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Perspective

Using causal loop diagrams to see the "big picture" and embrace complexity in human-wildlife coexistence governance

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A B S T R A C T

Sharing landscapes with wildlife is difficult because these landscapes have the potential to bring multiple costs for both people and wildlife. Finding solutions to promote human-wildlife coexistence is therefore critical, especially in the face of rapid global biodiversity loss. While traditionally the problem was addressed by implementing technological solutions to reduce negative wildlife impacts, more recently the complexity of the problem is recognized but tools and methods to deal with this complexity are scarce. In this perspective we apply causal loop diagrams and a leverage point perspective to synthesize the results of our long-term research in communal conservancies in the Zambezi region of Namibia and to better understand the complexity of this human-wildlife social-ecological system. After identifying 32 variables and 47 relationships between these variables, we constructed two causal loop diagrams consisting of two sub-systems — a "governance" sub-system and a "wildlife" sub-system. From the 32 variables, we identified four that could potentially leverage systemic change to improve human-wildlife coexistence. These were: 1. *conflict between people*, 2. *tolerance by people for wildlife*, 3. *policy clarity, relevance, and congruence*; and 4. *congruence and relevance of governance structure with local conditions*. Social learning programs involving training in nonviolent communication, global sustainability challenges and new governance models emerged as potentially valuable interventions. Our approach focusing on causal relationships and leverage points was useful to synthesize complex findings from long-term research and engage stakeholders in joint learning processes.

1. Introduction

Conservation biology was defined four decades ago to address the complex challenges associated with the decline of populations and the subsequent extinction of species (Soulé, 1985). Through time, the focus of conservation has shifted — from an initial focus on preserving species and wilderness areas, to a focus on the benefits of people from biodiversity to the question of how people can best live with nature (Mace, 2014). Living with nature, in turn, can be particularly challenging in contexts where wildlife directly interferes with human lives, such as in contexts of human wildlife-conflict (Gross et al., 2021). Because the connections between people and biodiversity are especially close in such settings, conservation social sciences (Bennett et al., 2017) and social-ecological systems thinking (Berkes and Folke, 1998; Ostrom, 2009) are emerging as useful analytical lenses for how to further increase peaceful human-wildlife coexistence (Ceauşu et al., 2019; Jacobson et al., 2022; Marchini et al., 2024). This however has not always been the case. Earlier approaches involved seeing the problem by applying a linear logic where implementing technological solutions was expected to solve the problem. This thinking typically applied the term human-wildlife conflict where the negative impacts from animals was the main framing (Fiasco and Massarella, 2022). However, over time there was a realization that damage or damage compensation did not always increase people's tolerance (Janeiro-Otero et al., 2023; Naughton-Treves et al., 2003), or the only factor driving tolerance (Dickman, 2010; Kansky and Knight, 2014), and therefore it was deemed necessary to delve more deeply into the complexity of human-wildlife conflicts (Dickman, 2010; Manfredo, 2008). Together with this change in focus was the emergence of the concepts of human-wildlife interactions (Thapa et al., 2024) and human-wildlife coexistence (Vasco & Massarella 2022). Complexities may arise, for example, when different stakeholders disagree on the best approaches (Lute and Attari, 2017; Lute et al., 2018; Jirren et al., 2021), when there is a history of underlying social conflicts (Manfredo, 2008; Rust et al., 2016; Jacobsen and Linnell, 2016; Zimmermann et al., 2020), when accountability is lacking, or when the governance system does not fit the local context (Ravenelle and Nyhus, 2017; Noga et al., 2018; Kansky, 2022).

Social-ecological systems thinking is the application of complex systems thinking to human-environment situations. It recognizes, among others, that systems are characterized by multiple levels of depth (from measurable parameters to their design, to the paradigms underpinning them; Norström et al., 2022), and complex interrelations that

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make it challenging to determine how to best govern them for the benefits of both people and nature (Game et al., 2014; Liu et al., 2015; Hartel et al., 2019). Notwithstanding growing interest in social-ecological systems thinking for human-biodiversity interfaces (Knight et al., 2019; Mahajan et al., 2019), few examples exist where systems thinking has been used to advance conservation governance for wildlife, especially in the context of managing the human-wildlife interface (but see Jacobson et al., 2022, Cui et al., 2021, Marchini et al., 2024). As sustainability challenges encroach on wildlife systems through land use change, habitat fragmentation, population growth and climate change, bringing people and wildlife in closer contact (Abrahms et al., 2023), and with more awareness and consideration of social justice issues and democracy (Loos et al., 2023), wildlife management has become a wicked problem — that is, a diverse set of stakeholders have different perceptions of the problem and hence advocate different solutions, such that there is need to embrace this complexity (Game et al., 2014).

Here, we draw on two complementary methods to synthesize our research and experience in an internationally recognized key area for biodiversity conservation: we use causal loop diagrams (Kim, 2022) to examine the wildlife-governance system, and we apply a leverage points perspective (Meadows, 2008; Abson et al., 2017) to propose interventions that could improve wildlife governance and human-wildlife coexistence. We focus on the Zambezi Region of Namibia as an interesting example of a complex social-ecological system (SES), which is part of the Kwando Wildlife Dispersal Area in the Kavango-Zambezi transfrontier conservation area (KAZA TFCA) (Fig. 1). KAZA is an initiative of five countries in southern Africa that aims to promote livelihoods and biodiversity conservation through the sustainable use of natural resources in a mixed-use landscape (https://www.kavangozambezi.org/).

First, causal loop diagrams have been widely used in many sustainability contexts (e.g. Hanspach et al., 2014), including examples specifically related to conservation (e.g. Fazey et al., 2011; Nguyen and Bosch, 2013), but rarely in relation to wildlife governance (but see Mattson et al., 1996, Cui et al., 2021). Causal loop diagrams, or cognitive maps, are tools to visually describe a system and the relationships between its components (Levy et al., 2018; Barbrook-Johnson and Penn, 2022). A key feature of a system is its attempt to maintain stability through feedback. Feedback occurs by providing information that lets the system know how it is doing relative to some desired state (e.g. when a thermostat provides feedback on the water temperature when it goes above or below a desired goal). Causal loop diagrams can visually map the feedbacks between system components. In contrast to linear thinking which focuses on paired cause-and-effect relationships, a system thinking perspective considers all the elements, relationships and feedbacks contributing to a problem thus better understanding its complexity (Kim, 2022).

A related concept in systems thinking are mental models, which are elicited when constructing causal loop diagrams (Jones et al., 2011; Kim, 2022; Moon et al., 2019). Mental models are the beliefs and assumptions we hold about how the world works. They emerge from a person's knowledge, experience, values, beliefs, and aspirations, explaining how they reason, make decisions, behave, and selectively filter and interpret information (Biggs et al., 2011; Jones et al., 2011; Lynam et al., 2012). In the context of understanding a system, the mental models held by different people will define a systems purpose, elements and feedbacks which together make up the systems structure (Barbrook-Johnson and Penn, 2022; Levy et al., 2018). For example, one mental model in understanding the causal factors of low human tolerance for damage-causing wildlife is that damage to crops causes farmers to kill wildlife. A solution from this perspective might then be to prevent damage by providing farmers with fences. On the other hand, a more complex understanding of the problem could be that since humans and wildlife are embedded in complex landscapes, many more factors are important, and these interact through multiple cause and effect interactions and feedbacks. This complexity, expressed through different

