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RESEARCH ARTICLE

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A multi-methods approach for assessing how conserving biodiversity interacts with other sustainable development goals in Nepal

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Abstract

Achieving the sustainable development goals (SDGs) requires a context-specific understanding of how actions to achieve one goal interact with others. We analyzed statistical data, and conducted online surveys and interviews with conservation professionals to understand how terrestrial conservation goals (SDG 15: Life on land) influence and are influenced by other goals in Nepal. Our findings suggest that SDG 15 synergized with economic growth (SDG 8), gender equality (SDG 5), water access (SDG 6), sustainable production and consumption (SDG 12), and climate action (SDG 13), but traded off with food security (SDG 2), energy access (SDG 7), poverty alleviation (SDG 1), and infrastructure development (SDG 9). Increased multi-sectoral collaboration between conservation and development stakeholders is urgently needed to address the negative impacts of other goals on SDG 15. Additionally, conservation measures in Nepal can benefit from being more people-focused, participatory, and contextualized to mitigate negative impacts on socioeconomic goals.

KEYWORDS
agenda 2030, buffers and multipliers, co-benefits and trade-offs, cross-sectoral collaboration, life on land, participatory conservation, sustainable development goals, synergies

1 | INTRODUCTION

The 2030 agenda comprises 17 sustainable development goals (SDGs) and 169 constituent targets that guide countries toward the simultaneous achievement of "economic development, environmental sustainability and social inclusion" (United Nations General Assembly, 2015). Among these 17 goals, SDG 15 (Life on land) and 14 (Life below water) are considered to be particularly important because biodiversity fundamentally underpins human wellbeing and is thus considered central to the achievement of multiple SDGs (Blicharska et al., 2019; Brooks et al., 2015; Obrecht et al., 2021; Opoku, 2019; Pham-Truffert et al., 2020; Wood et al., 2018). Despite the global importance of biodiversity, competing economic and social development goals are often prioritized nationally, which has resulted in rapid declines in biodiversity worldwide (Eisenmenger et al., 2020; United Nations, 2022). Additionally, current development scenarios show that conservation objectives negatively interact with other socioeconomic goals (Anderson et al., 2022). Therefore, to avoid costly trade-offs between achieving economic prosperity, social wellbeing, and environmental sustainability in the future, it is important to improve our understanding of the interactions between nature-related goals and other goals.

A variety of approaches have been developed to quantify interactions between SDGs, each providing different types of information (Horvath et al., 2022). These range from argumentative methods (i.e., qualitative and quantitative methods) that apply expert knowledge (Horvath et al., 2022), such as the seven-point typology of Nilsson et al. (2016), and cross-impact matrix (Breu et al., 2021; Weitz et al., 2018), to quantitative model simulation and statistical methods, such as correlation and regression analysis (Pradhan et al., 2017). Since each method has its own sets of strengths and limitations (see Horvath et al., 2022), applying a mixed-methods approach is likely to provide a deeper understanding and a more complete picture of interactions between different goals (Horvath et al., 2022; Pradhan, 2023).

Interactions between the SDGs are context-specific (McCollum et al., 2018; Moyer & Bohl, 2019). However, most studies that have mapped interactions between nature-related goals and other goals have done so at global scales. Scherer et al. (2018), for example, examined interactions between social and environmental goals, the latter consisting of SDGs 6 (Clean water and sanitation), 13 (Climate action), and 15. Huan and Zhu (2022) analyzed interactions specifically between SDG 15 and other SDGs through a literature review. Similarly, Singh et al. (2018) focused on interactions between SDG 14 and other goals. However, besides a few examples (see Hazarika & Jandl, 2019; Urban & Hametner, 2022), studies that examine interactions between nature-specific and other goals are uncommon at national and subnational scales.

The identification of such interactions is particularly important in highly biodiverse low-income countries, such as Nepal, where achieving economic and social goals is as urgent as achieving biodiversity goals (Eisenmenger et al., 2020). Existing studies on SDG interactions between subsets of goals in Nepal include that by Aryal et al. (2020), who analyzed the contribution of Nepal's community forestry toward the SDGs. However, and despite the urgency of addressing environmental issues in Nepal, no study to date has attempted to understand synergies and trade-offs between nature-related and other goals.

Here we fill this gap by assessing interactions between conservation (SDG 15) and development goals (other SDGs except SDG 14) at the national scale for Nepal, using a multi-method approach. We discuss key interactions detected by all methods as well as divergences and conclude with an attempt to identify pathways to strengthen co-benefits and address trade-offs between goals and targets in our study context.

2 | METHODS

Based on analyses of the strengths and limitations of current methods for assessing SDG interactions (Breuer et al., 2019), on data availability, and following Pradhan (2023) and others (e.g., Horvath et al., 2022; Urban & Hametner, 2022), we took a multi-methods approach and performed both argumentative (*sensu* Horvath et al., 2022) and statistical analyses. We used the seven-point typology (Nilsson et al., 2016) and structured elicitation of expert information as argumentative methods and a pairwise correlations method (Pradhan et al., 2017) as our statistical one. Data will be available at: https://doi.org/10.5281/zenodo.7835714.

2.1 | Argumentative method: SDG interaction scores

We conducted an online survey with experts (similar to Wood et al., 2018) from the conservation sector of Nepal to score the interactions between achieving SDG 15 and other goals on a seven-point ordinal scale following Nilsson et al. (2016). Because of the broad definition of SDG 15 (see United Nations General Assembly, 2015), and to avoid selecting only a subset of its targets, we asked the survey participants to rate the interactions between SDG 15 at the goal level and specific targets of the remaining 15 goals. While the seven-point scale is typically used to rate interactions between two targets, we believe that it is conceptually flexible enough to be applied for the rating of interactions between a goal and a target.

2.1.1 | Selection of SDG targets

First, we reduced the 169 targets to a limited set relevant for the Nepalese context. We did so by excluding the "means of implementation" targets (targets that create an enabling environment for outcome targets, e.g., target 1.a mobilization of financial resources for poverty alleviation) and retaining only the "outcome" targets (conditions to be attained, e.g., target 1.1 achievement of poverty eradication). We reduced the resulting set ($n = 126$) to targets prioritized by Nepal's government ($n = 42$) based on its 15th National Development Plan (Government of Nepal, 2020b) and the national review on progress toward the SDGs (Government of Nepal, 2020a). Finally, we further removed an additional 12 targets based on an internal assessment of redundancy, relevance, and broadness (see Data S1 for details). In total, we considered 30 targets.

2.1.2 | Online expert survey

We used Kobo Toolbox (Kobo Inc., 2022) to deploy our survey between May and June 2022. We disseminated the survey to experts working in governmental, intergovernmental, and non-governmental organizations. We identified additional experts within academic institutions familiar with conservation in Nepal. These people were chosen from institute mailing lists and networks and contacted primarily through emails and LinkedIn. To increase participation, we asked respondents to share the survey in their professional networks. Because we employed purposive and snowball sampling techniques, we have only calculated summary statistics (Hirschauer et al., 2021).

