.16)	-0.19 (0.12)
LandLoss_15Yrs (1 = Yes)	-2.63* (1.49)	-0.16 (1.06)	- 21.33*** (2.38)	-1.55 (1.00)	-0.56 (1.10)	- 21.70** (1.67)	-1.58 (1.02)
Decision_Land (1 = Yes)	0.12 (1.23)	-1.23 (0.87)	-1.05 (2.47)	-1.15 (0.87)	-0.77 (0.99)	-1.25 (1.43)	-0.68 (0.82)
Relative_Friend (1 = Yes)	0.25 (0.69)	-0.51 (0.62)	0.47 (0.87)	0.11 (0.54)	-0.22 (0.74)	-0.19 (0.95)	-0.13 (0.58)
Involve_Conservation [0;10]	0.11 (0.10)	0.05 (0.09)	-0.26 * (0.13)	0.01 (0.08)	0.11 (0.10)	-0.16 (0.13)	0.08 (0.08)
Constant	0.73 (2.46)	2.56 (2.36)	-3.68 (4.25)	2.79 (1.98)	-0.43 (2.82)	-3.09 (3.30)	1.32 (1.95)
Corridor-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	288	192	96	288	192	96	288
Pseudo R^2	0.02	0.07	0.59	0.05	0.07	0.61	0.07

Dependent variable is scaled by 1000 for easy interpretation of results. Standard errors in parentheses, clustered at individual level.

*p<0.1, **p<0.05, ***p<0.01*

Table 3A.VII: Treatment effects on environmental benefits among small farmers in the equal versus unequal subgroups: Ordered probit model

Dependent variable: Farmers decisions (LH = 3, H = 2, L =1 and N = 0)							
	First round	Second round			Third round		
Variables	Equal & Unequal	Equal	Unequal	Equal & Unequal	Equal	Unequal	Equal & Unequal
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Equal/unequal subgroups (LD) (Dummy: 1 = Equal, 0 = Unequal)	0.21 (0.24)			0.10 (0.28)			0.05 (0.28)
T1: PY (Dummy: 1 = TG, 0 = CG)		0.83*** (0.19)	0.30 (0.27)	0.39 (0.24)			
T1*LD				0.22 (0.30)			
T2: PY+AB (Dummy: 1 = TG, 0 = CG)					1.00*** (0.19)	1.09*** (0.28)	1.15*** (0.25)
T2*LD							-0.30 (0.31)
Age (Yrs)	0.00 (0.01)	-0.02 (0.01) *	0.02 (0.01)	-0.01 (0.01)	0.00 (0.01)	0.01 (0.01)	0.00 (0.01)
Educ (Yrs)	0.01 (0.03)	-0.07 * (0.04)	0.15* (0.07)	-0.02 (0.03)	-0.03 (0.04)	0.15* (0.07)	0.01 (0.03)
Farm_Own (Acres)	0.00 (0.01)	0.00 (0.01)	-0.03 * (0.02)	0.00 (0.01)	-0.01 (0.01)	-0.01 (0.02)	-0.01 (0.00)
Hh_Income (TZS)	-0.03 (0.03)	0.00 (0.03)	0.08 (0.06)	-0.01 (0.02)	-0.01 (0.03)	0.07 (0.06)	-0.02 (0.02)
Gender (1 = Male)	0.12 (0.16)	0.53** (0.19)	0.22 (0.30)	0.42** (0.15)	0.40 * (0.19)	0.22 (0.31)	0.32 * (0.16)
Famil_size (Persons)	0.01 (0.03)	0.00 (0.03)	0.01 (0.05)	-0.01 (0.03)	0.00 (0.03)	-0.02 (0.05)	0.00 (0.03)
Trust [0;10]	-0.04 (0.03)	-0.02 (0.04)	0.00 (0.06)	-0.02 (0.03)	-0.05 (0.04)	-0.03 (0.06)	-0.05 (0.03)
LandLoss_15Yrs (1 = Yes)	-0.63 * (0.33)	-0.08 (0.34)	-6.77** (0.00)	-0.47 (0.29)	-0.07 (0.33)	-5.86** (0.00)	-0.36 (0.29)
Decision_Land (1 = Yes)	-0.02 (0.26)	-0.45 * (0.27)	-0.39 (0.62)	-0.38 (0.24)	-0.12 (0.27)	-0.37 (0.59)	-0.10 (0.24)
Relative_Friend (1 = Yes)	0.05 (0.17)	-0.18 (0.20)	0.09 (0.32)	-0.01 (0.16)	-0.07 (0.20)	0.08 (0.33)	-0.04 (0.16)
Involve_Conservation [0;10]	0.03 (0.02)	0.02 (0.03)	-0.08* (0.05)	0.01 (0.02)	0.02 (0.03)	-0.04 (0.05)	0.02 (0.02)
Corridor-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	288	192	96	288	192	96	288
McFadden's Pseudo-R^2	0.39	0.59	0.08	0.13	0.11	0.20	0.11

Dependent variable is scaled by 1000 for easy interpretation of results. Standard errors in parentheses, clustered at individual level.

*p<0.1, **p<0.05, ***p<0.01*

Table 3A. VIII: The effect of rounds of the game on environmental benefits: Tobit model

Variables	(1)	(2)	(3)
Round_2	0.59	0.45	0.57
	(0.68)	(0.48)	(0.64)
Round_3	0.37	0.29	0.37
	(0.66)	(0.47)	(0.63)
Age (Yrs)		-0.04*	-0.06**
		(0.02)	(0.02)
Educ (Yrs)		-0.03	0.02
		(0.08)	(0.11)
Farm_Own (Acres)		-0.01	-0.01
		(0.01)	(0.02)
Hh_Income (TZS)		-0.10	-0.12
		(0.07)	(0.09)
Gender (1 = Male)		1.43**	2.36***
		(0.45)	(0.63)
Famil_size (Persons)		-0.07	-0.14+
		(0.06)	(0.08)
Trust [0;10]		-0.18*	-0.09
		(0.08)	(0.11)
LandLoss_15Yrs (1 = Yes)		-1.02	-0.66
		(0.80)	(0.96)
Decision_Land (1 = Yes)		-0.66	-0.70
		(0.66)	(0.85)
Relative_Friend (1 = Yes)		-0.05	0.05
		(0.51)	(0.74)
Involve_Conservation [0;10]		0.22***	0.25**
		(0.06)	(0.09)
Type of farmer (Dummy: 1 = Small farmer)			-3.13***
			(0.91)
Equal/unequal subgroups (LD) (Dummy: 1 = Equal, 0 = Unequal)			3.55**
			(1.09)
Constant	-0.90*	2.63*	4.20**
	(0.51)	(1.34)	(1.90)
Corridor-fixed effect	No	No	Yes
Enumerator-fixed effect	No	No	Yes
Observations	576	576	576

*Standard errors in parentheses, clustered at individual level. p<0.1, **p<0.05, ***p<0.01*

Table 3A. IX: Regressing total environmental benefits and individual-specific variables: Linear model

Variables	Control group	Treatment group
Age (Yrs)	-0.03 (0.04)	0.05 (0.04)
Educ (Yrs)	0.12 (0.25)	0.29 (0.18)
Farm_Own (Acres)	0.02 (0.04)	-0.04 (0.04)
Hh_Income (TZS)	-0.01 (0.17)	0.24 (0.15)
Gender (1 = Male)	1.84 (0.97)	0.17 (0.78)
Famil_size (Persons)	-0.19 (0.13)	-0.20 (0.18)
Trust [0;10]	-0.28 (0.24)	-0.27 (0.18)
Type of farmer (Dummy: 1 = Small farmer)	-1.50 (0.80) *	-2.60*** (0.66)
LandLoss_15Yrs (1 = Yes)	-4.37 (2.07) *	-1.44* (1.72)
Decision_Land (1 = Yes)	-0.85 (1.38)	2.69 (1.39)
Relative_Friend (1 = Yes)	1.81* (1.08)	-2.02* (0.83)
Involve_Conservation [0;10]	0.22 (0.16)	-0.04 (0.13)
Enmrt_Bias1	-5.46 (3.51)	9.24 (2.27) ***
Enmrt_Bias2	-2.94 (1.85)	0.43 (1.41)
Enmrt_Bias3	-6.45 (3.52)	-3.25 (1.52)
Village_1	4.99* (1.97)	1.75 (1.74)
Village_2	4.71 (3.28)	-1.73 (1.81)
Village_3	5.49 (3.98)	1.09 (2.37)
Village_4	4.51 (2.48)	2.88* (1.61)
Village_5	0.76 (2.11)	1.28 (1.92)
Village_6	-2.06 (1.89)	-3.26 (2.21)
Village_7	-1.71 (1.88)	-2.35 (2.22)
Village_8	-1.31 (1.96)	-0.32 (1.80)
Village_9	0.80 (1.70)	2.18 (2.07)
Constant	5.07 (4.27)	-0.01 (3.38)
Observations	96	96
R^2	0.388	0.499

Dependent variable is scaled by 1000 for easy interpretation of results

Appendix 3I: Example of signed consent form from one of the participants

Barua ya Makubaliano

Jina la Kijiji: NKONGOI **Tarehe:** 02/05/2022

Kwako mshiriki,

Mimi naitwa Qambemeda Masala Nyanghura, ni mwanafunzi wa shahada ya uzamivu kutoka Kituo cha Utafiti wa Maendeleo (ZEF), Chuo Kikuu cha Bonn, Ujerumani. Ninafanya utafiti kuhusu uhifadhi wa ushoroba nchini Tanzania. Utafiti huu utatumia mbinu za mchezo na dodoso.

Ninaomba ushiriki wako, ambao utahusisha kushiriki katika mchezo na baadaye dodoso fupi. Kipindi cha mchezo kitachukua muda wa masaa mawili na dodoso itachukua wastani wa dakika 30.

