Global Sustainability

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How R4D projects interact with the SDGs: an analysis of the links between sustainable land use projects across the Global South and the SDG targets

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Abstract

Non-technical summary. Research for development (R4D) projects are designed to enhance the research community's contribution to implementation of the 2030 Agenda of the United Nations. We studied seven R4D projects that specifically addressed Sustainable Development Goal (SDG) 15 (life on land) in 14 contexts across Asia, Africa, and South America. We then analyzed how these projects interacted with other SDGs. Our findings reveal that the positive and negative interactions between project objectives and SDG targets vary significantly across contexts, highlighting the importance of considering local conditions when designing and implementing R4D initiatives.

Technical summary. We analyze how the objectives of research for development (R4D) projects that focus on a particular Sustainable Development Goal (SDG) – SDG 15 (life on land) – interact with the targets of other SDGs. We studied seven R4D projects in 14 contexts across Asia, Africa, and Latin America, comparing expert judgement of interactions between project objectives and SDG targets. Our findings indicate that the success of these projects depends largely on whether they are also working toward SDG targets other than those contained in SDG 15. In particular, working toward targets contained within SDGs on poverty, hunger, water, energy, production and consumption, and global partnerships – was often considered indivisible from the project objectives. Further, while all of the projects focused on SDG 15, our findings suggest that addressing only this goal is not sufficient. A range of other targets that were *a priori* not the immediate focus of the projects were revealed as 'crucial' to the project objectives across contexts. Finally, we list several implications, such as the need for policies to integrate local realities and the need for environmental R4D projects to adopt a holistic scope, particularly in terms of (a) securing social foundations, (b) building enabling institutions, and (c) negotiating competing claims on land.

Social media summary. What can we learn from land-related research for development projects and their links to the SDGs in concrete contexts?

Research Article

Cite this article: Ehrensperger A *et al*. (2024). How R4D projects interact with the SDGs: an analysis of the links between sustainable land use projects across the Global South and the SDG targets. *Global Sustainability* **7**, e47, 1–13. https://doi.org/10.1017/sus.2024.42

Received: 20 March 2023
Revised: 6 September 2024
Accepted: 12 September 2024

Keywords:
2030 Agenda; competing claims; land use; research for development; SDG; synergies; trade-offs

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1. Introduction

The United Nations 2030 Agenda emphasizes the interconnected nature of its Sustainable Development Goals (SDGs) and the need to pursue their respective targets collectively (United Nations, 2015). Consequently, a key challenge of the 2030 Agenda lies in fostering positive interactions (i.e. synergies) and mitigating negative interactions (i.e. trade-offs) among SDGs and their targets. Since land lies at the intersection of diverse interests and claims related to societal needs for sustainable development (de Bremond, 2021; Meyfroidt et al., 2022; Sayer et al., 2013), it is a pivotal resource for promoting mutual benefits among complementary goals and skillfully managing trade-offs amidst competing land claims within the wider scope of the 2030 Agenda (Ehrensperger et al., 2019; Sachs, 2018). Knowing how land-related interventions interact with the SDGs is therefore critical in the quest for advancing sustainability transformations.

Indeed, in the face of global crises, such as climate change and the underlying issue of land use change, the role of research and researchers in society is changing (Horcea-Milcu et al., 2024). Transdisciplinary and transformative research are both key for the co-production of solution-oriented knowledge that is relevant to support transformations toward sustainable development (Hellin et al., 2022; Horcea-Milcu et al., 2024; Marshall et al., 2018). Hence, a growing research community is emphasizing the key role of science as one of the levers for societal transformation (Bulkeley et al., 2023; Fazey et al., 2020; Schneider et al., 2023). In this context, funding agencies have increasingly recognized the need for transdisciplinary collaborative research to bridge the potential gap between scientific knowledge and knowledge that would be useful and 'usable' for policymakers and practitioners (Tuohy et al., 2024). So-called 'research for development' (R4D) initiatives focusing on sustainable land use and systems are poised to take the forefront in designing corresponding approaches and it is crucial to learn more about how they address SDG interactions.

National and international research funding agencies have initiated various solution-oriented and often transdisciplinary programs over the last decade. Examples include Horizon Europe, the Belmont Forum, the Global Challenges Research Fund, the Swiss Programme for Research on Global Issues for Development, and others. These funding vehicles are designed to enhance the research community's contribution to the successful implementation of the 2030 Agenda (Schneider et al., 2023). Accordingly, funding agencies request project teams to reflect on their contributions to the SDGs in their proposals and to evaluate them in their reporting. Yet, to our knowledge, no analysis has been conducted on how R4D projects contribute to achieving the 2030 Agenda from a systemic perspective. Rather, consideration of the 2030 Agenda during the selection, conceptual development, design, and monitoring of such projects rarely goes beyond a simple ticking of SDG boxes. Funding agencies themselves have not yet made the step from listing priority SDGs toward reflecting on how the selected SDGs will interact with other SDGs in a project context.

Guidance and analytical frameworks that support such a reflection have emerged out of the field of SDG interaction studies, stimulating the scientific debate on actionable science for integrated decision-making. Recent scientific reviews synthetize the different methodologies that aim to identify synergies and trade-offs among the SDGs (Bennich et al., 2020, 2023), and evaluate how fit-for-purpose these methods are to support policy-making (Di Lucia et al., 2022; Horvath et al., 2022). These range from modeling (Allen et al., 2021b; Collste et al., 2017) and statistical methods (Kroll, 2015; Lusseau & Mancini, 2019; Pradhan et al., 2017) to archetypes approaches (Bandari et al., 2022), literature reviews (Pham-Truffert et al., 2020), and expert judgement (International Council for Science [ICSU], 2017; Le Blanc, 2015; Nilsson et al., 2016, 2018; Weitz et al., 2018).

The last approach – that of expert judgement – typically builds on a scoring system to qualify the interactions among SDG targets, to distinguish between various degrees of synergistic and antagonistic interactions. This approach is easy to use and allows to generate qualitative and semi-quantitative information on causal effects, which were key criteria for its selection as an analytical tool in the present study. Further, Nilsson et al. (2016, 2018) and Pham-Truffert et al. (2020) have called for the contextualization of such SDG assessments at national and sub-national levels. Following a case study in Sweden (Weitz et al., 2018), the 'SDG Synergies' approach was adopted in several studies and aimed to provide explicit guidance for national and sub-national policy development (e.g. Adhikari et al., 2023; Bandari et al., 2022; Breu et al., 2021; Lyytimäki et al., 2021; Stevenson et al., 2021). Other studies compared different levels of analysis in various contexts, for example, global and local levels in Northwestern Norway (Nerland et al., 2023) or national and subnational levels in Colombia (Hernández-Orozco et al., 2021). There is also an increase in comparative assessments of SDG interactions in and across different contexts. In a pan-African study, Jiménez-Aceituno et al. (2020) investigated SDG interactions through content analysis in 69 sustainability initiatives. Others have compared countries worldwide by using time series of SDG indicators (Lusseau & Mancini, 2019; Moinuddin & Zhou, 2017; Pradhan et al., 2017).