Before taking the survey, respondents received information about the survey's purpose as well as the seven-point interaction method and had to indicate their past and current affiliation as well as the number of

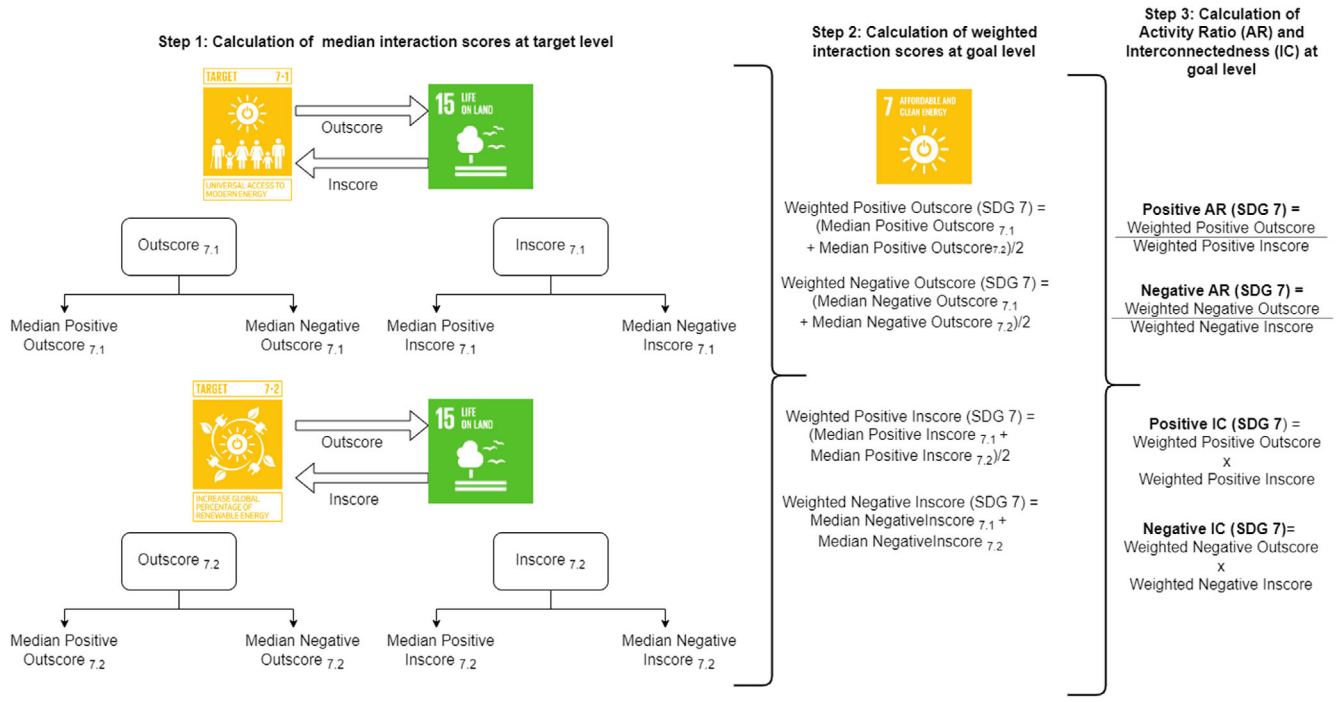

FIGURE 1 Calculation of activity ratio (AR) and interconnectedness (IC) for SDG 15 and SDG 7, including the calculation of median interaction scores at target level, calculation of weighted interaction scores at goal level, and calculation of AR and IC. A detailed explanation of each step is provided in Data S1.

years of experience in Nepal's conservation sector (0, 1–2 years, 2–5 years, and >5 years). Then, we asked each respondent to score (i) the effect of achieving five randomly selected targets on SDG 15 (outgoing interactions, or outscore), and (ii) the effect of achieving SDG 15 on the same randomly selected targets (incoming interactions, or inscore) using the seven-point scale. For each answer, respondents had the option to explain the reason for the scores they gave. Since we assigned targets regardless of the participants' background and expertise, we also asked them to rank their confidence in their answer from 1 (completely certain) to 4 (very uncertain). A sample of the online survey is available in Data S2.

2.1.3 | Analysis of responses

For each selected target, we calculated the proportion of responses ($N = 65$) for each category of the seven-point scale for both outscores and inscores (Figure 1). Following Pham-Truffert et al. (2020) and Breu et al. (2021), we also identified multipliers (i.e., goals that influence the achievement of SDG 15) and buffers (i.e., goals that are influenced by the achievement of SDG 15) through measurements of *activity ratio* (AR; the ratio of outscore by inscore; a target with AR >1 is a multiplier) and *interconnectedness* (IC; the product of outscore and inscore; high IC stand for strong interaction with SDG 15). For each goal, we calculated the AR and IC separately for positive and negative interactions.

We plotted the AR and IC in a coordinate system, with the logarithmic value of AR in the x-axis and IC in the y-axis. This helped us identify (i) buffers of co-benefits (positively interacting goals whose AR <1), (ii) buffers of trade-offs (negatively interacting goals whose AR <1), (iii) multipliers of co-benefits (positively interacting goals whose AR >1), (iv) multipliers of trade-offs (negatively interacting goals whose AR >1). To identify whether SDG 15 is a systemic buffer or multiplier, we calculated its AR as ratio of weighted out-degree centrality of SDG 15 by the weighted in-degree centrality of SDG 15, and the IC as the product of weighted out- and in-degree centralities (see Breu et al., 2021). Here, the weighted out/in-degree centrality of SDG 15 is the sum of inscore/outscore values respectively. Detecting negative buffers and multipliers was important as they point to trade-offs in need of particular attention for the achievement of SDG 15.

2.2 | Statistical method: Correlation analysis

We used time series of SDG indicators for Nepal from the Global SDG Indicators Database (https://unstats.un.org/sdgs/indicators/database/), with the requirement of a minimum of three data points between 1990 and 2020 per indicator. For Nepal, the database held data for 17 indicators out of the 30 selected targets, and four indicators for targets within SDG 15, that is, 21 indicators in total (see Data S3).

We conducted a pairwise correlation analysis for the 420 indicator pairs (21*20 indicators) using Spearman's rank correlation (ρ), following Pradhan et al. (2017). We used a statistical significance threshold of $\alpha = .05$ and grouped data pairs whose correlations

were not significant as "neutral." For the correlations that were statistically significant, we adopted an interaction threshold of ±0.6 for the correlation coefficient, that is, we classified the correlations as "positive" if ρ was greater than 0.6, "negative" if ρ was less than −0.6, and "neutral" if ρ lied in between. We reversed the sign of indicators that measured undesirable phenomenon (such as infant mortality rate), to avoid misleading interpretation of correlation results. We used R v. 4.1.2 (R Core Team, 2022) for all statistical calculations.

2.3 | Argumentative method: Expert elicitation

2.3.1 | Data collection

We conducted semi-structured interviews with 13 informants from the conservation sector. These informants included community forest chairpersons, wardens of national parks, NGO employees, as well as researchers. All had experience in different parts of Nepal. Except for one in English, all our interviews were in Nepali and covered the background of the informants, challenges in implementing conservation activities and possible solutions, and co-benefits and trade-offs with development activities (see Data S4). The interviews took between 20 and 60 min and we conducted them between August and October 2021.