Mchezo utahusisha mapato ya kweli. Mapato yatakua kwa mfumo wa fedha taslimu. Kiasi cha fedha utakazozipata kitategemea uamuzi wako na uamuzi wa jirani yako kwenye mchezo. Baada ya mchezo, utatakiwa kujibu dodoso kuhusu maisha yako na mtazamo wako kuhusu uhifadhi wa ushoroba. Mapato yako katika mchezo na majibu ya dodoso yatakuwa ya siri na yatatumika tu kwa madhumuni ya kitaaluma. Hakuna mahali popote jina lako litachapishwa.

Ushiriki wako katika utafiti huu ni wa hiari kabisa. Unaweza kuchagua kushiriki au kujiondoa kwenye utafiti wakati wowote. Hata hivyo, kama utaamua kuondoka kabla ya mchezo kuisha hutaweza kupata malipo yeyote. Malipo yatatolewa mara baada ya kumaliza kujibu maswali ya dodoso.

Pamoja na ushiriki wako, ninaomba kupiga picha wakati wa mchezo na / au dodoso. Picha hizo zinaweza kutumika kwa madhumuni ya utafiti kama vile katika mawasilisho na machapisho.

Tafadhali napenda kujua kama unakubali kuwa sehemu ya utafiti huu.

Wako,

Qambemeda M. Nyanghura.

[redacted]

Kwa kusaini hapa chini, unatoa idhini ya kushiriki katika utafiti kama ulivyoelezwa hapo juu na kukubaliana na masharti kama yaliyoonyeshwa.

Sahihi	Jina	Tarehe
[redacted]	[redacted]	T.R 2/5/2022

Appendix 3II: Example of lay out of posters in equal subgroup

Appendix 3III: Examples of decisions and associated personal and public benefit for equal and unequal subgroups in round one

Equal			**Unequal**		
Examples of decision	**Personal benefit *(Agricultural benefit from non-retired parcel)***	**Public benefit = *Environmental benefit from retired parcel***	**Examples of decision**	**Personal benefit *(Agricultural benefit from non-retired parcel)***	**Public benefit = *Environmental benefit from retired parcel +(possible additional of 2)***
Player 1 | Player 2 **L | H | H | L** **L | H | H | L** **Player 3 | Player 4** *No player retires any land*	**Player 1**: 2+4 = **6 TZS** **Player 2:** 2+4 = **6 TZS** **Player 3:** 2+4 = **6 TZS** **Player 4:** 2+4 = **6 TZS**	**Player 1**: = **0TZS** **Player 2**: = **0TZS** **Player 3**: = **0TZS** **Player 4**: = **0TZS**	**Player 1 | Player 2** **L | H | H | H_x | L | L** **L | H | H | H_x | L | L** **Player 3 | Player 4** *No player retires any land*	**Player 1**: 2+4 = **6 TZS** **Player2:**2+2+4+4= 2**TZS** **Player 3:** 2+4 = **6 TZS** **Player4:**2+2+4+4= **2TZS**	**Player 1**: = **0TZS** **Player 2**: = **0TZS** **Player 3**: = **0TZS** **Player 4**: = **0TZS**
Player 1 | Player 2 **L | H | H | L** **L | H | H | L** **Player 3 | Player 4** *Player 1 retire H and Player 2 retire H*	**Player 1**: = **2TZS** **Player 2: = 2TZS** **Player 3:** 2+4 = **6TZS** **Player 4:** 2+4 = **6TZS**	**Player 1**: 8+2 = **10 TZS** **Player 2**: 8+2 = **10 TZS** **Player 3**: = **0TZS** **Player 4**: = **0TZS**	**Player 1 | Player 2** **L | H | H | H_x | L | L** **L | H | H | H_x | L | L** **Player 3 | Player 4** *Player 1 retire H and Player 2 retire H*	**Player 1**: = **2TZS** **Player 2**: 2+2+4 = 8**TZS** **Player 3:** 2+4 = **6TZS** **Player4:**2+2+4+4= 2**TZS**	**Player 1**: 8+(2) = **10 TZS** **Player 2**: 8+2 = **10 TZS** **Player 3**: = **0TZS** **Player 4**: = **0TZS**
Player 1 | Player 2 **L | H | H | L** **L | H | H | L** **Player 3 | Player 4** *Player 1, 2 and 4 retire H each*	**Player 1**: = **2TZS** **Player 2: = 2TZS** **Player 3:** 2+4 = **6TZS** **Player 4**: = **2TZS**	**Player 1**: 8+2 = **10 TZS** **Player 2**: 8+2+2 = **12 TZS** **Player 3**: = **0TZS** **Player 4**: 8+2 = **10 TZS**	**Player 1 | Player 2** **L | H | H | H_x | L | L** **L | H | H | H_x | L | L** **Player 3 | Player 4** *Player 1 retire H and Hx*	**Player 1**: = **2TZS** **Player 2**: 2+2 = 4**TZS** **Player 3:** 2+4 = **6TZS** **Player 4**:2+2+4+4= 2**TZS**	**Player 1**: 8+2 = 10 **TZS** **Player 2**:8+8+(2) +(2) +(2) =**22 TZS** **Player 3**: = **0TZS** **Player 4**: = **0 TZS**
Player 1 | Player 2 **L | H | H | L** **L | H | H | L** **Player 3 | Player 4** *Player 1 retire L&H; player 2&3 retire H each and player 4 retire L.*	**Player 1**: = **0TZS** **Player 2: = 2TZS** **Player 3**: = **2TZS** **Player 4**: = **4TZS**	**Player 1:4+8+2+2= 16TZS** **Player 2: 8+2 = 10 TZS** **Player 3: 8+2 = 10 TZS** **Player 4: = 4 TZS**	**Player 1 | Player 2** **L | H | H | H_x | L | L** **L | H | H | H_x | L | L** **Player 3 | Player 4** *Player 1 retire LH; player 2&3 retire H each and player 4 retire LHx.*	**Player 1: = 0TZS** **Player 2: 2+2+4 = 8TZS** **Player 3: = 2TZS** **Player 4: 2+4 = 6TZS**	**Player 1:4+8+(2) +(2) = 16TZS** **Player 2: 8+2 = 10 TZS** **Player 3: 8+2 = 10 TZS** **Player 4: 8+4 = 12 TZS**

Appendix 3IV: Examples of decisions and associated personal and public benefit for equal and unequal subgroups in round two

Equal			**Unequal**		
Examples of decision	**Personal benefit** ***(Agricultural benefit+ subsidy)***	**Public benefit =** ***Environmental benefit from retired parcel***	**Examples of decision**	**Personal benefit** ***(Agricultural benefit+ subsidy)***	**Public benefit =** ***Environmental benefit from retired parcel +(possible additional of 2)***
Player 1 Player 2 L H H L L H H L Player 3 Player 4 *No player retires any land*	Player 1: 2+4 = 6 TZS Player 2: 2+4 = 6 TZS Player 3: 2+4 = 6 TZS Player 4: 2+4 = 6 TZS	Player 1: = 0TZS Player 2: = 0TZS Player 3: = 0TZS Player 4: = 0TZS	Player 1 Player 2 L H H H_x L L L H H H_x L L Player 3 Player 4 *No player retires any land*	Player 1: 2+4 = 6 TZS Player 2: 2+2+4+4 = 12TZS Player 3: 2+4 = 6 TZS Player 4: 2+2+4+4 = 12TZS	Player 1: = 0TZS Player 2: = 0TZS Player 3: = 0TZS Player 4: = 0TZS
Player 1 Player 2 L H H L L H H L Player 3 Player 4 *Player 1 retire H and Player 2 retire H*	Player 1: 2+2 = 4 TZS Player 2: 2+2 = 4 TZS Player 3: 2+4 = 6 TZS Player 4: 2+4 = 6 TZS	Player 1: 8+2 = 10 TZS Player 2: 8+2 = 10 TZS Player 3: = 0TZS Player 4: = 0TZS	Player 1 Player 2 L H H H_x L L L H H H_x L L Player 3 Player 4 *Player 1 retire H and Player 2 retire H*	Player 1: 2+2= 4TZS Player 2: 2+2+4+2= 10TZS Player 3: 2+4 = 6TZS Player 4: 2+2+4+4 = 12TZS	Player 1: 8+(2) = 10 TZS Player 2: 8+2 = 10 TZS Player 3: = 0TZS Player 4: = 0TZS
Player 1 Player 2 L H H L L H H L Player 3 Player 4 *Player 1, 2 and 4 retire H each.*	Player 1: 2+2 = 4 TZS Player 2: 2+2 = 4 TZS Player 3: 2+4 = 6TZS Player 4: 2+2 = 4 TZS	Player 1: 8+2 = 10 TZS Player 2: 8+2+2=12 TZS Player 3: = 0TZS Player 4: 8+2 = 10 TZS	Player 1 Player 2 L H H H_x L L L H H H_x L L Player 3 Player 4 *Player 1 retire H and Hx*	Player 1: 2+2 = 4TZS Player 2: 2+2+2+2 = 8TZS Player 3: 2+4 = 6TZS Player 4: 2+2+4+4 = 12TZS	Player 1: 8+2 = 10 TZS Player 2: 8+8+(2) +(2) +(2) = 22 TZS Player 3: = 0TZS Player 4: = 0TZS
Player 1 Player 2 L H H L L H H L Player 3 Player 4 *Player 1 retire L&H; player 2&3 retire H each and player 4 retire L.*	Player 1: 2+2 = 4 TZS Player 2: 2+2 = 4 TZS Player 3: 2+2 = 4 TZS Player 4: 2+4 = 6 TZS	Player 1:4+8+2+2= 16TZS Player 2: 8+2 = 10 TZS Player 3: 8+2 = 10 TZS Player 4: 4 TZS	Player 1 Player 2 L H H H_x L L L H H H_x L L Player 3 Player 4 *Player 1 retire LH; player 2&3 retire H each and player 4 retire LHx.*	Player 1: 2+2 = 4TZS Player 2: 2+2+4 +2 = 10TZS Player 3: 2+2= 4TZS Player 4: 2+2+2+4 = 10TZS	Player 1:4+8+(2) +(2) = 16TZS Player 2: 8+2 = 10 TZS Player 3: 8+2 = 10 TZS Player 4: 8+4 = 12 TZS