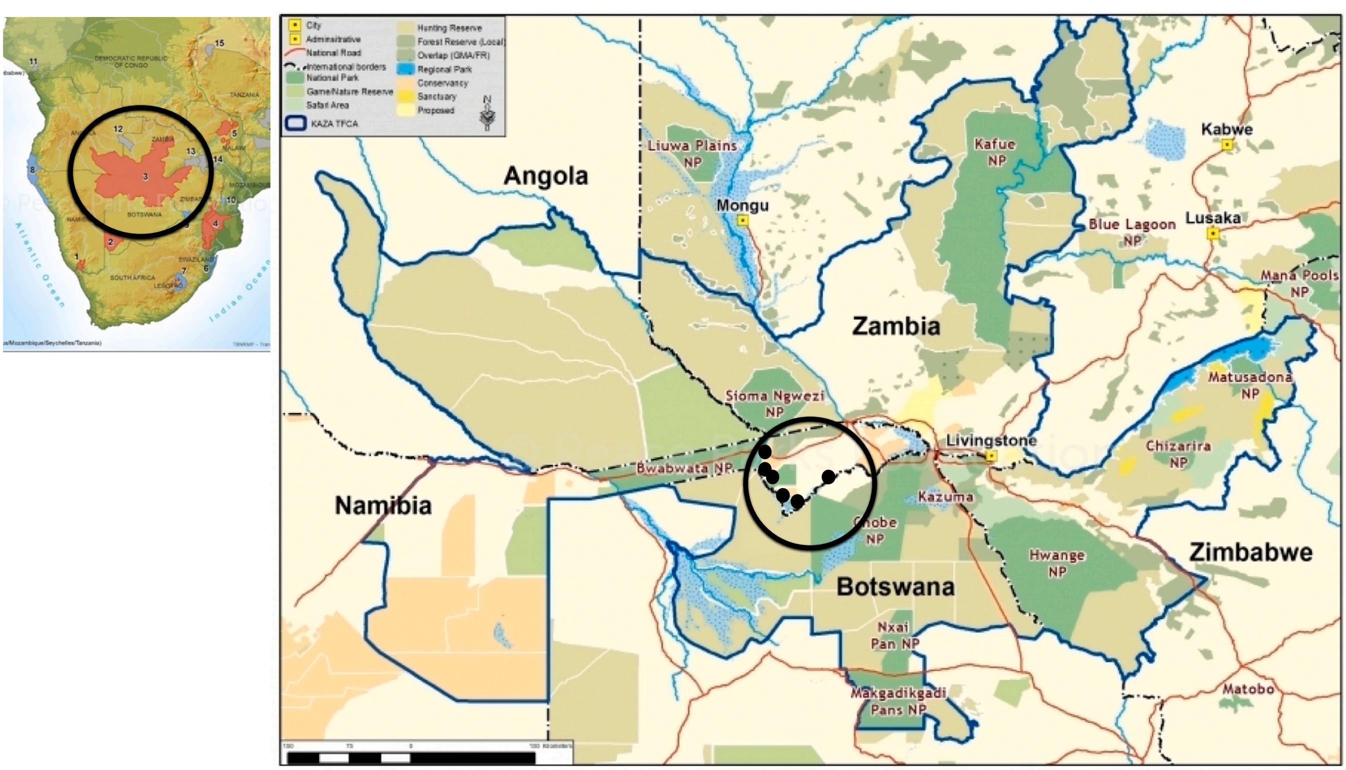

Fig. 1. Map of the study area — the Kavango-Zambezi Transfrontier conservation area in southern Africa, showing the Mudumu complex in the Zambezi region of Namibia. Conservancy locations are indicated in black dots.
Source: Map courtesy of NACSO.

and more numerous cause and effect mental models could then be shown using causal loop diagrams and could uncover more nuanced solutions (Biggs et al., 2017). Understanding the mental models of different stakeholders is proposed as a useful tool in understanding and managing complex environmental problems as their elicitation can be used to explore the similarities and differences between different stakeholders, which can lead to improved understanding of a system, improve communication, or assist in reaching consensus on conflictual topics through participatory stakeholder engagement methods (Bosch et al., 2007; Biggs et al., 2011; Cundill et al., 2012; Jones et al., 2011; Levy et al., 2018; Moon et al., 2019). It can also assist in understanding the extent to which different stakeholders cognitive maps embody systems thinking (Levy et al., 2018).

Second, we used a leverage points perspective (Fischer and Riechers, 2019; Chan et al., 2020; Leventon et al., 2021). Leverage points are places within a complex system where a small shift in one thing can produce big changes in everything (Meadows, 2008). Levers are the specific interventions that can be applied to impact the leverage point (Abson et al., 2017). Mental models expressed through causal loop diagrams are useful tools to identify leverage points because they can visually depict all the relationships between elements in a system. This then allows one to pinpoint which elements could potentially bring about the most change based on where they are positioned and how they are connected in the system. Finally, levers (strategies) can then be sought that would impact the leverage points.

The overarching goal of this perspective piece is to highlight how long-term research can help to better understand complex social-ecological systems, and how complex insights can be synthesized effectively via causal loop diagrams. More specifically, our objective was to use causal loop diagrams to provide a visual representation of the complex human-wildlife social-ecological system in the Zambezi region of Namibia, as observed during our in-depth research between 2017 and 2023. We show how the results and impacts of our transdisciplinary approach conducting social learning programs with communities enabled us to identify leverage points to intervene in the system that could shift the system towards more positive human-wildlife coexistence. While our case study is specific to the Zambezi region of Namibia, our approach can easily be replicated in other contexts.

2. Context of the Zambezi region of Namibia

This perspective piece is a synthesis of multiple studies that took place in communal conservancies in the Zambezi region of Namibia between 2017 and 2023 (Kansky and Maassarani, 2022; Kansky, 2022; Kansky et al., 2024). This region is an important wildlife corridor within the Kavango-Zambezi Transfrontier Conservation Area (KAZA TFCA) (Fig. 1). KAZA is an initiative of the Southern African Development Community and a collaborative landscape conservation project of Angola, Botswana, Namibia, Zambia, and Zimbabwe. It is the largest TFCA in the world (520,000km^2) and one of 18 existing and proposed TFCAs in Southern Africa. It is characterized by large-scale migrations of megafauna such as elephant (*Loxodonta africana*), buffalo (*Syncerus cafra*) and zebra (*Equus quagga*), is home to numerous, red-listed species, and contains the world-heritage listed Okavango Delta (KAZA TFCA Secretariat, 2015). Seventy-one percent of its area is under some form of wildlife management, leaving 29 % for agricultural use, rangeland, and development. It is also home to 27 million people, most living in currently unprotected sections (Glatz-Jorde et al., 2014). KAZA therefore presents an ideal area to examine questions of human-wildlife coexistence in multiple-use landscapes under global developmental pressures (Glatz-Jorde et al., 2014; KAZA TFCA Secretariat, 2015; Salerno et al., 2020).

Communal conservancies in Namibia were established post-independence (1990) through policies and legislation that granted rights over wildlife and tourism to communal conservancies. Conservancies are legal entities managed by two bodies: (1) an elected conservancy Management Committee elected by conservancy members and consisting of a chairman, vice chair, area representatives from the villages, a representative from the tribal authority and a treasurer; and (2) an executive committee consisting of salaried staff who are recruited based on their experience and skills, and who run the day-to-day activities of the conservancy. They consist of a manager, a secretary, enterprise officer, field officer (who oversees the game guards), and a bookkeeper. Several policy documents guide the governance and functioning of the conservancy including a constitution, benefit distribution plan, wildlife management plan, zonation plan and human-wildlife conflict management plan (Nuulimba and Taylor, 2015; NACSO, 2022). In terms of national policy, all conservancies must hold annual general meetings according to their constitutions and to hold committees and managers to account, to elect new committee members, and to present financial reports and budgets for approval to the community.

Conservancies are divided into smaller areas based on spatial aggregation of villages, generally based on sub-khuta demarcations (a level of management of a local tribal authority). One or two Area Representatives are elected from each of these areas to represent their area in the conservancy management committee and to transfer information and communication between their communities and the conservancy management committee.

