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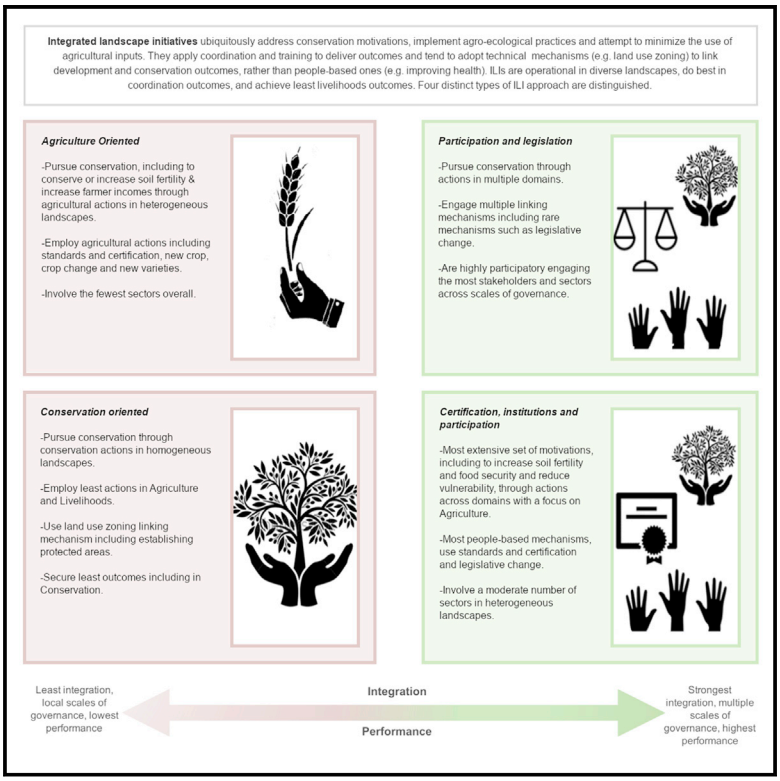
Characterizing and Evaluating Integrated Landscape Initiatives

Graphical Abstract



Highlights

- We characterize the diversity of Latin American integrated landscape initiatives
- Four distinct types of landscape initiatives exist along a spectrum of integration
- Strongly integrated approaches engage multiple sectors and scales of governance
- Integration underscores performance

Authors

Rachel Carmenta, David A. Coomes, Fabrice A.J. DeClerck, ..., James Reed, Bhaskar Vira, Natalia Estrada-Carmona

Correspondence

rachelcarmenta@gmail.com

In Brief

Integrated landscape initiatives (ILIs) are a leading approach to achieving sustainability across the tropics. Considerable diversity among ILIs has created uncertainty regarding what a landscape approach is, how it is pursued, and what outcomes it can deliver. We show that four distinct strategies exist, two of which are only weakly integrated and another two of which more ambitiously attempt integration, engage more sectors and scales of governance, and target the structural barriers to sustainability. We show that integration underscores performance.

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Characterizing and Evaluating Integrated Landscape Initiatives

Rachel Carmenta,[1,10,*] David A. Coomes,[2] Fabrice A.J. DeClerck,[3] Abigail K. Hart,[4] Celia A. Harvey,[5] Jeff Milder,[6,7] James Reed,[1,8] Bhaskar Vira,[1] and Natalia Estrada-Carmona[3,9]

[1]Conservation Research Institute, Department of Geography, University of Cambridge, Cambridge CB2 3QZ, UK
[2]Conservation Research Institute, Department of Plant Sciences, University of Cambridge, Cambridge CB2 3QZ, UK
[3]Productive and Resilient Farms, Forest, and Landscapes, The Alliance of Bioversity International and CIAT, Parc Scientifique Agropolis II, 1990 Boulevard de La Lironde, 34397 Montpellier, France
[4]The Nature Conservancy, 201 Mission Street, 4th Floor, San Francisco, CA 94105, USA
[5]Monteverde Institute, Apdo 69-5655, Monteverde, Puntarenas, Costa Rica
[6]Global Programmes, Rainforest Alliance, 125 Broad Street, 9th Floor, New York, NY 10004, USA
[7]Department of Natural Resources, Fernow Hall, Cornell University, Ithaca, NY 14853, USA
[8]Sustainable Landscapes and Livelihoods, Centre for International Forestry Research, Situ Gede, Sindang Barang, Bogor (Barat) 16115, Indonesia
[9]Farming Systems Ecology Group, Plant Sciences, Wageningen University and Research, 6700 AK Wageningen, The Netherlands
[10]Lead Contact
*Correspondence: rachelcarmenta@gmail.com
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SCIENCE FOR SOCIETY The sustainable management of tropical landscapes is critical for wildlife conservation and society at large. Integrated landscape initiatives are expected to deliver sustainable outcomes through integrating objectives and sectors to reconcile competing demands on land. These initiatives are widespread across the tropics and exhibit considerable diversity, leading to uncertainty regarding what a landscape approach is, how it is pursued, and what outcomes it can deliver. We show that four distinct strategies exist, two of which are weakly integrated, relatively local in scope, and dominated by a focus on agriculture or conservation. Another two types are more ambitiously attempting integration, engage more sectors and scales of governance, and target the structural barriers to sustainability. We show that integration underscores performance, and we offer the policy, practitioner, and research community an explicit set of strategies for selection, evaluation, and support.

SUMMARY

Sustainability agendas increasingly recognize that attaining conservation and development outcomes demands greater integration across sectors. Integrated landscape initiatives (ILIs) are a leading approach to reconciling multiple objectives. However, a characterization of the diversity of approaches under the ILI umbrella and the comparative performance of different types of approach is lacking. Here, we analyze questionnaire data obtained from project proponents to delimit four particular types of ILI: one type was dominated by agricultural interventions and another by conservation interventions, and these partially integrated ILIs engage local scales of governance; the remaining two types exhibit strong integration, with aims and actions across multiple sectors and scales of governance. We show that integrated projects were deemed to be more successful by project proponents. The typology offers the practitioner and research community an explicit set of strategies for selection, evaluation, and support and attests to the need for integration to achieve sustainable outcomes.

INTRODUCTION

Halting environmental degradation in tropical forest-agriculture landscapes is vital for biodiversity, climate-change mitigation, and water flow regulation, among other ecosystem services that provide many benefits to indigenous societies and humanity at large.[1–4] The focus on forest-agriculture landscapes is increasing in the international policy arena with recent commitments to halt deforestation (e.g., New York Declaration on Forests),[5] achieve large-scale restoration (e.g., the Bonn Challenge),[6] and emphasize the interdependence of the environment and human well-being (e.g., Sustainable Development Goals and Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services).[7,8] Such momentum is critical for achieving sustainable futures for people and nature. Nevertheless, environmental conservation remains an immense challenge and concerted, integrated, and immediate action is

necessary to protect ecosystems and avoid further transgression of planetary boundaries.[9,10]

Traditional approaches to environmental conservation, climate-change mitigation, and rural development have typically been sectoral in nature. For example, the establishment of protected areas to conserve biodiversity has been a leading strategy and can safeguard habitats and the species therein.[11–13] However, strategies focused on protected areas have inadequately considered the effects of leakage,[14] weak additionality,[15] and the significant burdens incurred by local communities, including opportunity costs, transformed cultural identities, and livelihood practices.[16–19] Focusing on agricultural intensification and livelihoods is another suggested pathway to forest conservation and is based on land-sparing principles.[20,21] However, the relationship between intensification and reduced demand for new land is inconclusive,[22] and potential perverse outcomes include incentivized agricultural expansion into forest areas,[23] higher costs of conservation,[24] negative impacts on farmers,[25] and contested externalities that detract from environmental gains.[26,27]