Appendix 3V: Examples of decisions and associated personal and public benefit for equal and unequal subgroups in round three

Equal			**Unequal**		
Examples of decision	**Personal benefit = *Agricultural benefit + subsidy+ bonus***	**Public benefit = *Environmental benefit from retired parcels***	**Examples of decision**	**Personal benefit *Agricultural benefit + subsidy+ bonus***	**Public benefit = *Environmental benefit from retired parcel +(possible additional of 2)***
Player 1 Player 2 **L H H L** **L H H L** **Player 3 Player 4** *No player retires any land*	**Player 1**: 2+4 = **6 TZS** **Player 2:** 2+4 = **6 TZS** **Player 3:** 2+4 = **6 TZS** **Player 4:** 2+4 = **6 TZS**	**Player 1: = 0TZS** **Player 2: = 0TZS** **Player 3: = 0TZS** **Player 4**: = **0TZS**	**Player 1 Player 2** **L H H H_x L L** **L H H H_x L L** **Player 3 Player 4** *No player retires any land*	**Player 1**: 2+4 = **6 TZS** **Player 2:** 2+2+4+4 = **12TZS** **Player 3:** 2+4 = **6 TZS** **Player 4:** 2+2+4+4 = **12TZS**	**Player 1: = 0TZS** **Player 2: = 0TZS** **Player 3: = 0TZS** **Player 4**: = **0TZS**
Player 1 Player 2 **L H H L** **L H H L** **Player 3 Player 4** *Player 1 retire H and Player 2 retire H*	**Player1**:2+2+1.5= **.5TZS** **Player2:**2+2+1.5= **.5TZS** **Player 3:** 2+4 = **6TZS** **Player 4:** 2+4 = **6TZS**	**Player 1**: 8+2= **10 TZS** **Player 2**: 8+2 =**10 TZS** **Player 3**: = **0TZS** **Player 4**: = **0TZS**	**Player 1 Player 2** **L H H H_x L L** **L H H H_x L L** **Player 3 Player 4** *Player 1 retire H and Player 2 retire H*	**Player 1**: 2+2+(1.5) = **5.5TZS** **Player2:**2+2+4+2+(1.5) = **1.5TZS** **Player 3:** 2+4 = **6TZS** **Player 4:** 2+2+4+4 = **12TZS**	**Player 1**: 8+(2) = **10 TZS** **Player 2**: 8+(2) = **10 TZS** **Player 3**: **0TZS** **Player 4**: **0TZS**
Player 1 Player 2 **L H H L** **L H H L** **Player 3 Player 4** *Player 1, 2 and 4 retire H each.*	**Player 1**:2+2+1.5=**5.5TZS** **Player2**:2+2+1.5+1.5=**7TZS** **Player 3:** 2+4 = **6TZS** **Player 4**:2+2+1.5 = **5.5TZS**	**Player 1**: 8+2 =**10 TZS** **Player 2**:8+2+2=**12TZS** **Player 3**: = **0TZS** **Player 4**:8+2 = **10 TZS**	**Player 1 Player 2** **L H H H_x L L** **L H H H_x L L** **Player 3 Player 4** *Player 1 retire H and Hx*	**Player 1**: 2+2+(1.5) = **5.5TZS** **Player 2**:2+2+2+2+(1.5)+(1.5)+(1.5)=**12.5TZS** **Player 3:** 2+4 = **6TZS** **Player 4**: 2+2+4+4 = **12TZS**	**Player 1**: 8+2 = **10 TZS** **Player 2**:8+8+(2) +(2) +(2) = **22 TZS** **Player 3**: = **0 TZS** **Player 4**: = **0 TZS**
Player 1 Player 2 **L H H L** **L H H L** **Player 3 Player 4** *Player 1 retire L&H; player 2&3 retire H each and player 4 retire L.*	**Player1**:2+2+1.5+1.5=**7TZS** **Player2**:2+2+1.5 = **5.5TZS** **Player3**:2+2+1.5 = **5.5TZS** **Player4**:4+2 = **6TZS**	**Player1**:4+8+2+2= **16TZS** **Player 2**:8+2 = **10 TZS** **Player 3**:8+2 = **10 TZS** **Player 4**: = **4 TZS**	**Player 1 Player 2** **L H H H_x L L** **L H H H_x L L** **Player 3 Player 4** *Player 1 retire LH; player 2&3 retire H each and player 4 retire LHx.*	**Player 1**: 2+2+(1.5) +(1.5) = **7TZS** **Player 2**: 2+2+4 +2 +(1.5) = **11.5TZS** **Player 3**: 2+2+(1.5) = **5.5TZS** **Player 4**: 2+2+2+4 = **10TZS**	**Player1**:4+8+(2)+(2)= **16TZS** **Player 2**: 8+(2) = **10 TZS** **Player 3**: 8+(2) = **10 TZS** **Player 4**: 8+4 = **12 TZS**

Appendix 3VI: Ethical clearance certificate

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Certification

The following research has been pre-reviewed for ethical standards by the ZEF Research Ethics Board. The researcher named below submitted an application for ethical clearance prior to commencing the research. The application was independently reviewed by two reviewers of the Board and found to be ethically sound. The ZEF Research Ethics Board includes senior researchers from ZEF and the Institute for Food and Resource Economics (ILR) at the Faculty of Agriculture in Bonn. The Ethical Clearance is based on the ZEF Ethics Policy[1]

Registration code:	6c_ 21Qambemeda Nyanghura
Title of the research study:	Effectiveness of Conservation Policies to Improve Landscape Connectivity: Evidence from a Wildlife Corridor in Tanzania.
Location(s) of field research	Tanzania
If applicable, name of a larger project:	-
Name of the researcher:	Nyanghura Qambemeda
Department / affiliated institute:	ZEFb
Source of funding:	BMZ via DAAD/EPOS
Date of approval of the ethical clearance:	11.1.22

11 January 2022

[redacted]

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[1] https://www.zef.de/fileadmin/webfiles/downloads/doc-program/Website_2014_various/ZEF_ethic_policy-web.pdf

Appendix Chapter 4

Table 4A.1: Mean comparison test between personal values endorsed by farmers across different socioeconomic characteristics: Mann-Whitney test except for land ownership (Kruskal-Wallis test).

Variables	Category	Mean biospheric	p-value biospheric	Mean egoistic	p-value Egoistic
Gender	1 = Male	5.12 (1.52)	0.33	4.47 (1.74)	0.84
	0 = Female	4.77 (1.55)		3.96 (1.80)	
Land ownership (acres)	0 = landless farmers	4.77 (1.67)	0.49	4.03 (1.89)	0.45
	1 = less than mean size	5.09 (1.46)		4.23 (1.80)	
	2 = more than mean size	4.85(1.64)		4.51 (1.66)	
Age (years)	0 = youth (below 35 years)	5.02 (1.58)	0.03	4.29 (1.78)	0.01
	1 = adult (above 35 years)	4.91 (1.46)		4.25 (1.79)	
Annual household income (TZS)	0 = below mean	5.03 (1.54)	0.39	4.08 (1.84)	0.00
	1 = above mean	4.89 (1.54)		4.72 (1.55)	
Education (years of schooling)	0 = below mean	4.52 (1.76)	0.03	3.9 (1.87)	0.08
	1 = above mean	5.07 (1.49)		4.35 (1.75)	
Family size (persons)	0 = below mean	5.09 (1.51)	0.12	4.15 (1.90)	0.20
	1 = above mean	4.85 (1.58)		4.45 (1.60)	
Marital status	0 = not married	4.80 (1.49)	0.38	3.52 (1.85)	0.00
	1 = married	5.00 (1.55)		4.37 (1.75)	

Note: in parentheses are standard deviations

Table 4A.2: The effect of experimental variables on personal values.

Variables	Dependent variables = personal values	
	Biospheric	Egoistic
Equal/Unequal: (Equal = 1)	0.304	0.102
	(0.257)	(0.290)
Treatment/Control: (Treatment = 1)	0.161	0.067
	(0.151)	(0.170)
Small/Large farmer: (Small = 1)	−0.185	0.300
	(0.209)	(0.235)
Age (Yrs)	0.009	0.002
	(0.006)	(0.007)
Educ (Yrs)	0.086*	0.101**
	(0.034)	(0.038)
Hh_Income (TZS)	−0.007	0.078**
	(0.026)	(0.029)
Gender (1 = Male)	0.272	0.342*
	(0.178)	(0.201)
Famil_size (Persons)	−0.052*	0.033
	(0.027)	(0.030)
Marital_status (Married =1,0)	0.063	0.292
	(0.269)	(0.303)
Farm_Own (Acres)	0.006	−0.003
	(0.006)	(0.006)
Trust [0;10]	0.112**	0.143***
	(0.035)	(0.039)
Decision_Land (1 = Yes)	0.372	−0.207
	(0.254)	(0.286)
Relative_Friend (1 = Yes)	−0.128	0.007
	(0.174)	(0.196)
Constant	3.641***	1.284*
	(0.642)	(0.723)
Corridor-fixed effect	Yes	Yes
Enumerator-fixed effect	Yes	Yes
N	381	381
R2	0.206	0.240

Standard errors in parentheses, clustered at individual level. p<0.1, **p<0.05, ***p<0.01

Table 4A.3: The effect of personal values on environmental benefits.