2.3.2 | Data coding and analysis

We used MAXQDA v. 20.4.1 (VERBI Software, 2021) to store and analyze our qualitative data. The lead author translated all interviews to English and transcribed them. We attributed each development intervention mentioned by the informants to the SDG it could help achieve, and recorded whether the intended progress toward that SDG led to a co-benefit or a trade-off with SDG 15 targets. We also recorded whether achieving SDG 15 could lead to co-benefits or trade-offs with other SDGs. Accordingly, we coded each interaction as incoming (effect of SDG 15 toward other SDGs) and outgoing (effect of other SDGs toward SDG 15). For example, we coded "Another issue is from transmission lines and poles. Obviously, trees were cut down because of this, but this also impacted animals because they are constructed in dense forests where biodiversity is high" as SDG 7 (Affordable and Clean Energy) and classified as an outgoing trade-off.

We categorized the challenges in implementing conservation activities that informants mentioned using the framework method (Gale et al., 2013). Following this method, we first went through our transcripts line by line and assigned initial codes (Saldana, 2013) to answers pertaining to conservation challenges. We then assigned the initial codes to four broader categories of challenges. We repeated the same steps to uncover opportunities to address the existing challenges (Section 3.3.3).

2.4 | Synthesis of findings from the three approaches

We aggregated the results of the interaction scoring and the correlation analysis at the goal level to compare results of all three methods. For this, we aggregated the number of co-benefits and trade-offs (both incoming and outgoing) of targets with SDG 15 obtained from the SDG interaction scores to their respective goals and calculated the proportion of co-benefits and trade-offs of each goal with SDG 15. We followed the same steps for the correlation analysis.

2.5 | Research ethics

No local research ethics committee was available to approve the proposed online survey and interviews. To meet ethics standards for collecting consents, we collected personal information from the online survey on a voluntarily basis from participants who were interested in further contributing to the study. We informed respondents of the online survey and the interview about the use of their anonymized responses in scientific publications before starting data collection. All participants consented. Responses that could lead to the identification of respondents are not included in this manuscript.

3 | RESULTS

3.1 | SDG interaction scores

Sixty-five individuals participated in the survey, scoring 325 interactions between SDG 15 and specific targets. Besides five unspecified participants, respondents were affiliated to international and regional government organizations (31%), international and national non-government organizations (26%), government (21%), research institutes and universities (19%), and private institutions (3%). Most respondents (63%) had worked more than 5 years in the conservation sector in Nepal, while 20% and 7% had worked there between two to 5 years, and up to 2 years, respectively. We excluded data from the remaining 10% who reported no experience.

3.1.1 | Co-benefits and trade-offs with SDG 15

More than two-third of all interaction values were positive (from +1, enabling, to +3, indivisible) for both outgoing and incoming interactions between SDG 15 and selected targets (Figure 2). All respondents assigned positive outgoing interactions for all selected targets under SDG 13 (Climate action), as well as for targets 12.2 (Sustainable management of natural resources) and 5.5 (Participation of women in leadership positions). SDG 8 (economic growth) targets, as well as targets 11.4 (conservation of natural and

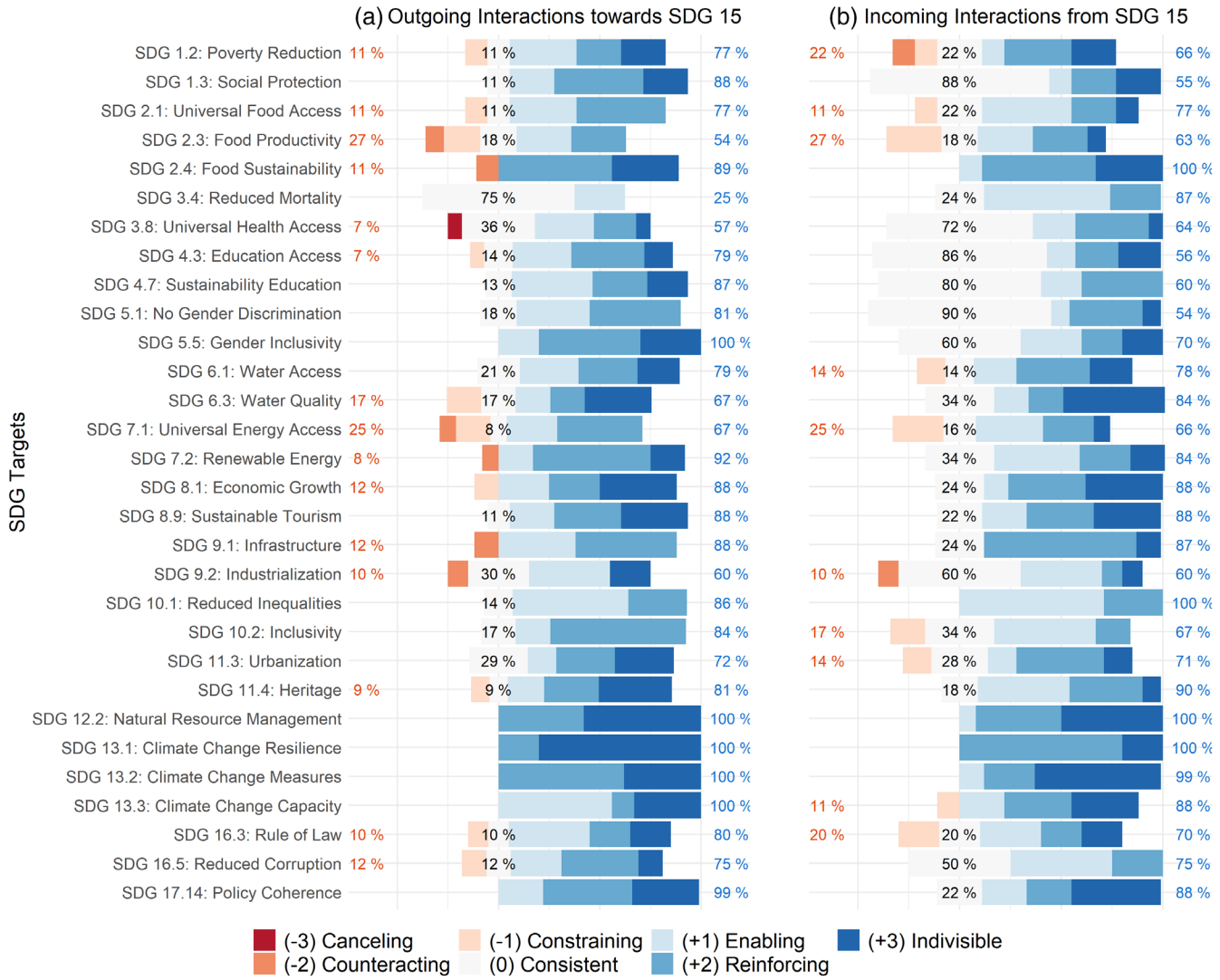

FIGURE 2 Levels of (a) outgoing and (b) incoming interactions between SDG 15 and each target as assigned by the experts. The sum of percentages indicates more positive (blue) than negative (red) interactions. The black percentage values represent percentage of neutral interactions.

cultural heritage), 7.2 (renewable energy), and 10.1 (reduced inequalities) also had high proportions of positive outgoing interactions. Negative outgoing interactions were mostly concentrated around targets 2.3 (Double the productivity of small-scale food producers) and 7.1 (Access to modern energy).