In Namibia, wildlife is legally owned by the Ministry of Environment, Forestry and Tourism but annual hunting quotas for each species are allocated to each conservancy. A conservancy then provides a concession to a professional hunter who can hunt the species allocated to him and pays the conservancy directly. Generally, a conservancy also tries to add to the professional hunter contract other development projects to pay for in addition to the amounts for each species hunted — such as building a kindergarten, drilling boreholes, or buying a vehicle for the conservancy. Conservancies also negotiate joint venture agreements with private investors to establish lodges or campsites whereby a percentage of beds occupied is paid to the conservancy.

Conservancies are supported by several NGO's who provide guidance, training and assist with negotiating contracts with a professional hunter and joint ventures with private concessions. These organizations collaborate under an umbrella organization called Namibia Association of Community Based Natural Resource Management Support Organizations (NACSO) For more information on conservancies and support organizations see https://www.nacso.org.na/.

3. Analytical frameworks: causal loop diagrams and leverage points perspective

3.1. Causal loop diagrams

Causal loop diagrams (CLD) are simple but powerful tools to visually represent cause-and-effect relationships in complex systems. They can be used to describe the dynamics of the system by creating a visual story about the complex issues and provide a snapshot of important relationships. In a causal loop diagram, variables are represented as nodes, and the causal relationships between them are depicted as arrows indicating the direction of influence. A minus sign indicates a negative influence (e.g as the value of influencing variable increases the value of the influenced variable decreases), a plus sign indicates an enhancing influence (e.g., as the value of the influencing variable increases, the value of the influenced variable also increases) (Senge, 2006; Meadows, 2008). The components (nodes) can include any ideas that an individual (or group) considers as part of the system such as physical quantities (e.g. groundwater levels), social concepts (e.g. crop subsidies), or normative goals (e.g. social justice), but they must be able to increase or decrease (Barbrook-Johnson and Penn, 2022). All systemic behavior can be described through two basic processes — reinforcing and balancing processes and these processes give rise to the dynamic behavior in systems (Kim, 2022). Balancing processes bring equilibrium to a system by resisting change in one direction resulting in change in the opposite direction, for example, when a thermostat shuts down the heat after it exceeds the thermostat setting. In organizations managerial tasks could be seen as balancing processes as they keep the system running smoothly to achieve its goals (Kim, 2022). Reinforcing loops on the other hand destabilize a system through positive feedback, where change in one direction results in even more change in that direction keeping the change going in the same direction over time. For example, money in a savings account accumulates interest, as interest accumulates the amount of money increases leading to a repeated cycle of growth. In this example the outcome of this growth loop is positive or "virtuous" but when the outcome is negative, they become "vicious" cycles, for example, poverty. A farmer with few resources to prevent wildlife damage will incur more damage and lower yields. Each season the negative spiral increases resulting in less to sell or eat each year. Mapping such processes explicitly onto causal loop diagrams allows deeper understanding of a problem and to get a big picture view of the dynamics of the system. The visual representation allows collective discussion and improve more effective responses (Barbrook-Johnson and Penn, 2022). In causal loop diagrams where two or more variables are connected in a circular loop, we can identify the type of loop by counting the number of "−" signs. An uneven number indicates a balancing loop while an even number or zero negative signs indicates a reinforcing loop (Kim, 2022; Senge, 2006; Meadows, 2008).

3.2. Leverage points

Leverage points can be categorised into different types based on the extent they can impact system change. Meadows (2008) proposed a hierarchy of twelve intervention points where "shallow" leverage points are likely to induce minor changes while "deep" leverage points could lead to transformational change. Abson et al. (2017) collapsed the twelve leverage points into four system characteristics: parameters, feedbacks, design, and intent. Using an iceberg metaphor, at the surface are *parameters* which are visible and easily quantifiable (e.g., amount of damage caused by an animal). Below the surface are *feedbacks* — the interactions between elements within a system of interest that drive internal dynamics (e.g., as savings go up so do interest payments, and as interest payments go up so do savings). *Design* characteristics relate to the structure of information flows, rules, power and self-organization (e.g. a hierarchical design in an organization determines the rules of how work is organized). *Intent* characteristics are the deepest place to intervene in a system as it has the potential to change the goal of the system. *Intent* relates to the norms, values, goals, and the underpinning paradigms held by the actors operating within a given system (Abson et al., 2017). For example, utilitarian wildlife values underpin a wildlife governance system with the goal to utilize wildlife for the benefit of people while the goal of a system underpinned by mutualistic wildlife values would aim to manage wildlife for their existence value, irrespective of benefiting people (Jacobs et al., 2014).

4. System understanding

The primary data we used to generate the system structure (elements, relationships and feedbacks) was based on our long-term research in the Zambezi Region. Individual studies had used three types of methodologies, namely quantitative surveys, scenario planning workshops and social learning programs (Appendix 1). Unlike most studies that produce system diagrams from individual or group mental model elicitation (Jones et al., 2011; Moon et al., 2019; Ozesmi and Ozesmi, 2004; Barbrook-Johnson and Penn, 2022), we did not elicit mental models from participants in the system. Rather, we constructed the causal loop diagrams after the completion of our research — as such the diagrams are based on the mental models of the author team (and especially the first author), resulting from her long-term subjective understanding, interpretation and experience gained by conducting transdisciplinary research in the study area (Moon et al., 2019). The resulting causal loop diagrams can therefore be understood as akin to the elicitation of the "expert" opinion of the first author and not as a summary of the mental models of the communities and stakeholders in the study area (Barbrook-Johnson and Penn, 2022; Levy et al., 2018).

Quantitative surveys of community members were undertaken to understand the drivers of tolerance to problematic wildlife species based on the Wildlife Tolerance Model (WTM) (Kansky et al., 2021; Kansky and Kidd, 2024). The WTM surveys have been applied in nine different countries with 12 different wildlife species, and surveys typically examine 28 variables as potential drivers of tolerance (Kansky and Kidd, 2024). Not all of these have been found to be significant but empathy, tangible and intangible benefits from wildlife are consistently significant across these case studies including in Namibia, and therefore these variables were included in the causal loop diagram (Kansky and Kidd, 2024).

The *scenario planning workshops* with diverse stakeholders in four conservancies (Jirren et al., 2021) were based on the SEEDS (Ceauşu et al., 2019) and three horizons (Sharpe et al., 2016) frameworks.

The two *social learning programs* with community members were based on systems thinking, learning based approaches and nonviolent communication (Appendix 1). In 2019, the *Human-Wildlife Coexistence Social Learning Program* worked with farmers from four conservancies. It included training in Nonviolent communication (Kansky and Maassarani, 2022; Kansky et al., 2024) and dialogues with conservancy management committees, with the aim of better understanding what was working and what were the challenges in the conservancy governance system (Kansky, 2022; Kansky et al., 2024). In 2022, the *Innovation in Leadership and Governance Social Learning Program* involved participants from three conservancies. It again included training in Nonviolent communication, but it also covered topics on global sustainability challenges, the growth economy and its negative impact on the environment, and human values as guiding principles in life and organizational structures (based on Laloux (2014) and the Nonviolent Global Liberation community (www.ngl.org)). This second program sought to improve leadership skills and explore novel governance structures to solve some of the governance challenges identified earlier. Additional descriptions of the empirical studies upon which the system diagrams were based are reported in Appendix 1.

4.1. Construction of causal loop diagrams

Based on the insights gained through the empirical studies summarized above, we constructed causal loop diagrams. Our aim was to synthesize the most important variables and relationships operating in the Zambezi system in relation to human-wildlife governance and coexistence. First, we made a list of the system components (variables) that were deemed most important as driving the human-wildlife social-ecological system. Next, we created an adjacency table with these variables. The matrix cells were then filled in and the direction of influence was indicated if a plausible relationship between two components was hypothesized to exist. A "+" indicated an enhancing influence, while a "−" indicated a decreasing influence. Next, the adjacency table was converted into a causal loop diagram using the program Vensim. This resulted in a highly detailed causal loop diagram with 37 elements and 103 connections (Appendix 2). This initial level of complexity was not easily digestible, and therefore we subsequently simplified this causal loop diagram by focusing only on relationships for which we had especially strong evidence (see Section 4). This was an iterative process (i.e., author discussion, going back and forth into the data) to make highly complex data intuitively usable and draw out the most important variables and relationships (Barbrook-Johnson and Penn, 2022). Based on this, in Appendix 3, we provide summaries of the evidence and justification of each of a reduced number of relationship pairs (32 variables and 47 relationships).

