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ORIGINAL RESEARCH

# Assessing the aftermath of tripling the tigers' population in Nepal: socio-economic and eco-environmental sustainability perspectives

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**Abstract**

Tiger conservation is a global priority, and Nepal's program has achieved notable success. However, rapid population growth has intensified human–wildlife conflicts. This study assessed the socio-economic costs of rising tiger populations, evaluated ecological and environmental risks, and examined stakeholder perspectives to inform sustainable human–nature coexistence using a sustainability framework and the theory of change. Wild tiger numbers nearly tripled from 2009 to 2023, reaching 355 (95% CI: 318–392), coinciding with an 11-fold increase in human–wildlife incidents. Over 15 years, conflicts caused an average of 18 (95% CI: 12–24) human casualties, 152 ± 34 injuries, and 47 ± 10 cattle losses annually. Tiger abundance was strongly correlated with human injuries ($r = 0.71$–$0.74$), casualties ($r = 0.81$), and livestock losses ($r = 0.75$). Relief expenditures averaged US$1.1–1.18 million per year, highlighting substantial economic burdens. Mann–Kendall analyses revealed significant upward trends in tiger numbers, human injuries, casualties, livestock loss, and relief distribution ($p < 0.05$). Ecological challenges include at least 20 tigers in captivity (2024) and 558 wildlife deaths in 2022/23, including retaliatory killings. Stakeholder priorities varied: safety and compensation for local communities, law enforcement for officials, coordination for NGOs, policy reform for political leaders, and awareness for the media. Current interventions—rescue, caging, and relief distribution—impose pressures on social, economic, ecological, and environmental systems without fully mitigating risks. Applying the theory of change, findings underscore the need for integrated, community-centered, long-term strategies combining conflict prevention, livelihood protection, habitat and prey management, and policy reform. Such approaches can reconcile ecological sustainability with socio-economic welfare, ensuring effective tiger conservation while minimizing adverse human and environmental impacts.

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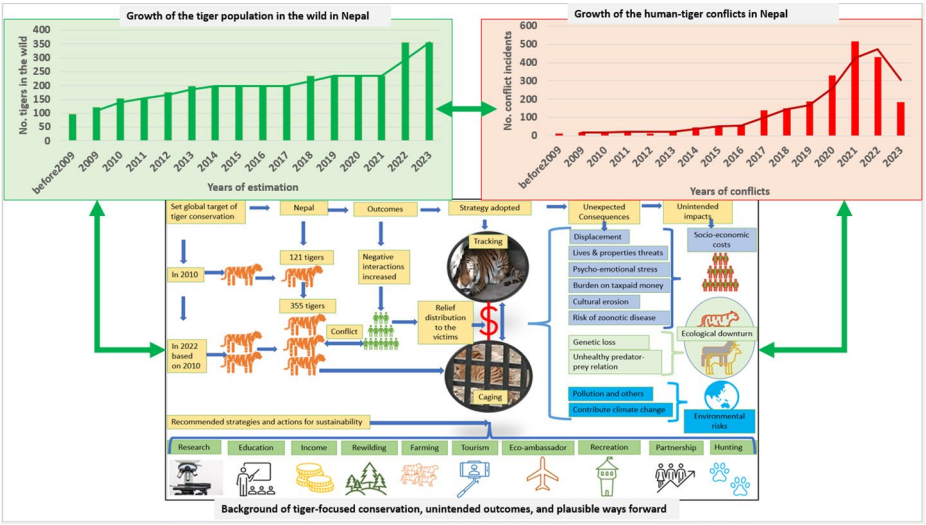
## Graphical abstract




**Keywords** Co-existence · Ecosystem health · Environmental challenge · Human-wildlife conflict · Social equity

## Introduction

Wildlife conservation is a global priority due to declining populations driven largely by human activities (Abbott and van Kooten 2011; Lynam 2010; Margulies 2019; Nyhus et al. 2010; Smith et al. 2018; Ten et al. 2021). Local efforts face challenges from the costs of supporting species with large home ranges, such as pachyderms and mega-carnivores, and this triggers the displacement of the people to create an inviolate and isolated landscape (Harihar et al. 2014). Modern strategies often displace people to create human-free habitats, differing from traditional coexistence models (Khadija et al. 2022; Menon and Borah 2024; Pandey et al. 2024a). Understanding and managing trade-offs between societal welfare and ecosystem integrity while emphasizing tiger conservation in the Anthropocene is crucial.

In 2010, tiger range countries pledged to double their populations by 2022. Nepal achieved this target early, now hosting over 350 wild tigers in the Terai Arc Landscape (TAL) – only a tiger-bearing landscape connected with Indian protected areas (DNPWC and DFSC 2022), highlighting the importance of inviolate protected areas (GoN 1973, 2016, 2019a). However, conservation has displaced over 4,800 families (Pandey et al. 2024a), imposed socio-economic costs (Joshi 2024; Lam and Paul 2013) and increased human-wildlife conflicts (DNPWC 2023, 2022; MoFE 2021) from the same landscape, despite protecting tigers, their prey base, and other wildlife, and their critical habitats, including biological corridors (Pandey et al. 2025a). Nepal's success illustrates both ecological achievement and the challenges of reconciling conservation with social impacts (DNPWC, 2022Pandey et al. 2024a, 2025b, c).

To address rising human-wildlife conflicts, Nepal has implemented multiple policies, plans, and programs, including the National Forest Policy 2019 (GoN/MoFE 2019), the National Biodiversity Strategy and Action Plan 2014–2020 (GoN/MoFSC 2014), the Protected Area Management Strategy 2022–2030 (DNPWC, 2022), the National Tiger Conservation Action Plan (2023–2032), and the suggestions and plans outlined in the report on the status of tigers and prey in Nepal 2022 (DNPWC and DFSC 2022). On the ground, strategies supported by development partners and local communities include awareness programs, relief distribution, insurance schemes, alternative livelihoods, ecotourism, habitat management, law enforcement, and caging of problematic tigers (DNPWC 2023; GoN/MoFE 2019; MoFE 2018, 2021). The main approach involves identifying, tracking, and capturing incident-causing tigers for rescue centers while providing relief to victims (OPMCM, 2023; Thakur et al. 2025). Moreover, Nepal is a party to more than 30 international environmental agreements, conventions, and conferences (GoN 1973, 1982; Pokharel and KC 2024), having required policy instruments (DNPWC, 2022; DNPWC and DFSC 2022; GoN/MoFE 2019), and adheres to international frameworks (CBD, 1992; CITES, 1973; GoN 2016) to conserve all wildlife, including mega carnivores like tigers, in the ground level. Also, Nepal has implemented the 2016 wildlife rescue procedure to standardize technical care (GoN/MoFSC 2016), but lacks guidance on effective management of problematic tigers and assessment of ecological and social outcomes.

Numerous studies address human–wildlife interactions with mega-carnivores globally, including the Sumatran tiger in Indonesia (Nugraha and Sugardjito 2009), the Malayan tiger (Ten et al. 2021), Royal Bengal Tiger in India (Harihar et al. 2015; Khadija et al. 2022) and the South China tiger (Traylor-Holzer et al. 2010). However, few studies explicitly examine the socio-ecological impacts, particularly when adopting an immediate, short-term strategy of rescuing and caging problematic tigers without tangible benefits. Further, the effectiveness of wildlife rescue centers and relief distribution mechanisms remains largely unassessed. Several critical questions persist: What insights do national and international policies offer for mega-carnivore conservation? What are the socio-economic implications of increasing mega-carnivore populations and cascading wildlife increases for forest-dependent Indigenous peoples and local communities? What unintended ecological and environmental consequences arise from short-term government strategies, such as tracking and caging conflict-prone mega carnivores like tigers? Realizing these research gaps, this study addresses these gaps by taking a case of Nepal's Terai Arc Landscape (TAL) – only a tigers-bearing landscape of Nepal, by adopting dimensions of the Sustainability Framework (Tilzey 2002; World Commission on Environment and Development et al. 1987) and the theory of change (TC) principles (Funnell and Rogers 2011; Walton et al. 2000). By doing so, the study demonstrates how changes in conservation inputs, including policies, strategies, and practices, can lead to improved socio-economic and ecological outcomes.