This study aims to illustrate how R4D projects addressing land-related SDGs across three continents interact with other SDGs. To this end, we assessed the interactions between the SDG targets and seven international R4D projects, operational in 14 case study regions across 10 countries in Africa, Latin America, and South-East Asia. All projects included in our study were funded by the Swiss Programme for Research on Global Issues for Development, a 10-year program that supported transboundary, partnership-based, and inter- and transdisciplinary research with a focus on low- and middle-income countries. For our assessment, we specifically focused on projects grouped under the 'ecosystem' theme. These initiatives primarily aimed to promote the protection, restoration, and sustainable use of terrestrial ecosystems, aligning with the objectives of SDG 15 (life on land). Through this examination, we aim to draw meaningful lessons from the observed interactions to inform the strategic design of future R4D projects.

Our goal is to understand the synergies and trade-offs arising between, on the one hand, the objectives of projects that aim specifically to address SDG 15 – and, on the other, the SDGs that were not in the project focus. We aim to understand how pursuing the project objectives affects (positively or negatively) the ability to achieve targets of other SDGs, but also how the project objectives are supported or hindered by the pursuit of these other SDG targets in the same region. Within this scope, we are particularly interested in identifying 'crucial' interactions that are at the same time strongly synergistic and address development priorities of concern in the respective contexts. By taking a comparative lens, we aim to achieve generic insights into commonalities and differences between the contexts in which the projects were active. This comparative systemic perspective allows our

https://doi.org/10.1017/sus.2024.42 Published online by Cambridge University Press

results to provide useful insights for designing, evaluating, and implementing R4D projects in support of the 2030 Agenda.

2. Methods

2.1 Data collection

Our study appraises the bi-directional interactions between the objectives of seven R4D projects and SDG targets across 14 project cases (Figure 1). These seven projects were selected under a call with a distinct 'ecosystem' focus, all aligning to achieve SDG 15. In contrast to conventional research projects, R4D projects are expected to develop and test small interventions, based on the scientific evidence established. While one might anticipate that these projects predominantly exhibited synergies with SDG 15, our focus was on discerning how they also engaged with the other 16 SDGs and their targets. This exploration was contingent on the projects' specific thematic emphasis and geographical locations.

As proposed by Weitz et al. (2018), our rating methodology is based on knowledge provided by experts in different geographical contexts. Since its inception (Helmer-Hirschberg, 1966), expert elicitation as a method has been used widely and involves qualitative and quantitative methods (Butler et al., 2015). In each project case, we opted for an assessment by a team of three experts on topics related to land systems (Figure 1), facilitated by a member of the project team. The facilitators were tasked with putting together a team of experts, who were required to be well-informed about the respective project's objectives and to be conversant with the 2030 Agenda and its targets. Most of the experts were researchers within the projects; some were students working on their theses in the project area, and others were project partners.

The facilitators and experts received detailed instructions from the study authors via a video tutorial, as well as an Excel file with additional information and a preformatted sheet for the coding. Workshops lasted between 6 and 8 hours and were conducted in each project case between August 2019 and May 2020. At the beginning of each workshop, the expert team agreed on and jointly formulated a main objective of the project. They were requested to use this main project objective as an analytical lens for the subsequent rating of interactions, which was conducted in two directions and based on the following two questions:

(1) How does pursuing the project's main objective affect the ability to achieve other SDG targets in the same area (project to SDG interaction or P2S)?
(2) How does pursuing an SDG target affect the ability to achieve the project's main objective in the same area (SDG to project interaction or S2P)?

In the case of SDG targets that were not directly being addressed by the development actors in the project area, the expert teams were requested to formulate hypothetical questions, such as 'assuming someone would implement a project focused on achieving SDG target XYZ in your project area, how would this affect the ability of your project to achieve its main objective?'. In other words, each team of experts was asked to assess both, how the implementation of their project affects the ability to achieve SDG targets, and how their project objective is being affected by initiatives aiming to achieve other SDG targets. In doing so, they had to consider the project's target area (e.g. administrative or geographic boundaries). This was of particular importance, since interactions among development targets materialize in different ways on a plot, in a district, or a watershed.

The P2S and S2P interactions were rated using the 7-point scale proposed by Nilsson et al. (2016) to conceptualize SDG interactions: 'cancelling' (−3), 'counteracting' (−2), 'constraining' (−1), 'consistent' (0), 'enabling' (+1), 'reinforcing' (+2), and 'indivisible' (+3). Furthermore, each team of experts was asked to evaluate the likely importance of each interaction for the area's overall development, using a scale of 0 (irrelevant) to 5 (crucial). This 'importance' indicator was used to ponder the rating of interactions: Those can be strongly antagonistic (−3, cancelling) or strongly synergistic (+3, indivisible), and yet have only little impact on the area because of the low relevance of the related development issue.

2.2 Data analysis

Using a consistent analytical framework for an ex-post analysis of qualitative expert knowledge allows for a direct comparison between projects and intervention sites. The coding sheets of the 14 expert teams were verified and consolidated in a master file that was used to conduct various analyses and visualizations using descriptive statistics:

- We identified the distribution of interaction types (based on the 7-point scale by Nilsson et al. [2016] from cancelling to indivisible) and importance scores across project cases and across SDGs by summing up the ratings of the 14 expert teams.
- The 'indivisible score' is the number of the instances a P2S or S2P interaction was rated as an indivisible synergy (a 7-point scale score of + 3) across all 14 project cases. Twenty-eight is the maximum for this score, which would be attained if all 14 expert teams rated the interaction as indivisible in both S2P and P2S directions.
- In contrast, the sum of 'importance' is the sum of all the ratings (0–5) of the level of importance of the interaction, also across the 14 project cases. Thus, the maximum sum of importance is 70 and is attained if all expert teams rated the importance as very high (5).
- We multiplied the 'indivisible' and 'importance' scores to obtain a 'cruciality index' for each target, which we see as a measure to rank the most 'crucial' targets, that is, those that are at the same time (a) often indivisible from the assessed projects' main objectives and (b) of high importance given their relevance in the project contexts. For example, we found that the 14 expert teams rated 15 times the interaction of target 15.1 with the projects' main objectives as indivisible (six times in S2P and nine times in P2S directions). At the same time, the 14 expert teams rated the importance of this interaction from 3 to 5 ($1 \times 3 + 5 \times 4 + 8 \times 5$) resulting in an importance score of 63. The multiplication of the indivisible and importance scores (15×63) results in a cruciality index of 945. The maximum score for the cruciality index is 1960, corresponding to the maximum indivisible score (28) times the maximum importance score (70).
- We built a cross-impact matrix (Weitz et al., 2018) from the ratings of the 14 expert teams on P2S and S2P interactions and visualized it to identify recurring patterns of interactions between SDG targets and project objectives.
- Finally, we calculated the standard deviations of interaction ratings between cases belonging to the same