4.2. Identification of leverage points

Abson et al. (2017) highlight two main categories regarding how the term 'system' is understood and used — ontological and epistemological. The ontological view considers systems as real-world phenomena that can be objectively studied while an epistemological approach defines a system more subjectively according to the worldviews and concerns of actors involved. While Meadows and other early systems researchers typically worked from an ontological perspective, her conception of leverage points as places within a complex system where a small shift in one thing can produce big changes in everything would have been measurable and quantifiable, such as in system dynamic models (Meadows, 2008; Barbrook-Johnson and Penn, 2022). However, in an epistemological approach where systems are seen as a perspective or way of thinking, leverage points are qualitative (Abson et al., 2017). In this perspective we apply the epistemological approach and define leverage points as places within a complex system where a shift in one thing can produce changes in the system, but we do not quantify the impact of these changes. That is, after constructing the causal loop diagrams and thereby gaining new perspectives on the wildlife-governance system, we sought to identify which variables could potentially bring the most impactful change to the system. We identified the tolerance leverage point (LP2) based on the results of the WTM surveys, which showed that empathy and non-monetary benefits from wildlife are important drivers of tolerance, and that perceptions of monetary benefits drive perceptions of non-monetary benefits (Kansky and Kidd, 2024). We identified LP1, LP3 and LP4 based on the positive impacts of our social learning programs, including nonviolent communication training (Kansky, 2022, Kansky and Maassarani, 2022, Kansky et al., 2024, Kansky, forthcoming, Appendix 1, Appendix 3)

5. Visual representation of the complex human-wildlife social-ecological system in the Zambezi region

5.1. Causal loop diagrams

The causal loop diagrams with 32 system components and 47 causal relationships are described in Table 1 and Figs. 2 and 3. The diagram was deconstructed into two sub-systems consisting of a "governance" narrative (Fig. 2) and a "wildlife" narrative (Fig. 3). In Appendix 3 we provide a narrative description and the primary sources of data on which we based our justification of the relationships. In the following, we explain the two sub-systems and discuss leverage points that could improve human-wildlife coexistence and reduce conflicts. For ease of following the descriptive narrative with the causal loop diagrams, each element was given a number.

5.1.1. CLD 1: Governance narrative (Fig. 2)

We identified three undesirable reinforcing loops in this subsystem. In R1 (Fig. 2., outermost loop), when the *costs of collaboration* (1) are high, members are unmotivated to *engage in conservancy activities* (2), which includes attending meetings. When members do not attend meetings, they do not get relevant *information* (3) on what the conservancy is doing. Without this information they lack the information and *power to hold both leaders and other members accountable* (4). Without the power to hold leaders and members accountable, a vacuum is created where *interference from more powerful individuals* (5) or groups influences decisions and behavior (e.g. Traditional authority, people believed to have supernatural powers). This leads to a *lack of rule enforcement* (6) *and contributes to lack of wildlife damage compensation* (7), ultimately *eroding trust in leadership* (8) which fuels overall *conflict in the conservancy* (9), which leads to *high costs of collaboration* (1).

Within this larger loop, two additional undesirable reinforcing feedback loops were found (labelled R2 and R3 in Fig. 2). In R2, a lack of *power to hold leaders accountable* (4) leads to *poor leadership accountability* (10), which leads to a lack of *equity in benefit distribution* (11) followed by

Table 1
Description of system elements.

	System element and level of leverage point	Description
1.	Costs of collaboration	These are the costs in time, energy, motivation, resources etc. that result when people collaborate as members of a conservancy.
2.	Community engagement with Conservancy Management Committee and conservancy	The number and quality of interactions and meetings between the community and conservancy management.
3.	Information and communication between Conservancy Management Committee and community (and within community)	The number and quality of exchange of information, knowledge, and communication among the community and between the community and conservancy management.
4.	Power to hold leaders and community accountable to implement policies and rules	Through the policies and governance structure of conservancies, communities get membership in a conservancy. Members in turn are required to take part in conservancy matters, including attending meetings, voting in representatives, and holding them accountable. In practice this is often difficult because members are not always informed about the conservancy office affairs (see Kansky, 2022).
5.	Amount interference by powerful people/stakeholders in policy and rule enforcement	Although the intention of the policies and governance structure of conservancies aimed to ensure transparency and community participation in the management of conservancies, this is not always achieved because some high-status community members exert more power and influence.
6.	Policy and rule enforcement	The extent to which policies and rules and processes are followed and enforced.
7.	Monetary compensation for wildlife damage	The Namibian government has a special fund – the Game Products Trust Fund (GPTF) that contributes to the Human Wildlife Self Reliance Scheme – where farmers can claim compensation for wildlife damage. Conservancies also contribute funds towards compensation for wildlife damage in equal amount to the GPTF.
8.	Trust in leadership	Relying on and having confidence that leaders will be honest and do their job in good faith.
9.	Amount conflict between people	The number of disagreements and lack of harmony, understanding and respect between conservancy members and between management and members.
10.	Accountability of leaders	Leaders include those working in the conservancy management who are appointed or elected by members.
11.	Equity in benefit distribution from wildlife	Each conservancy has a benefit distribution plan based on the annual budget. Village meetings should take place before the annual general meeting (AGM) to discuss and propose the budget and benefit allocation which is then approved at the AGM.
12.	Amount of inclusion of community in rule and decision making in conservancy	Conservancy members are expected to attend meetings and contribute to changing the constitution or amending rules.
13.	Policy clarity, relevance, and congruence	Conservancy management is guided by various policy documents including the constitution, a zonation

(*continued on next page*)

Table 1 (*continued*)