There is now widespread support and renewed recognition that forest conservation, and achieving sustainable futures more broadly, will require integration across scales and sectors.[10,28–30] Integrated landscape initiatives (ILIs) are approaches to landscape management that aim to reconcile the multiple objectives of agricultural productivity, conservation of ecosystems and wildlife, and improved livelihoods[31] by confronting sectoral thinking, managing trade-offs, and seeking synergies through selected investments, dialog, and negotiation across previously disparate sectors, stakeholders, and knowledge systems.[10,32,33] While conceptually appealing,[34] ILIs have thus far evaded prescriptive definition and there is only tenuous understanding of the distinctions among the diverse ILI strategies applied in practice.[31,35]

ILIs are often implemented as continuations of pre-existing interventions within project areas, and this adds to their diversity.[36] These historical legacies, and subsequent adaptations, may be evident in the stakeholders involved and the types of actions applied across the domains of agriculture, conservation, and livelihoods.[37] For example, while there is a broad understanding that ILIs seek to integrate land management across the spectrum of agricultural production and conservation needs at the landscape scale, they may distribute forms of management across individual parcels of land disproportionately, or apply distinct "linking mechanisms" in order to combine agricultural and conservation objectives. These "linking mechanisms" are also diverse; for example, they may involve business-like principles such as conditionality (i.e., making rewards conditional on conservation performance) or technical approaches such as land-use zoning (collectively referred to hereafter as technical coupling mechanism). Alternatively, linking mechanisms may involve particular types of agricultural activities depending on how they approach the relationship between agriculture and conservation (e.g., using agro-ecological practices or increasing inputs to boost yields and spare land for nature). Finally, they may tend toward people-based mechanisms that more explicitly engage a human dimension to build goodwill and trust (e.g., activities to improve health or gender equality).[24,25,38]

Despite the evident scope for diverse approaches to implementing landscape initiatives, performance assessments routinely subsume the array of ILI initiatives under blanket definitions (e.g., REDD+,[39] payments for environmental services,[40] climate-smart landscapes,[41] ILIs,[42–44] jurisdictional approaches,[45,46] or sustainable use reserves).[47] This weak characterization of ILIs and corresponding ambiguity of the term presents a significant challenge to performance assessment, weakens our understanding of whether integration does in fact lead to better and more diverse (i.e., cross-sectoral) outcomes, and may impede policy uptake since it is not clear what constitutes an integrated landscape approach.[43,48,49]

Here, we develop a typology of integrated landscape initiatives and assess their comparative performance in the domains of agriculture, conservation, livelihoods, and coordination. We apply multi-factor analysis (MFA) and hierarchical clustering on principal components (HCPC) to a regional, empirical dataset from 104 Latin American ILIs. Four distinct types of ILIs were defined according to the particular sets of motivations: the factors that led to their creation, the specific bundles of actions they pursued, and the stakeholders and sectors that they involved. We assess the cross-domain flow between motivations and actions and specific linking mechanisms through visualization by using Sankey plots—giving further insight into the particular strategies used by the four ILI types. Furthermore, we explore the relationship between ILI type and their performance by using a metric that captures outcome diversity reported by ILI proponents across a number of different domains (i.e., agriculture, conservation, livelihoods, and coordination). Latin America provides a particularly salient research context given its significant potential for agricultural expansion—together with diverse wildlife, high forest cover, and carbon stocks—and the contested nature of development trajectories in tropical forest-agriculture landscapes.[50] Our research questions (RQs) were as follows: (1) can distinct types of ILIs be distinguished; (2) what types of linking mechanisms (e.g., land-use zoning, increased agricultural inputs, and health care services) are employed by different ILI types to secure integrated outcomes, and what is their relationship to performance; and (3) what is the outcome diversity of distinct types of ILIs?

RESULTS AND DISCUSSION

Defining Integrated Landscape Initiatives for Inclusion

The ILIs included in this study were identified through a regional review of Latin American ILIs[42] and defined as projects, programs, platforms, initiatives, or sets of activities that (1) explicitly seek to improve food production, biodiversity or ecosystem conservation, and rural livelihoods; (2) work at the landscape scale and include deliberate planning, policy, management, or support activities at this scale; (3) involve inter-sectoral coordination or alignment of activities, policies, or actions at the level of ministries, local government, farmer and community organizations, civil society groups, donors, and/or the private sector; and (4) are highly participatory and support adaptive, collaborative management within a social learning framework.[42,44]

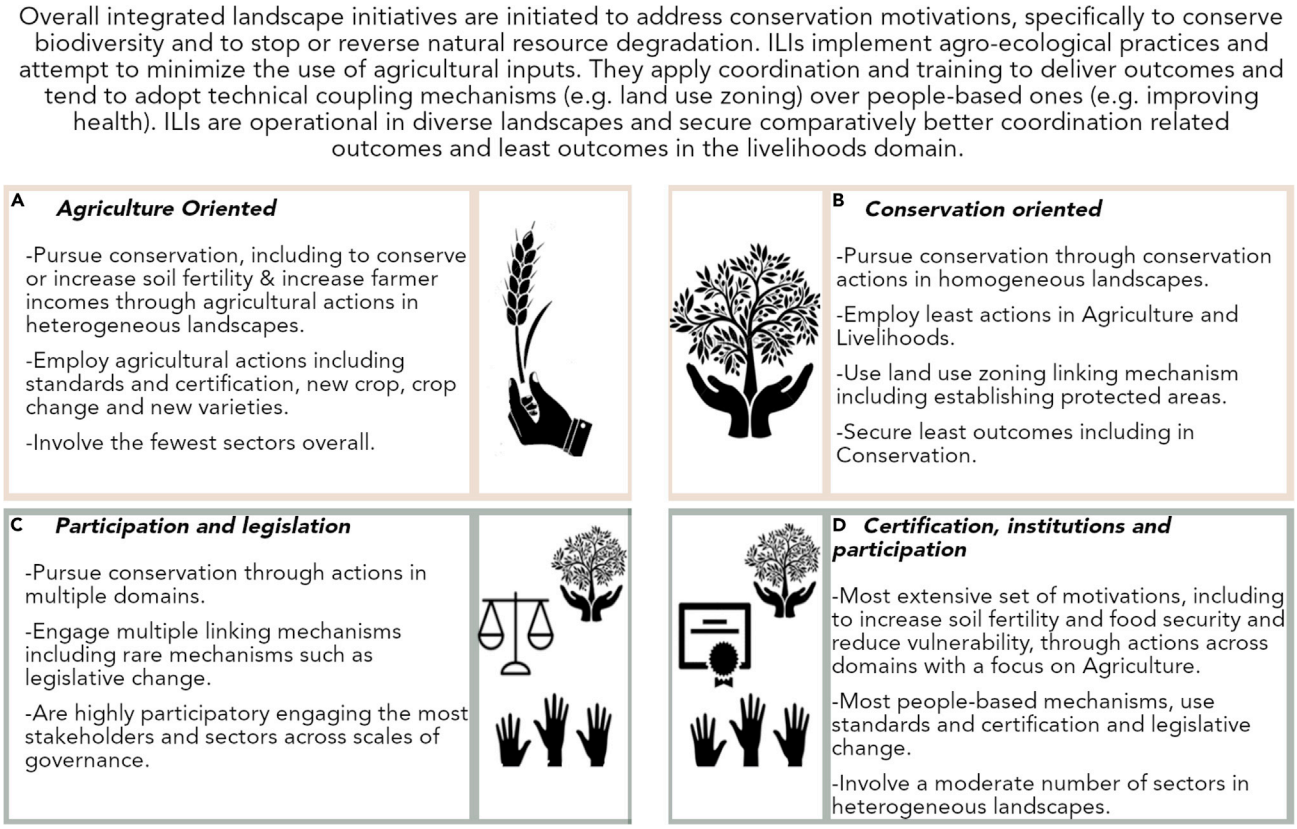

Figure 1. Four Types of Integrated Landscape Initiatives in Latin America

Integrated landscape initiative (ILI) types were distinguished by multi-factor analysis of data reported by project proponents. ILIs have common traits (top panel) and characterizations along the spectrum of integration from partial (A and B) to strong integration (C and D).