Variables	(1)	(2)	(3)
Biospheric	0.109***	0.104***	0.087***
	(0.013)	(0.013)	(0.013)
Egoistic	−0.043***	−0.046***	−0.063***
	(0.010)	(0.010)	(0.010)
Age (Yrs)		−0.002	−0.002*
		(0.001)	(0.001)
Educ (Yrs)		0.005	0.005
		(0.008)	(0.007)
Hh_Income (TZS)		−0.001	0.000
		(0.006)	(0.006)
Gender (1 = Male)		0.155***	0.152***
		(0.041)	(0.039)
Famil_size (Persons)		−0.009	−0.008
		(0.006)	(0.006)
Marital_status (Married =1,0)		0.093	0.073
		(0.065)	(0.064)
Farm_Own (Acres)		−0.004**	−0.003*
		(0.001)	(0.001)
Trust [0;10]		−0.017*	−0.011
		(0.007)	(0.007)
Decision_Land (1 = Yes)		−0.142*	−0.124*
		(0.057)	(0.054)
Relative_Friend (1 = Yes)		0.003	0.012
		(0.040)	(0.038)
Treatment/Control: (Treatment = 1)			0.239***
			(0.033)
Equal/Unequal: (Equal = 1)			−0.013
			(0.066)
Small/Large farmer: (Small = 1)			−0.023
			(0.045)
Round two (ref = round one)			0.169***
			(0.039)
Round three (ref = round one)			0.258***
			(0.039)
Constant	−0.251***	−0.022	−0.170
	(0.068)	(0.146)	(0.153)
Corridor-fixed effect	Yes	Yes	Yes
Enumerator-fixed effect	Yes	Yes	Yes
N	1143	1143	1143
Pseudo R^2	0.043	0.071	0.142

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A.4: The interaction effect of incentives and personal values (full sample of 1143 observations).

Variables	(1)	(2)	(3)	(4)
Treatment/Control: (Treatment = 1)	0.239***	0.305**	0.204**	0.279**
	(0.033)	(0.125)	(0.085)	(0.130)
Biospheric	0.087***	0.094***	0.087***	0.097***
	(0.013)	(0.018)	(0.013)	(0.019)
Egoistic	−0.063***	−0.063***	−0.067***	−0.071***
	(0.010)	(0.010)	(0.014)	(0.015)
Treatment × Biospheric		−0.013		−0.020
		(0.023)		(0.025)
Treatment × Egoistic			0.008	0.015
			(0.018)	(0.020)
Age (Yrs)	−0.002*	−0.002*	−0.002*	−0.002*
	(0.001)	(0.001)	(0.001)	(0.001)
Educ (Yrs)	0.005	0.005	0.006	0.006
	(0.007)	(0.007)	(0.008)	(0.008)
Hh_Income (TZS)	0.000	0.000	0.000	0.000
	(0.006)	(0.006)	(0.006)	(0.006)
Gender (1 = Male)	0.152***	0.152***	0.150***	0.151***
	(0.039)	(0.039)	(0.039)	(0.039)
Famil_size (Persons)	−0.008	−0.008	−0.008	−0.008
	(0.006)	(0.006)	(0.006)	(0.006)
Marital_status (Married =1,0)	0.073	0.070	0.075	0.070
	(0.064)	(0.064)	(0.064)	(0.064)
Farm_Own (Acres)	−0.003**	−0.003**	−0.003**	−0.003***
	(0.001)	(0.001)	(0.001)	(0.001)
Trust [0;10]	−0.011	−0.011	−0.010	−0.010
	(0.007)	(0.007)	(0.007)	(0.007)
Decision_Land (1 = Yes)	−0.124**	−0.123**	−0.123**	−0.120**
	(0.054)	(0.054)	(0.054)	(0.055)
Relative_Friend (1 = Yes)	0.012	0.012	0.014	0.014
	(0.038)	(0.038)	(0.038)	(0.038)
Equal/Unequal: (Equal = 1)	−0.013	−0.016	−0.012	−0.015
	(0.066)	(0.066)	(0.066)	(0.066)
Small/Large farmer: (Small = 1)	−0.023	−0.023	−0.022	−0.023
	(0.045)	(0.045)	(0.044)	(0.045)
Round two (ref = round one)	0.169***	0.169***	0.169***	0.169***
	(0.039)	(0.039)	(0.039)	(0.039)
Round three (ref = round one)	0.258***	0.258***	0.258***	0.258***
	(0.039)	(0.039)	(0.039)	(0.039)
Constant	−0.170	−0.199	−0.160	−0.198
	(0.153)	(0.168)	(0.155)	(0.168)
Corridor−fixed effect	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes
N	1143	1143	1143	1143
Pseudo R^2	0.142	0.143	0.143	0.143

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A.5: The interaction effect of incentives and personal values (for treatment rounds—second and third rounds, 762 observations).

Variables	(1)	(2)	(3)	(4)
Treatment/Control: (Treatment = 1)	0.338***	0.419**	0.318**	0.398**
	(0.038)	(0.143)	(0.098)	(0.149)
Biospheric	0.084***	0.092***	0.084***	0.095***
	(0.015)	(0.020)	(0.015)	(0.021)
Egoistic	−0.057***	−0.057***	−0.060***	−0.064***
	(0.012)	(0.012)	(0.017)	(0.017)
Treatment × Biospheric		−0.016		−0.021
		(0.026)		(0.028)
Treatment × Egoistic			0.005	0.011
			(0.021)	(0.023)
Age (Yrs)	−0.002	−0.002*	−0.002	−0.003*
	(0.002)	(0.002)	(0.002)	(0.002)
Educ (Yrs)	0.003	0.003	0.003	0.003
	(0.009)	(0.009)	(0.009)	(0.009)
Hh_Income (TZS)	−0.001	−0.001	0.000	−0.001
	(0.006)	(0.006)	(0.006)	(0.006)
Gender (1 = Male)	0.173***	0.174***	0.172***	0.173***
	(0.044)	(0.044)	(0.044)	(0.044)
Famil_size (Persons)	−0.010	−0.009	−0.010	−0.009
	(0.007)	(0.007)	(0.007)	(0.007)
Marital_status (Married =1,0)	0.078	0.074	0.079	0.074
	(0.072)	(0.072)	(0.072)	(0.072)
Farm_Own (Acres)	−0.003**	−0.003**	−0.003**	−0.003**
	(0.001)	(0.001)	(0.001)	(0.001)
Trust [0;10]	−0.010	−0.010	−0.010	−0.010
	(0.008)	(0.008)	(0.008)	(0.008)
Decision_Land (1 = Yes)	−0.151*	−0.150*	−0.150*	−0.147*
	(0.061)	(0.061)	(0.061)	(0.062)
Relative_Friend (1 = Yes)	0.003	0.003	0.004	0.004
	(0.043)	(0.043)	(0.043)	(0.043)
Equal/Unequal: (Equal = 1)	−0.037	−0.040	−0.036	−0.039
	(0.075)	(0.075)	(0.075)	(0.075)
Small/Large farmer: (Small = 1)	−0.014	−0.014	−0.014	−0.014
	(0.050)	(0.050)	(0.050)	(0.050)
Round three (ref = round two)	0.090**	0.090**	0.090**	0.090**
	(0.035)	(0.035)	(0.035)	(0.035)
Constant	−0.015	−0.053	−0.010	−0.051
	(0.170)	(0.189)	(0.173)	(0.189)
Corridor−fixed effect	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes
N	762	762	762	762
Pseudo R^2	0.180	0.181	0.181	0.181

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A. 6: The interaction effect of T1 and personal values for equal and unequal subgroups.

Variables	Equal subgroup				Unequal subgroup			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
T1: PY (Dummy: 1 = TG, 0 = CG)	0.333***	0.966**	0.967***	1.343***	0.246***	0.045	−0.026	−0.030
	(0.072)	(0.334)	(0.281)	(0.379)	(0.074)	(0.241)	(0.143)	(0.241)
Biospheric	0.099**	0.159***	0.091**	0.137**	0.070**	0.048	0.071**	0.071*
	(0.031)	(0.046)	(0.029)	(0.045)	(0.026)	(0.038)	(0.025)	(0.041)
Egoistic	−0.046	−0.054*	0.016	0.000	−0.066**	−0.066**	−0.108***	−0.107***
	(0.029)	(0.029)	(0.038)	(0.039)	(0.021)	(0.021)	(0.029)	(0.031)
T1 × Biospheric		−0.119**		−0.090		0.040		0.001
		(0.060)		(0.058)		(0.044)		(0.050)
T1 × Egoistic			−0.129**	−0.108*			0.074*	0.074**
			(0.056)	(0.056)			(0.031)	(0.035)
Age (Yrs)	−0.006*	−0.007**	−0.006*	−0.007**	0.001	0.001	0.000	0.000
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Educ (Yrs)	−0.025*	−0.026*	−0.029*	−0.029*	0.021	0.020	0.022	0.022
	(0.013)	(0.013)	(0.014)	(0.013)	(0.018)	(0.018)	(0.018)	(0.018)
Hh_Income (TZS)	0.003	0.003	0.003	0.003	0.012	0.013	0.013	0.013
	(0.009)	(0.010)	(0.010)	(0.010)	(0.014)	(0.014)	(0.013)	(0.013)
Gender (1 = Male)	0.169**	0.191**	0.206**	0.217**	0.242**	0.243**	0.244**	0.244**
	(0.075)	(0.076)	(0.075)	(0.077)	(0.089)	(0.089)	(0.090)	(0.089)
Famil_size (Persons)	−0.002	0.001	−0.004	−0.002	−0.020	−0.020	−0.017	−0.017
	(0.012)	(0.011)	(0.012)	(0.012)	(0.013)	(0.013)	(0.014)	(0.014)
Marital_status (Married =1,0)	0.179	0.119	0.140	0.100	0.002	0.004	−0.006	−0.006
	(0.126)	(0.124)	(0.117)	(0.118)	(0.127)	(0.126)	(0.125)	(0.125)
Farm_Own (Acres)	−0.002	−0.002	−0.001	−0.001	−0.005	−0.005	−0.006	−0.006
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Trust [0;10]	−0.013	−0.013	−0.014	−0.014	−0.006	−0.005	−0.003	−0.003
	(0.015)	(0.015)	(0.014)	(0.014)	(0.013)	(0.014)	(0.014)	(0.014)
Decision_Land (1 = Yes)	−0.193*	−0.173	−0.197*	−0.181	−0.201	−0.202	−0.176	−0.176
	(0.112)	(0.113)	(0.109)	(0.111)	(0.136)	(0.134)	(0.133)	(0.134)
Relative_Friend (1 = Yes)	−0.074	−0.052	−0.066	−0.051	0.026	0.038	0.049	0.049
	(0.077)	(0.080)	(0.076)	(0.078)	(0.080)	(0.080)	(0.078)	(0.079)
Small/Large farmer: (Small = 1)					−0.029	−0.029	−0.027	−0.027
					(0.071)	(0.070)	(0.070)	(0.069)
Constant	−0.069	−0.343	−0.402	−0.553	0.005	0.119	0.104	0.107
	(0.334)	(0.354)	(0.317)	(0.344)	(0.330)	(0.367)	(0.329)	(0.373)
Corridor−fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	191	191	191	191	190	190	190	190
Pseudo R^2	0.234	0.252	0.257	0.267	0.217	0.221	0.235	0.235

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A. 7: The interaction effect of T2 and personal values for equal and unequal.