Every respondent assigned positive incoming interactions for targets 13.1 (Resilience to climate related disasters), 13.2 (Integrate climate change measures into policies), 12.2 (Sustainable management of natural resources), 10.1 (Reduce income inequalities), and 2.4 (Sustainable food production and resilient agricultural practices). SDG 8 targets also had high proportions of positive incoming interactions. Negative incoming interactions were concentrated around targets 1.2 (Reduction of poverty), 2.3 (Double the productivity of small-scale food producers), 7.1 (Access to modern energy), and 16.3 (Promote rule of law and ensure equal access to justice).

3.1.2 | Buffers and multipliers of SDG 15

Based on the AR and IC values we calculated for each goal (Figure 3a), we observe that:

- Influences between SDGs are primarily positive (predominance of blue points, coherent with the high proportion of positive interactions described above) and positive influences are stronger than negative ones (IC values are higher for positive interactions)
- Sustainable production and consumption (SDG 12) is the biggest multiplier of co-benefit for SDG 15 (positive multiplier with the highest IC).
- Clean water and sanitation (SDG 6), climate action (SDG 13), and partnership for the goals (SDG 17) are the biggest buffers of co-benefits of SDG 15 (positive buffers with the highest ICs). These SDGs have a high proportion of "Indivisible" (+3) outgoing interactions (Figure 2).

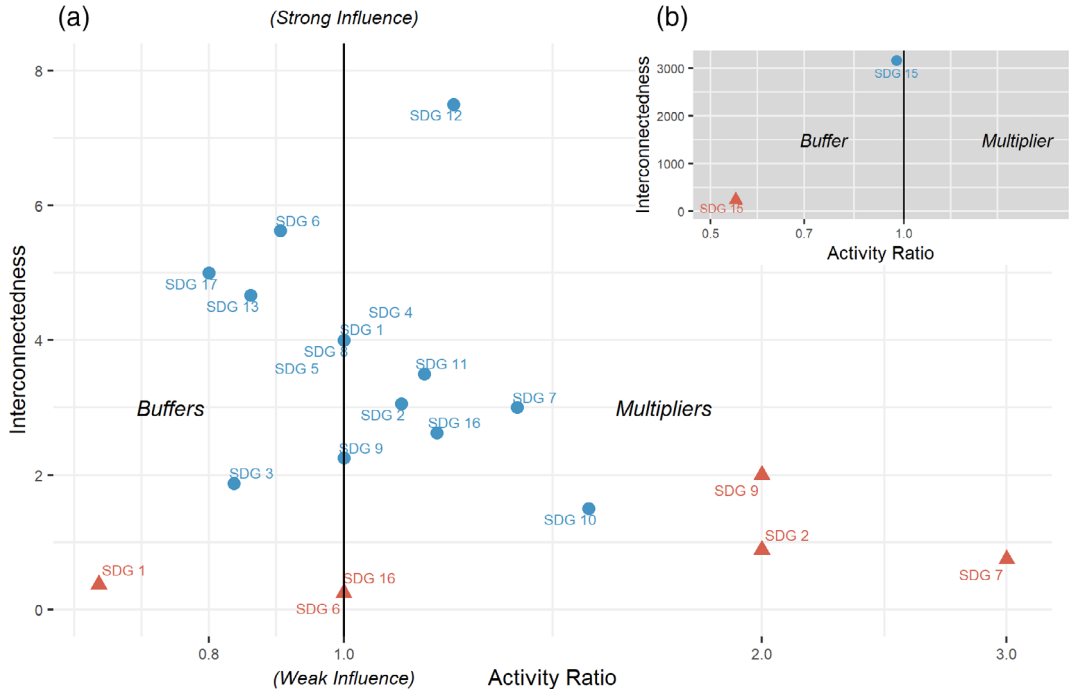

FIGURE 3 (a) SDG targets that act as buffers (AR <1) and multipliers (AR >1) toward SDG 15. Blue circles indicate positive and red triangles indicate negative buffers/multipliers. (b) AR and IC values of SDG 15. Two separate plots are used because the ICs are incomparable for SDG 15 and other SDGs.

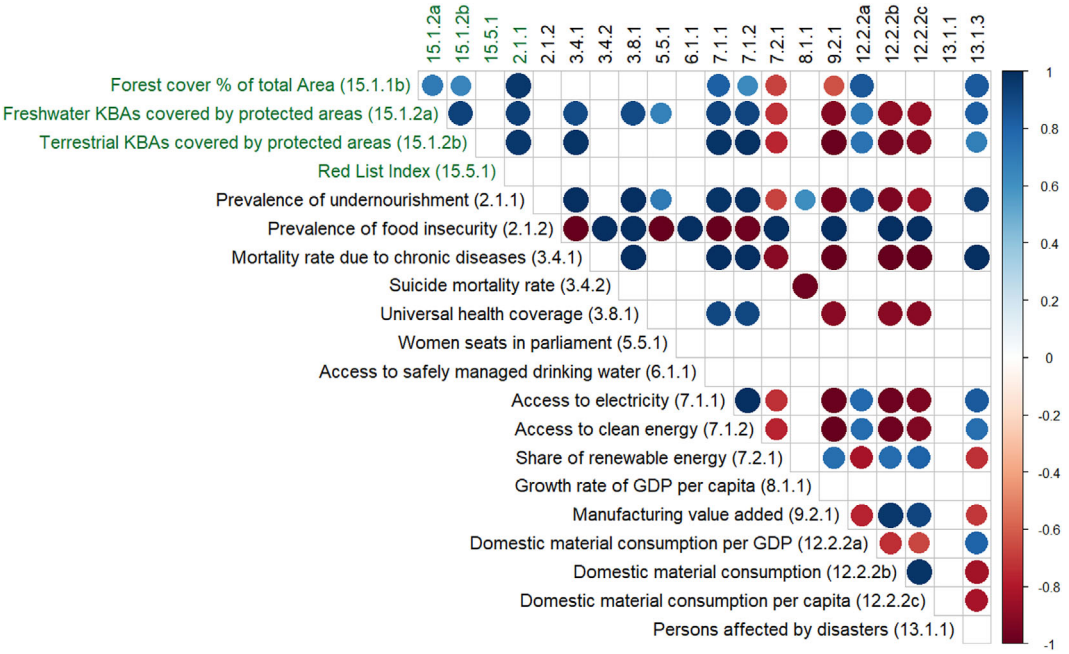

FIGURE 4 Plot of significant correlations between indicator pairs. DRR, disaster risk reduction; GDP, gross domestic product; KBA, key biodiversity area. Green labels are indicators of SDG 15. Blue and red dots indicate positive and negative correlations, respectively. The bigger the size of the dots, the stronger the correlations between indicator pairs. White cells indicate no significant correlation. Detailed description of each indicator is provided in Data S3.