Data on Motivations, Actions, and Outcomes of ILIs

We collected survey data on 104 ILIs within Latin America and the Caribbean jurisdictions of Puerto Rico, Cuba, and the Dominican Republic (see Experimental Procedures). The dataset representatively samples nearly one-third of ILIs identified in the region (n = 382). The survey was delivered electronically to project proponents who reported on the ILI under their expertise. The survey captured data on the individual motivations that were considered important in leading to ILI creation, the specific actions applied on the ground by each ILI, and the perceived performance (i.e., outcomes across domains) of the ILI (see Table S1 for a full list of individual motivations, actions, and outcomes). The individual motivations associated with establishing ILIs addressed predominantly local concerns across domains (such as "conserve biodiversity," "food security," "reduce conflict," and "reduce vulnerability to extreme weather"), although these involve feedbacks relevant at global scales. The ILI performance score uses the outcomes perceived by ILI proponents across domains; hence, larger scores indicate more numerous outcomes. The motivation, action, and performance data were organized as individual responses in the survey and grouped across five domains: agriculture, climate change (for motivations only), conservation, livelihoods, and coordination (hereafter, the "domains"). Additional information (e.g., concerning the sectors and stakeholders involved and the land uses in the landscape) on the ILIs was also captured in the survey. Overall, 105 ILI variables were reported on by project proponents through questions that solicited categorical nominal, numeric continuous, and discrete responses. An additional 26 indicators were calculated for each domain linked to the motivations, actions, sectors, and stakeholders among other survey themes (see Table S1).

Commonalities and Distinctions between ILIs

MFA and HCPC using questionnaire data revealed four distinct types of ILIs that differed in the sets of individual motivations that led to their creation, in the actions they pursued, and in the sectors and stakeholders involved (Figures 1 and S1). The data variability explained by the first dimensions of the MFA and HCPC was around 27%, and bootstrapping with RandomForest indicated an overall low cluster classification error of 4% (Table S2). The clusters, hereafter referred to as ILI types, differentially emphasized actions and motivations within the five focal domains that were solicited in the questionnaire and ranged on an integration spectrum from partially to strongly integrated (see Table S3). Of the four ILI types, we identified two with only partial integration: (1) agriculture oriented and (2) conservation oriented. We also identified two that were multi-domain oriented and represented the strongly integrated approaches within the sample: (3) participation and legislation

and (4) certification, institutions, and participation. The four ILI types were also distinct in their association with additional themes captured by the questionnaire, including the land uses, sectors, and stakeholders involved (Table S3).

Some common tendencies were evident across the four types of ILI we identified (Figure 1). For example, all ILIs were motivated foremost by goals within the conservation domain. Individual conservation motivations that were cross-cutting included "conserve biodiversity," "stop or reverse natural resource degradation," and "enhance sustainable land management." ILIs routinely applied agro-ecological approaches to agricultural production (Figure 2). Overall, ILIs had the fewest actions in the livelihood domain except for training (i.e., non-agricultural actions such as those focused on gender equality, increasing equity, and securing tenure), confirming the need to better address human dimensions and equity in conservation and development initiatives.[8,25,51] Actions in coordination (e.g., creating new landscape organizing bodies) were also cross-cutting and used to pursue motivations in other domains such as agriculture and conservation (Figure 2). The apparent ubiquity of coordination actions, particularly for the strongly integrated ILIs, suggests that coordination is seen as central to engaging multiple, routinely disparate sectors with different visions and aspirations for landscape management.[10,33] This perceived need for coordination suggests that ILIs would benefit from sustained sources of support potentially beyond routine funding life cycles.[42] Despite these particular common features that were shared by all ILIs, important distinctions characterize ILI types and their strategies (Figure 2).

Partially Integrated Approaches to Landscape Management

The partially integrated types of ILI (agriculture or conservation oriented) resembled single-domain approaches, engaged predominantly local actors in their design and implementation, and were those with the lowest number of cross-domain motivations and lowest investments in actions across domains, evidenced in the lowest and below-average scores for investment index values (e.g., fewer actions across domains) (Table S3). These types also applied the least diverse mix of linking mechanisms (see Figure 6 for a full list of linking mechanisms), and while conservation motivations were cross-cutting, these types pursued their motivations differently either through agriculture-dominated actions (agriculture oriented) or through conservation and coordination actions (conservation oriented). Agriculture-oriented (n = 31, 30%) and conservation-oriented (n = 24, 23%) ILI types were respectively the second and third most commonly identified types of ILI in the dataset.

Agriculture-Oriented ILIs

Agriculture-oriented ILIs (agriculture) were primarily motivated by conservation (49% of all motivations) but were distinguished by individual motivations of increasing soil fertility and increasing farmer incomes. They were further characterized by seeking to achieve these motivations through actions in agriculture (59% of all actions), with only 6% of actions accounted for by conservation. Individual agricultural actions were commonly related to sustainable intensification through training or capacity building, agro-ecological intensification, soil conservation practices, and agroforestry expansion in the most heterogeneous landscapes (i.e., landscapes with higher land-use diversity) (Table S3). Agriculture ILIs distinctly tended toward linking mechanisms that were generally less common overall, including market-based approaches such as standards and certification and new varieties and crop change (Figure 2). The agriculture ILIs predominantly worked with local governance actors including the agricultural sector, and commonly engaged with the ministry of natural resources, conservation, or environment. They involved the least number of sectors comparative with the other ILI types. Stakeholders often involved during the implementation stage included local farmers or producers' associations and local or district government leaders and staff (Table S3).

Conservation-Oriented ILIs

Compared with the other ILI types, conservation-oriented ILIs (conservation) were the least integrated approach (Figure 2 and Table S3). These ILIs had the least motivations overall, predominantly adopted actions in conservation (36% of all actions) and coordination (35%), and had the least in agriculture (21%) and livelihoods (8%). Individual conservation actions included extension or capacity-building programs to support natural resource management and establish management plans for existing and new protected areas, whereas coordination actions included those to improve coordination, capacity building, and dialog (Table S3). Conservation ILIs also utilized the fewest linking mechanisms (Figure 3). Common linking mechanisms included coordination, planning, and mediation combined with land-use zoning. The conservation ILIs engaged local actors and often involved indigenous peoples and local nongovernmental organizations, particularly during ILI design stages. The sectors involved tended to be natural resources, conservation or environment, tourism, and health in the least heterogeneous landscapes (lowest number of minor land uses; Table S3).