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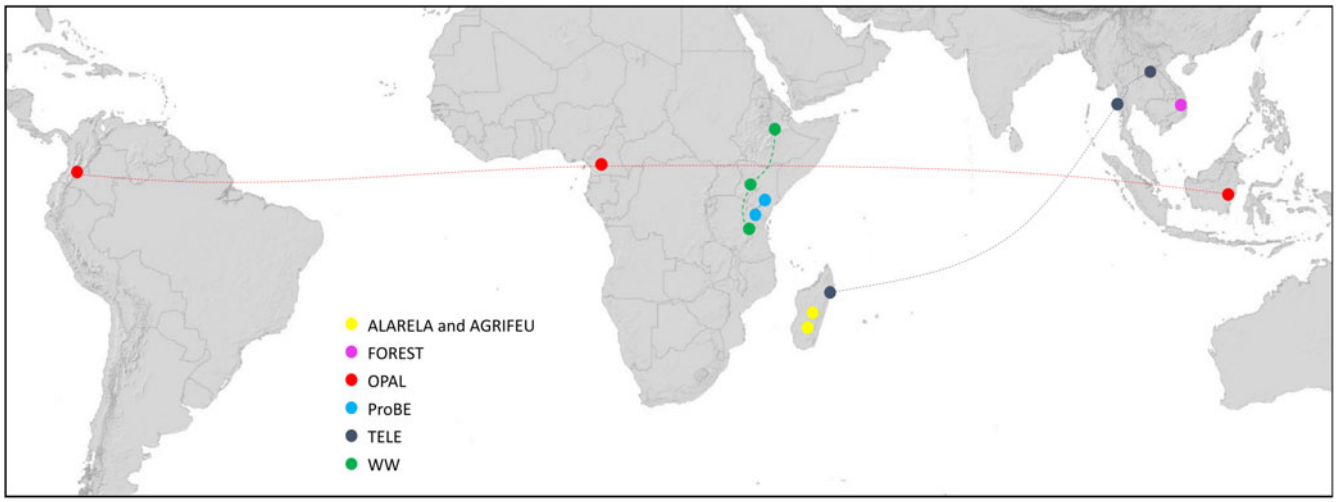

Project	Full name	Objectives (short version)	Study region	Experts
AGRIFEU	Experimental assessment of innovative slash & burn cultivation practices for sustainable land use and deforestation prevention in Central Menabe.	Assess the use of local trees to produce organic fertilizers, the sustainable use of land with slash-and-burn practices coupled with agroecological methods, and the socio-economic impacts of the method.	Central Menabe, Madagascar	Forest economy, plant ecology, and pedology
ALARELA	Alaotra Resilience Landscape, Madagascar	Balancing conservation and development by formulating stakeholders' understanding of change.	Alaotra Mangoro Region, Madagascar	Forest economy, biogeography, and agronomy
FOREST	Assessing the 'nature' of a 'forest transition' in Vietnam: ecosystem services and social-ecological resilience in locally managed forest landscapes.	Produce knowledge on ecological characteristics of forests and their ecosystem services under different management regimes.	Thua Thien Hue Province, Vietnam	Forest engineering, environmental science
OPAL	Oil Palm Adaptive Landscapes.	Sustainable production of palm oil across the tropics.	Palm oil production basins, Cameroon	Geography, agronomy, environmental sciences
			Cravo Sur & Aracataca basins, Andes-Orinoco piedmont, Colombia	Economy, journalism, ecology
			East Kalimantan, Indonesia	Two doctoral students and project manager
ProBE	The prospects of pro-poor biomass energy value chains in rural–urban contexts in East Africa.	Improve access to energy for cooking and safeguard income opportunities. Scale out improved biomass energy technologies and sustainable biomass energy value chains.	Kilimanjaro Region, Tanzania	Community development, sustainable energy, environmental management
			Kitui County, Kenya	Environmental sciences, development economy
TELE	Managing telecoupled landscapes for the sustainable provision of ecosystem services and poverty alleviation.	Understand the capacity of socio-ecological systems at different stages of telecoupling to provide ecosystem services for human wellbeing.	Maroantsetra, Madagascar	Forest economy, zoology, plant ecology
			Luang Namtha, Laos	Forestry, land sciences
			Tanintharyi Region, Myanmar	Sustainable land use, forestry and agriculture
WW	Woody invasive alien species in East Africa	Mitigate the threat of invasive species on stakeholder needs and thus contributes to the sustainable use of terrestrial ecosystems.	Baringo County, Kenya	Environmental management, forestry, geography
			Afar Region, Ethiopia	Agricultural economy, rangeland management, environmental sciences
			Amani Forest, Tanzania	Forestry, invasion ecology

Figure 1. Overview of the 14 project cases (note that some of the projects have more than one intervention site). Names, acronyms, objectives, project locations, as well as fields of competence of the expert teams are provided in the table under the map. Detailed information on each project is available on the website of the Swiss National Science Foundation's R4D program: www.r4d.ch/modules (to access project information, select the 'thematically open projects' and 'ecosystems' sub-menus).

project (and thus pursuing the same objectives), to assess the importance of context specificity in influencing the P2S and S2P interactions.

The results and visualizations were discussed with representatives of all the expert teams during two professionally facilitated virtual synthesis workshops. The workshops enabled us to

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double-check certain ratings and to achieve consensus on the interpretation of the results.

3. Results

3.1 Nature of interactions between project objectives and SDG targets

In total, the 14 expert teams rated 3840 interactions between SDG targets and project objectives. Of these, more than half (2065) were rated as 'consistent', meaning that the concerned SDG targets and the objectives of the R4D projects could be pursued in parallel without mutual positive or negative interference (Figure 2). The other half of the rated interactions were almost exclusively synergistic: 246 were rated as 'indivisible' (6%), 610 as 'reinforcing' (16%), and 872 as 'enabling' (23%) interactions. The expert teams identified only 46 trade-offs: 36 'constraining' and 10 'counteracting' interactions. No 'cancelling' interactions were reported.

The results show a slight difference between S2P and P2S interactions, with S2P more often synergistic, and P2S more often merely consistent (Figure 2). At the same time, the S2P interactions included more trade-offs (28) than the P2S interactions (19). This indicates that the success of the R4D projects is more dependent on the successful implementation of SDG targets in the same area than conversely.

The share of indivisible interactions strongly varies among SDGs (Figure 3). Many SDG 15 (life on land) targets interacted in an indivisible way with the objectives of the R4D projects, which reflects the fact that through their land use focus, all the projects aimed to contribute to SDG 15. There are six other SDGs with above-average (6.45%) shares of indivisible interactions: SDG 1 (no poverty), SDG 2 (zero hunger), SDG 6 (water and sanitation), SDG 7 (energy), SDG 12 (sustainable production and consumption), and SDG 17 (global partnerships).

3.2 Nature of interactions per SDG

The expert teams considered **SDG 1** (no poverty) to be strongly synergistic with the project objectives (125 synergies, 37 consistent interactions, and 2 trade-offs). Strikingly, 14 S2P interactions but only 4 P2S interactions were rated as indivisible, indicating that poverty alleviation is an essential condition for achieving the R4D project objectives of sustainable land use, whereas the opposite is not necessarily true. The eradication of extreme poverty (target 1.1) and equal rights to resources, including land (target 1.4), were the targets most often rated as indivisible.

SDG 2 (zero hunger) targets and R4D project objectives are also mainly synergistic, even though the share of merely consistent interactions (60%) is double that of SDG 1. Overall, SDG 2 strongly interacts with project objectives through agricultural land use. Ensuring a sustainable food production system (target 2.4) is, therefore, considered indivisible from achieving project objectives in five cases. Conversely, achieving the projects' objectives is considered necessary to ensure that these sustainable food systems can be put in place (four cases) and to increase agricultural productivity (target 2.3; four cases). SDG 2 is the only goal for which P2S was rated as more important than S2P, highlighting the intimate link between land systems and food systems. The AGRIFEU project (innovative slash-and-burn cultivation practices in Central Menabe, Madagascar) and the three WW project cases (sustainable management of woody invasive species in Eastern Africa) contributed most to this rating.