- Industry and infrastructure (SDG 9), affordable and clean energy (SDG 7), and zero hunger (SDG 2) are the multipliers of trade-offs for SDG 15 (negative multipliers with highest IC)
- Poverty alleviation (SDG 1) is the only buffer of trade-offs of SDG 15 (negative buffer)
- At the systemic level, SDG 15 serves as a buffer for both co-benefits and trade-offs (Figure 3b). The positive effects from other

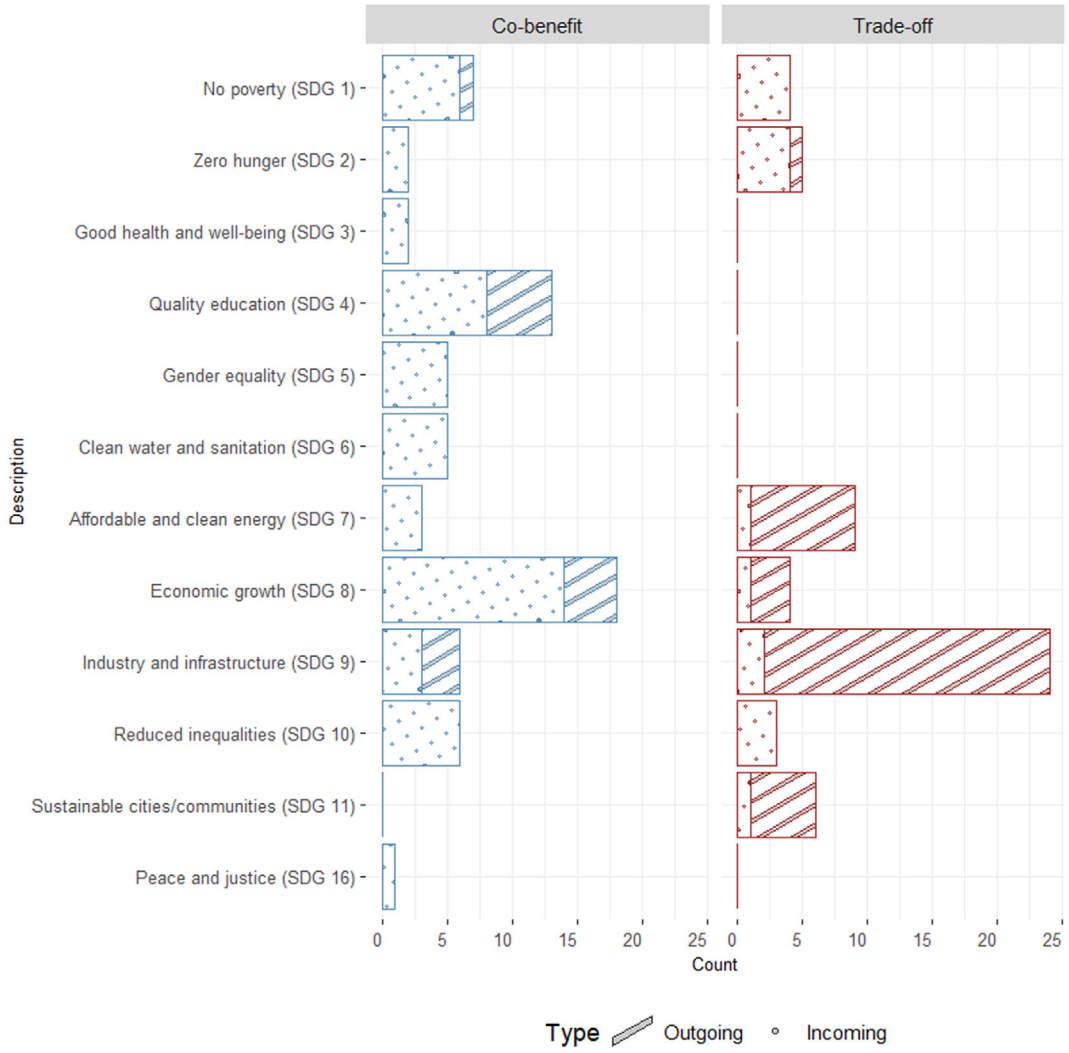

FIGURE 5 Outgoing/incoming co-benefits and trade-offs between SDG 15 and other goals according to informants. The counts correspond to the number of times each co-benefit/trade-off was mentioned in the transcript.

goals are stronger than the negative effects (higher IC for the co-benefits compared with the trade-offs).

3.2 | Correlation analysis

Out of 420 data pairs from the 21 selected indicators, we identified 33% positive, 21% negative, and 46% neutral correlations (Figure 4). Indicators 2.1.1 (Reduction in undernourishment), 7.1.1 (Access to electricity), 7.1.2 (Clean energy), and 13.1.3 (persons affected by disasters) had the highest proportion of co-benefits with SDG 15, while indicators 7.2.1 (Share of renewable energy), and 9.2.1 (Manufacturing value added) had the highest trade-offs. While SDG 15 had co-benefits with domestic material consumption per capita (12.2.2a), they had trade-offs with 12.2.2b (domestic material consumption) and 12.2.2c (domestic material consumption per capita).

Indicators that a had higher proportion of positive correlations with other indicators had desirable trends (i.e., trends that were in line with meeting SDG targets). For example, percent forest cover of total area (SDG 15.1.1), which has increased in Nepal from 40% to 42% between in 1990 and 2020 (Government of Nepal, 2020a), has positive correlations with other indicators that are also following desirable trends such as indicators 2.1.1 and 7.1.1. Conversely, the proportion of negative correlations were higher in SDG 12.2 (Domestic consumption), 9.2 and 7.2, whose current trends over the time period were not desirable.

3.3 | Expert elicitation

3.3.1 | Co-benefits and trade-offs between SDG 15 and other SDGs

According to the 13 informants, there was a higher proportion of co-benefits than trade-offs between interventions that aimed to achieve socioeconomic goals and environmental goals (Figure 5). A higher proportion of co-benefits (80%) were incoming (i.e., from SDG 15 toward

other SDGs) while most trade-offs (70%) were outgoing (i.e., from other SDGs toward SDG 15). Data S1 provides a synthesis of co-benefits and trade-offs mentioned by informants.

The SDGs benefiting most from progress toward nature conservation (incoming co-benefits) were SDG 8 (specifically ecotourism), because of increasing forest coverage and biodiversity. SDGs 1, 2, 4, 5, 6, 9, and 10 also benefited as a result of targeted investments of protected areas and community forests into poverty alleviation, food security, education, gender equality, sanitation, infrastructure, and participation of marginalized communities, respectively. SDG 15 in turn benefited most (outgoing co-benefits) from the increase in education and awareness (SDG 4), which led to better participation in conservation activities; ecotourism (SDG 8), which provided revenue for the operation of protected areas, and roads and infrastructure (SDG 9), which made rural areas accessible for monitoring and also increased participation.

Progress toward SDG 15 was impeded most (outgoing trade-offs with SDG 15) by measures taken toward SDG 9 through nationwide road expansion and SDG 7 through the building of hydropower infrastructures, which both led to deforestation and habitat degradation. Unregulated use of chemical fertilizers and pesticides (SDG 2) also caused pollution of rivers and streams. Measures taken to achieve progress toward SDG 15, in turn, were reported to impede progress toward SDG 1 and 2 through restricted access of local communities to income sources, and agriculture as well as grazing, respectively (incoming trade-offs).

3.3.2 | Challenges in implementing conservation activities

Informants mentioned several challenges in implementing conservation activities in Nepal. We divided them into four categories (statements are taken from the interview):

Governance

The establishment of Nepal as a federal democratic republic in 2015 allowed newly formed autonomous local governments to take major decisions within their constituency (e.g., building roads and extracting riverbed resources). These decisions were often taken without environmental considerations and have substantial impacts on ecosystems and biodiversity. The introduction of local authorities also created coordination challenges between different government sectors, stakeholders, and local communities for the management of various conservation projects. An additional challenge resulted from the use of national policies and national park management guidelines that were outdated, not completely participatory, and not contextualized.