	System element and level of leverage point	Description
		plan, a benefit distribution plan, and a HWC management plan (NACSO, 2022). These local level policies are in turn guided by national policies including Nature Conservation Amendment Act no 5 of 1996, CBNRM Policy, National HWC policy and Standard operating procedures (MET 2013).
14.	Amount congruence and relevance of governance structure with local conditions and values	The extent to which the governance structure of conservancies promotes, facilitates or hinders optimal functioning of the conservancy so as to reduce the costs of collaboration by aligning with the culture, lived experiences and values of its members
15	Belief in supernatural powers of influential people	Believing that some people have special powers that cannot be explained by science or the laws of nature to impact other people.
16.	Empathy for people	The ability to "put oneself in another person's shoes" – to understand them and feel compassion for them in difficult situations
17.	Development projects/tangible benefits	The number and value of projects or cash distribution that conservancies pay to members or spend in community development projects. For e.g. constructing water points, materials for damage prevention, electricity infrastructure
18.	Intangible benefits from wildlife	These are the non-monetary benefits that people perceive from wildlife such as the cultural value of a species, appreciation of the beauty of a species, its existence, or relational values (see Kansky and Maassarani, 2022, Kansky and Kidd, 2024)
19.	Human tolerance for wildlife	Tolerance is defined as the willingness to share the landscape with wildlife and to accept actual or potential costs from wildlife (Kansky et al. 2016, Kansky and Kidd, 2024).
20.	Mitigation measures	The number of measures used to prevent or reduce the risks from wildlife such as building fencing, burning chili powder, guarding fields or using cattle herders to protect livestock.
21	Tangible costs from wildlife	These are the monetary impacts due to sharing the landscape with wildlife such as the monetary value of crop loss, livestock depredation, damage to property, medical bills from wildlife injury, etc.
22.	Amount of illegal hunting	In addition to legal hunting, many community members will also hunt wildlife without a permit for their own use or to sell to other community members. In the region there are also wildlife crime syndicates who hunt elephants for the ivory trade.
23.	Amount of legal hunting (trophy and local)	Conservancies receive hunting quotas from by the Ministry of Environment, Forestry and Tourism for both trophy hunting and "own use" hunting. The trophy quotas are sold to professional hunters who bring mostly foreign hunters to hunt. The "own use" quotas are to provide meat for the community, and these are hunted either by the professional hunter or community members who may buy a permit to hunt.
24.	Conservancy budget and reliability	The amount of money available and the extent to which it is consistently available to run the conservancy and provide benefits to the members.
25.	Empathy and intrinsic value for wildlife	Empathy — The ability to "put oneself in the shoes of wildlife" — to understand them and feel compassion for them. Intrinsic value — The extent to which a person believes wildlife have value in itself and not only because it has a utilitarian value for people.
26.	Support to community from outside	Various groups provide different kinds of support to conservancies that may include both monetary and non-monetary support such as advice, donations, training, and resources.
27.	Amount wildlife	Wildlife numbers are monitored by the Ministry of Environment, Forestry and Tourism and partners as well as by the employed game guards from each conservancy. Wildlife roams freely across the Zambezi landscape moving between the neighbouring countries of Botswana, Zambia and Angola.
28.	Amount of land used for hunting and tourism	Each conservancy has a zonation plan where land is allocated either for agriculture and human settlement or for wildlife. However, these zonation plans are not legally binding.
29.	Amount available water and food for wildlife	The main sources of water in the Zambezi are rivers, bore holes and municipal water (Namwater). Most community members rely on free water from bore holes or the river as municipal water is expensive.
30.	Amount of land for agriculture	All land in the Zambezi conservancies is communal land and managed by the tribal authorities and a land management board. Land is allocated based on local knowledge of ancestral land of a family. The Namibian government is encouraging individuals to register land and obtain title deeds.
31.	Amount of people in landscape	The annual population growth rate in Namibia between 1991 and 2023 was 3.6 % with a total population size of 3 million in 2023. In the Zambezi Region in 2023 there were 142,373 people with an annual growth rate of 1.7 % since 1991 (Namibia Statistics Agency 2024. Preliminary report.)
32.	Amount tourists	Some conservancies have joint venture contracts with private lodges to accommodate mostly international and regional tourists who are attracted to the Zambezi region for its wildlife and the natural beauty of the landscape. Some local community members have also established campsites for tourists.

See Kansky, 2022 for a deeper understanding of these.

low *trust in leadership* (8), *increased conflict* (9) and increased *costs of collaboration* (1). In R3, a lack of *power to hold leaders accountable* (4) leads to a lack of *accountability of leaders* (10) leading to less *inclusion of community members in rule and decision making* (12). This then leads to both reduced *policy clarity, relevance and congruence* (13) and less *congruence & relevance of governance structure with local conditions* (14), which both lead to increasing the *costs of collaboration* (1). Lastly, *belief in supernatural powers of leaders* (15) and other influential people is an

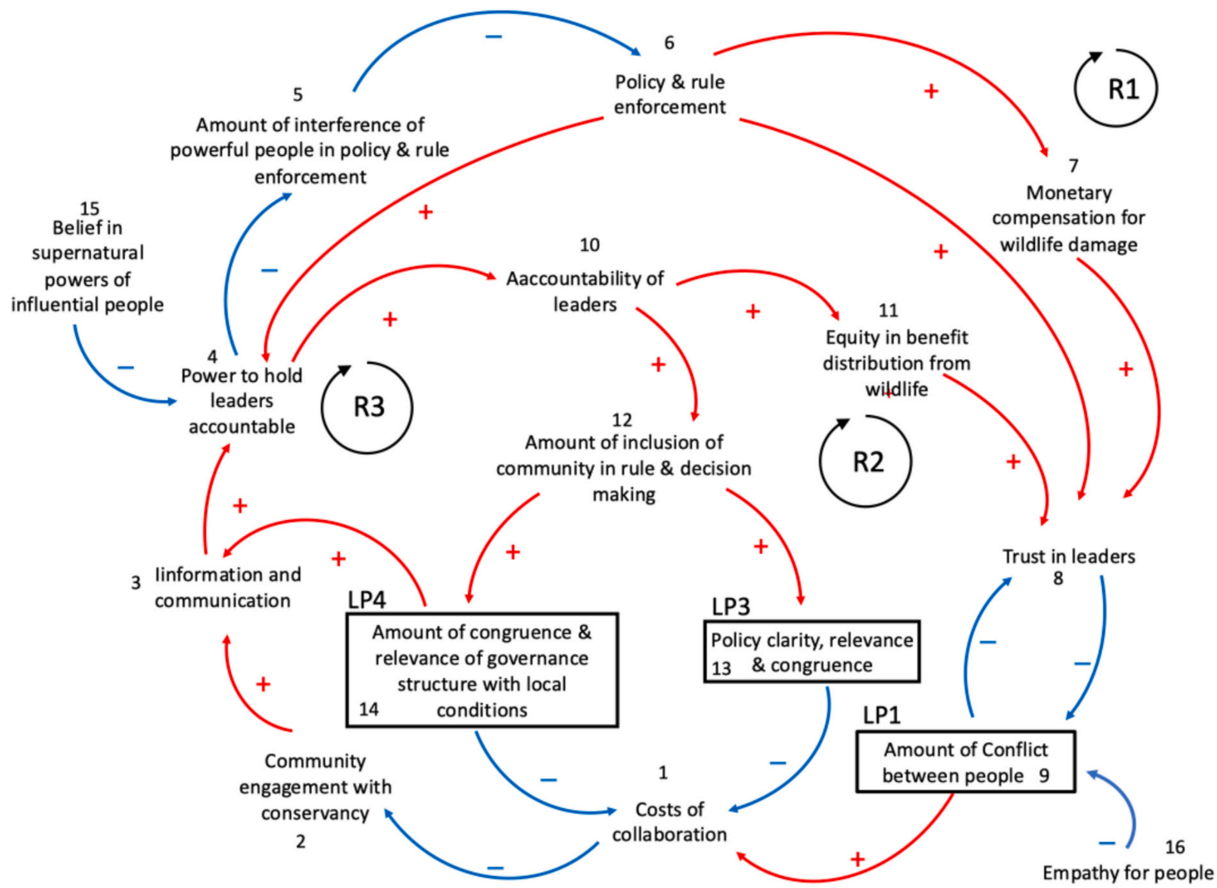

Fig. 2. Causal loop diagram of the "governance" sub system showing leverage points in boxes (LP) and reinforcing feedback loops (R). See Table 1 for descriptions of the variables.

important driver contributing to *lack of power to hold leaders accountable* (4). Also, *empathy for people* (16) can lead to reduced *conflict between people* (9).

5.1.2. CLD 2: Wildlife narrative (Fig. 3)

We identified three undesirable reinforcing loops in this subsystem where the *amount of conflict* (9) connects the two sub-systems (CLD 1 & 2). In R4, the lack of *tangible benefits* (17) from wildlife drives a lack of *intangible benefits from wildlife* (18) resulting in lower *tolerance for wildlife* (19), which in turn demotivates people to implement *mitigation measures* (20) resulting in higher *wildlife damage costs* (21). This in turn increases *illegal hunting* (22) of wildlife and reduces amount of wildlife available for *legal hunting* (23). Since income from *legal hunting contributes* to the *budget of the conservancy* (24), *less conservancy budget* means less *development projects and tangible benefits from wildlife* (17). Linked to this loop is the *amount of empathy for wildlife* (25) *that drives tolerance towards wildlife* (19). Also, the *amount of support from outside the conservancy* (26) drives increases the *conservancy budget* (24), increasing the amount of *tangible benefits* (17) leading to increased perceptions of *intangible benefits from wildlife* (18) *and increased tolerance for wildlife* (19) ultimately increasing the *amount of wildlife* (27).