In this context, this study critically examines the implications of increasing wild tiger populations in Nepal. Specifically, this study aimed to (i) assess the socio-economic costs of increasing tiger populations in Nepal, (ii) evaluate ecological and environmental risks associated with wildlife management, and (iii) examine stakeholder perspectives to inform sustainable human-wildlife coexistence. It offers three key contributions: evaluating global and Nepal's conservation strategies across legal, ecological, and social dimensions; addressing trade-offs between ecosystem integrity and societal welfare; and advancing landscape-level connectivity to support both eco-environmental sustainability and social welfare.

## Theoretical frameworks

In this study, we adopted two theoretical frameworks, tailored to the characteristics and context of our research area: the sustainability framework (SF) and the theory of change (TC). Firstly, the SF provides a structured approach to balance environmental, social, and economic goals to ensure long-term well-being for people and the planet (Lockie and Ransan-Cooper 2015; Niesenbaum 2019). It guides decision-making by integrating principles such as resource efficiency, equity, resilience, and intergenerational responsibility (Tilzey 2002; World Commission on Environment and Development et al. 1987). Key models include the triple bottom line (people, planet, profit) and systems thinking, which emphasize the interconnectedness of ecological health, social equity, and economic viability (Laladhas et al. 2017). Such a robust sustainability framework helps assess trade-offs, align policy and practice, and promote actions that meet present needs without compromising future generations (Fang et al. 2018; Holden et al. 2014). Using the three dimensions of the Sustainability Framework—social, economic, and environmental—we discuss the issues and unintended consequences of wildlife conservation, with particular focus on the challenges faced by tigers in Nepal. Lastly, based on the findings and observations of this study, we propose improved strategies and practices adopting the TC to explore plausible future pathways.

## Conceptual framework and practical approaches

Drawing the fundamental concepts of the theory of change (TC) in management (Funnell and Rogers 2011; Walton et al. 2000) with biodiversity conservation as a management approach, we analyzed the institutional arrangement and changes necessary by reviewing existing policies, plans, programs, projects, and practices to achieve better outcomes (Broman and Robèrt 2017; Clement et al. 2015). The core idea of this theory is that if the inputs change in a system, the outputs, outcomes, and impacts change accordingly. Customization and adaptation of these TC principles in our study is achieved by reinventing the policies and plans on the management of problematic wildlife, especially the tigers, moving away from the current blanket approach of just tracking, caging, and relief distribution to the victims to more beneficial and better approaches from socio-economic, ecological, and environmental perspectives. Achieving more beneficial conservation outputs from these perspectives will, in turn, lead to more positive outcomes in the entire socio-ecological dimensions (Margoluis et al. 2013). These can be achieved by revisiting existing conservation strategies, including policies, rules and regulations, guidelines, preventive and remedial measures, and, ultimately, affirmative actions. These changes can contribute to positive progress toward the Sustainable Development Goals by promoting the conservation of megacarnivores, fostering a healthy and harmonious ecosystem, and supporting broader sustainability objectives (CBD, 2022; Lockie and Ransan-Cooper 2015; UN, 2015). By revisiting conservation policies at the national level and achieving potential positive outcomes, we can ultimately contribute to extracting the lessons learned for attaining international policy goals and targets on a global scale. Drawing the key essence of this theoretical background to achieve our intended study objectives and overarching aim of the study, we adopted the basic steps of the research as a practical framework to guide the overall study processes (Fig. 1).

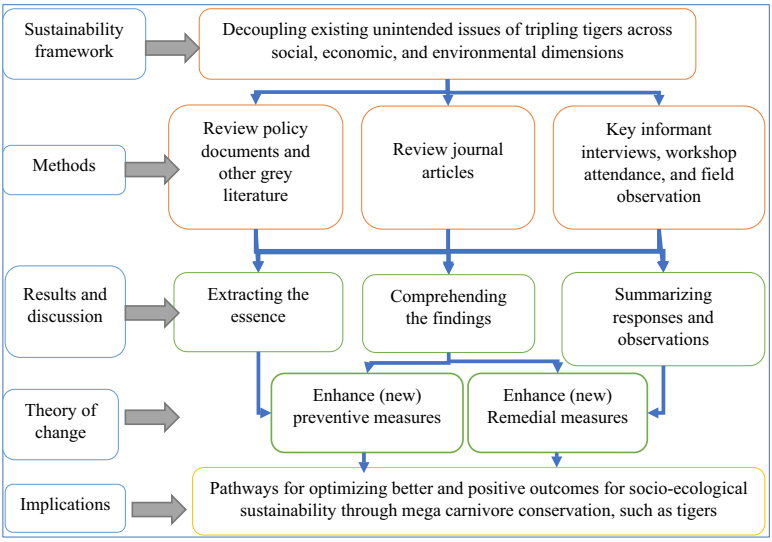



**Fig. 1** The amalgamation of the theoretical and conceptual frameworks of the study and its implications

## Methods

Before starting this study, ethical approval was obtained from the Human Research Ethics Committee [Ethics application ETH2023-0568 (HREC)] at the University of Southern Queensland, Australia. In addition, an official permission was obtained from the Government of Nepal, Ministry of Forests and Environment, Department of National Parks and Wildlife Conservation (DNPWC) [Letter number: 2080/08-Eco-214; Correspondence number: 3020], for conducting interviews, field observations, protected area entry permits, and participating in related workshops. The data were collected in four different but integrated approaches. First, we reviewed relevant international and national policy documents ($n=30$, *see details in* Table 1). For the policy review, we examined international treaties, agreements, conferences, and their adopted protocols related to biodiversity conservation, and national policies, standards, rules, and regulations with a focus on tiger management (Table 1). Second, we conducted a systematic review of published literature ($n=52$). For this, we utilized four prominent databases: Web of Science, Scopus, Science Direct, and Google Scholar, to conduct a literature search using specific keywords. The final keywords were, "tiger management" or "tiger rescue" or "man-eater tiger" or "problematic tiger" or "human-tiger conflict", finalizing after referring to past literature and consensus made among the research team ($n=3$), ensuring sensitivity and specificity of the systematic literature review method (Haddaway et al. 2020; Pandey et al. 2024c). Articles and literature addressing issues such as problematic tigers, tiger rescue, tiger management, caging of tigers, tigers in captivity, or human-tiger conflict were included for further assessment. This review critically examines existing scholarship on problematic tiger management—including tracking, capture, caging, and relief distribution—with a focus on their unintended long-term conservation and human–wildlife coexistence outcomes. Despite extensive literature on human–tiger conflict, empirical studies specifically assessing the rescue and prolonged