Sociocultural

Lack of adequate participation of marginalized groups in conservation planning exacerbated poverty as conservation measures led to restrictions on income generating activities. This was mostly prevalent in geographically remote and economically isolated regions of Nepal. An additional challenge resulted from increasing human-wildlife conflicts, which exacerbated the animosity of local communities toward conservation.

Financial

The lack of financial resources and the need for comparatively more resources in mountain regions were major challenges, which were exacerbated by the lack of field-based staff resulting from the harsh working conditions. This led to ineffective monitoring of activities and to the discontinuation of conservation interventions.

Socioeconomic

In attempts to meet urgent socioeconomic requirements through, for example, energy infrastructure, increased export, and intensified agriculture, environmental considerations were not diligently incorporated, leading to trade-offs with conservation targets through, for example, deforestation, habitat fragmentation, and landscape degradation. These challenges, as well as increases in needs, standard of living, and consumption patterns were perceived as by-products of development, with which conservationists needed to balance out.

These four challenges were exacerbated by distance and climatic conditions. The implementation of participatory activities was often hindered because communities were geographically dispersed, state-based support within specific conservation programs remained inaccessible for remote communities, and because of the short working season in the high-Himalayas.

3.3.3 | Opportunities to address the challenges

Informants identified numerous opportunities to address contemporary challenges in conservation. In the short-term, a priority is to clarify the roles and responsibilities of the regulatory environment introduced by the new constitution as well as the challenges and opportunities associated with local governments. The election of many community forestry members as local government representatives, for example, offers an opportunity as these members can spearhead the coordination gap and drive the conservation and development sectors together. This can even lead to improved participatory approaches, which could potentially solve conflicts between communities and conservation actors. Additionally, the new constitution also provides the opportunity for provincial governments to develop new provincial policies for protected area governance, which can address context-specific socioecological and economic challenges and trade-offs.

Informants also emphasized the importance of incorporating biodiversity values into development efforts. For this, they stressed the need for local governments and development stakeholders to collaboratively find solutions that balance both socioeconomic and conservation needs. For example, hydropower developers could coordinate their interventions with the departments of forests and roads, respectively, to minimize disturbances by aligning transmission lines with roads and adding wildlife corridors.

According to the informants, convincing local governments about the importance of conservation emerged as an additional pathway toward a streamlined implementation of conservation actions in the long-term. Capacity building of local officials on, for instance, integrating environmental aspects in project selection criteria, or on the SDG Agenda could encourage sustainable development at the local level. Awareness and education programs on conservation to the broader public could also positively influence public support toward conservation.

3.4 | Synthesis of results

A comparison of results of interactions across the three methods at the goal level (Figure 6) showed that the interaction scores method had the highest proportion of co-benefits (78%) and the lowest proportion of trade-offs (6%), while the expert elicitation method revealed that co-benefits and trade-offs were almost equally shared (co-benefits: 54%, trade-offs: 46%). Co-benefits were lowest from correlation analysis (only 28%), partly because of a high proportion of neutral interactions (57%).

Comparing results of interaction with SDG 15 by individual SDGs (Figure 7), we found the following:

- Although SDG 12 showed the greatest co-benefit based on SDG interaction scores, it exhibited a greater percentage of trade-offs according to correlation analysis and was reported to have no interactions by informants from expert elicitation.
- Likewise, SDG 17 and 13 demonstrated numerous co-benefits according to SDG interaction scores, which was not reflected in the other two methods.
- SDG 7 and 9 had a high proportion of trade-offs with SDG 15 based on all three methods and SDG 2 had the highest proportion based on both argumentative methods.
- Overall, co-benefits with SDG 15 were generally high for SDGs 1, 3, 4, 5, 6, 8, 10, 13, and 16 whereas trade-offs with SDG 15 concentrated on SDGs 2, 7, and 9 (Figure 7).

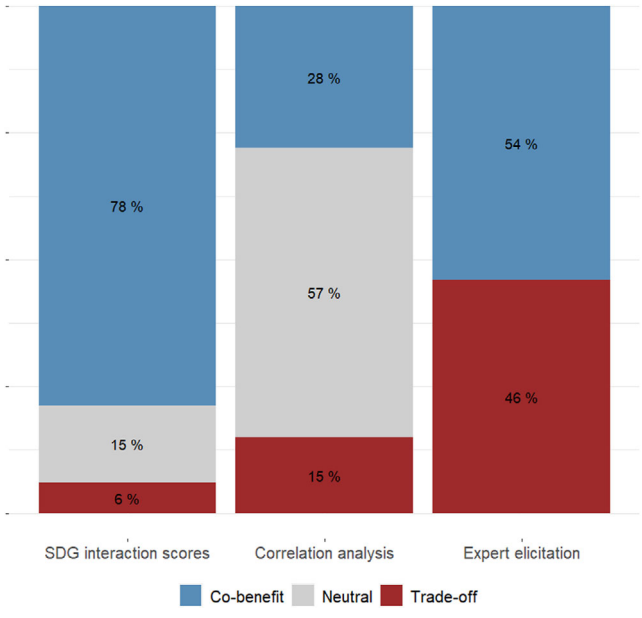

FIGURE 6 An overall synthesis of co-benefits, trade-offs, and neutral interactions between SDG 15 and other SDGs from the three different methods applied in the study.

4 | DISCUSSION

4.1 | Insights from a Nepalese case study

In line with others, we found that co-benefits between SDGs were more numerous than trade-offs, irrespective of the approach adopted (Breu et al., 2021; McCollum et al., 2018; Pradhan et al., 2017; Warchold et al., 2021) and that conservation and development goals are largely synergistic with each other (Aryal et al., 2020).

Both argumentative methods showed that SDG 15 shared the highest mutual co-benefit with SDG 8. Specifically, protecting terrestrial biodiversity promoted eco-tourism (SDG 8.9). This is consistent with other findings that eco-tourism and conservation are synergistic in different contexts (Mossaz et al., 2015; Olmsted et al., 2020). Specifically for Nepal, the increase in eco-tourism was attributed to habitat restoration near protected areas (den Braber et al., 2018). The mutual co-benefits between these two goals indicates a positive feedback loop. Based on the number of outgoing and incoming co-benefits detected with the argumentative methods, another possible positive feedback loop exists between SDG 15 and SDG 4 (Quality education) (Figures 2 and 5). Education and awareness is one of the major levers toward biodiversity conservation in local communities (Bhattarai & Fischer, 2014; Karanth & Nepal, 2012; Pérez et al., 2019) and revenues from conservation activities are in turn essential to support education. Significant portions of community conservation revenue in Nepal are already allocated toward supporting education, including initiatives such as teacher remuneration and school infrastructure development (Aryal et al., 2020; Bhandari et al., 2019). This highlights both that achieving SDG 4 targets is important for advancing SDG 15 and that actions taken toward SDG 15 are critical to achieving SDG 4.