The second reinforcing loop R5 is a smaller loop within R4 where the amount of *development projects* and *tangible benefits* (17) drive the amount of *illegal hunting* (22). The third reinforcing loop R6 shows how *conflict between people* (9) reduces the amount of *land available for hunting and tourism* (28) which reduces the amount of *legal hunting* (23) further affecting the *conservancy budget* (24) and amount of *development projects* (17), which in turn affects *conflict between people* (9) through the *conservancy budget* (24) and amount of *development projects* (17).

In addition to these reinforcing loops, additional variables that are important in determining the *amount of wildlife* (27) in the system include the *amount of water and food available for wildlife* (29), which is determined by the *number of tangible benefits and development projects* (17) and *amount of land used for agriculture* (30). Water infrastructure is one of the development projects. When these are placed strategically to provide sufficient water for both wildlife and livestock, it reduces competition and conflict between them and therefore increase wildlife numbers. The amount of *water and food available for wildlife* (29) is also determined by the amount of *land available for agriculture* (30) which in turn is driven by size of the *human population* (31). Lastly, the *amount of tourism* (32) is driven by the *amount of land available for tourism and hunting* (28) while the *amount of tourism* (32) in turn drives the *conservancy budget* (24).

The *conservancy budget* is also determined by external *support from NGO's* and other outside sources of funding such as the professional hunter, who in addition to paying for hunting, may donate funds for soccer tournaments, building a kindergarten or other shortfalls as requested from time to time by the conservancy.

5.2. Leverage points

We identified four leverage points to intervene in the system based on the outcomes from our social learning programs and WTM surveys (see Section 4.2 and Appendix 1 and 3). These were: LP1: *amount of conflict between people* (9), LP2: *Human tolerance for wildlife* (19), *LP3: policy clarity, relevance, and congruence* (13), *LP4: congruence between governance structure and relevance with conditions on the ground* (14) (Figs. 2 & 3).

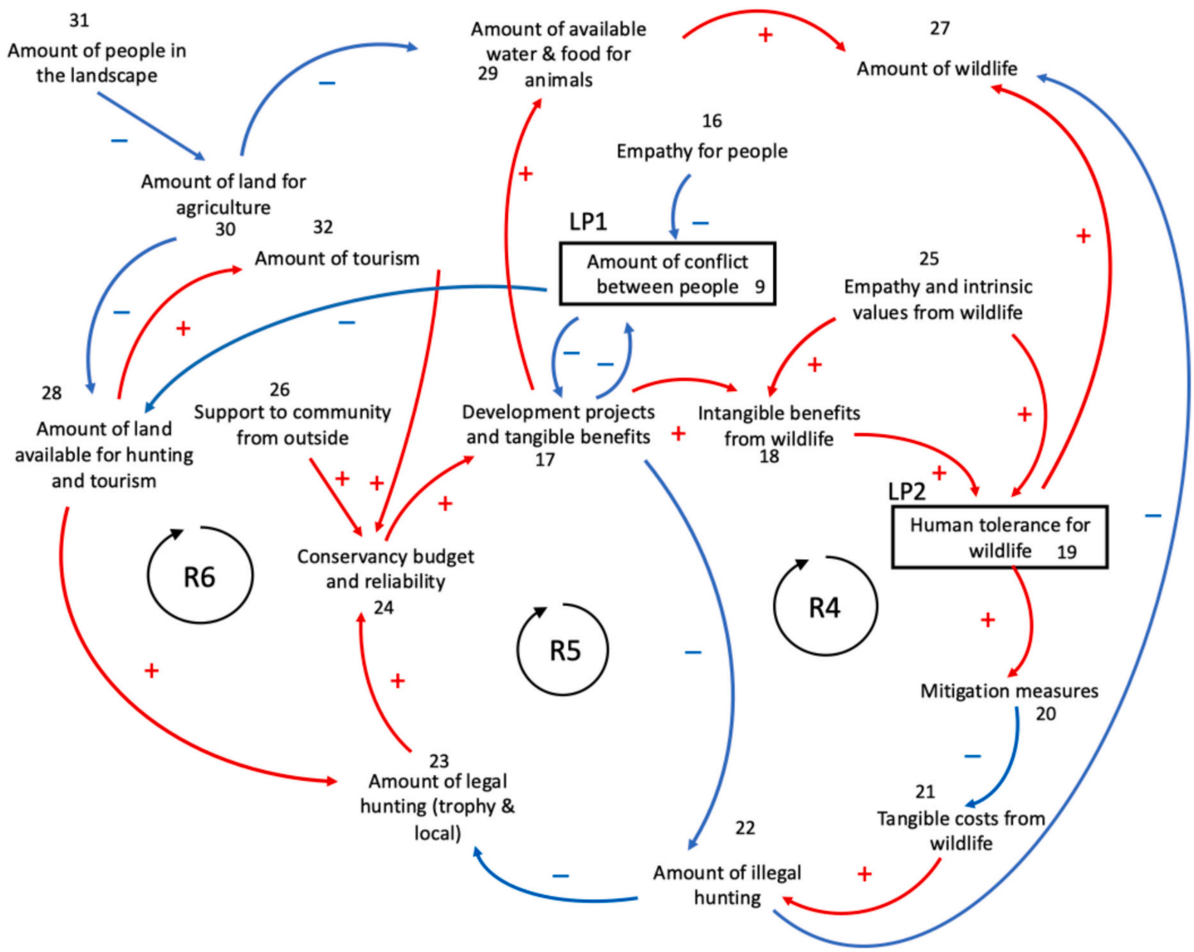

Fig. 3. Causal loop diagram of the "wildlife" sub system showing leverage points in boxes (LP) and reinforcing feedback loops (R). See Table 1. for descriptions of the variables.

5.2.1. LP1: Amount of conflict between people (9) (Figs. 2, 3)

The social learning programs included training in nonviolent communication (Rosenburg, 2005), a communication tool used to increase empathic connection between people in conflict, which we found to be very effective (Kansky and Maassarani, 2022). Reducing the *amount of conflict between people* (9) would lead to an increase in the *amount of development projects and tangible benefits* (17), thus feeding into the wildlife loop (R4, R5). In the governance loop reduced *conflict between people* feeds into all the reinforcing loops (R1, R2, R3). In the dialogues from the social learning programs, it emerged that there were numerous conflicts around development projects which result in them not being implemented. For example, people living in wildlife areas designated for hunting or tourism refused to move and this prevented income generating activities to take place (trophy hunting and tourist lodges). Others built campsites in the wildlife area but would not contribute income to the conservancy, and other development projects do not get off the ground or fail because people compete over positions or struggle to collaborate to implement the projects (Kansky, 2022).

5.2.2. LP2: Human tolerance for wildlife (19) (Fig. 3)

This element refers to the ability and willingness of a person to bear the extra potential costs of sharing the landscape with wildlife (Kansky et al., 2016). Our previous research showed that empathy and perceptions of non-monetary value of wildlife are significant drivers of human tolerance to many species, including in Namibia (Kansky et al., 2024). These findings informed the training in nonviolent communication in the social learning programs where in addition to increasing empathy between people, also increased empathy towards wildlife. By strengthening *empathy and intrinsic value of wildlife* (25), *tolerance for wildlife* (19) would increase and will be followed by the willingness of farmers to implement *mitigation measures* (20) and feed into the wildlife loop (R4, R5, R6).