Variables	Equal subgroup				Unequal subgroup			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
T2: PY+AB (Dummy: 1 = TG, 0 = CG)	0.449***	1.629***	1.510***	2.217***	0.542**	0.285	0.2708*	0.222
	(0.078)	(0.396)	(0.300)	(0.417)	(0.072)	(0.231)	(0.151)	(0.235)
Biospheric	0.105**	0.218***	0.090*	0.179***	0.059*	0.031	0.061*	0.053
	(0.038)	(0.048)	(0.037)	(0.047)	(0.026)	(0.036)	(0.025)	(0.039)
Egoistic	−0.033	−0.050	0.068*	0.036	−0.070**	−0.069**	−0.112***	−0.109**
	(0.032)	(0.032)	(0.038)	(0.040)	(0.022)	(0.022)	(0.031)	(0.034)
T2 × Biospheric		−0.220**		−0.170*		0.051		0.013
		(0.070)		(0.068)		(0.042)		(0.047)
T2 × Egoistic			−0.214**	−0.173**			0.075*	0.070*
			(0.060)	(0.059)			(0.036)	(0.040)
Age (Yrs)	−0.002	−0.005*	−0.003	−0.005*	0.003	0.003	0.003	0.003
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Educ (Yrs)	−0.015	−0.017	−0.021	−0.021	0.046**	0.044*	0.047*	0.046*
	(0.015)	(0.014)	(0.014)	(0.014)	(0.018)	(0.018)	(0.018)	(0.018)
Hh_Income (TZS)	−0.001	−0.001	−0.003	−0.002	0.010	0.011	0.010	0.010
	(0.011)	(0.011)	(0.011)	(0.012)	(0.014)	(0.014)	(0.014)	(0.014)
Gender (1 = Male)	0.158*	0.193*	0.219*	0.234**	0.172*	0.175*	0.175*	0.176*
	(0.090)	(0.088)	(0.089)	(0.088)	(0.089)	(0.089)	(0.088)	(0.089)
Famil_size (Persons)	0.005	0.009	0.001	0.005	−0.023	−0.023	−0.020	−0.020
	(0.013)	(0.012)	(0.012)	(0.012)	(0.015)	(0.015)	(0.016)	(0.016)
Marital_status (Married =1,0)	0.065	−0.043	−0.005	−0.076	0.069	0.070	0.057	0.058
	(0.158)	(0.156)	(0.144)	(0.147)	(0.147)	(0.145)	(0.146)	(0.145)
Farm_Own (Acres)	−0.004*	−0.004*	−0.003	−0.003	−0.005	−0.005	−0.006	−0.006
	(0.002)	(0.002)	(0.002)	(0.002)	(0.004)	(0.004)	(0.004)	(0.004)
Trust [0;10]	−0.031*	−0.031*	−0.034*	−0.034*	−0.005	−0.003	−0.002	−0.002
	(0.018)	(0.018)	(0.017)	(0.018)	(0.015)	(0.015)	(0.015)	(0.015)
Decision_Land (1 = Yes)	−0.142	−0.092	−0.148	−0.108	−0.138	−0.141	−0.113	−0.116
	(0.123)	(0.115)	(0.120)	(0.114)	(0.125)	(0.122)	(0.123)	(0.123)
Relative_Friend (1 = Yes)	−0.035	0.000	−0.024	0.000	−0.030	−0.014	−0.004	−0.001
	(0.089)	(0.092)	(0.087)	(0.090)	(0.095)	(0.095)	(0.093)	(0.093)
Small/Large farmer: (Small = 1)					0.003	0.003	0.005	0.004
					(0.067)	(0.067)	(0.067)	(0.067)
Constant	−0.392	−0.916*	−0.939*	−1.232**	−0.317	−0.164	−0.213	−0.180
	(0.402)	(0.384)	(0.391)	(0.395)	(0.327)	(0.355)	(0.323)	(0.362)
Corridor−fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
N	191	191	191	191	190	190	190	190
Pseudo R^2	0.203	0.239	0.244	0.265	0.299	0.304	0.314	0.315

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A. 8: The interaction effect of T1 and T2 and personal values for small farmers in unequal.

Variables	(1)	(2)	(3)	(4)
T1: PY (Dummy: 1 = TG, 0 = CG)	−0.157	−0.424*		
	(0.380)	(0.248)		
T2: PY+AB (Dummy: 1 = TG, 0 = CG)			0.271	0.054
			(0.318)	(0.212)
Biospheric	0.012	0.053	0.025	0.059*
	(0.058)	(0.035)	(0.050)	(0.033)
Egoistic	−0.055*	−0.141**	−0.051	−0.123**
	(0.031)	(0.044)	(0.033)	(0.043)
T1 × Biospheric	0.071			
	(0.068)			
T1 × Egoistic		0.158***		
		(0.053)		
T2 × Biospheric			0.057	
			(0.061)	
T2 × Egoistic				0.130**
				(0.053)
Age (Yrs)	0.004	0.003	0.002	0.001
	(0.005)	(0.005)	(0.004)	(0.004)
Educ (Yrs)	0.040	0.042	0.050**	0.053**
	(0.025)	(0.026)	(0.021)	(0.022)
Hh_Income (TZS)	0.005	0.005	0.001	0.001
	(0.025)	(0.025)	(0.021)	(0.022)
Gender (1 = Male)	0.163	0.114	0.197	0.164
	(0.124)	(0.129)	(0.130)	(0.126)
Famil_size (Persons)	0.011	0.019	−0.002	0.006
	(0.025)	(0.027)	(0.022)	(0.024)
Marital_status (Married =1,0)	−0.216	−0.175	−0.231	−0.211
	(0.213)	(0.217)	(0.207)	(0.211)
Farm_Own (Acres)	−0.006	−0.006	−0.002	−0.002
	(0.007)	(0.007)	(0.006)	(0.005)
Trust [0;10]	−0.003	0.001	−0.013	−0.008
	(0.022)	(0.022)	(0.021)	(0.021)
Decision_Land (1 = Yes)	−0.207	−0.137	−0.187	−0.138
	(0.299)	(0.300)	(0.228)	(0.229)
Relative_Friend (1 = Yes)	0.120	0.186	0.008	0.065
	(0.119)	(0.115)	(0.138)	(0.131)
Constant	0.005	−0.013	−0.023	−0.046
	(0.581)	(0.554)	(0.460)	(0.449)
Corridor−fixed effect	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes
N	94	94	94	94

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Table 4A. 9: The interaction effect of T1 and T2 and personal values for large farmers in unequal.

Variables	(1)	(2)	(3)	(4)
T1: PY (Dummy: 1 = TG, 0 = CG)	0.194	0.216		
	(0.278)	(0.173)		
T2: PY+AB (Dummy: 1 = TG, 0 = CG)			0.289	0.455*
			(0.352)	(0.208)
Biospheric	0.049	0.058*	0.031	0.057
	(0.045)	(0.034)	(0.053)	(0.041)
Egoistic	−0.084**	−0.095**	−0.099***	−0.117**
	(0.026)	(0.036)	(0.029)	(0.044)
T1 × Biospheric	0.018			
	(0.051)			
T1 × Egoistic		0.021		
		(0.039)		
T2 × Biospheric			0.054	
			(0.063)	
T2 × Egoistic				0.032
				(0.048)
Age (Yrs)	−0.002	−0.002	0.000	0.001
	(0.004)	(0.004)	(0.004)	(0.004)
Educ (Yrs)	0.012	0.013	0.040	0.043
	(0.030)	(0.030)	(0.030)	(0.031)
Hh_Income (TZS)	0.025	0.024	0.011	0.010
	(0.019)	(0.019)	(0.023)	(0.024)
Gender (1 = Male)	0.327**	0.333**	0.145	0.154
	(0.117)	(0.118)	(0.108)	(0.110)
Famil_size (Persons)	−0.050*	−0.051*	−0.053*	−0.056*
	(0.021)	(0.022)	(0.025)	(0.027)
Marital_status (Married =1,0)	0.103	0.094	0.261	0.248
	(0.125)	(0.127)	(0.169)	(0.173)
Farm_Own (Acres)	−0.004	−0.004	−0.007	−0.007
	(0.006)	(0.006)	(0.006)	(0.006)
Trust [0;10]	0.001	0.002	0.016	0.016
	(0.016)	(0.017)	(0.020)	(0.020)
Decision_Land (1 = Yes)	−0.268*	−0.261*	−0.153	−0.131
	(0.145)	(0.145)	(0.144)	(0.141)
Relative_Friend (1 = Yes)	0.025	0.024	0.018	0.008
	(0.124)	(0.122)	(0.145)	(0.143)
Constant	0.437	0.427	0.088	−0.006
	(0.501)	(0.458)	(0.533)	(0.499)
Corridor−fixed effect	Yes	Yes	Yes	Yes
Enumerator−fixed effect	Yes	Yes	Yes	Yes
N	96	96	96	96