**Table 1** Essence of global and Nepalese policy frameworks regarding biodiversity conservation from the lens of minimizing human-wildlife conflict, human-nature coexistence, and sustainability, particularly focusing on mega carnivore management

| International frameworks | International policy provisions regarding wildlife management, including tigers |
|---|---|
| Biodiversity Framework for 2030 | • One health; biodiversity will be conserved, managed, and utilized through sustainable use principles (CBD, 2022, 1992). |
| Conventions on Biological Diversity (CBD) Principles 1992 | • The CBD of 1992 emphasizes the conservation of biodiversity, sustainable use of its components, and fair sharing of benefits; wildlife like tigers should be conserved in situ through protected areas and other conservation standards (CBD, 1992). |
| Nagoya Protocols 2010 | • Focuses on access to genetic resources and fair benefit-sharing; emphasizes sustainable use and equitable benefit-sharing of conservation outcomes with local communities, ensuring fair compensation for conservation efforts (Morgera et al. 2014). |
| The World Trade Organization 1994 | • Allow for exceptions to trade rules to protect endangered species like tigers; permit trade restrictions for the conservation of exhaustible natural resources, provided they are not a means of arbitrary discrimination or disguised trade restrictions (Safrin 2002). |
| Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) – 1973 | • Tiger is listed in Appendix I, and therefore, non-commercial exchange upon the written consent from management authorities from both countries of origin and to the country of disposition of the specimen must be prior approved before the exchange of the specimen; supports initiatives that mitigate human-tiger conflicts, emphasizing non-lethal solutions and community involvement (Garrison 1994; GoN 2016). |
| Global Tiger Forum 1994 | • Focuses on the conservation of tigers across their range; emphasizes collaborative efforts to manage problematic wildlife (Kühl 2011). |
| UNESCO – World Heritage 1972 | • Emphasizes the protection and conservation of sites with outstanding universal value, including habitats of endangered species like tigers; it promotes integrated management plans that balance conservation with local community needs (Labadi, 2020). |
| Nepal's regulatory framework regarding human-wildlife coexistence | |
| Constitution of Nepal (2015) | • Natural resources and biodiversity are national assets, with all citizens and governments responsible for their conservation and sustainable management for the well-being of both people and nature; all levels of government must conserve biodiversity and manage natural resources effectively within their jurisdictions (GoN 2015). |
| Forest Act 2019 | • Biodiversity shall be conserved by authorized officials appointed by the Government of Nepal, who will be responsible for managing natural resources and conserving biodiversity; wildlife-related matters will be managed under existing laws and regulations (GoN 2019a). |
| National Park and Wildlife Conservation Act 1973 and Regulations 1975 | • Tigers are listed in Annex-I of the protected wildlife list and can only be killed or captured under specific conditions following authorization from officials; to hunt wildlife, a valid license is required; wildlife can be used as souvenirs internationally, and activities such as opening zoos, conducting research, wildlife farming, and hunting for management purposes are regulated under existing standards and regulations (GoN 1973). |
| Nepal's CITES Act 2016 and its regulations 2017 | • In alignment with CITES agreements, Nepal has established a separate CITES Act that stipulates that wildlife can be gifted but not traded; breeding of Appendix-I species, such as tigers, is permitted, with their second-generation classified as Appendix-II; use of Appendix-I species for research, education, or income generation through zoos or demonstrations is allowed and not considered trade (GoN 2016). |
| National Nature Conservation Trust Fund 1982 and Regulations 1985 | • Provide technical support to the government for wildlife and biodiversity conservation, including research and rescue efforts; generate funds to support biodiversity conservation and research initiatives (GoN 1982). |

**Table 1** (continued)

| International frameworks | International policy provisions regarding wildlife management, including tigers |
|---|---|
| Environment Protection Act 2019 and Regulations 2020 | • The environment must be kept healthy, and polluters are required to pay the costs according to prevailing regulations; wildlife is considered a national heritage (GoN 2019b). |
| National Criminal (Procedure (Code) Act 2017 | • Wildlife-related crimes are treated as special cases and are handled with caution in district courts; investigations into wildlife species listed in Annex I are carried out by police officers or equivalent officials (GoN 2018a). |
| Local Administrative Act (1971) | • Weapons are to be monitored by the Chief District Officer (CDO); any ambiguities in sectoral laws fall under the jurisdiction of the CDO (HMG, 1971). |
| Nepal Treaty Act 1993 | • All treaties ratified by Nepal must be implemented and regarded as equivalent to national laws and regulations; ratified treaties must be published in the Nepal Gazette, and their implementation, along with periodic compliance reviews, should be reported to relevant authorities and stakeholders (HMG, 1993). |
| Local Self-Governance Act 2018 | • Biodiversity within local jurisdictions is the responsibility of local governments to conserve; biodiversity conservation should align with federal laws without contradicting them (GoN 2018b). |
| Watershed Management Act 1982 and Regulations 1985 | • Watersheds should be managed in a holistic and integrated manner; local tools and techniques for conservation should be promoted and emphasized (HMG, 1982). |
| Biodiversity Conservation Laws Across Government Tiers Under Nepal's Constitution | • Biodiversity within a province and/or in the local units shall be managed by the designated authority as per the Constitution of Nepal; provincial and local governments may create conservation rules, provided they do not conflict with federal laws (GoN 2015). |

confinement of "problematic" tigers, or the conservation and social implications of ad hoc relief distribution strategies, remain limited.

Third, we conducted key informant interviews ($n=50$) across the Terai Arc Landscape (TAL) to explore conflict mitigation and pathways toward coexistence and safe human–wildlife interactions. Informants were purposively selected from professionals working in Nepal's conservation sector, particularly within the TAL, and included local policymakers ($n=5$), policy practitioners from district forest offices and park authorities ($n=10$), Indigenous peoples and local communities ($n=10$), civil society organization representatives ($n=10$), security personnel ($n=10$), and media personnel ($n=5$). Face-to-face interviews followed a pre-determined checklist (Annex I). Findings were cross-validated through a stakeholder workshop focused on human–wildlife interfaces—particularly tigers and their prey base—in the Khata Transboundary Biological Corridor of Bardiya, Nepal, adjoining India's Katerniyaghat Wildlife Reserve inviting the similar six categories of stakeholders (local policy makers, media personnel, law implementers, security and forest guards, representative of indigenous people and local communities, and conservation – non-government organizations' members) through workshops to gather insights on minimizing human–wildlife conflict, with a focus on tiger conservation, and asked participants to rank their priorities on a 10-point scale (1 = lowest, 10 = highest). In addition, we undertook repeated field observations (≥15 visits in total) at all tiger rescue centres across Nepal's TAL between 2021 and 2024 to assess on-ground operational realities. These combined methodologies provide comprehensive information and validation of primary information. Finally, we gathered quantitative time series data on wildlife casualties, human and property loss, relief distribution, and budgetary information from the respective parks and the DNPWC and cross-

referred from the annual reports of the respective parks, reports of the Ministry of Forests and Environment, and audit reports of Nepal.

All data were analyzed using Microsoft Excel and RStudio with its associated packages, and libraries such as '*ggcorrplot'*, *agricolae*, and '*corrplot'* (Core Team 2023). Specifically, we applied Spearman rank correlation tests, Mann–Kendall trend tests, and Sen's slope estimators to examine the relationships between variables, quantify the rate of change over time, and determine whether the growth or decline of the variables exhibited statistically significant trends. Descriptive statistics and respondent rankings are presented in tabular form, while other results are shown using a combination of graphical, tabular, and narrative formats.

## Policies to practices in biodiversity conservation

### Policy landscape of mega carnivore conservation at the global level and in Nepal

International frameworks and Nepal's policy measures provide comprehensive guidelines for wildlife conservation, particularly for managing mega carnivore species like tigers (Table 1). Even a single narrative in policy documents significantly impacts ground-level affirmative actions and ecosystems, underscoring the importance of judicious international decisions and interpretation to drive effective ground-level conservation. In gist, these policies envision the coexistence and sustainability of humans and natural systems on Earth.

Grounded in global and national policy instruments of respective countries, communities worldwide implement various strategic programs and practices to minimize human–wildlife conflict. In the context of Nepal, where tiger numbers have tripled, these lessons are directly relevant for understanding and managing the associated impacts and are therefore pertinent to this study.

### Ground reality – a tiger conservation case of Nepal

#### Unintended socio-economic consequences

Results indicate that while the tripling of tiger populations and increasing prey reflect conservation success, they also amplify social and economic challenges. In Nepal, wildlife attacks cause dozens of deaths and over 150 injuries annually (Fig. 2), with unrecorded stress, minor injuries, and socio-cultural impacts among technicians, staff, volunteers, and local communities. Annual relief expenditures average US$1.1–1.18 million, covering 17 species but excluding snakebites and wildlife-related road accidents, concentrated in six tiger-bearing protected areas of the Terai Arc Landscape. Additional costs arise from tiger tracking and captive management. Between 2009 and 2023, wild tiger numbers rose from under 100 to over 350, accompanied by an 11-fold increase in human casualties, livestock depredation, and compensation claims, alongside habitat changes affecting grassland-dependent birds and other fauna. These findings underscore that conservation gains in Nepal have been accompanied by intensified human–wildlife conflict and rising financial pressures on public resources.