The expert teams consider **SDGs 3** (health), **4** (education), and **5** (gender equality) to be mainly consistent (82%, 50%, and 71% of all interactions, respectively), or slightly synergistic (12%, 25%, and 18% enabling interactions, respectively) with the projects' objectives. Indivisibility mainly concerns target 4.7 (ensure that all learners acquire the knowledge and skills needed to promote sustainable development). Reinforcing interactions are also dominant in SDG 4 and mainly concern targets 4.7 and 4.4

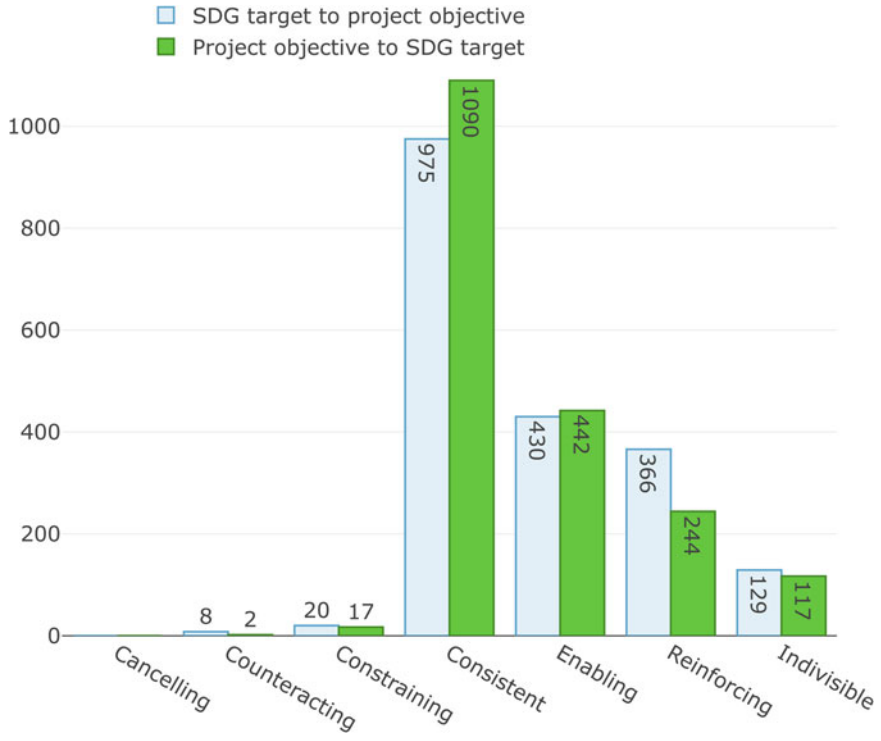

Figure 2. Assessment of interactions from SDG targets to project objectives, and vice-versa. The *Y*-axis indicates the total number of interactions identified by the 14 expert teams.

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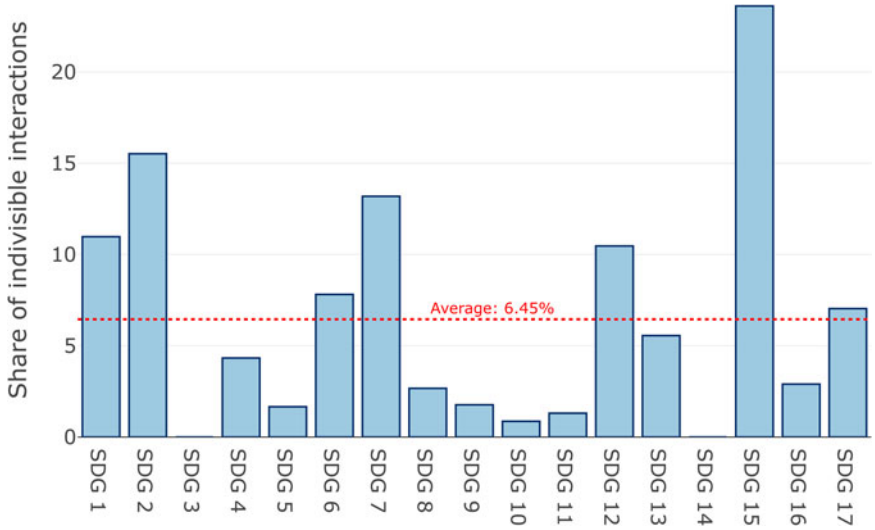

Figure 3. Share of indivisible interactions (in % of all interactions within the same SDG) between SDG targets and project objectives (in both directions: S2P and P2S).

(improving technical and vocational skills), which are both seen as important preconditions for the successful implementation of environmental projects. The OPAL-Indonesia team of experts is the only one that rated three targets of SDG 5 (5.5, 5.a, 5.c) as indivisible from their project's objective, because their approach included a component for the effective participation of women and minorities.

SDGs 6 (water) and **7** (energy) each have similar shares of synergistic and consistent interactions. Targets with a high significance in terms of protection of land resources were rated as particularly synergistic by some expert teams. The protection of water-related ecosystems (target 6.6) scored six indivisible interactions in the OPAL, TELE, and FORESTS projects, while the improvement of energy efficiency (target 7.3) scored four indivisible interactions in the ProBE project. However, trade-offs between SDG 7 and project objectives were also identified: three counteracting interactions were reported by the expert team of the WW project in Baringo (Kenya). In this region, the project aims to mitigate the impacts of an invasive tree (*Prosopis juliflora*), which is used for charcoal production. To resolve a potential conflict of interest with charcoal producers who depend on this resource, the project needs to offer solutions for a transition to native species.

SDG 8 (economic growth) was rated as being mostly consistent with project objectives (54% of all interactions). Synergies identified by most expert teams were weak to medium (24% enabling and 17% reinforcing interactions). They mainly concerned interactions between project objectives and SDG targets related to per-capita economic growth (target 8.1), economic productivity (targets 8.2 and 8.3), and resource efficiency (target 8.4). These economic parameters are all intimately linked with environmental sustainability and target 8.4 is the only SDG 8 target with an explicit reference to land resources. Expert teams in the three WW workshops identified reinforcing P2S interactions in sustainable tourism (target 8.9), because of the shared interest of preserving attractive multi-functional landscapes. Teams of experts identified six constraining interactions and one counteracting S2P interaction between targets of SDG 8 and project objectives. Four of them were recorded by the WW team of experts in Amani (Tanzania). Thus, SDG 8 is, together with SDG 11, the SDG exhibiting the highest number of trade-offs with the objectives of the assessed cases.

Interactions between **SDGs 9** (infrastructure), **10** (reduced inequality), or **11** (sustainable cities) and the objectives of R4D projects are mainly consistent, but with a fair number of synergies (mainly enabling), particularly in the S2P direction. Teams of experts indicated that the project objectives did not significantly impact these three SDGs, but that the latter provided the necessary foundations for a successful implementation of any environmental R4D projects (e.g. research and innovation [target 9.5], social foundations such as decent income [target 10.1], social inclusion [target 10.2], equal opportunities [target 10.3], equity [target 10.4], and securing cultural and natural heritages [target 11.4]). SDG 11 is the only one among these three goals with a substantial number of trade-offs (7 constraining interactions). The TELE-Myanmar expert team rated interactions with targets 9.1 (infrastructure development) and 9.2 (industrialization) as 'counteracting' because of the impacts of large-scale investments in mining, forestry, and agriculture.