Strongly Integrated Approaches to Landscape Management

The two strongly integrated ILI types (participation and legislation [participation] and certification, institutions, and participation [certification]) had the most diverse and numerous cross-domain links between motivations and actions (i.e., when a motivation in one domain is pursued by actions in another reflecting the integrated nature of domains), as well as the most individual motivations and actions within each of the domains (Figure 2 and Table S3). The strongly integrated ILIs were also primarily motivated by conservation (participation [32%] and certification [35%]) and particularly by motivations related to water quality and flow. However, conservation motivations dominated less overall than for the partially integrated ILIs. Rather, the motivating factors that led to ILI establishment and the actions pursued were more evenly spread across domains in the strongly integrated types (Figure 2). Overall, strongly integrated ILIs were associated with moderately complex landscapes representing many land uses, tended to engage more stakeholder groups and sectors (e.g., from agriculture to forestry to health) across scales of governance (from local to international), and invested highly in coordination actions. Integrated ILIs utilized more linking mechanisms than the partially integrated approaches, including those aimed at

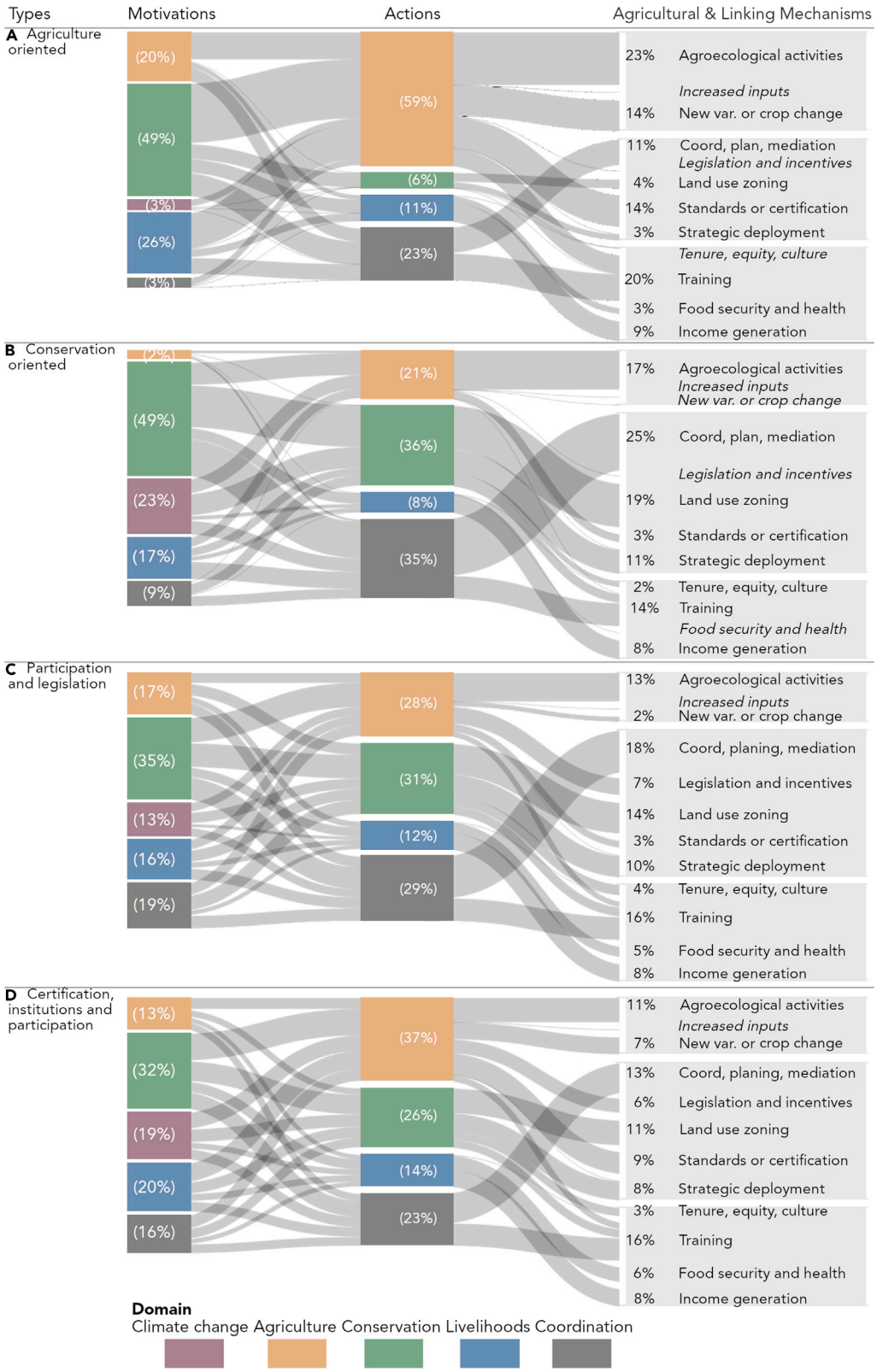

Figure 2. Relationships between Motivations, Actions, and Specific Linking Mechanisms across Latin American ILI Types

Strategies were identified through multi-factor criteria analysis and are expressed as the flows between the motivations that were instrumental to ILI creation (far left), the actions (middle) employed by ILIs to achieve their remit, and how the actions represent specific linking mechanisms (right).

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structural shifts through legislative change. Conservation motivations were pursued through more cross-domain relationships (Figure 2)—for example, the two strongly integrated ILIs tended to pursue agriculture motivations through conservation actions somewhat more than the partially integrated types. This suggests that these ILIs recognize the role of biodiversity in agricultural production and are reminiscent of land-sharing approaches to reconciling production and conservation.[27] These cross-domain relationships also suggest that the more strongly integrated ILIs most ambitiously attempt to manage system dynamics within complex social-ecological systems.[52] Our findings support the largely theoretical claims that integrated approaches outperform single-domain-focused approaches because landscapes are complex social-ecological systems influenced by diverse policy objectives beyond the conservation sector.[10,30,53]

Participation and Legislation

Participation and legislation (participation) ILIs demonstrated complex linkages between motivations and actions (Figure 2) and invested in a notably larger amount of actions in coordination (e.g., actions included dialog and conflict mediation among local communities or resource users and creation of landscape-coordinating bodies) in comparison with other types (Table S3). Participation ILIs had the highest involvement of stakeholders across scales of governance (local to international) and were characterized by their participatory approach. They had the greatest involvement of stakeholders during the ILI design and implementation stage (14 stakeholder groups), the highest number of sectors (six) involved (including agriculture, education, tourism, and health), and were associated with heterogeneous landscapes. In particular, participation ILIs were characterized not only by investing in establishing coordination bodies for the ILIs but also by agro-ecological intensification (agriculture domain), community-based natural resource management, management plans for existing or new protected areas (conservation domain), and activities to promote income generation (livelihoods domain) (Table S3). The use of the linking mechanisms of coordination, planning, and mediation; land-use zoning; agro-ecological activities; and training were most common, whereas those of food security, health, legislation, and incentives were rarely utilized (Figure 3).