We detected additional co-benefits between SDG 15 and SDG 6, likely because SDG 15.1 integrates conservation and restoration of freshwater ecosystems, which can ultimately contribute toward improving water availability (Vörösmarty et al., 2018). Finally, the co-benefits we detected between SDG 15 and SDG 5 and 10 might be due to community forestry policies that stipulate that at least 50% of the executive committees' positions need to be filled by women and that implementation programs need to be focused on economically and socially marginalized groups (Sapkota et al., 2020), which helps

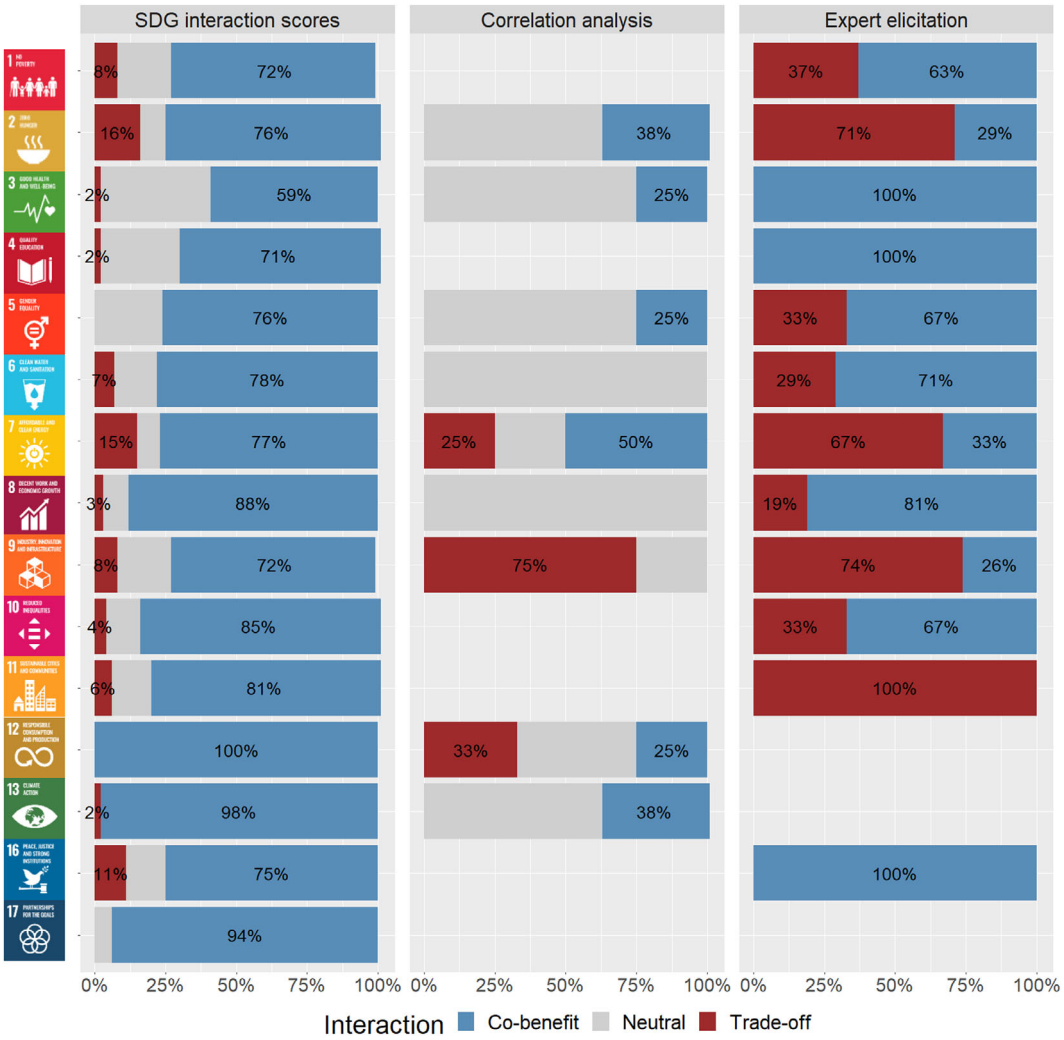

FIGURE 7 A synthesis of co-benefits, trade-offs and neutral interactions between SDG 15 and other goals from the three different methods applied in this study by individual SDGs. Co-benefits in blue, trade-offs in red, neutral in white, and no fill for interactions with no data.

empower women and marginalized communities (Sapkota et al., 2019).

As for trade-offs, all three methods detected trade-offs between SDG 15 and SDGs 7 and 9. Infrastructure projects in Nepal, particularly road expansion, is one of the leading causes of habitat degradation, fragmentation, spread of invasive species, and consequently biodiversity loss (Adhikari et al., 2020; Adhikari et al., 2022; Quintana et al., 2022). Infrastructure development has also been found to be the biggest source of trade-off for SDG 15 in another global study (Mantlana & Maoela, 2020). Additionally, energy infrastructure, particularly hydropower, is associated with deforestation in the wider Himalayan region (Verma et al., 2021). SDG 15 meanwhile, was found to negatively impact the achievement SDG 1 and SDG 2 in some instances. These negative effects stemmed from conservation activities that restrict access to forest resources, farming, and grazing. Other studies have also reported that these restrictions hinder progress toward poverty alleviation, food security, and social equality (Aryal et al., 2020; Dhakal & Thapa, 2015). In line with previous research (Bhattarai et al., 2019; Bhattarai & Fischer, 2014), other trade-offs involved increase in wildlife (from successful conservation measures) that resulted in crop depredation, economic losses, and human injuries and fatalities.

4.1.1 | Differences across the three methods

The three methods produced some conflicting results (see Section 3.4). The interaction scores method revealed co-benefits between SDGs 15 and 12 while correlation analysis showed trade-offs. One reason for this is the data used. Different units of measurement of indicator 12.2.2 produced differing results from the correlation analysis. Thus, interpretation of results from correlation analysis should consider the source and unit of data used, since detection of interactions from correlation is sensitive to the data used (Warchold et al., 2022). Another reason may be because sustainable production and consumption is conceptually linked to better environmental health (e.g., see Adhikari & Prapaspongsa, 2019; Akenji & Bengtsson, 2014), which

might be why experts assigned co-benefits between the two goals. However, Nepal's plan to graduate from a least-developed country status means that it needs to achieve certain economic objectives, including an increase in domestic material production and consumption (Baniya & Aryal, 2022), which is at odds with SDG 12 targets. So, although ideally SDG 12 and 15 are synergistic (cf. interaction scores), increasing material production and consumption of developing countries in particular (United Nations Statistics Division, 2021) leads to trade-offs between the two goals (cf. correlation analysis).

Another difference in results was the interaction between SDG 15 and SDG 13. Consistent with other studies (Breu et al., 2021; Pham-Truffert et al., 2020), the interaction scores and correlation analysis found that SDG 13 co-benefitted SDG 15. However, this correlation was barely mentioned in the expert elicitation method. This may be because informants focused on local contexts, while progress toward SDG 13 likely synergize with SDG 15 at regional or global scales (e.g., see van Soest et al., 2019).

Generally, the interaction scores detected a higher frequency of co-benefits than trade-offs in comparison to the other two methods. This may be because when we asked experts how the achievement of one SDG affects another, they might have inherently referred to prospective interactions if interventions were sustainably carried out, as framed by the 2030 Agenda (Urban & Hametner, 2022). An implication of this is that asking people to score interactions based on what has happened in practice, rather than what would ideally happen, will give different responses. Therefore, a degree of caution is required while interpreting results of interactions derived through expert opinions (Breuer et al., 2019; Nilsson et al., 2018), since differently phrased questions can yield different results (Sutherland & Burgman, 2015).