SDG 12 (responsible consumption and production) has a relatively high proportion of indivisible interactions (10%) with project objectives, particularly – in both S2P and P2S directions – targets 12.2 (sustainable management and efficient use of natural resources) and 12.8 (awareness for sustainable development and lifestyles in harmony with nature). Seven expert teams identified an enabling effect of their R4D projects on target 12.5 (reduce waste generation). Only four trade-offs were identified, out of which two counteracting interactions were recorded for target 12.4 (management of chemicals and waste) in the context of ProBE-Kilimanjaro. This project aims to promote solid biomass fuels, which could lead to an increase in fine particle and carbon monoxide pollution, thus, potentially, counteracting target 12.4.

SDG 13 (climate action) is clearly synergistic with the objectives of the studied projects (72 synergies, 35 consistent interactions, and 0 trade-offs), even though two expert teams (ALARELA and TELE-Laos) found only consistent interactions between climate action and their projects' objectives. Climate resilience and adaptation (target 13.1), as well as awareness creation on climate issues (target 13.3) yielded 86% of synergistic interactions, whereas climate change mitigation (13.2) obtained only 64% of synergistic ratings, with the rest being consistent interactions.

SDG 14 (life in water) does not interact at all with the projects' objectives, because none of the 14 case study areas is in a coastal

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region. Accordingly, expert teams only recorded consistent interactions for this development goal.

SDG 15 (life on land) is the development goal with the highest proportion of synergies with the projects' objectives. This is to be expected, as the projects mainly address development concerns that are spelled out in the SDG 15 targets. Most expert teams identified an indivisible P2S interaction between their projects and the sustainable use of ecosystems (targets 15.1 and 15.2). Almost half of them thought that achieving these two targets and target 15.9 (integrating ecosystem and biodiversity values into national and local planning) are a crucial precondition for achieving their R4D projects' objectives. Similarly, half of the expert teams found a reinforcing interaction between the reduction of habitat degradation and biodiversity loss (target 15.5) and their projects' objectives. A few trade-offs were recorded, but the expert teams' justifications for these ratings are debatable: the expert team of the WW-Baringo case rated a counteracting interaction with target 15.3 (combat desertification, restore degraded soils) with the argument that the project aims to eradicate the invasive shrub *Prosopis*, which was initially introduced in Eastern Africa to halt desertification. However, as the project also aims to restore grasslands and replace *Prosopis* with indigenous trees, this argument is not fully convincing.

The expert teams mostly perceived **SDG 16** (just, peaceful, and inclusive societies) as being consistent with their projects' objectives. They rated most issues addressed in this SDG (violence, torture, illicit financial flows, legal identity, etc.) as being mostly unrelated to what their projects are focusing on. Accordingly, they found only marginal potential for their projects to affect any targets of SDG 16 but agree that SDG 16 targets – particularly 16.5 (corruption and bribery), 16.6 (effective and accountable institutions), and 16.7 (responsive, inclusive, participatory, and representative decision-making) – can be fundamental conditions, without which the implementation of any environmental project would be compromised.

Finally, interactions between **SDG 17** (global partnerships for sustainable development) and projects' objectives were rated as more synergistic in both S2P and P2S directions (270 interactions) than consistent (250 interactions). S2P synergies are more frequent (155 interactions) than P2S synergies (115 interactions). This is consistent with the design of SDG 17, which includes financial, technological, capacity-building, trade-related, and systemic means of implementation. Eight expert teams rated the S2P interaction of target 17.7 (development, transfer, dissemination, and diffusion of environmentally sound technologies to developing countries) as reinforcing without providing additional information.

3.3 Importance and cruciality of interactions

In a next step, the expert teams were requested to rate the importance of the interactions between project objectives and SDG targets – independently of whether the interaction was a synergy or a trade-off – on a scale of 0 (irrelevant) to 5 (crucial). Among the 10 interactions with the highest sum of 'importance' scores are five SDG 15 targets. SDG 12 is represented with two targets, and SDGs 1, 2, and 6 with one target each.

Our 'cruciality' index is shown in Figure 4. Twenty-two SDG targets yielded above average 'cruciality' scores, which means that they were rated by the expert teams as being at the same time strongly synergistic with project objectives as well as 'very important'. Targets 15.1, 15.2, and 12.2 rank much higher than the others, which illustrates the very strong dependencies between the R4D project objectives and overall efforts toward ecosystem conservation (15.1 and 15.2) and sustainable resource management (12.2). The remaining 19 interactions with above average cruciality scores further underline this environmental emphasis, but also highlight the need for integrating environmental considerations into national policies and planning (e.g. 15.9, 17.14) ensuring coherence across sectors. Interactions with targets that emphasize partnerships and cooperation at various levels also yielded high scores owing to their importance for achieving broad environmental objectives (e.g. some of the SDG 17 targets). Finally, those crucial interactions include targets that focus on raising awareness and education around sustainability (e.g. 4.7 or 12.8), linking knowledge dissemination to environmental outcomes.

Figure 4 also shows a range of targets with relatively high levels of indivisibility but low levels of importance, particularly target 8.2 and those located immediately below. These targets mainly concern economic growth and infrastructure development, and their low importance scores can be attributed to the fact that such developments are unlikely to be major drivers in relation to the R4D projects operating in rather rural areas. Further up, targets 8.1 and 8.3 achieved similar ratings (i.e. high indivisibility but low importance scores). Target 1.2 is also among those indivisible but not important interactions. Expert teams acknowledged that reducing poverty is a condition for achieving land-related development targets of SDG 15 but were doubtful that poverty reduction efforts in the project area would yield significant results and thus become an important lever for the fulfilment of the project objectives. Similar considerations were voiced regarding target 10.2 on social inclusion or 17.3 on the mobilization of funds for developing countries.

3.4 Patterns of SDG interactions across the 14 project cases

We found that the rating of interactions at SDG level (averages of the ratings of interactions at target level), in both P2S and S2P directions, varies substantially among the 14 cases. Only two patterns cut across projects and their sites (Figure 5):

1. The very low occurrence of trade-offs across all cases and the fact that, as a rule, addressing multiple SDG targets (or SDG targets and environmental R4D project objectives) at the same time in the same context is usually beneficial for achieving all targets (win–win situation), rather than hindering the achievement of some of them (win–lose situation).
2. Alleviating poverty (SDG 1), achieving sustainable food systems (SDG 2) and quality education (SDG 4), sustainably managing water resources (SDG 6), achieving sustainable consumption and production (SDG 12), mitigating climate change (SDG 13), and protecting terrestrial ecosystems (SDG 15) are goals that are strongly synergistic with the objectives of almost all project cases, independently of the context in which they are implemented. This homogenously high to very high synergy is particularly marked for SDGs 1, 13, and 15, for which it applies in both directions, P2S and S2P.

Apart from these two aspects, there are no clear patterns across the 14 project cases in terms of SDG interactions (Figure 5). Indeed, it seems like the ratings of interactions depend very much on particularities of the projects and of the contexts in which these projects are implemented.