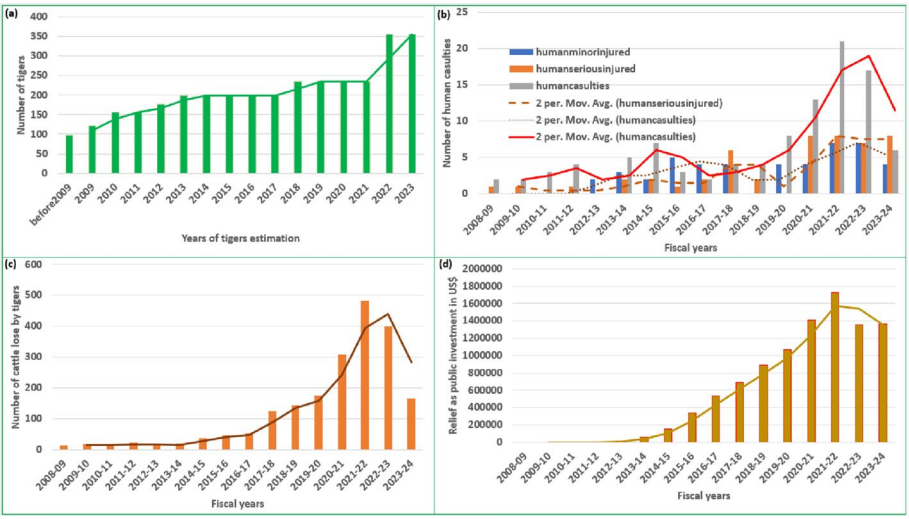



**Fig. 2** Trends in the wild tiger population and corresponding incidents involving humans and their property (livestock depredation), along with wildlife relief distributed through public investment (1 US$ = NRs 100.00). Given that this study spans the period from 2009 to 2024, average values are used for indicative purposes rather than reflecting annual variability. (a) Estimated trend of the wild tiger population in Nepal; (b) human casualties, including deaths and serious or minor injuries caused by tiger attacks; (c) depredation of domestic livestock—buffaloes, pigs, goats, and sheep—by tigers; and (d) trend of relief distribution over the fiscal years for wildlife-related damages, including tiger attacks on humans and property. The relief distribution amount encompasses conflicts involving all 17 wildlife species eligible for compensation under Nepal's prevailing regulations. Tiger populations in Nepal grew steadily, while cattle losses and relief payments peaked in 2021–2022 but declined sharply by 2024, reflecting improved conflict management, livestock protection, resumption of patrolling and law enforcement, timely compensation, and community awareness post-COVID-19

While Nepal's tiger population continued to rise, cattle losses and associated relief expenditures peaked in 2021–2022 before declining sharply during 2022–2024 (Fig. 2). This reduction coincided with the resumption of enhanced human–wildlife conflict management following the COVID-19 period, including improved livestock protection, timely compensation, strengthened patrolling, and community awareness programs. These interventions mitigated economic losses and reduced relief dependency. The results also highlight the strong link between conservation outcomes and broader socio-economic conditions, as pandemic-related livelihood and governance pressures intensified conflicts during 2019–2022.

Further, tiger abundance was strongly and positively correlated with key human–wildlife conflict indicators. Tiger numbers showed strong associations with human injuries ($r = 0.71$–$0.74$), cattle losses ($r = 0.90$), total incidents ($r = 0.91$), and total human incidents ($r = 0.83$). Relief distribution closely tracked conflict severity, exhibiting near-perfect correlations with cattle losses ($r = 0.95$) and strong correlations with total incidents ($r = 0.75$) and total human incidents ($r = 0.88$). Total incidents were very strongly correlated with human casualties ($r = 0.90$–$0.91$), indicating a close linkage between livestock depredation, human harm, and compensation responses (Fig. 3).

Furthermore, the Mann–Kendall trend analysis with Sen's slope estimator revealed statistically significant increasing trends across all variables examined (Table 2). The wild tiger population showed a positive trend ($z = 4.68$, $n = 16$, $p = 2.89 \times 10^{-6}$) with a Sen's slope

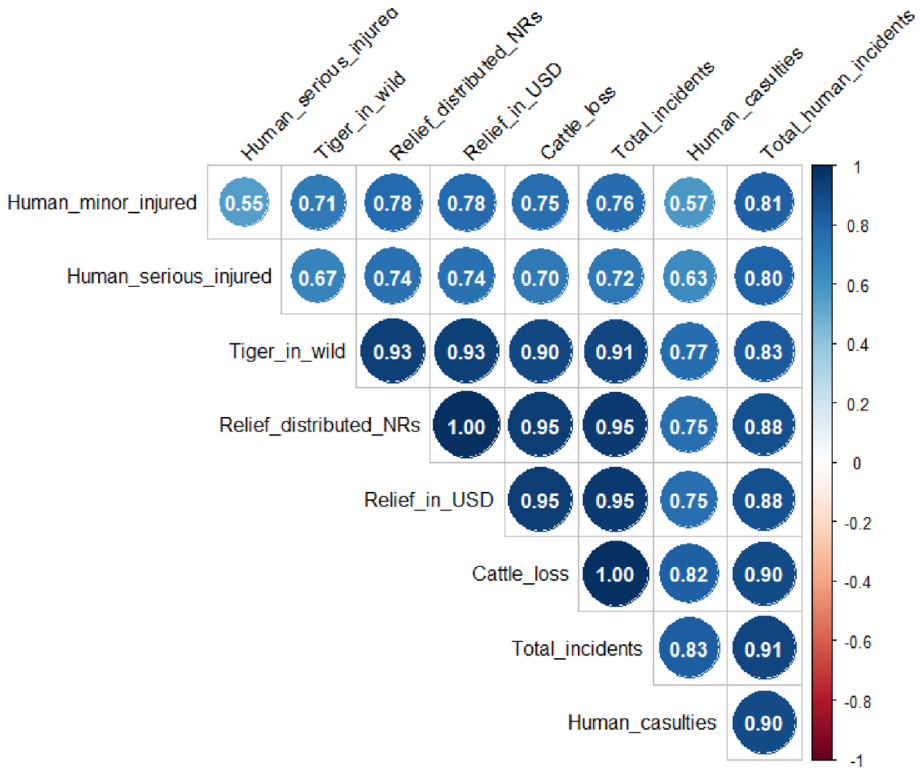



**Fig. 3** Spearman correlation tests of the number of tigers in the wild with human casualties and associated wildlife-related public funding pressure as a relief distribution to the wildlife victims

of 11.11. Human minor injuries ($z=3.22$, $p=0.0013$), serious injuries ($z=2.91$, $p=0.0036$), and casualties ($z=3.09$, $p=0.0020$) also exhibited significant upward trends with slopes of 0.4, 0.5, and 0.67, respectively. Similarly, total human incidents increased significantly ($z=3.52$, $p=0.0004$; slope = 1.41). Cattle losses ($z=4.46$, $p=8.30\times10^{-6}$) and total incidents ($z=4.51$, $p=6.58\times10^{-6}$) both showed steep positive trends with slopes of 17.30 and 17.64, respectively. Correspondingly, the relief distributed to victims, both in Nepalese rupees ($z=4.77$, $p=1.85\times10^{-6}$; slope = 12,273,302 NRs) and US dollars ($z=4.77$, $p=1.85\times10^{-6}$; slope = 122,733 USD), showed significant increases over time. These results collectively indicate a consistent upward trend in tiger numbers, associated human–wildlife conflict incidents, and corresponding compensation payments in Nepal over the study period.