5.2.3. LP3: Policy clarity, relevance, and congruence (13) (Fig. 2)

This element refers to the national and local policies developed to establish and manage conservancies in general and specifically to human-wildlife conflict (Table 1). Our previous research had shown that most community members were either not aware these policies existed, or if they had heard about them, were not aware of their content. Further, there was inconsistent application of the local policies, and they were not detailed enough so many were being interpreted and applied differently by different people. There was also no written information on many processes (Kansky, 2022) (Table 1). By strengthening *policy clarity, relevance, and congruence* (13) the *cost of collaboration* (1) could be decreased leading to more *community engagement* (2) and feed into the governance loop (R1, R2, R3). Interventions within this leverage point could be revising and updating the conservancy policies and producing new detailed ones which are missing through engaging members in transparent and accountable deliberative processes, producing written policies that are available freely for members to examine in communal places such as the conservancy and traditional authority offices or school library, and conducting regular outreach of the policies from time to time to ensure everyone is aware of them.

5.2.4. LP4: Congruence between governance structure and relevance with conditions on the ground (14) (Fig. 2)

All communal conservancies have similar governance structures consisting of two bodies: (1) an elected Conservancy Management Committee (CMC); and (2) an executive committee (Table 1). Due to the lack of ability of conservancy members to hold leaders accountable, our research has questioned whether this structure is suitable to the conditions on the ground and has explored other governance structures that may be more suitable (Kansky, forthcoming). By strengthening the governance structure, the *costs of collaboration* (1) would decrease leading to increased *community engagement* (2) and feed into the governance loop (R1, R2, R3).

5.3. Social learning programs as levers for change

After constructing the causal loop diagrams and identifying the leverage points, we realised that our social learning programs (see Section 4.2) could act as valuable levers in the system (Figs. 2 & 3). The social learning programs included training in nonviolent communication (Rosenburg, 2005; Williams et al., 2021), which is a tool used in peace and conflict mediation to increase empathy between people. We included this training in the social learning programs to see if it could foster empathy between people and of people for wildlife and had found it to be effective for both (Kansky and Maassarani, 2022). Training in nonviolent communication could therefore be an effective lever for LP1 to reduce conflict between people. The social learning program conducted in 2019 also included dialogues with guests from conservancy management where participants could ask questions on any topic related to wildlife and conservancy governance (Appendix 1). Dialogues with game guards were especially impactful in learning about animal behavior and how to behave during wildlife encounters as well as which prevention measures to apply and how to implement them to reduce crop and livestock damage. This further promoted tolerance to wildlife (LP2) and provided skills and motivation to implement mitigation measures. For example, one group reported successfully doing outreach with community members that resulted in increased implementation of mitigation measures and improved crop harvests (Kansky and Maassarani, 2022). Increased implementation of *mitigation measures*, in turn, feeds into R4 in the wildlife loop leading to reduced *illegal hunting* and increased *legal hunting*, ultimately increasing the *conservancy budget and tangible benefits* (Fig. 3). This program also served to help both participants and the researchers to unpack the governance system to understand what was working and what the challenges were. This new knowledge can contribute to increase *policy clarity, relevance, and congruence*, our third leverage place to intervene (Fig. 2).

Based on our findings from the first social learning program, we designed a second social learning program in 2022 on *Innovation in leadership and governance* (see Section 4.2 & Appendix 1). This included training in global sustainability challenges and also contributed to promoting the intrinsic value of nature and wildlife (Kansky, forthcoming) and therefore represents an additional lever to promote tolerance (LP2). This second program resulted in improved leadership skills, increased accountability, and new models of governance (Kansky, forthcoming). Such programs can provide a framework to innovate and improve *policy clarity relevance and congruence* (LP3) and *congruence between the governance structure and conditions on the ground* (LP4), which could ultimately reduce the *costs of collaboration* and break the cycle of conflict (LP1) in the governance loop (Fig. 2).

6. Discussion

6.1. Causal loop diagrams as tools for research synthesis and communication

We constructed causal loop diagrams to create a narrative of the human-wildlife governance system in the Zambezi region of Namibia. The construction of the causal loop diagrams was based on the understanding and perspectives acquired by the first author through long-term empirical research with diverse stakeholders. This research did not specifically elicit mental models from stakeholders as is typically done in constructing causal loop diagrams (Barbrook-Johnson and Penn, 2022; Jones et al., 2011; Moon et al., 2019; Ozesmi and Ozesmi, 2004; Horowitz et al., 2018) and therefore can be seen as the “expert” opinion of the researcher (Barbrook-Johnson and Penn, 2022; Levy et al., 2018). We thus demonstrated how constructing causal loop diagrams can be used as a research synthesizing tool to summarize a large body of research around a specific topic. This application of causal loop diagrams could be useful for other research teams to consolidate long-term research projects. They can then be used as a learning tool to share, communicate, or discuss the topic with other stakeholders (Bosch et al., 2007; Biggs et al., 2011; Cundill et al., 2012; Jones et al., 2011; Levy et al., 2018; Moon et al., 2019), acting also as a boundary object for coexistence discussions (Fiasco and Massarella, 2022), to inform the design of evaluation of human-wildlife coexistence projects (Kenzie, 2021). They may also contribute to reduce the research-implementation gap, a widely recognized problem in conservation science where scientific knowledge is not always used to make policy and practice decisions, limiting the effectiveness of conservation efforts (Knight et al., 2019; Dubois et al., 2019).

The causal loop diagrams also highlighted the complexity of the human-wildlife governance system of communal conservancies in Namibia's Zambezi region. This complexity is likely not unique to this system as human-wildlife interactions are increasingly being acknowledged as embedded within complex social-ecological systems (Carter et al., 2014; Ceauşu et al., 2019; König et al., 2020; Hohbein and Abrams, 2022; Marchini et al., 2024). By embracing this complexity, causal loop diagrams can provide a useful tool to unpack and understand these systems, and our specific diagrams could be used to engage stakeholders working in other landscapes. In the specific context of our case study, the diagrams can be used to promote better multi-sector collaboration in order to transition to a more resilient and sustainable future (Jirren et al., 2021).

We identified 32 variables with 47 path connections to describe our system. These variables and paths were the outcome of the reduced model, and its complexity is in line with other studies using causal loop diagrams (e.g Coletta et al., 2021; Crookes and Blignaut, 2015). When constructing models, a degree of subjectivity is unavoidable when prioritizing which causal relationships to retain (Barbrook-Johnson and Penn, 2022). Levy et al. (2018) suggest that less complex models may be better for quicker decision making compared to more complex models. However, complex models will reduce the risk of overlooking important and less obvious components and effects. Our model could be reduced or expanded upon as necessary according to the needs of those using it, but its complexity can be useful because lay people may oftentimes show more simple mental models than experts (Halbrendt et al., 2014; Levy et al., 2018).

6.2. New insights on the complexity of wildlife governance for coexistence

Coexistence governance is generally understudied in the wildlife coexistence literature (Linnell and Kaltenborn, 2019; Hohbein and Abrams, 2022). Our synthesis contributes to this field by providing new perspectives on wildlife governance systems and the factors that contribute to their effectiveness in achieving human-wildlife coexistence.

The system we describe in our model consists of two subsystems: a “governance” and a “wildlife” subsystem. The goal of the governance subsystem is to ensure good governance principles (Lockwood, 2010; Hohbein and Abrams, 2022) to ensure human-wildlife coexistence. The goal of the wildlife system is to ensure sustainable wildlife populations. Interestingly, these two subsystems are connected through the element of *conflict between people*, highlighting a potential key role that *conflict* *between people* can play in both subsystems. In the "governance" loop conflict between community members and the conservancy and its policies is reinforced through variables that relate to lack of *accountability* and *trust* in leaders as well as *policy and governance incongruence*. In the wildlife loop, *conflict between people* persists through the three reinforcing loops (R4, R5, R6) and their link with the amount of *development projects and tangible benefits*. Since *conflict between people* is central to both subsystems, interventions to reduce conflict could be an important place to intervene (LP1). Managing conflict and promoting trust in institutions is often overlooked in institutional design but is one of Ostrom's nine design principles — it is, in fact, key in reducing the costs of collaboration in common pool resource management (Ostrom, 1990). In our work in Namibia, we found no formal policies or processes for conflict management within conservancies. Informal investigations revealed that when setting up the institutional policies for conservancy governance system, it was assumed that conflicts would be managed by local tribal authorities. However, in our dialogues as part of our social learning programs it emerged that many of the conflicts involved these tribal authorities who in policies are supposed to be neutral entities but in practice were not (Kansky, 2022).