Figure 5 does not indicate particularly strong similarities among the sites of a same project. Figure 6 provides more details

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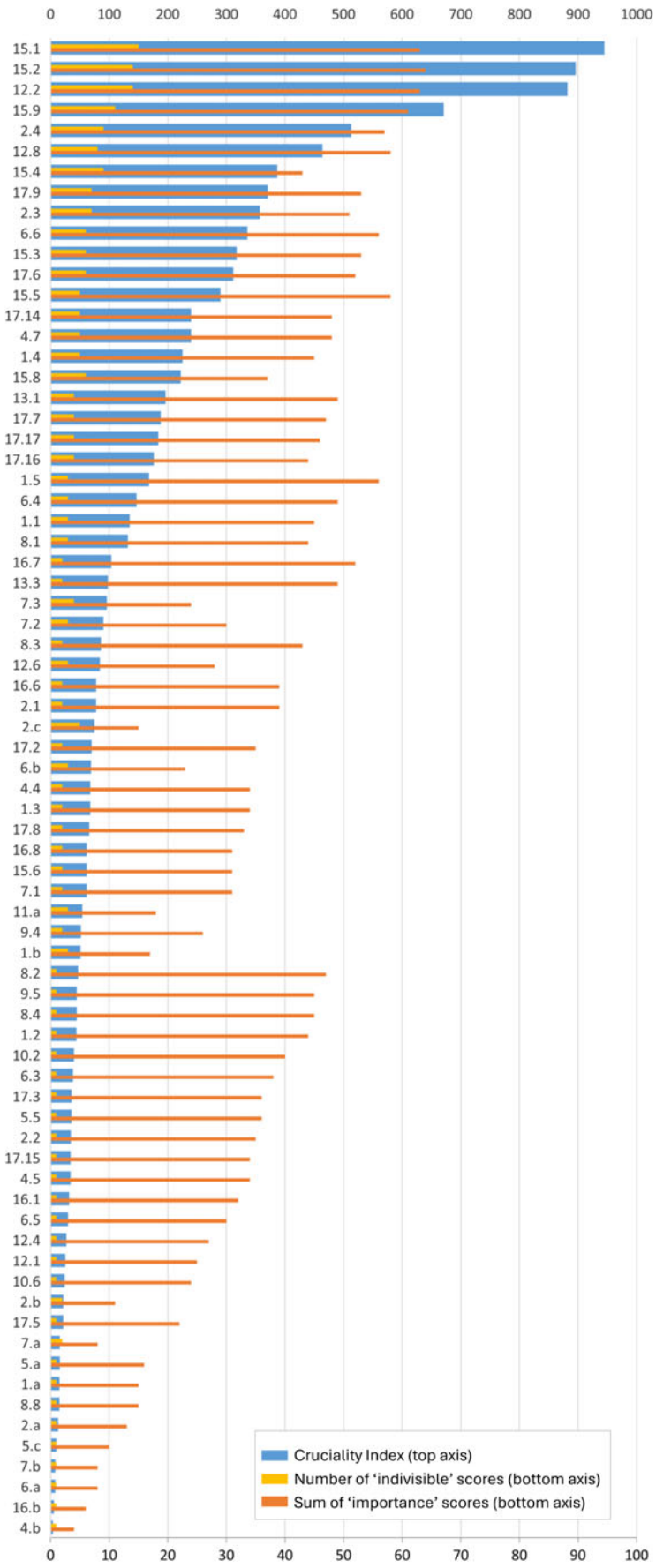

Figure 4. 'Cruciality' index for S2P and P2S interactions between SDG targets and the main objective of the assessed projects. The index is calculated by multiplying the number of 'indivisible' scores with the sum of 'importance' scores. The figure excludes 96 targets with 'cruciality' scores of zero.

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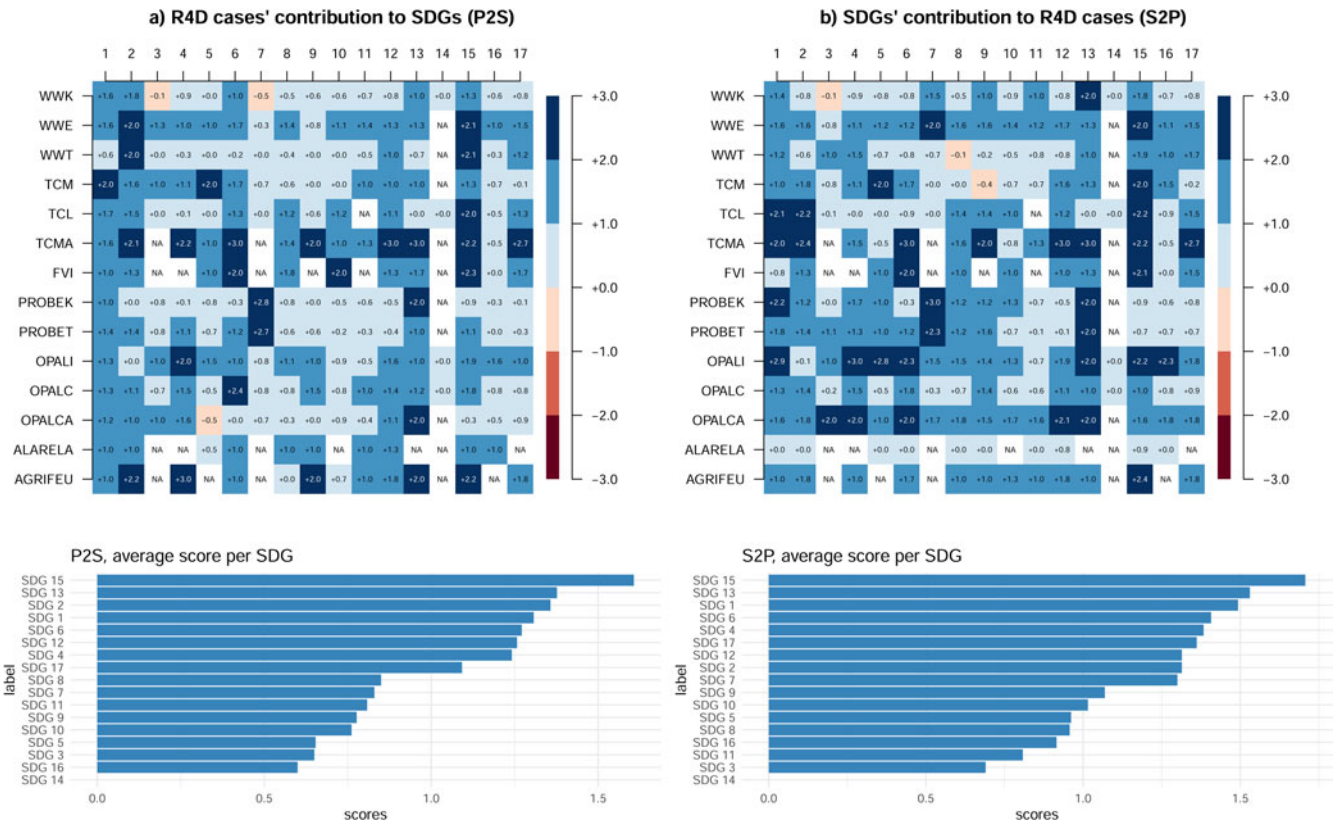

Figure 5. Average score of interaction (a) from project cases to SDGs, and (b) from SDGs to project cases. NA means that the importance of the interaction was rated as 0 (no importance) and that therefore the scoring assessment of the interaction was excluded from the analysis.