## Ecological and environmental risks

In the fiscal year 2022/23 alone, 558 wildlife were killed, including 11 tigers, due to natural and anthropogenic causes (Fig. 4). Of these, 488 (87%) were recorded from the protected areas (PAs) in the TAL region. Moreover, during the same period, 734 wildlife individuals were rescued, including eight tigers, of which 490 (66.75%) were from the TAL. If regulated hunting is applied to ecologically vulnerable wildlife populations, including tigers, it could generate substantial revenue for conservation, reduce the risk of human–wildlife conflict,

**Table 2** Trend test results of the wild tiger number, and corresponding human-tiger conflicting incidents, and burden to the public finance in Nepal's tiger-bearing landscape (TAL) between 2008 and 2023

| Variables | Maximum | Minimum | Mean | Sens slope coefficient |
|---|---|---|---|---|
| Tiger in the wild | >355 | <97 | 209 | 11.11* |
| Minor injured by tigers | 7 | 0 | 3 | 0.40* |
| Humans seriously injured by tigers | 8 | 0 | 3 | 0.50* |
| Human casualties by tigers | 21 | 0 | 6 | 0.67* |
| Total human incidents with tigers | 36 | 2 | 12 | 1.42* |
| Cattle loss by tiger depredation | 481 | 12 | 127 | 17.30* |
| Total incidents by tigers | 517 | 15 | 139 | 17.64* |
| Relief distribution in NRs | 172,802,460 | 0 | 59,954,678 | 12,273,302* |
| Relief in USD | 1,728,020 | 0 | 599,547 | 122,733* |

[Note: Positive Sen's slope value indicates the increasing trend, and negative value indicates the decreasing trend, asterisk (*) indicates the 5% level of significance, NRs stands for Nepalese Rupees, and USD stands for Dollars of the United States of America; the exchange rate is taken as 1USD = 100 NRs, given that this study spans the period before 2009 to 2024 (Fig. 2), average values are used for indicative purposes rather than reflecting annual variability]

often associated with conflict-prone or susceptible wildlife, including tigers, and support alternative livelihood options for forest-dependent communities (personal communication with the National Trust for Nature Conservation, Bardia, Nepal). However, none of the rescued tigers have been released back into their natural habitats to resume ecological functions, nor euthanized or otherwise managed under regulated frameworks that could generate revenue (e.g., through sanctioned use of other wildlife resources such as bushmeat). Instead, these tigers were housed in rescue centers or zoos (Table 3).

Further, field observations revealed that 20 adult "problematic" tigers are currently held in captivity in Nepal (Table 3). Six of these tigers are housed in the Central Zoo—the only zoo in Nepal that keeps tigers, as no private organizations or individuals are reported to do so—while the remaining individuals are maintained in government-operated rescue centers across the five tiger-bearing protected areas of the lowland TAL. Of these captive tigers, six are females, and fourteen are males. Their care is fully supported by public funding for infrastructure, feeding, and additional staffing, with no direct return on investment, except for those displayed in the zoo.

## Stakeholders' perspectives on human-wildlife co-existence

Findings reveal that stakeholders hold diverse perspectives on human–wildlife coexistence and on strategies to reduce the pressures of growing tiger populations on human lives and property. Accordingly, we synthesize insights from participatory consultations with ground-

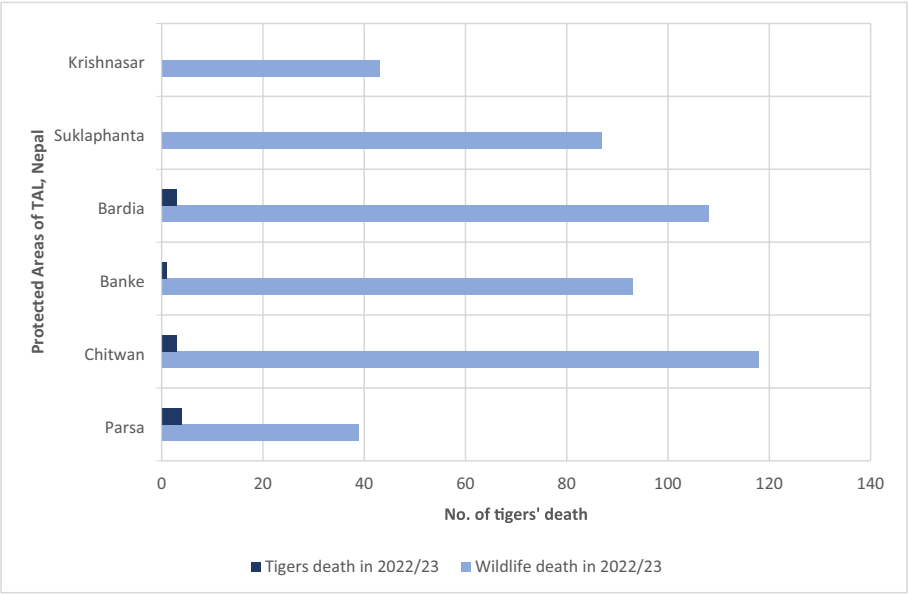



**Fig. 4** The toll of wildlife deaths, including tiger fatalities, across the Terai Arc Landscape (TAL) area of Nepal, as an example for the fiscal year 2022/23 (DNPWC 2023)

**Table 3** The captive tiger status in different rescue centers and in a zoological garden in Nepal

| Tiger habitats | Wild tigers (in 2023) | Wildlife rescue center (WRC) | Number of caged tigers |
|---|---|---|---|
| Parsa NP and its adjoining habitats | 41 | Parsa NP WRC | 2 (males) |
| Chitwan NP and its adjoining habitats | 128 | Chitwan NP WRC | 6 (2 females) |
| Banke NP and its adjoining habitats | 25 | Banke NP WRC | 2 (1 female) |
| Bardia NP and the Khata Corridor | 125 | Bardia NP WRC | 4 (1 female) |
| Suklaphanta NP and its adjoining habitats | 36 | Central Zoo, Kathmandu | 6 (2 females) |
| Total | 355 | | 20© |

© This is an indicative figure, as it may vary from time to time; however, it was the actual figure recorded during the latest field data collection period in February 2024

level stakeholders on minimizing tiger-related conflicts to inform future policy and practice (Table 4).

Stakeholders consistently identified human–wildlife conflict as a multidimensional governance and management challenge, driven by habitat degradation, inadequate infrastructure, and weak coordination (Table 4). Communities emphasized immediate livelihood risks—crop depredation, human injuries, and proximity to forests and corridors—advocating insurance, compensation, and physical barriers such as electric fencing. Park and forest officials framed these concerns within institutional constraints, noting guard shortages, limited enforcement capacity, and the need for long-term mitigation, including bio-fencing

**Table 4** A prioritized summary of perspectives from diverse stakeholder groups on minimizing human–wildlife conflict, with a particular focus on the management of problematic tigers in Nepal. Values in parentheses indicate priority rankings on a scale of 1 to 10, where 1 represents the lowest priority and 10 the highest