Certification, Institutions, and Participation

The certification, institution, and participation ILI type (certification) was similar to the agriculture type in that they had a mutual emphasis on standards and certification and new varieties mechanisms, yet there was a key point of difference. Certification ILIs greatly emphasized participatory processes and stood out as the most ambitious in terms of attempting to integrate domains and objectives through cross-domain relationships (Figure 2). These ILIs were triggered by motivations across all domains, including to increase water quality or water flow, reduce the environmental impacts of agriculture, conserve soil or increase soil fertility, enhance food security, and reduce vulnerability to extreme weather. They invested in actions that were rare overall, notably including legislative change in the agricultural domain—an action with the potential to address structural change in support of sustainability. Certification ILIs also had comparatively numerous actions across domains in comparison with other ILI types (Table S3), including in agriculture (37%), livelihoods (14%), and conservation (26%) (Figure 2). Agricultural actions included certification of products, establishment of home gardens, promotion of native food species, and agricultural biodiversity. Conservation domain actions included watershed management and improved forestry management, whereas programs to improve gender equity, to secure land tenure, human health, and to reduce malnutrition and hunger were defining individual livelihood domain actions. These were in combination with capacity-building and training activities, dialog and mediation of conflicts, and technical assistance to support integrated landscape management (coordination domain) to name a few (Table S3). Furthermore, these ILIs utilized a diverse range of linking mechanisms, such as training, coordination, planning, mediation, and land-use zoning (Figure 3). They were applied in combination with standards and certification and people-based mechanisms (PBMs). Certification ILIs were associated with relatively diverse landscape mosaics and a moderately diverse set of sectors (including agriculture, education, forestry, and tourism).

Linking Mechanisms across ILI Types

Linking mechanisms were employed by all ILI types (Figure 3). The most common linking mechanisms overall were the technical coupling mechanisms (accounting for an average 49% of the linking mechanisms used by ILI types overall), notably through coordination, planning, and mediation, and followed by people-based linking mechanisms (31%), notably through training. The least common were the agricultural activity mechanisms (20%), which tended to involve agro-ecological activities (Figures 2 and 3). Agricultural mechanisms that involve increased agricultural inputs (e.g., crop intensification with increased mechanization, fertilization, and pest control) were rare overall and support the finding that ILIs generally adopt agro-ecological practices over conventional intensification. Land-use zoning, a technical mechanism that includes establishing new management plans or conservation zones, was also commonly applied by ILI types except the agriculture type. The dominance of agriculture within the agriculture type ILIs most likely relates to a farmgate focus and scale, reducing the perceived necessity to zone and coordinate.

The agriculture ILI type was also noticeable for its use of new varieties and crop change, an otherwise rare agriculture activity mechanism. There has been increasing interest in the potential contribution of certification schemes and "greening" supply chains as part of the toolkit toward sustainability.[37,54] However, the technical coupling mechanism of standards and certification was relatively rare; it occurred in the top five linking mechanism of only two ILI types (agriculture and certification) (Figure 3). Training was the people-based mechanism that was cross-cutting and prevalent, presumably to better involve and

Motivations and actions were reported by multiple choices given across five and four domains, respectively (domain). The size of the boxes indicates the percentage of ILIs within each type and each domain; percentages are specified inside each box. The thickness of the lines represents the number of ILIs holding the cross-domain relationships at each link in their strategy, displayed when cited by ≥20% ILIs within the ILI types (A–D). Italic font indicates where a linking mechanism was absent.

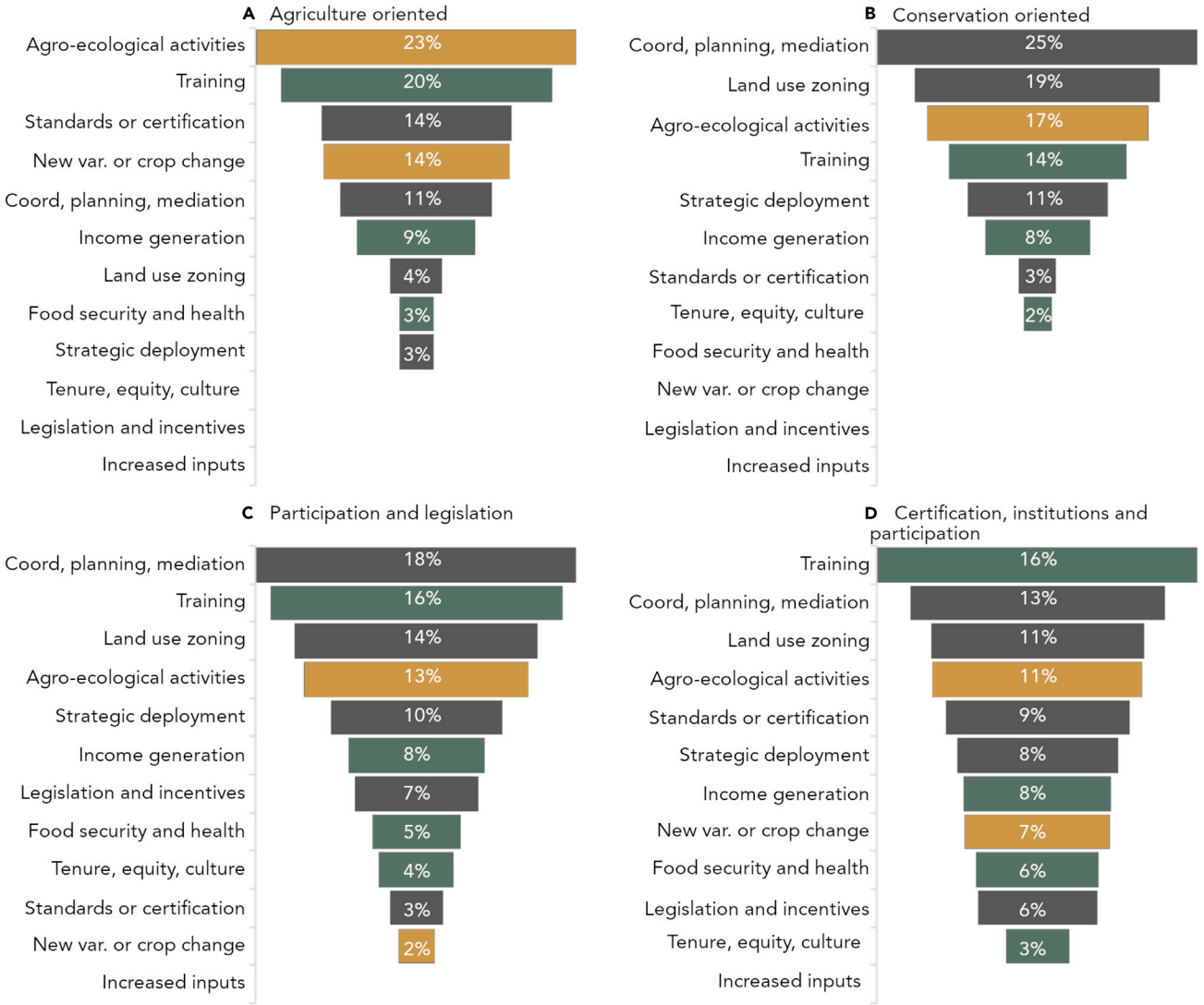

Figure 3. Distribution of the Linking Mechanism Used by Integrated Landscape Initiatives in Latin America

Agricultural (orange), technical (dark gray), and people-based (green) mechanisms used across distinct types of ILIs (A–D). Mechanisms present in >20% of the ILIs within each type are indicated.

enhance the capacity of local stakeholders in models of landscape management. Concerningly, other PBMs, particularly those associated with improving tenure, rights, equity, and culture, were less common across ILI types (Figure 3), possibly as a result of the apparent conservation legacy of the interventions that may impede stronger engagement with the human dimensions of sustainability challenges.