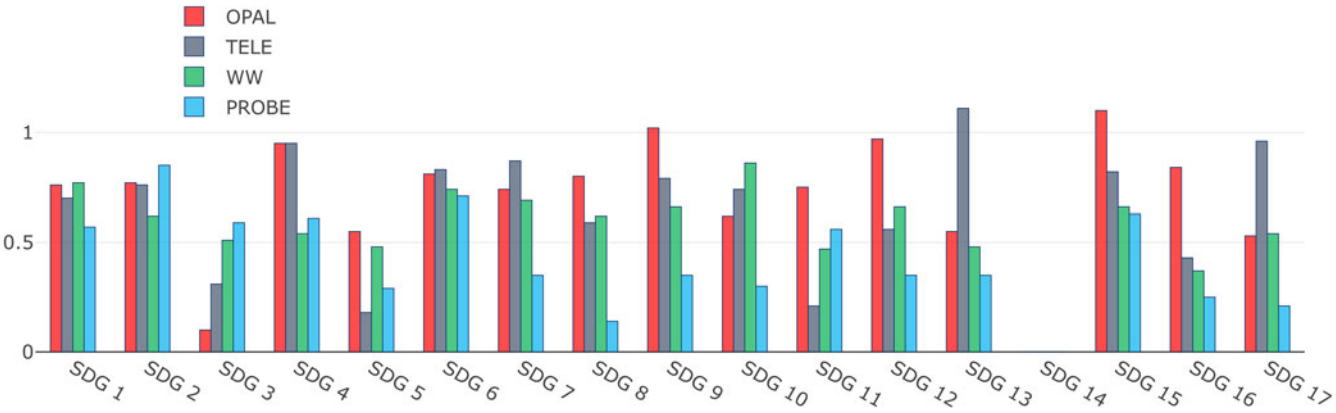

Figure 6. Intra-project average standard deviations of nature of interaction ratings. Only projects with more than one project case were included in the analysis. The standard deviation was calculated separately for each project (3 sites each for OPAL, TELE, and WW; 2 sites for PRoBE).

on the intra-project variabilities in projects with more than one project case and shows that these variabilities tend to be higher in projects with sites that are far apart (on different continents), such as the OPAL and TELE projects, though not for all SDGs. This could be an indication that, moving toward the global scale, contextual specificities gradually take precedence over thematic specificities in determining interactions with SDGs.

4. Discussion

There are pieces of evidence that environmental SDGs and SDG targets that rely on ecosystem services are under-prioritized (Custer et al., 2018; Scown et al., 2023). Despite the real effort to integrate environmental concerns into the design of many SDG targets (Elder & Olsen, 2019), the environmental components of sustainable development continue to be poorly monitored due to inadequate or insufficient indicators (Eisenmenger et al., 2020). In addition, unlike evidence-based, integrated approaches to decision making, political cherry-picking (Forestier & Kim, 2020) inevitably puts environmental SDGs in jeopardy (Dawes, 2020; Zeng et al., 2020).

And yet, our study has confirmed how pivotal land and natural resources are for the 2030 Agenda: sustainable land use, as broadly pursued by the 14 analyzed project cases, can hold many synergies for people and the environment across all SDGs (de Bremond et al., 2019; Turner et al., 2007; Young & Lutters,

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2015). Land plays a critical role in achieving several of the SDGs, and the pursuit of different SDG targets affects how land is used (Ehrensperger et al., 2019).

In our study, synergies of sustainable land use were by far more commonly reported than trade-offs, thus echoing the findings of the International Science Council, which conducted a detailed analysis of SDG interactions focusing on four SDGs (International Council for Science [ICSU], 2017). This conclusion is also in line with the Global Sustainable Development Report (GSDR) (Independent Group of Scientists, 2019), which states that addressing the 2030 Agenda in a holistic way offers a possibility to take advantage of synergies.

Our study shows that the objectives of the assessed R4D projects are consistent with approximately half of the 169 SDG targets of the 2030 Agenda, which means that they can be pursued in parallel without mutual positive or negative interference. Many of these consistent interactions concern socio-political and economic priorities, which were often interpreted by the respondents as not having an important footprint on land and therefore no major trade-offs with land-related project objectives. Such consistent interactions are less frequent with environmental priorities and hunger, which have an important footprint on land. The consistent interactions are also less frequent with poverty. The other half of the interactions between the assessed R4D projects and SDG targets are mostly synergistic. Beyond the obvious very strong interactions between project objectives and environmental targets of SDG 15, our results point to three ways in which synergistic interactions manifest themselves.

- **Universality**: in 11–13 project cases out of 14, SDGs with an obvious footprint on land (SDGs 2, 6, 13, 15, and partly to SDG 12), the goals of zero poverty (SDG 1) and of quality education (SDG 4) are strongly synergistic with the respective projects' objectives. The consensus is particularly high for SDGs 1, 13, and 15.
- **High indivisibility**: SDG 2 (zero hunger) is the goal with the highest share of indivisible interactions with project objectives, after SDG 15. This illustrates the strong interdependence between land systems and food systems, often taking the form of competing claims over scarce land resources.
- **Importance and cruciality**: Three targets that explicitly address the management of habitats, ecosystems, and resources (15.1, 15.2, and 12.2) emerge as those with the most crucial (indivisible and important) interactions with the projects' objectives. Respondents perceived that the success of their projects depends on the presence of effective and enforceable management frameworks. They also perceive their projects as important contributors to setting up such frameworks.

The results of our contextualized exercise of assessing interactions (see Figures 5 and 6) show that the only cross-cutting patterns that emerge are the predominance of positive interactions and stronger synergies between SDGs 1, 2, 13, 15, and the objectives of environmental r4d projects. Other interactions seem to be more context-specific. This confirms that while some recurring patterns can be used to inform global policies (Bennich et al., 2023), the regional complexity of pathways toward achieving several SDGs simultaneously needs to be taken into account when building scenarios of desirable futures (Bennett et al., 2021).

At the same time, the teams of experts participating in the rating workshops found the SDG framework useful to encourage and facilitate discussions on the concrete impacts of R4D projects on the ground and to identify crucial challenges of unsustainable development. This framework can be used for the rating of interactions between SDG targets and project objectives. Further, it can act as a stepping stone or a boundary object to facilitate exchange among stakeholders from different sectors. It can also be used as a basis for promoting local sustainable development policies.

5 Implications of our findings for policy and practice

5.1 Investing in SDG interaction competencies

So far, the idea of using SDG interactions as a framework for the design and implementation of R4D projects or sustainable development interventions has not been common. Only few countries use an interaction perspective in their voluntary national reviews on their national contributions to the 2030 Agenda (Breu et al., 2021). Similarly, funding agencies usually do not integrate an interaction perspective into their call documents and do not request an interaction-oriented evaluation and reporting from R4D project teams. As a result, project proposals and reports often do not go beyond the ticking of SDG boxes and usually do not address the interactions of development initiatives with other SDGs in the same location.

However, our study shows that a lack of a systemic perspective makes it difficult to develop a better understanding of the actual contribution of sustainable development initiatives and R4D projects to the achievement of the 2030 Agenda in a particular context. A first implication of our study for both policy and practice, therefore, is to invest in SDG interaction competencies of development practitioners, decision-makers, and stakeholders at various decision-making levels, that is, in the understanding of interactions and of their influence on envisaged development strategies. This requires a more assertive mainstreaming of transdisciplinary approaches toward identifying sustainability pathways. It echoes the findings of other scholars who concluded that assuming an interaction perspective should become standard practice for implementing the 2030 Agenda at a national level (Allen et al., 2021a).