Standard errors (in parentheses) are clustered at individual level. *p<0.1, **p<0.05, ***p<0.01

Appendix for extended analysis

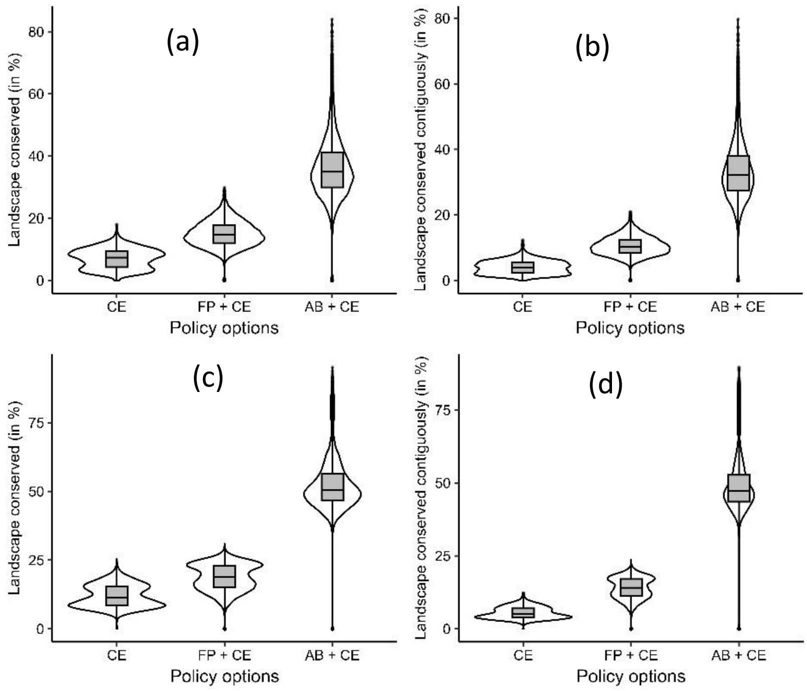


Figure 6A.1: Percent of landscape conserved and connected under each policy option and for two ecological corridors. (a) and (b) shows percent of landscape conserved and connected respectively in IIWC. (c) and (d) shows the same for BKG.

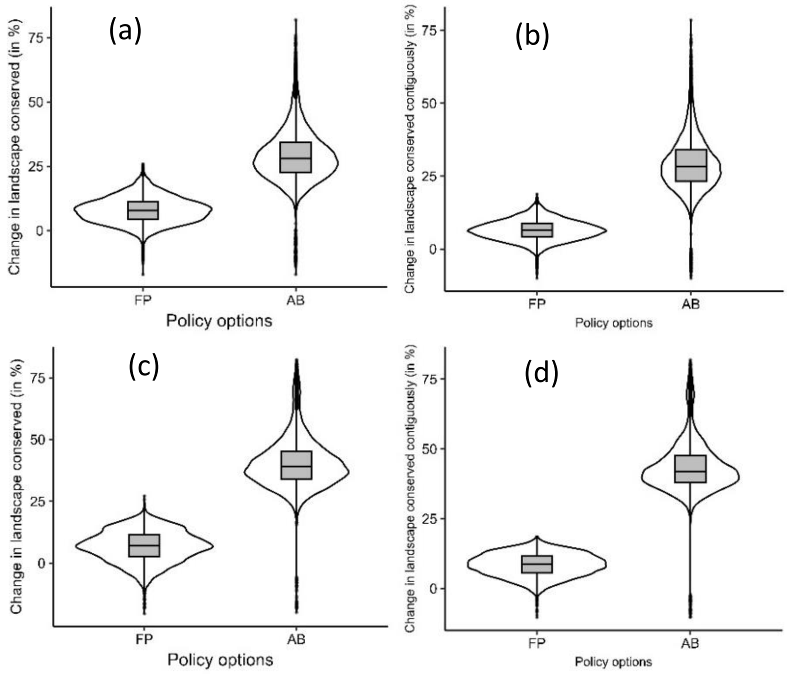


Figure 6A.2: Change in landscape conserved and connected under each policy option and for two ecological corridors. (a) and (b) shows percent change of landscape conserved and connected respectively in IIWC. (c) and (d) shows the same for BKG.

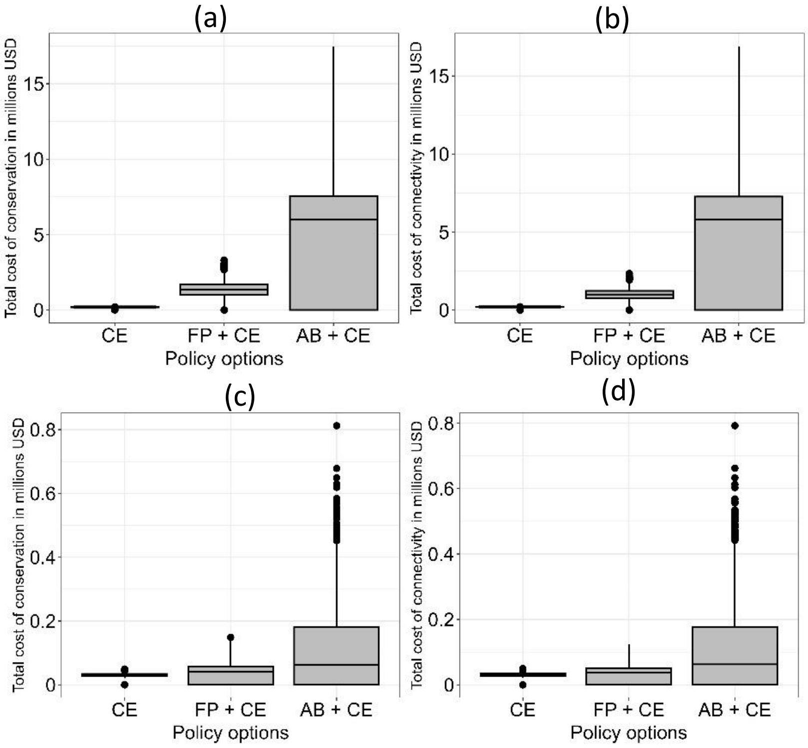


Figure 6A.3. Total costs for landscape conservation and connectivity under each policy option and for two ecological corridors. (a) and (b) shows the total costs of landscape conservation and connectivity respectively in IIWC. (c) and (d) shows the same for BKG.

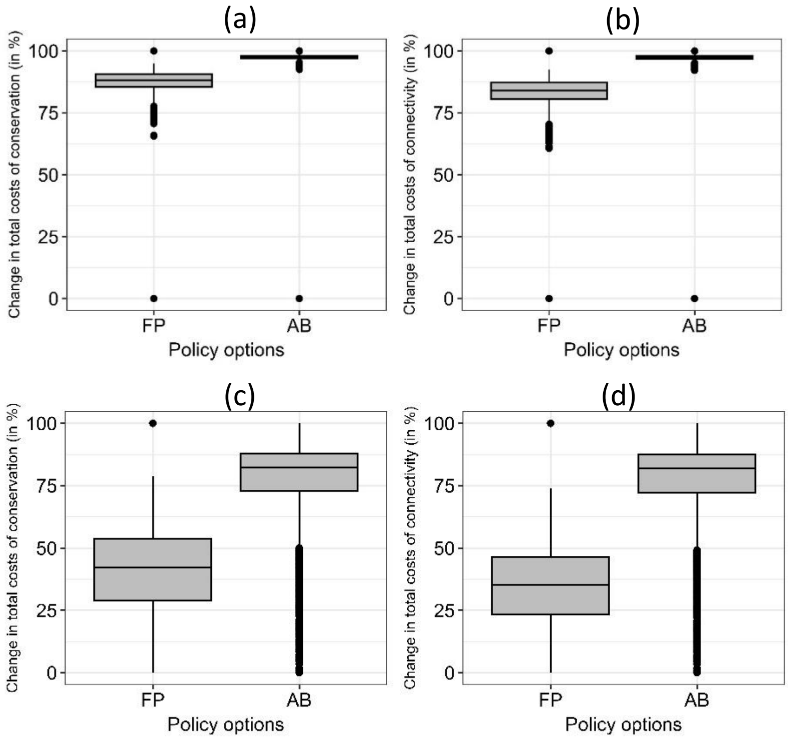
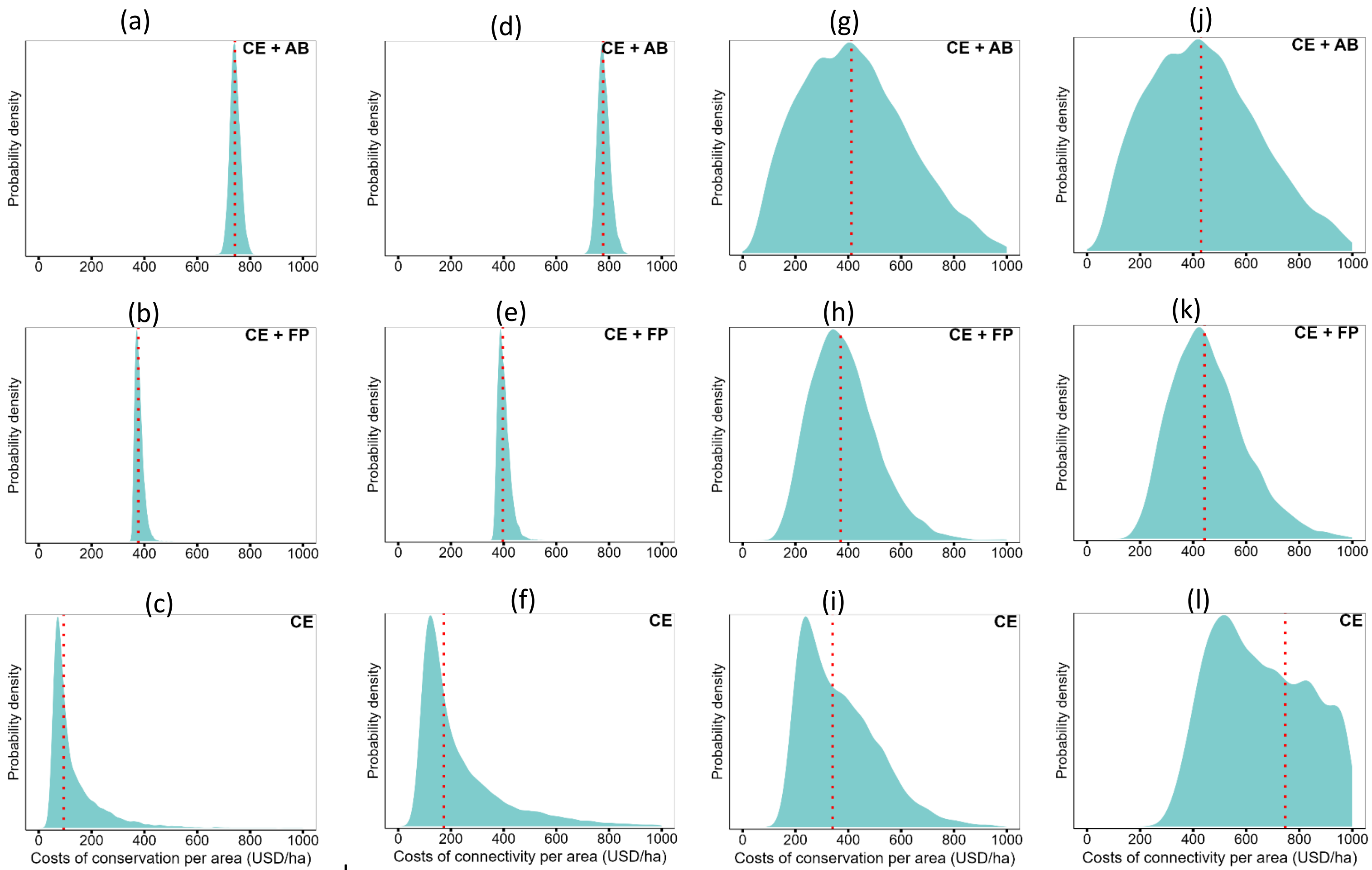