The strongly integrated ILIs (participation and certification) employed the most diverse combinations of mechanisms and were the only ILIs to attempt legislative changes within their actions, particularly the certification type (Figures 3 and 4). These data suggest that the more strongly integrated ILIs made more ambitious attempts to influence the structural conditions and remote drivers that influence attainment of conservation and development objectives in telecoupled landscapes.[10,28,53] This result is consistent with the finding that the most integrated ILIs are also those that engage most stakeholders across scales of governance (Table S3).

Integration Underscores Performance in Landscape Approaches

The strongly integrated multi-domain ILI types (participation and certification) reported a comparatively larger number of perceived outcomes than the partially integrated types (Figure 4). Table S1 presents the full list of individual outcomes (at the subdomain level) that were included in the survey and were used for calculating the performance metric. The performance metric serves as a proxy for performance because it will be higher for ILIs with more perceived outcomes overall than for those with fewer, even if both ILIs achieved 100% of their intended outcomes. However, the results show that the multi-domain, strongly integrated ILIs performed better than the less

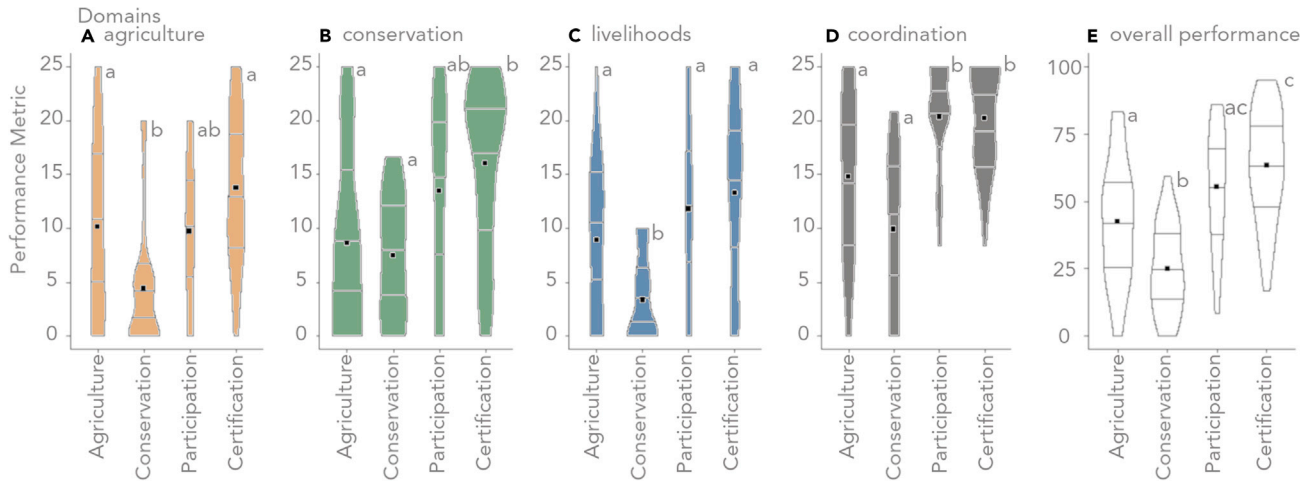

Figure 4. Performance of Distinct ILI Types

Violin plots of the distribution of performance metric scores (see Experimental Procedures) across distinct types of ILIs (agriculture oriented, conservation oriented, participation and legislation, and certification, institutions and participation) and for different domains: (A) agriculture, (B) conservation, (C) livelihoods, and (D) coordination. The graph (E) shows the overall cumulative performance metric scores (score scale 0–100). The thickness represents the proportion of ILIs in each type, and the dot represents the average performance score index of the ILI type. Different letters indicate that there is a significant difference between types (post hoc Dunn's test significance at p value < 0.05).

integrated types. Strongly integrated ILIs secured positive benefits across all domains and are thus making more progress toward the integrated outcomes thought necessary to reconcile conservation and development objectives. All ILIs reported outcomes across multiple domains, yet the certification type scored the highest performance overall, indicating a larger set of perceived outcomes within and across domains. Conservation type ILIs reported the lowest performance metric score both overall and within each domain (including conservation) with statistically significant lower average values for agriculture and livelihood domains (Figure 4). The weaker performance of conservation ILIs could be due to an overly biocentric focus, which is also understood to partly explain the perceived failure of the integrated conservation and development projects approach.[55,56] Of concern, the data indicate that livelihoods and agriculture are the domains with the lowest reported performance metric (Figure S2). This could be explained by the strong inter-linkages between the agriculture and livelihood domains resulting in cumulative outcomes shared across domains. However, the low performance in livelihoods and agriculture domains raises concerns around equity, particularly when combined with the evidence that ILIs are dominated by motivations for nature conservation over people, and perform best in the coordination domain (i.e., rather than local livelihoods). Despite these insights into livelihood outcomes, our data do not address knowledge gaps surrounding the impacts of agricultural intensification, or conservation interventions more broadly, on multi-dimensional human well-being or on the flow of nature's contributions to people and relational values between people and place.[25,40,57,58] Across domains, coordination had the highest reported outcomes (Figure 4), yet coordination itself is a means to an end rather than an end in itself.[33] Nevertheless, outcomes in coordination indicate that ILIs are achieving engagement between stakeholders. Such engagement suggests that ILIs are moving toward the coordination and mediation that will be necessary to reconcile competing demands for land use. ILIs are likely to necessitate long-term relationship and trust building to reconcile diverse stakeholder interests across sectors and scales. We show that the most integrated ILIs are achieving the greatest cross-sectoral engagement, involve more stakeholders across scales of governance, and address structural challenges. These are features not shared by the more local and less integrated ILI types. Furthermore, the long-term engagement required may be incommensurable with conventional funding mechanisms and time frames and require new models of support.[59]

Performance Scores and Linking Mechanisms

Linking mechanisms are considered cornerstones of success for "integrated" interventions because they can help ensure (e.g., through planning, rewards, or sanctions) that increases in agricultural production or profitability lead to sparing land for conservation, and address the people-based needs in a landscape thus supporting more equitable outcomes, social acceptability, and buy-in.[24,38,60] However, we found that the performance metric was inconsistently correlated with linking mechanisms across ILI types and had positive and significant (p value < 0.05) correlations in only a few instances (e.g., agro-ecological activity for participation and certification ILI types) (Figure 5). Strategic deployment of activities and income-generation mechanisms were positively related to the overall performance metric of participation and certification ILIs, respectively. Particular combinations of linking mechanisms appear to be used in some instances, for example, income generation with standards and certification. These results suggest that there is no panacea; rather, the influence of linking mechanisms is related to the combinations of mechanisms employed and their appropriateness to the context of each ILI.[61]