5.2 Context and scale specificities

Our study shows that there are only few universal patterns among the interactions between project objectives and SDG targets in the 14 assessed locations. Further, beyond obvious regional differences, such as between the OPAL project cases in Colombia, Cameroon, and Indonesia, the scale at which SDGs and project objectives are tackled is likely to have an impact on how the interactions between the two must be factored into workable pathways. This is particularly so for interactions involving the more 'instrumental' SDGs 10, 16, and 17 (the 'overarching objectives' in the understanding of the GSDR report [Independent Group of Scientists, 2019]). This is substantiated by a recent study that compared expert-rated SDG interactions at the national scale in Colombia with sub-national assessments of these interactions in the department of Antioquia and found profound differences between the two assessments (Hernández-Orozco et al., 2021). Unfortunately, in our rating exercise it proved difficult to estimate the scale at which the impacts of development initiatives would manifest and whether this matches the scale at which the assessed projects are operating. The participating experts often did not have information on the scale of implementation of the development initiatives pursued by national governments or other actors.

The second implication of our study is that change agents in policy and practice must remember that the unique specificities

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of geographic, social, and economic contexts often overrule general conclusions about the interactions of various development goals within their contexts. Consequently, policies on sustainable development need to be flexible to integrate local realities, even when they claim to have national or universal validity. It would be valuable to build up a spatially explicit knowledge base to better direct national strategies and policies that foster investments into SDGs.

5.3 Cross-sectoral perspectives

Our study also confirms the need for cross-sectoral perspectives and strategies that integrate SDG targets in a holistic way. The most obvious example is the need for environmental R4D projects to account for and contribute toward reconciling the priorities of conflicting land claims related to food production and environmental protection. Beyond this often-indivisible interaction, development initiatives and R4D projects must integrate other development goals, in order to be successful. In other words, they cannot restrict their attention to environmental sustainability concerns alone.

The importance of such a cross-sectoral perspective is illustrated in a graphical synthesis (Supplementary material 1). Below, we summarize the main insights to be gained from this synthesis:

1. **Securing social foundations**: Stakeholders who are resilient (targets 1.5, 9.5, and 13.1) are much more likely to take risks in testing new and more sustainable practices or livelihood strategies, particularly if their basic needs (targets 1.1, 1.2, and 1.4) are secured. They are also more likely to change their behavior toward greater sustainability if they are aware of and understand the meaning of sustainability and if they perceive the benefits that they can derive – directly or indirectly – from it (targets 4.7, 12.8, and 13.3).
2. **Building enabling institutions**: Practitioners need to understand that their environmental initiatives take place in institutional settings that can hinder or favor their successful implementation. Settings that favor collaborative governance and allow stakeholders to shape a common destiny (targets 16.7, 17.14, 17.17) are more likely to build consensus on environmental goals. Similarly, settings with inclusive economic growth (targets 8.1 and 8.2) are more likely to foster diversification and thus reduce pressure on natural resources. Global partnerships (targets 17.6, 17.7, 17.9, and 17.16) are also a type of institutional setting that can help to deal with the multiple development claims of various and sometimes distant actors.
3. **Negotiating competing land claims**: Finally, practitioners need to be aware of competing land claims in the contexts in which they implement environmental initiatives. Such competing claims may be related to aspects of production (agriculture, forestry, or mining), which strongly depend on access to natural resources and land (targets 2.4, 6.4, 12.2), or aspects of consumption (targets 2.3 and 8.4), particularly their performance in terms of resource efficiency and waste production.

6. Limitations

In our study, we were unable to assess with certainty what elements might have influenced the rating results and how they can be properly factored into the analysis of future ratings. For example, we conducted the rating for a hypothetical landscape that can accommodate, side-by-side, different measures or actions aimed at meeting certain SDG targets. However, in a limited space (e.g. an agricultural plot), these measures or actions might clash. Thus, interactions that the 14 expert teams in our study rated as synergies could turn into trade-offs, illustrating the importance of the scale of assessment. For future rating exercises, it would make sense to agree on clear geographical system boundaries and assessment scales. Factors that might have influenced the rating of SDG interactions could include, but are not limited to, the breadth or focus of a project's objectives; the specific thematic lens through which the rating is conducted; the scale of activities toward the SDGs; the time horizon at which impacts might manifest, and whether those impacts are direct or indirect; and the disciplines represented in the rating. With regard to context, while our results indicate that geographical context influences the nature of interactions between the R4D projects' objectives and SDG targets, we are unable to distil which contextual variables – for example, economic development, climate, land tenure, etc. – could explain those differences.

7. Conclusions and future research

Our study shows that funding agencies could enhance the contribution of R4D projects toward achieving the 2030 Agenda by integrating a systemic 'SDG interaction perspective' into their funding mechanisms and calls. Ideally, this would take place at the design stage, for example, by requesting applicants to include an SDG interaction perspective or specific nexus of interest in their impact hypotheses or logical frameworks, and to demonstrate systemically how their transdisciplinary approach will – in concrete terms – contribute to fostering synergistic interactions or mitigating conflicts. That said, we are aware that project teams often face excessive demands and inflated expectations of project impacts, and it is not our aim to propose another level of complexity to an already overburdened endeavor. The integration of an SDG interaction perspective must therefore go hand in hand with a realistic and rather conservative prioritization of the sustainable development pathways to be addressed. Also, as it is unrealistic for one R4D project to address all the important interactions between their project objectives and other development priorities, funding agencies could increasingly support coalitions of – and collaboration between – several R4D projects working on complementary sustainable development challenges in the same geographic area.

In terms of future research, the different causal pathways that lead to changes in SDG outcomes need to be disentangled to better anticipate how synergies between several SDGs can be achieved. In particular, research into innovations for land use and land management options needs to be streamlined, to create synergies between investments into sustainable land use (SDG 15) and other SDGs. This could involve applying a transdisciplinary approach – building on or combining different approaches from the SDG interaction studies and involving academic and non-academic stakeholders – to investigate options for the co-design and co-management of sustainable land use interventions.

Supplementary material. The supplementary material for this article can be found at https://doi.org/10.1017/sus.2024.42.

Acknowledgements. This research contributes to the Global Land Programme (GLP). The research presented in this paper is part of the R4D synthesis process funded by the 'Swiss Program for Research on Global Issues for Development' (r4d program). The program is an initiative jointly

supported by the Swiss Agency for Development and Cooperation (SDC) and the Swiss National Science Foundation (SNSF). We wish to thank the expert teams in the 14 project sites and Justine de Groote, who participated in data analysis.

Author contributions. Albrecht Ehrensperger, Julie G. Zaehringer, and Myriam Pham-Truffert: conceptualization, methodology, formal analysis, data curation, writing original draft, visualization. Anne Dray: conceptualization, methodology, formal analysis, review. Ana Maria Roldan Ortiz, Beatrice Adoyo, Boniface Kiteme, Bruno Ramamonjisoa, Svitlana Lavrenciuc, Tri Ngo Dung, Fakhrizal Nashr, Fideline Mboringong, Harifidy Rakoto Rasimbola, John Richard Mbwambo, Ketema Bekele, Mélanie Feurer, Mesmin Tchindjang, Micah Ingalls, Nwenwe Tun, Thoumthone Vongvisouk: investigation and review.

Funding statement. This work was supported by the Swiss National Science Foundation (SNSF) through a mandate. Julie G. Zaehringer was supported by the Swiss Programme for Research on Global Issues for Development (r4d programme), which is funded by the Swiss National Science Foundation (SNSF) and the Swiss Agency for Development and Cooperation (SDC), under grant No. 400440 152167 and by the Wyss Academy for Nature.

Competing interests. None.

Research transparency and reproducibility. All data will be made available upon request.

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https://doi.org/10.1017/sus.2024.42 Published online by Cambridge University Press