| **Communities' voices** | **Parks and forest officials' voices** |
|---|---|
| ✓ Riverbed mining in the Khata Biological Corridor exacerbates the human-tiger conflict (7).<br>✓ Shortage of forest guards due to resource constraints impacts wildlife management (5).<br>✓ Effective wetland management is crucial for tiger habitat security (6).<br>✓ Coral pans/fencing proves effective in mitigating tigers and leopards' invasion (8).<br>✓ Wildlife corridors like postal corridors are major sites of human-wildlife conflict (7).<br>✓ Strategies to prevent accidents are necessary for community safety (7).<br>✓ Proximity of houses to forests leads to frequent crop raids by tiger-prey based (10).<br>✓ Tragic incidents like the case of the loss of life of a 26-year-old woman in the Bardia NP highlight the risks of entering forests alone (9).<br>✓ Insurance schemes are needed to compensate for wildlife-related losses (9).<br>✓ Financial support is essential for bush clearance efforts to reduce wildlife conflicts (8). | ✓ Strengthen patrolling and law enforcement efforts to mitigate human-wildlife conflict (10).<br>✓ Enforce wildlife regulations to maintain stable wildlife populations (9).<br>✓ Implement sustainable solutions to address wildlife conservation challenges (9).<br>✓ Utilize bio-fencing, including electric fencing, as an effective wildlife deterrent (8).<br>✓ Use mesh wire fencing effectively to reduce human-wildlife conflict (8).<br>✓ Promote awareness to foster positive attitudes towards wildlife conservation (7).<br>✓ Balance social and environmental considerations in conservation practices (7).<br>✓ Promote alternative cropping methods that benefit farmers and deter wildlife interference (6).<br>✓ Conduct further studies on tigers' behavior to develop effective mitigation strategies (6).<br>✓ Avoid blaming national parks alone for wildlife issues; focus on overall wildlife management (5). |
| **Civil societies, and I/NGOs' voices** | **Local-level security personnel's voices** |
| ✓ Coordination among stakeholders is needed (10).<br>✓ Correct information on time to a chain of coordination village to village along the route of the wildlife movement (9).<br>✓ Awareness is still insufficient (9).<br>✓ Wildlife-risk zonation requires updated data on the movement, and the villagers are required to communicate the correct information (8).<br>✓ Cooperate for saving and conserving wildlife (8).<br>✓ Remove the invasive species in the forest – since forests are turning into bushes, there is no grassland for wild and domestic animals (7).<br>✓ Low-grade habitat tends to attract wildlife in the villages and raid the crops, increasing the negative human-wildlife confrontation (7).<br>✓ A shift in dependency on the forests reduces the firewood collection and livestock grazing, thereby increasing the bushes and vines in the forests (6).<br>✓ Consistency of the rotation and crop diversification among the villagers (6).<br>✓ Wildlife movement information is to be clearly communicated to the communities (5). | ✓ Shared responsibility among all stakeholders is essential for effective wildlife management (10).<br>✓ Awareness campaigns are crucial for educating communities about wildlife safety (9).<br>✓ Mass media, mobile apps, and alert systems can effectively disseminate life-saving information (9).<br>✓ Promoting awareness to safeguard both humans and tigers is critical (9).<br>✓ Schools play a pivotal role in educating children and adults about wildlife behavior to prevent incidents (8).<br>✓ Addressing communication gaps horizontally and vertically can enhance safety measures (8).<br>✓ While animal behavior remains unchanged, human behavior must adapt to coexist safely (7).<br>✓ Advocating for a "do no harm" campaign is essential to minimize conflicts (7).✓ Installing rubber-made speed breakers and wildlife movement warning signs can improve safety awareness (6).<br>✓ Preparation with sky fire or bullets is advised for self-protection when entering forests (3). |
| **Local political leaders' voices** | **Media personnel's voices** |

**Table 4** (continued)

| | |
|---|---|
| ✓ Centring human interests since they elect us (10).<br>✓ Balancing conservation with contemporary development needs (9).<br>✓ Consideration of local governance, community perspectives, and local scenarios in decision-making, benefit sharing, and knowledge generation for conservation (9).<br>✓ Amendment of development-preventing legislation and anti-humanity laws by federal and provincial governments (8).<br>✓ Increased funding from the federal governments and donors in human-wildlife conflict areas (8).<br>✓ Promotion of alternative livelihoods for forest-dependent local and indigenous communities, encouraging their participation in wildlife management and fostering cooperation with authorities (7).<br>✓ Implementation of wildlife-friendly linear infrastructure such as roads and irrigation channels (6).<br>✓ Preservation of ecological functionality in Khata Transboundary Corridor (6).<br>✓ Engagement in international forums to discuss and implement tiger conservation strategies, leveraging global knowledge and support for local governments and indigenous communities (5).<br>✓ Village relocation to facilitate undisturbed tiger movement (4). | ✓ Media should be considered one of the key stakeholders in wildlife conservation and social change and safeguarding (10).<br>✓ Wildlife movement and problematic animal information should be shared with the media for timely awareness (9).<br>✓ Right-time information to the right person should be adopted by all conservation stakeholders, including government officials, communities, and donor agencies (9).<br>✓ Modern technologies should be used to minimize human-wildlife confrontations, including with tigers (8).<br>✓ Relief distribution – procedural part needs to be eased (8).<br>✓ Crop depredation – the process of evaluating and recommending relief funds is limited and tedious (7).<br>✓ Relief is very nominal (7).<br>✓ Exposure visits should be organized to learn modern technologies for mitigating human-wildlife conflict beyond national boundaries (6).<br>✓ Tiger moving corridors block by villagers – coordination and leadership required (5).<br>✓ Buffer zone border – highly problematic (5). |

and alternative cropping. Civil society organizations and I/NGOs highlighted systemic gaps in coordination and information along wildlife corridors, and the impacts of invasive species and changing forest-use practices. Security personnel stressed shared responsibility and behavioural adaptation, promoting awareness campaigns, early-warning systems, and improved communication across institutions and communities. Political leaders focused on balancing conservation with development, advocating policy reforms, increased funding, alternative livelihoods, and wildlife-friendly infrastructure. Media representatives emphasized real-time information dissemination, streamlined relief processes, and technology use to reduce conflict.

## Discussion

Nepal's tiger population nearly tripled between 2010 and 2022 to 355 individuals (95% CI: 318–392), representing a major conservation success; however, this recovery coincided with an 11-fold increase in human–tiger conflict, particularly human casualties, despite preventive efforts (Fig. 2b). In the Terai Arc Landscape of Nepal (TAL), rising tiger abundance has intensified human deaths and injuries, livestock losses, and imposed an annual public relief burden of US$1.1–1.18 million. Strong positive correlations between tiger numbers and conflict indicators—including human injuries, livestock depredation, and total incidents—indicate increasing spatial overlap between tigers and local communities, with livestock depredation emerging as the primary driver of compensation claims. Additional challenges, including wildlife fatalities as retaliatory killings and the growing number of tigers held in captivity, further complicate management. Stakeholders consistently emphasize the need

for integrated, multidisciplinary strategies that align tiger recovery with sustainable human–wildlife coexistence.

## Unintended socio-economic aspects

### Social implications

Rising tiger populations have intensified threats to human safety, particularly in areas with frequent human–wildlife interactions (Atreya et al. 2021). Despite significant management efforts, human fatalities persist; in 2022/23 alone, tigers killed at least 18 people in Nepal, including multiple incidents on single days, and injured over 100 individuals in the Terai Arc Landscape (TAL), making tigers the second-highest wildlife threat after elephants. Similar trends occur in Bangladesh, where tigers average 24 human deaths annually (Reza et al. 2002). Human casualties often provoke retaliatory killings of tigers, documented in Nepal (Bhattarai and Fischer 2014; Dhungana et al. 2016; MoFE 2021; Thakur et al. 2025), Bangladesh, (Reza et al. 2002; Saif et al. 2018), India (Chouksey and Singh 2018; Margulies 2019) and Indonesia (Nugraha and Sugardjito 2009), complicating conservation. These patterns underscore the urgent need for revised, proactive policies to safeguard both human lives and tiger populations.

Further, wildlife attacks on property, including livestock and crops, are frequent, yet official figures likely underestimate the problem, as only 17 species qualify for government relief in Nepal (OPMCM, 2023). Injuries or fatalities from snakes, monkeys, birds, and other wildlife often go unrecorded (Bhandari et al. 2024). High tiger densities, small habitats, low carnivore–prey ratios, and dependence on forest resources exacerbate conflicts, displacing poorer forest communities and restricting resource access (Menon and Borah 2024). Field observations indicate that coordinated, effective measures reduced human–wildlife incidents, particularly following COVID-19 restrictions (Fig. 2). Pandemic-related disruptions—employment losses, return migration, restricted mobility, and limited livelihoods—increased forest dependence and illegal activities, elevating encounters with wildlife and human fatalities (Maraseni et al. 2022; Weinbrenner et al. 2021). Simultaneously, constrained budgets, limited mobility, and weakened law enforcement intensified risks. These findings highlight the need for integrated, cross-sectoral strategies that align conservation with broader development goals to support sustainable human–wildlife coexistence.