A second central insight worth highlighting is the inclusion of *tolerance to wildlife*. We define tolerance as "*The ability and willingness of an individual to absorb the extra potential or actual costs of living with wildlife*" as anyone living in an area with wildlife must bear the risk of added costs which would not be present in the absence of wildlife (Kansky et al., 2016). We define human-wildlife coexistence as "*the willingness of communities to share the landscape and tolerate possible costs from wildlife while ensuring sustainable wildlife populations*" (Kansky et al., 2021). *Tolerance* is thus a key component of coexistence and an important goal of human-wildlife systems but is often not measured in the evaluation of wildlife community based natural resource management programs (Frank, 2016), possibly because of an implicit assumption that simply providing economic benefits increases tolerance and support for conservation, which is not always the case (e.g Gandiwa et al., 2013; Unks and Goldman, 2021; Drake et al., 2021; Hohbein and Abrams, 2022; Vehrs et al., 2022). In our model, low *tolerance for wildlife* negatively affects *wildlife numbers*, the *amount of legal and illegal hunting* and therefore is key to ensuring sustainable wildlife populations, another key component of coexistence (Kansky et al., 2021). Linked to the inclusion of tolerance is the inclusion of antecedent drivers of *tolerance-intangible benefits* from wildlife and *empathy and intrinsic value of nature*. These variables are not typically considered as important drivers of tolerance, but our past research in the region had shown them to be highly significant (Kansky and Kidd, 2024). Our social learning programs proved effective in promoting all three variables and this could play a significant role in changing the values and intent of the system (deep leverage point) (Abson et al., 2017). Currently, the values underlying most wildlife CBNRM programs in southern Africa are utilitarian and based on obtaining economic benefits from wildlife (Muchapondwa and Stage, 2015; t' Sas-Rolfes, 2017; Child, 2019; Hohbein and Abrams, 2022). In addition to the mixed results of this approach in "buying" tolerance and support for conservation (Gómez-Baggethun and Ruiz-Pérez, 2011; Muradian et al., 2013; Hohbein and Abrams, 2022; Kansky et al., 2021; Drake et al., 2021) it may not be wise to rely only on economic incentives to promote support and tolerance for wildlife because not all species or landscapes can provide economic benefits (Hohbein and Abrams, 2022) and even where they do, in the long term they may be insufficient to satisfy the needs and future growth aspirations of rural communities. This is because conservation will struggle to compete with other land use types in the face of developmental pressures (e.g cattle, industry, commercial agriculture, mining) (Seto et al., 2012; Laurance et al., 2015), and because of the insatiable human desire for increasing material goods. Including non-utilitarian motivation to promote tolerance and intrinsic value of nature could therefore be an additional strategy to ensure long-term sustainability and resilience (Biggs et al., 2015) in human-wildlife systems (Kansky and Kidd, 2024).

The third insight from our model was the central role of the *costs of collaboration* (Fig. 2). This variable is generally not considered in the literature on human-wildlife conflict, coexistence and governance but is an important consideration in common pool resource collaboration (Ostrom, 1990). In the social learning program discussions, it emerged that conservancy members were not motivated to participate in conservancy affairs because there were insufficient benefits, they did not trust leaders and there were consist disputes. We therefore concluded that the costs of collaboration were higher than the benefits of collaboration for most members besides those directly employed by the conservancy. Since *costs of collaboration* was central in the reinforcing loops of the governance subsystem (R1, R2, R3) and was connected to three of the four leverage points, reducing the *costs of collaboration* could be achieved through interventions targeting these leverage points (LP3 & LP4) (Fig. 2).

Lastly, we highlight the inclusion of the element *belief in supernatural powers* in Fig. 2. Belief in supernatural powers of leaders still plays a crucial role in the level of trust in leaders in Africa but is rarely acknowledged because it is a sensitive topic (Adolfsson et al., 2024). In the social learning program, discussions showed that these beliefs are widespread and prevent members from holding their leaders accountable. A common response when asked "what will happen if you contest or challenge a decision of a leader" was "you may find you do not wake up the next morning". After discussing this topic extensively participants acknowledged that there were no easy solutions to this problem of fear of the supernatural. However, we feel it is important to bring this factor to the fore as we saw some indication that talking about it could bring about some change. A participant in our program reported a shift it their beliefs after attending the program: "B: *Before the workshop tradition was there and we have no say over it. It was taboo to change them, for example, for the first rain at night, the next day all the tools used for farming must be gathered in the center of the village and not be used. So, we grew up doing that not knowing what would happen if we didn't do it. So, after the workshop I tried to understand our traditions and our culture story and question their utility. So, I tried stopping those customs and nothing happened. So now I am free. After the workshops I started thinking about things and thought if we are all humans and we are the same so why is your culture not saying we shouldn't do this and that etc. R: So now you don't believe in supernatural powers? B. No I don't and it's working for me.*"

7. Conclusions

As calls increase for more interdisciplinary and transdisciplinary approaches to resolve the challenges of wildlife governance in complex human-wildlife social-ecological systems, the need for long-term research to better grasp the complexity of these challenges is becoming increasingly clear. Using causal loop diagrams as a synthesis tool, as we did in this paper, can be useful to distil key insights from long-term projects, which inevitably produce large amounts of data. Although in the current perspective the causal loop diagrams resulted from the "expert" opinion of the first author in particular, in larger research teams this could be a more collaborative process. With diverse approaches and tools to elicit mental models to understand complex systems (Jones et al., 2011; Moon et al., 2019; Barbrook-Johnson and Penn, 2022; Kenzie et al., 2024), we encourage researchers and practitioners alike to more widely use these tools to explore the complexity in different wildlife systems. The further development of systems thinking (Levy et al., 2018), in turn, will likely lead to improved decision making as well as enable future comparisons across case studies.

Addressing the complexities of wildlife governance in human-wildlife social-ecological systems requires long-term research. This study demonstrates the value of causal loop diagrams (CLDs) in synthesizing large datasets, revealing new research directions and actionable strategies. This study presents a proof of concept for integrating CLDs with a leverage points approach, using communal conservancies in

Namibia as an example. While CLDs have been applied to stakeholder engagement in diverse contexts, their use in wildlife governance remains limited. By structuring narratives around governance complexities, CLDs clarify system interrelationships, foster sense-making and help to identify leverage points through systematic evaluation.

Key barriers to human-wildlife coexistence identified in this study include high conflict levels, low tolerance for wildlife, lack of policy clarity, and governance misalignment. These elements function as leverage points where interventions can disrupt undesirable reinforcing feedback loops. Social learning programs, implemented as part of this research, emerged as promising interventions. These programs, not widely used for promoting coexistence to date, offer a holistic approach for researchers and stakeholders to engage with human-wildlife governance complexities. Early results suggest their potential for behavioral and structural change, but broader stakeholder inclusion is necessary for system-wide impact. Finally, CLDs serve as useful visual tools for communicating system dynamics, fostering stakeholder engagement, and building consensus around governance issues. Their application in wildlife governance presents an opportunity for more adaptive and effective management strategies.

CRediT authorship contribution statement

Ruth Kansky: Writing – review & editing, Writing – original draft, Investigation, Funding acquisition, Formal analysis, Conceptualization. **Maraja Riechers:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Joern Fischer:** Writing – review & editing, Writing – original draft, Methodology, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.biocon.2025.111198.

Data availability

No data was used for the research described in the article.

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