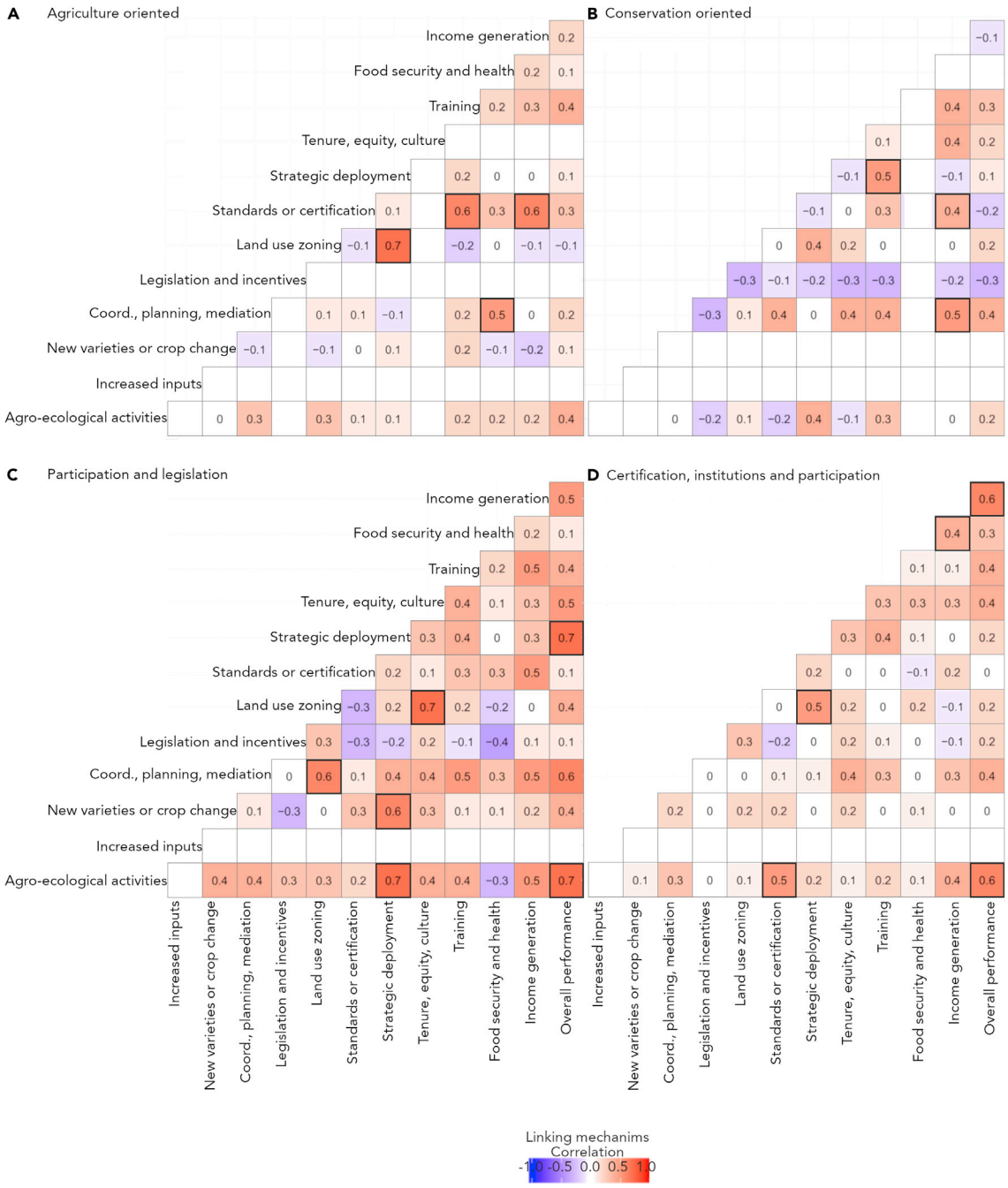

Figure 5. Correlation Matrix between Linking Mechanisms and Performance

The correlation matrix indicates cases where the use of one linking mechanism was associated with the use of another and with the performance metric scores across distinct types of ILIs (A–D). Numbers inside the squares indicate the correlation value, whereas the black outlined squares indicate significant associations at p value ≤ 0.05. Data are displayed only for common strategies—when linking mechanism combinations were applied by $\geq$20% ILIs in each type.

Conclusion

ILIs are a relatively recent innovation that aims to reconcile conservation and development objectives by achieving multiple outcomes within a given landscape through diverse strategies and integration across sectors.[31,42] On the basis of our assessment of 104 ILIs in Latin America, we have developed a typology that identifies the core attributes, and the distinctions, across landscape approaches. The typology is based on analysis of the motivations that led to the creation of the landscape initiative and the actions implemented. In an additional step, we assessed the comparative performance of the distinct types of ILIs by using survey data provided by ILI proponents and found that integration underscores performance.

Figure 6. Operationalizing Linking Mechanism from Original Survey Data

This figure demonstrates how each original survey response variable was recoded to map to the various linking mechanisms identified in the literature, specifically the (1) agricultural activity mechanisms, (2) technical coupling mechanisms, and (3) PBMs. Original survey responses are for ILI actions in the domains agriculture (A), conservation (C), livelihood (L), and coordination (Cd). The full survey is available in Estrada-Carmona et al.[42] Sources: *adapted from Rasmussen et al.,[25] **adapted from Phalan et al.,[38] ***adapted from Phelps et al.,[24] Duchelle et al.,[39] and Wilebore et al.[62]

Our analysis identified four distinct types of ILIs. These ILIs occupied a gradient of integration from partially to strongly integrated. Two ILI strategies (agriculture oriented and conservation oriented) demonstrated only partial integration. They were dominated by a single-sector focus toward either agriculture or conservation motivations and actions, respectively, and tended toward engagement at the local level. These ILIs are unlikely to be sufficient alone to deliver the transformational change and systematic shifts that are increasingly demanded to secure sustainable futures.[10,29,63] Two other ILI types demonstrated comparatively more cross-domain links and were more strongly integrated with motivations, actions, and outcomes across all domains. Of the two strongly integrated ILIs, one (participation) focused on a strategy involving legislative change and participation; the other (certification) focused on processes of certification, institutions, and participation. The strongly integrated ILIs were associated with more sectors and stakeholders across scales of governance and attempt the structural changes (e.g., legislative change) that are likely necessary for sustainable outcomes, particularly as tropical landscapes are ever more connected to distant drivers of land-use change.[53] This typology identifies an explicit set of distinct ILI strategies (flows between motivations, actions, and specific linking mechanisms) for diverse practitioners to select, support, and implement. We also show that ILIs have common core attributes; notably, all ILIs were predominantly motivated by conservation goals and used training, coordination, and agro-ecology to achieve these aims, and all were integrated to some extent.

Our analysis of the performance across types supports the hypothesis that integration is fundamental to achieving multiple gains in tropical landscapes. Notably, the two strongly integrated ILIs (i.e., participation and certification) scored better performance metrics within and across domains than the partially integrated approaches (i.e., agriculture and conservation). Overall, ILIs secured highest performance metric scores for coordination and mediation outcomes and did least well

delivering to local livelihoods. Our findings confirm that the current approach of referring to ILIs under one definition precludes an improved understanding of which sets of strategies work best for achieving integrated conservation and development outcomes.

Future analysis could triangulate the performance assessment provided here with geospatial analysis on the basis of remote-sensing-derived data or additional quantitative and qualitative datasets on agricultural, ecological, and socio-cultural performance to validate the accuracy of the performance assessment data. While our analysis provides the first attempt to distinguish different types of ILIs, it does little to fill the knowledge gap surrounding the impact of agricultural intensification, or conservation interventions and their integrated combinations more broadly, on the subjective and relational dimensions of human well-being that may be affected by interventions that alter the relationship between people and place (e.g., through modified use, access, and rights).[17,25,40,51] The scientific debate about what strategy is preferable for equitably achieving sustainability can be moved forward by expanding performance metrics to capture locally salient place-based indicators that include subjective and relational dimensions (rather than externally defined, predominantly material ones).[8,58,64,65] Indeed, developing multi-dimensional indicators that are locally salient but internationally relevant remains a contemporary research frontier.[58,66] Understanding more about how each type of ILI performs has important implications for practice and can allow for better selection of which bundles of actions to apply, advocate, and support. The sample does not reflect the true extremes of the spectrum of intervention types in forest agricultural landscapes (e.g., from forest protection to agricultural intensification). However, our findings suggest that if performance across these extremes followed identified trends, sectoral approaches of agricultural intensification or strict forest protection would likely have the least combined outcomes.[25] These insights are important considering that improving yields and closing yield gaps in the region, and elsewhere across the tropics, remain political priorities that drive many intervention actions.[67] We demonstrate the competitive advantage of ILIs and their potential role for contributing to combined outcomes in multi-functional landscapes.