Furthermore, living alongside tigers imposes substantial psycho-emotional stress on park staff, security personnel, and local communities(Odinye and Mokwe 2025; Paudyal 2019). This stress is compounded by incidents such as staff fatalities in Chitwan NP (Dhungana 2016), attacks on residents in Bardia NP (Atreya et al. 2021), and severe injuries in the Khata Corridor (*Amateur conservationist from Nepal- Loss own an eye by a tiger but conserving it*, *heart-touched story*, 2022). Field observations indicate that psychological impacts on Indigenous peoples and local communities are profound, underreported, and difficult to quantify. Staff working near captive tigers under inadequate safety conditions also experience heightened anxiety and emotional strain (Bhattacharjee et al. 2015). Tigers themselves are affected by stress during caging or reintroduction, as poorly managed facilities increase aggression and risk; for example, an escaped tiger in Banke NP killed four people in 2020 (GoN/MoFSC 2016). These findings underscore the need for alternatives to captivity, in line

with national (GoN 1973, 2016) and international (CITES, 1973) frameworks, to minimize human–tiger conflict while protecting communities, staff, and wildlife.

### Economic and cultural implications

Rescue, caging, and relief efforts for tigers impose substantial economic and social costs. Public funds support capture, transport, enclosure construction, veterinary care, and feeding, yet generate limited returns from tourism, research, or breeding. Annual relief distribution alone exceeds US$1 million, while maintaining the 18 tigers in captivity costs the Ministry of Forests and Environment nearly US$100,000 yearly (Joshi 2024). During events such as the COVID-19 lockdown, even Central Zoo's modest income proved insufficient, requiring additional government support. Communities near rescue centers also face unquantified social risks, including threats to life, injuries, financial losses, and fear of animal escape, often without tangible local benefits.

Managing captive tigers imposes substantial economic, ecological, and cultural costs. To reduce expenses, some zoos restrict feeding, such as fasting tigers weekly (Farsa 2022; Republica 2023). Similar financial burdens occur in India (Khadija et al., 2022; Kumar et al. 2017), Bangladesh (Farsa 2022), China (Abbott and van Kooten 2011; Nyhus et al. 2010; Yuan et al. 2021), Indonesia (Herdiana et al. 2022), and Africa (Manoa and Mwaura 2016; Potgieter et al. 2016; Sifuna 2009; Subalya et al. 2024), where compensation and captive management divert funds from critical areas like community development, anti-poaching, and healthcare. Captivity also reduces the appeal of natural wildlife experiences, decreasing tourism revenue (Abbott and van Kooten 2011; Nunes et al. 2021; Nyhus et al. 2010), and increases long-term costs and risks, including escape-related conflicts (Gratwicke et al. 2007). Regulated trophy hunting linked to human-safety measures has been suggested as a potential revenue-generating alternative, as practiced in Nepal's Dhorpatan Hunting Reserve.

Cultural impacts are equally significant. Tigers are integral to Nepal's natural heritage and cultural identity (GoN 2019b; Kanesh 2021), and their removal from the wild disrupts symbolic, spiritual, and ancestral connections, diminishing local respect and engagement with wildlife. Similar cultural attachment is reported in China (Cao et al. 2024; Traylor-Holzer et al. 2010) and India (Menon and Borah 2024). Captivity undermines these traditions, particularly for younger generations, eroding cultural pride and restricting access to ancestral lands (Lam and Paul 2013; Pandey et al. 2024a, 2025b, c, d). Therefore, management strategies for problematic tigers should prioritize culturally respectful, community-centered approaches that preserve heritage while minimizing human–wildlife conflict.

## Ecological and environmental consequences

### Ecological implications

In the wild, tigers regulate prey populations, controlling prolific species and maintaining ecosystem balance. In Nepal, prey density in Terai Arc Landscape protected areas increased from 2018 to 2022, reflecting positive tiger conservation outcomes (DNPWC and DFSC 2022). Removing tigers from the wild disrupts these dynamics, contributing to prey overpopulation, heightened human–wildlife conflict, and increased wildlife damage claims

(DNPWC 2023). Similar patterns in India show reduced tiger numbers correspond with herbivore surges, including deer and wild boar(Ramakrishnan et al. 1999; Upadhyay et al. 2019), threatening future tiger habitats and ecosystem functioning globally (Sanderson et al. 2019). Thus, in-situ tiger conservation is critical, with captivity reserved as a temporary measure.

Captivity substantially restricts gene flow in tigers, as individuals in rescue centres or zoos have limited breeding opportunities compared to wild populations (Wilting et al. 2015). In Nepal, aside from the Central Zoo, most captive tigers are confined due to space constraints rather than structured breeding programs. Across the Terai Arc Landscape, over 50 tigers remain genetically isolated, and removal of adults from the wild disrupts metapopulation dynamics, reducing overall genetic diversity and increasing susceptibility to disease and environmental changes(Singh et al. 2017; Smith et al. 2018; Walston et al. 2015; Wilting et al. 2015). Currently, only Chitwan and Bardia National Parks support viable (meta)populations (~50 breeding pairs), while other areas struggle to sustain wild tigers. Of the 20 tigers in captivity, strategic rewilding could enhance allelic richness and heterozygosity, as shown in Thailand, India, and China, providing complementary ex-situ support while mitigating the reproductive and genetic risks of prolonged confinement(Abbott and van Kooten 2011; Ash et al. 2023; Bay et al. 2014; Nyhus et al. 2010; Traylor-Holzer et al. 2010). Reintroducing captive tigers offers a practical pathway to restore gene flow, strengthen population viability, and support long-term metapopulation stability in the TAL.

### Potential environmental implications

Environmental challenges in tiger conservation encompass climate change, carbon sequestration, pollution, and health risks near rescue centers. While tiger conservation in protected areas can enhance carbon storage and climate mitigation (Lamba et al. 2023; Sills and Kramer 2023), Nepal-specific studies indicate that reduced forest management in Protected Areas—core tiger habitats—limits carbon sequestration and participation in carbon trading schemes (Pandey et al. 2024b; Thapa et al. 2023). Tigers also support forest regeneration by maintaining prey populations that facilitate seed dispersal (Brodie and Gibbs 2009; Jansen et al. 2010), and deterring deforestation reduces emissions, whereas caging tigers increases livestock demand and carbon output (Nunes et al. 2021). Additionally, pollution and poor sanitation around rescue centers pose environmental and health risks, underscoring the ecological and social benefits of reintroducing tigers to the wild.

Overall, building safe coexistence between people and wildlife, particularly mega-carnivores, is essential for sustainable development. Nepal faces intense human–tiger conflict due to its relatively high tiger density and human-to-tiger ratio, unlike China, Vietnam, and Myanmar, where smaller populations result in fewer clashes and minimal negative interactions (Cheng et al. 2024; Cao et al. 2024). While tiger management efforts exist across Bangladesh, Bhutan, India, Indonesia, Malaysia, Myanmar, Nepal, Russia, and Thailand, strategies often overlook species- and site-specific challenges (Cao et al. 2024). Effective conservation therefore requires addressing socio-environmental risks, distributing responsibilities among stakeholders, and adapting lessons from other regions to local ecological and socio-economic contexts.

## Theory of change in tiger conservation management in Nepal

Drawing on the Theory of Change for effective tiger conservation management (Quinn and Cameron 1988), we propose enhanced preventive measures to reduce human–wildlife conflict and promote ecological sustainability. Key strategies include balancing community participation with conservation goals and benefit sharing; implementing early warning systems, predator-proof fencing, and compensation schemes; and building capacity through climate-resilient, diversified livelihoods and youth and forest-official engagement. Habitat restoration, protected-area management, and prey-based enhancement support tiger populations, while public education fosters coexistence. Strengthening scientific research, transboundary cooperation, and anti-poaching laws further improves management. Finally, international partnerships and landscape-level planning ensure habitat connectivity and long-term stability, emphasizing that sustainable mega-carnivore conservation requires integrated, policy-aligned approaches (Aryal et al. 2023; Thatte et al. 2018).