Figure 6A.4. Change in total costs for landscape conservation and connectivity under each policy option and for two ecological corridors. (a) and (b) shows the change in total costs of landscape conservation and connectivity respectively in IIWC. (c) and (d) shows the same for BKG.



d

Figure 6A.5. Costs per hectare of landscape conserved and connected under each policy option and for the two ecological corridors. (a), (b) and (c) shows the costs of conservation per hectare in IIWC. (d), (e), and (f) shows the cost of connectivity per hectare in IIWC. (g), (h) and (i) shows the costs of conservation per hectare in BKG. (k), (l), and (m) shows the cost of connectivity per hectare in BKG.

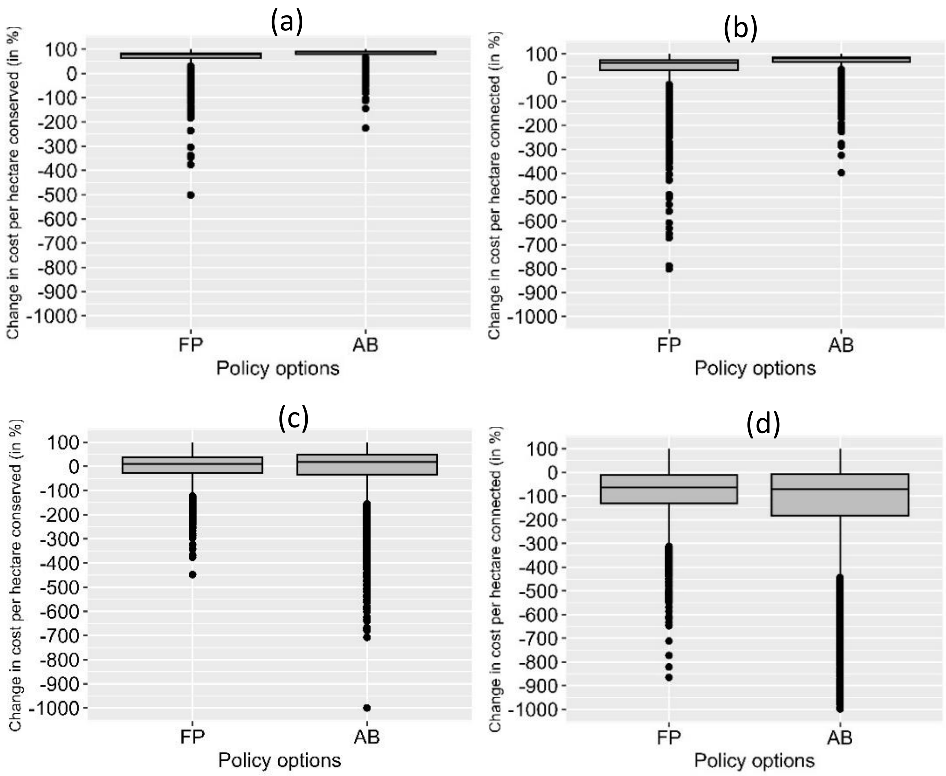


Figure 6A.6. Change in costs per hectare for a landscape conserved and connected under each policy option and for two ecological corridors. (a) and (b) shows the change in costs per hectare of a landscape conserved and connected respectively in IIWC. (c) and (d) shows the same for BKG.

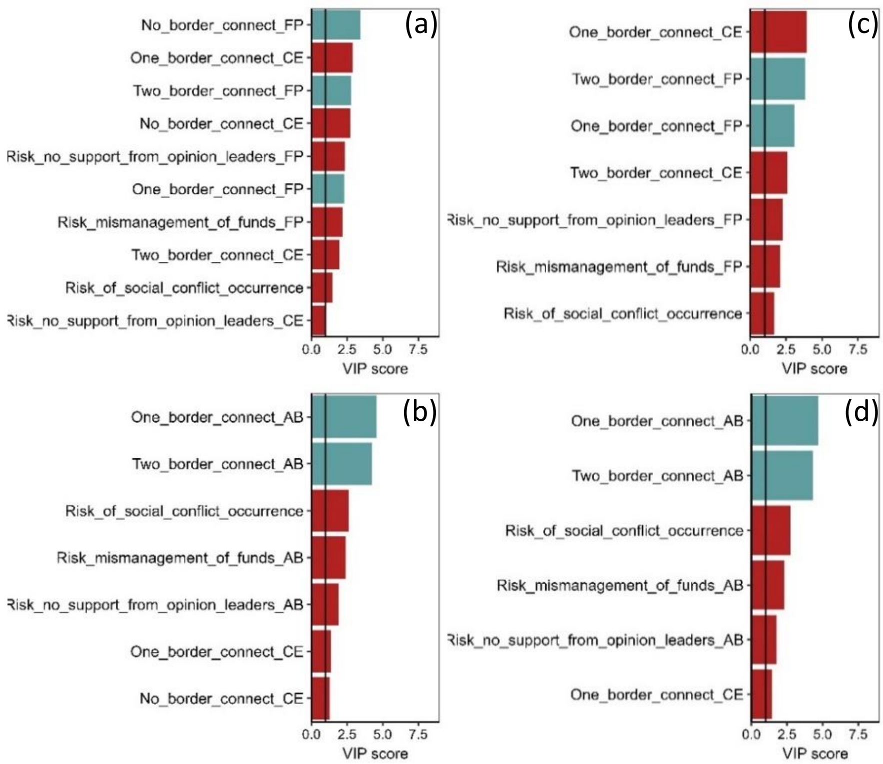


Figure 6A.7. VIP scores for difference in landscape conserved (a and c) and connectivity (b and d) due to additional of FP (a and b) and AB (c and d) to CE in IIWC

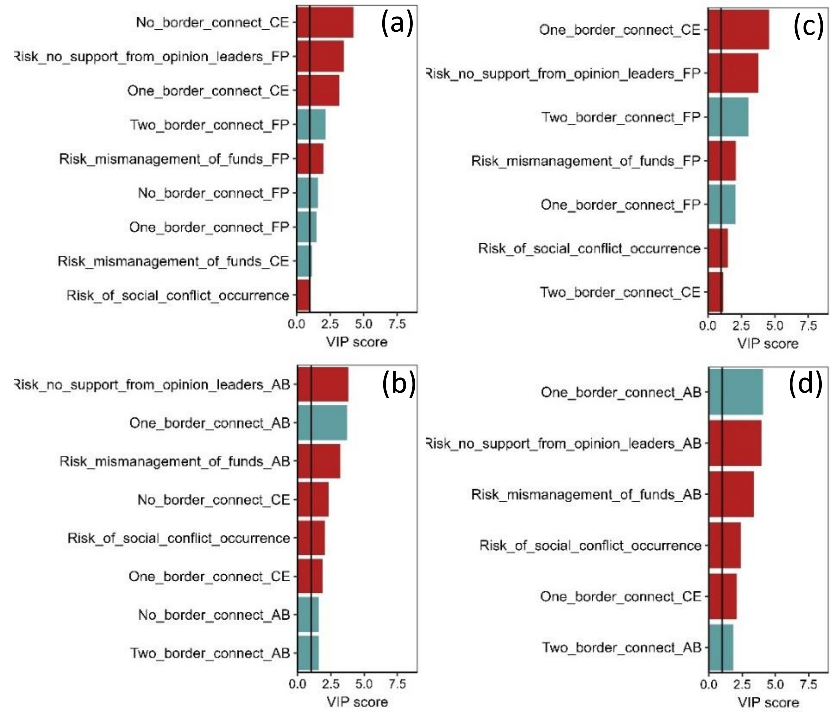


Figure 6A.8. VIP scores for difference in landscape conserved (a and c) and connectivity (b and d) due to additional of FP (a and b) and AB (c and d) to CE in BKG