4.2 | Opportunities for addressing conservation and development trade-offs in Nepal

Progress toward SDG 15 in Nepal is influenced by the achievement of other goals. Road development (SDG 9), in particular, is a significant threat to future conservation efforts in Nepal, as the country aims to expand its road infrastructure significantly over the next decade, including through protected areas (Quintana et al., 2022). Similarly, despite examples of the negative impacts of hydropower projects (SDG 7) on biodiversity and the environment (Anderson et al., 2018; Jumani et al., 2017), more than half of all future hydropower projects lie within Nepal's highly biodiverse areas (Ghimire & Phuyal, 2022).

Trade-offs are not inherent to targets or goals themselves, but rather stem from inadequate governance and lack of coordination among different sectors (Breuer et al., 2019). We found that SDG 15 is a buffer of trade-offs at the systemic level, in line with other global studies (Huan & Zhu, 2022; Pham-Truffert et al., 2020), meaning that addressing challenges to SDG 15 will largely depend on actors from other sectors considering and addressing trade-offs between SDG 15 and other goals. Therefore, policy-makers responsible for SDG 15 need to work together with relevant ministries and departments across all levels of the government, especially including Nepal's Ministry of Energy, Water Resources and Irrigation, and Ministry of Physical Infrastructure and Transportation in this case. Bowen et al. (2017) suggest various ways to do this, including collaboration, secondments of officials across ministries, cross-sectoral training, and co-production of knowledge through research.

Even with collaboration, a win-win situation is not always possible, and difficult compromises are inevitable (Bowen et al., 2017). As Nepal is a low-income country, its government prioritizes socio-economic development with various nation-wide infrastructure projects, while subsistence requirements will always be a priority for local communities (Sharma et al., 2018), despite generally high awareness and positive attitudes toward biodiversity and conservation (Dhungana et al., 2022; Hanson et al., 2019). However, if key interlinkages across SDGs are identified, conservation officials can negotiate compromises with relevant actors to generate outcomes that minimize trade-offs. The compensatory plantation of trees felled by development projects that is already ongoing is one outcome of such negotiations. However, in practice, development projects rarely comply with environmental considerations, even though they are mandated by environmental impact assessments (Ghimire et al., 2021). Accordingly, conservation stakeholders in the government need to coordinate with local governments to ensure that compensatory measures are enforced and trade-offs are thereby minimized.

Conservation interventions, in turn also need to be considered in the light of the negative impact they have on goals such as poverty and hunger-reduction. These impacts often stem from a failure to include the diverse needs and values of communities that directly depend on nature for their wellbeing (Chaudhary et al., 2018). All measures taken to achieve all SDGs, including SDG 15, are likely to benefit from placing considerable emphasis on including poor and marginalized communities in the decision-making process (Bowen et al., 2017; Henfrey et al., 2023), since this can not only contribute toward ameliorating trade-offs, but also drive the success of any conservation activity (De Jong et al., 2018).

Finally, there are other opportunities for Nepal to achieve the SDG 15. Existing successes in conservation are mostly limited to protected areas (e.g., Nepal has already met target 15.1, including meeting its targets on forest coverage and protected area coverage (Government of Nepal, 2020a)). However, there is still ongoing habitat destruction affecting biodiversity outside of these areas (Government of Nepal, 2018). Nepal already has existing landscape-based conservation measures focusing on connectivity of wildlife corridors, as wells as on prioritizing community livelihood (Government of Nepal, 2016). The expansion of conservation landscapes along with other Effective Area-based Conservation Measures offers viable alternatives for Nepal to expand protected area coverage and simultaneously preserve traditional landscapes and indigenous territories (Gurney et al., 2021).

4.3 | Methodological considerations

Following previous recommendations (McCollum et al., 2018; Pradhan, 2023; Pradhan et al., 2017), we applied multiple methods for

identifying SDG interactions. Argumentative methods are effective in detecting the direction, polarity, and degree of interactions, providing the flexibility to include context-based quantitative and qualitative information, and are easily interpretable (Horvath et al., 2022). Although the Nilsson scale does not typically allow for the detection of directionality of interactions (Horvath et al., 2022), we specifically asked experts to rate bi-directional interactions, thereby ameliorating this methodological limitation. In view of the fact that structured elicitation of expert knowledge is one of the most effective methods for revealing contextualized SDG interactions (Horvath et al., 2022), we included in-depth interviews to obtain rich qualitative information on interactions and the possible reasons behind them. Finally, the availability of national data on SDG indicators in Nepal allowed us to incorporate correlation analysis as a statistical method, since it provides easily interpretable quantitative information on possible interactions with relatively limited time and effort (Horvath et al., 2022). While the multi-methods approach to assessing SDG interactions is increasingly adopted, our study is among the few that apply three rather than two methods simultaneously (Horvath et al., 2022).

A trade-off of involving independent experts in scoring interactions between the SDGs through an online survey, is that we had to be mindful of not overburdening experts with too many interactions to score, and thus restricted our focus on interactions with a single SDG (SDG 15) and not between all SDGs. Focusing on more SDGs would have required each expert to rank interactions between 380 target pairs and a substantially larger sample size of experts. This still could not completely address biases since we used purposive sampling in the online survey. However, the method can produce insightful results for advancing a particular SDG, taking into account its interrelationship with other goals. Additionally, since a majority of experts and informants for our argumentative methods come from the conservation background, our insights are limited to a conservation lens. This bias could potentially influence the perceived co-benefits and trade-offs in our results.

Selection of priority targets, particularly during deliberations between co-authors, also involved a certain degree of subjectivity. Since it is not always possible to provide a comprehensive assessment of all interactions across all targets (Nilsson, 2017), most studies select relevant targets as the first step in the interaction scoring approach (although there are examples of studies that take into account all possible interactions; see Pradhan et al., 2021). This might lead to important interactions being left out of the study. Systematic methods for target selection (e.g., see Breu et al., 2021) require additional participants, time, and resources. In case of a lack thereof, defining criteria for target selection and filtering them through national priorities and deliberation, as we have done, appears to be an acceptable alternative.

5 | CONCLUSION

Successfully achieving the 2030 Agenda requires nations to adopt innovative policies that benefit multiple SDGs, and identify solutions to address trade-offs between competing goals. A suite of tools for recognizing potential co-benefits and trade-offs already exists in the literature. In our case study, we have provided an example of how multiple tools can be used and complement each other to identify such synergies and trade-offs as well as opportunities for the conservation sector of Nepal. Specifically, addressing trade-offs between road and energy infrastructure development and conservation objectives through multi-sectoral collaboration and negotiations is urgently needed. Additionally, to avoid negative consequences on other socio-economic goals such as poverty alleviation and food security, conservation interventions need to be people-focused, participatory, and guided by contextualized policies.

The combination of SDG interaction scores, correlation analysis, and expert elicitation proved to be effective in gathering broad ranging qualitative and quantitative information on interactions between conservation and development goals for Nepal. The suite of methods we used can be complementarily used to investigate interlinkages with a focus on a different goal, and for different countries at national, sub-national or regional scales.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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