Similarly, Remedial measures for managing mega-carnivores like tigers should align national policies with international commitments within the theory of change framework. This study identifies ten strategies across policy, institutional, and practical levels to enhance sustainability, including engaging tigers in academic research, promoting them as ecological ambassadors, supporting scientific studies, involving the private sector in tourism, and advancing behavioural research for reintroduction. In line with CITES, tigers may also contribute to farming, education, trade, or genetic conservation under strict governance (Abbott and van Kooten 2011; GoN 2016). Under the NPWC Act, problematic tigers posing safety risks can be removed and used for research or exhibition, supporting conservation and genetic diversity (Bay et al. 2014; GoN 1973). Rescue centers and wildlife hospitals can provide temporary care, after which tigers may be reintroduced to natural habitats to aid population recovery (Lynam 2010).

Further, there is significant potential for tiger reintroduction through habitat restoration, clustering, and connectivity, as 70% of tigers remain confined to only 6% of their natural range (Walston et al. 2015), highlighting opportunities for rewilding in historic habitats with minimal public-financing burden and expanded ecological roles. Lethal control should remain a last resort, as historically practiced in Nepal during the monarchical era (Mishra 2010). Enhanced transboundary cooperation could facilitate the release of tigers within or beyond national borders. Lessons from Indonesia demonstrate that integrating ex-situ conservation (zoos and captive management) with in-situ wildlife programs can yield effective socio-ecological and environmental outcomes (Tilson et al. 1997). Realizing these strategies requires revising policies, institutional arrangements, and management practices, strengthening governance, and improving on-ground implementation. These alternatives aim to balance social welfare and ecological sustainability while supporting biodiversity conservation targets (Balmford et al. 2024; CBD, 2022) and the UN Sustainable Development Goals (UN, 2015).

## Future policy pathways and limitations

This study underscores key policy implications for managing problematic tigers in Nepal and similar contexts. First, it advocates shifting from reactive, captivity-focused strategies toward holistic, science-based, and socially inclusive approaches, as current caging prac-

tices, while mitigating immediate conflict, impose high economic, ecological, and cultural costs. Second, policies should prioritize in-situ conservation through habitat restoration, prey management, and metapopulation connectivity, with captivity limited to temporary, goal-oriented rehabilitation or rewilding. Third, governments should implement cost-effective measures such as transboundary cooperation, research integration, and ecotourism linkages within ethical and legal frameworks like CITES. Fourth, community-centered solutions—including early-warning systems, benefit-sharing, cultural rights recognition, and youth engagement—must be central to reform. Finally, sustainable mega-carnivore conservation requires coordinated governance across institutions, legislation, and international partnerships, aligning national priorities with global biodiversity and climate objectives under the theory of change framework.

We acknowledge three main limitations. First, the study does not quantitatively evaluate alternative management strategies such as rewilding or community-based interventions. Second, its geographic focus on Nepal's Terai Arc Landscape may limit broader generalizability. Third, proposed policy alternatives were not validated through stakeholder consultation or scenario analysis. Future research should adopt interdisciplinary, participatory, and data-driven approaches. While this study highlights the unintended social and ecological consequences of Nepal's tiger population recovery, it does not question existing conservation strategies but aims to inform more practical, equitable, and sustainable approaches that move beyond rescue, caging, and ad hoc relief measures.

## Conclusion

Harmonious human–wildlife coexistence is fundamental to sustainable socio-ecological systems. Using tiger conservation in Nepal as a case study, this research demonstrates that rapid mega-carnivore recovery, while a major conservation success, has generated unintended social, economic, ecological, and public-health costs. Despite the tripling of Nepal's tiger population, human–tiger conflict has intensified, annual compensation expenditures now exceed US$1 million, and rescue-and-captivity practices impose ecological disruptions, genetic risks, environmental pollution, and significant social and cultural burdens with limited local benefits. Strong associations between rising tiger numbers, human injuries, livestock losses, and compensation claims underscore the cumulative nature of these challenges. These findings highlight the need to embed conflict mitigation, livelihood protection, and landscape-level planning within conservation strategies.

Stakeholder perspectives further emphasize community-centered, integrated approaches combining early-warning systems, habitat and prey management, infrastructure planning, and strengthened transboundary cooperation. Moving beyond reactive rescue-and-caging toward long-term, in-situ coexistence strategies—including rewilding where feasible, inclusive governance, and coordinated transboundary management—is critical. Although context-specific, this study provides a science-based and socially inclusive framework for aligning biodiversity recovery with human well-being, offering policy-relevant insights for conservation practice in rapidly changing human–wildlife landscapes.

## Annex 1: Sample checklist for stakeholders' interviews and consultation meetings

### Checklist for the interviews

Date: Address: Time: Name: ……. (optional), Age: …. Year. Education: ……, Profession: …… Political affiliation: …… (optional).

### Belongingness of the stakeholders

(a) Local and Indigenous communities (Buffer zone management committees, forest management communities, ethnic groups, religious groups, representatives).
(b) Forest officials and park staff.
(c) Representatives of civil society organizations (NTNC, WWF, ZSL, BCN, …).
(d) Political decision makers from local, provincial, and central levels, both elected and representative members,
(e) Local-level security personnel.
(f) Media workers.

### Sample guiding questions

Have you experienced human-wildlife conflict in your area?

What are the main wildlife species that pose the greatest threat to human lives in your area?

Are there habitats for mega-carnivores in your village or nearby areas? Does the increase in tiger numbers bring socio-economic challenges? What are these challenges? What measures have been adopted to overcome these challenges while increasing the number of tigers in your vicinity? Are these measures sufficient?

What could be done to enhance socio-economic benefits rather than increasing challenges through tiger conservation?

What could be the ecological benefits of increasing tiger numbers? Does the increased number of tigers effectively control herbivores that raid your farmland? Despite protected areas, habitat management, and other safeguards, why do crop raiding and human casualties persist?

Have any residents been displaced for conservation reasons, particularly to safeguard tiger habitats? Does displacing communities for conservation help or harm the ecosystem? Are the benefits of conservation realized by local and Indigenous communities who sacrificed their ancestral land, or by the families of wildlife victims who suffer losses every year?

What preventive measures could minimize human-tiger conflict?

What remedial measures, besides caging tigers in rescue centers, could be effective?

Do you benefit from tiger-rescue centers in your area? If so, how? If not, why not? What are the positive and negative outcomes of having a tiger-rescue center in your area?

Do you have any additional thoughts on achieving harmonious and safe coexistence between humans and wildlife, particularly tigers?

What possible measures could further minimize human-wildlife conflict, especially with tigers?

Do you want to add anything more?

Thank you very much for your time and opinions.

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**Data availability** Human-related primary data are not publicly available due to ethical restrictions under Human Research Ethics Clearance [ETH2023-0568 (HREC)]. These data will be anonymized and deposited in the University of Southern Queensland data repository, with access subject to university approval after one year. Other primary and secondary data are publicly available through government reports, policy documents, and tiger status assessments ( [www.mofe.gov.np](http:/www.mofe.gov.np) , [www.dnpwc.gov.np](http:/www.dnpwc.gov.np) ). Raw human–wildlife conflict data from the tiger-bearing landscape (TAL) of Nepal will be made available upon reasonable request to the corresponding authors.

## Declarations

**Competing interests** The authors declare no competing interests.

**Informed consent** All participants involved in this study provided informed consent before data collection. The purpose of the research, procedures, potential risks, and intended use of the data were clearly explained to participants in a language they understood. Participation was voluntary, and respondents were informed of their right to withdraw at any stage without penalty. No personally identifiable information has been disclosed in this manuscript.

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