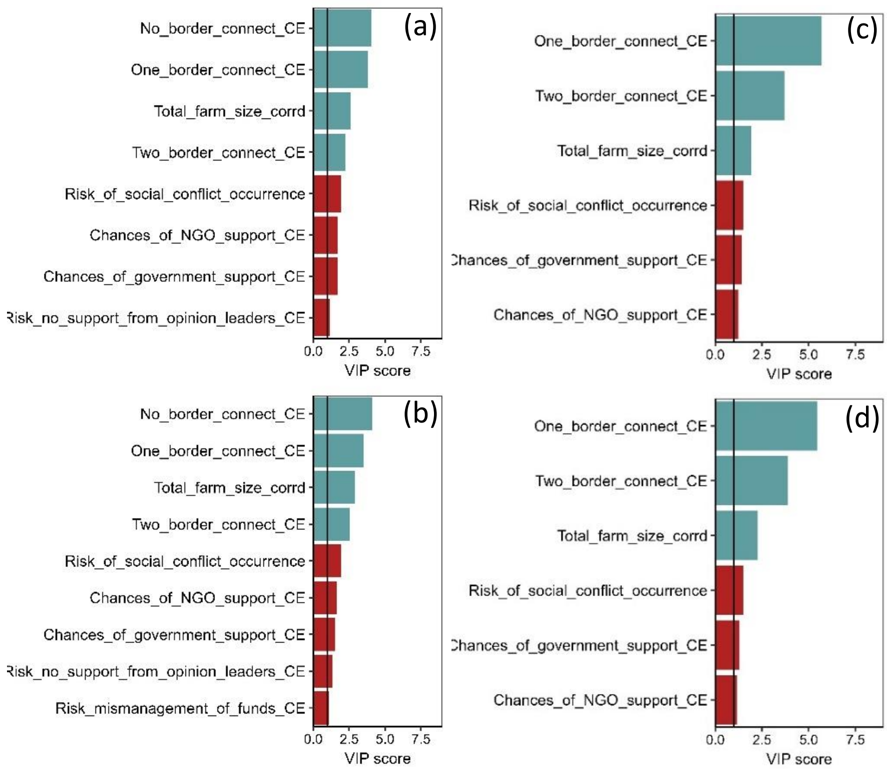


Figure 6A.9. VIP scores for difference in cost effectiveness for conserved (a and c) and connectivity (b and d) due to additional of FP (a and b) and AB (c and d) to CE in IIWC

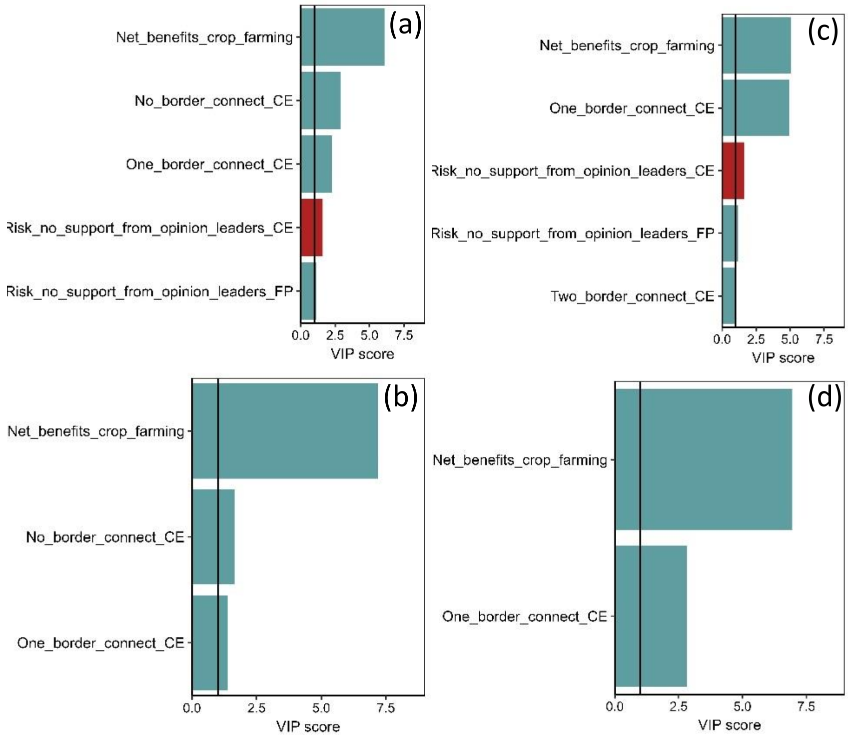


Figure 6A.10. VIP scores for difference in cost effectiveness for conserved (a and c) and connectivity (b and d) due to additional of FP (a and b) and AB (c and d) to CE in BKG

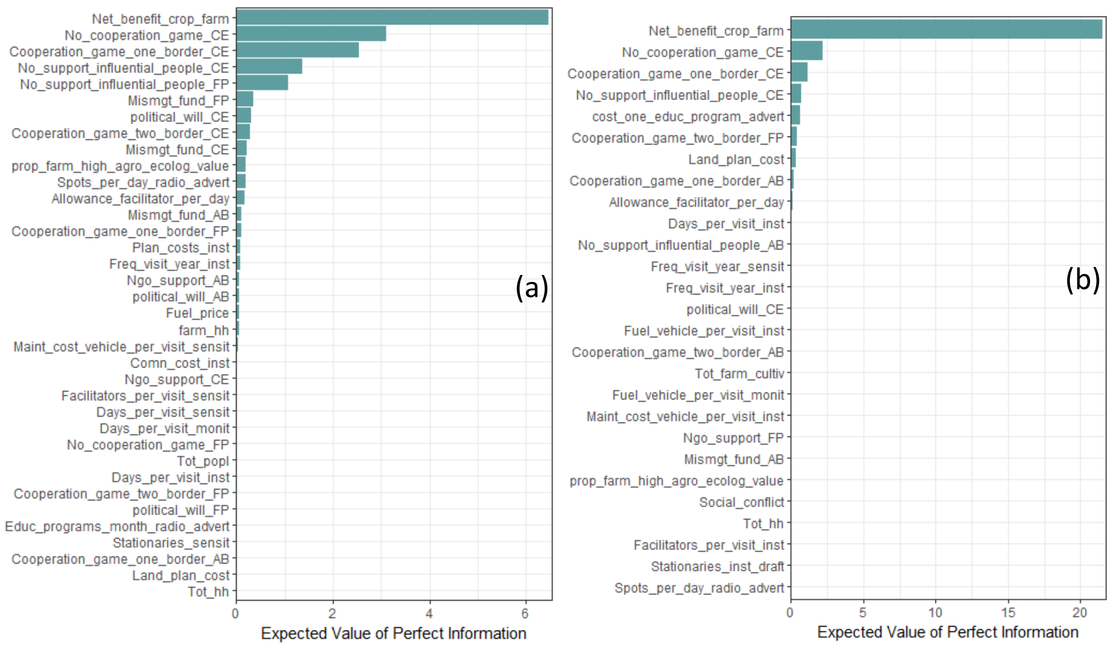


Figure 6A.11. EVPI scores (in USD) for difference in cost effectiveness for conserved due to additional of FP (a) and AB (b) to CE in BKG

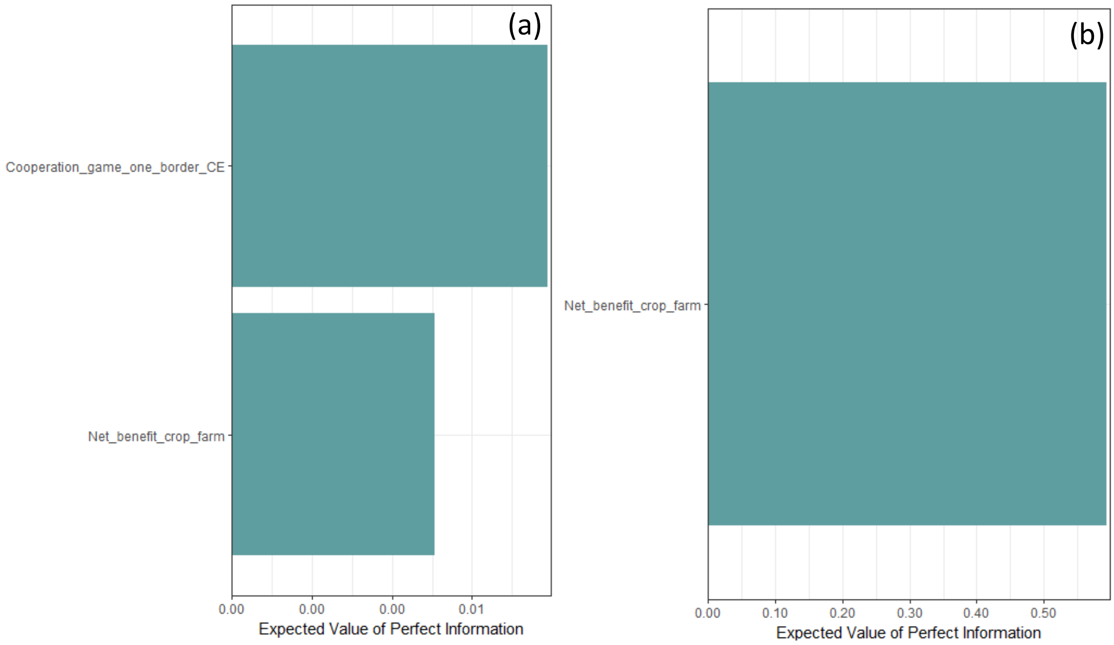


Figure 6A.12. EVPI scores (in USD) for difference in cost effectiveness for connectivity due to additional of FP (a) and AB (b) to CE in BKG