Overall, the strongly integrated ILIs (participation and certification) were the most comprehensive in the sense that they engaged with policy and legislative change, utilized markets, engaged diverse scales of governance, and delivered to people through agriculture, conserving forests, social equity, human health, and land tenure. The lower performance metric perceived by proponents of the conservation and agriculture ILI types suggests that the single-domain style ILIs are inadequate when embedded in landscapes where multiple objectives co-exist and where strong drivers for land-use change operate. Indeed, integrated approaches are expected to better reflect the complexity of social-ecological systems, and integration is considered a necessary step for improving the performance, and equity, of environment-facing interventions.[68] For example, REDD+ has adopted an integrated type strategy in its jurisdictional approach and integrated landscape approaches advocate for the same, as does the contemporary restoration agenda.[31,45,69] However, while these features might create more potential for achieving the systemic changes necessary for transitions to sustainability,[67] even the strongly integrated ILIs in our sample routinely omit relevant sectors, including energy, roads, transportation, and infrastructure. These sectors will need to be engaged in landscape initiatives to achieve long-term sustainability due to their influence in determining land-use change decisions.[70,71]

EXPERIMENTAL PROCEDURES

Survey Data Collection

After the inclusion criteria definition of ILIs (see Defining Integrated Landscape Initiatives for Inclusion), survey data were collected between September 2012 and May 2013 from project proponents (including community leaders, international NGO representatives, or government officials). The survey requested that respondents differentiate between the "importance" of the motivations (categories were "very important," "important," and "moderately important"), define whether the actions were "core" (i.e., part of the landscape initiative itself) or "exterior" (i.e., undertaken by additional initiatives in the landscape), and offer a perception-based performance assessment of outcomes in each domain (agriculture, conservation, livelihoods, and coordination). Information was collected on additional themes, including the spatial features (e.g., area and location), context (e.g., age of the ILI), and the stakeholders involved at different stages of the ILI cycle (e.g., in design and implementation). Respondents were briefed on the mandate of the research project, which was to build a better knowledge base of the challenges, constraints, and successes of ILIs, and agreed to share representative insights on their cases. Nevertheless, all data are perception-based data offered from project proponents and therefore have potential for bias, although this approach has been applied successfully in other contexts.[72,73]

Coding Linking Mechanisms and Agricultural Activity Types

We drew on recent contributions in the literature that define specific actions used in conservation and development interventions to inform our appraisal and analysis of a typology of ILIs. Specifically, we coded the original subdomain response variables linked to ILI actions (Table S1) to the linking mechanisms employed by the ILI: (1) the agricultural activity types of Rasmussen et al.,[25] which specify the type of agricultural strategy (e.g., new variety and mechanization); (2) the technical linking mechanisms (e.g., conditionality and land-use zoning) of Phalan et al.;[38] and (3) the "soft" PBMs (e.g., supporting gender equality and improving health) of Phelps et al.,[24] Duchelle et al.,[39] and Wilebore et al.,[62] which are employed to generate goodwill, trust, and equity and that may ultimately induce compliance (e.g., in-kind incentives related to health care and income) (Figure 6). An additional goal of mapping original survey response options to these mechanisms was to provide insight regarding their prevalence, frequency, and diversity on the ground. The lead authors (R.C. and N.E.-C.) conducted the coding, and overall there was a good fit and a logical match, giving confidence to the reclassifications. In the two cases where discrepancy arose, discussion resolved differences.

Furthermore, we used data on the relationship between the motivations of ILIs and their actions to interpret the distinctions between the types (clusters) of ILIs in response to RQ1. We assessed the frequency of linking mechanisms and their correlation with performance in response to RQ2. Finally, we used the perception-based outcomes reported across the agricultural, environmental, livelihood, and coordination domains to assess the performance of each ILI type (in response to RQ3). All analysis was conducted in R.[74]

Characterizing Integrated Landscape Initiatives

We used exploratory MFA to classify ILIs in response to RQ1. MFA handles continuous and categorical variables simultaneously and balances the influence of different "themes" with unequal numbers of constituent variables, meeting the needs of the data.[75] The MFA included the full set of closed-ended responses from seven of the themes in the questionnaire, specifically (1) motivations, (2) actions (investments), (3) stakeholder groups involved, (4) sectors involved, (5) land uses, (6) mechanism created to support the ILIs, and (7) ILI management (e.g., base line and adaptive management). The MFA also included indicators calculated to account for the frequency of response

variables (e.g., total number of sectors involved). We analyzed the distances (from a multi-dimensional point of view) among individual ILIs from the MFA results with hierarchical clustering (presented as a dendrogram) on principal components (HCPC), which integrates clustering (Ward's method) and principal-component methods to better describe the characteristics of each cluster according to the significance of the different variables (Figure S1). The importance of the survey response variables and the calculated indicator variables was indicated by a statistically significant effect in explaining each cluster with the v test ($|v\ test| > 2$) (continuous variables) or a χ^2 test (categorical variables).[74] We assessed the accuracy of the clusters and calculated cluster classification error through the statistical classifier RandomForest (Table S3). We excluded the linking mechanisms and outcomes data in the MFA, HCPF, and Random Forest stage of the analysis. The next step was to characterize the clusters, which we enabled by identifying the most common (but not necessarily significant) motivations and actions within each cluster. This enabled us to better characterize each distinct type of landscape approach in terms of individual motivation or actions at the subdomain level that were either strongly associated to each cluster or common to the cluster (i.e., implemented by >50% ILIs but not significant) (Table S3). We used the R packages FactoMineR and RandomForest.[76–78]

Identifying the Strategies of Distinct Types of ILIs

To differentiate between the ILI types (clusters), we mapped the strategies they commonly employed (i.e., by >20% of ILIs), defined as the flows between motivations, actions, and specific linking mechanisms. For each ILI type, Sankey diagrams visualized the relationship between the motivations across the five domains reported on to the types of action domains reported and between the action domains to the individual linking mechanisms employed (i.e., the recoded action variables, see Figure 6).[79] Specifically, we graphed the sum of motivations and actions weighted by the total number of variables (i.e., options in the closed-ended questionnaire) per domain ranging on a scale from 0 to 1 to facilitate comparability (e.g., between domains with different numbers of variables). We did the same when graphing the linking mechanisms. The "very important" motivations and the "core" actions across domains implemented by ILIs were included in the Sankey graph (Figure 2).

Comparative Performance of ILIs across Types

We assessed the performance of ILIs and the relationship between performance and the linking mechanism employed by using the performance metric developed by Estrada-Carmona et al.[42] The performance metric quantified the relative number of self-reported outcomes in each domain (agriculture, conservation, livelihoods, and planning) and was calculated as the ratio of reported outcomes to the total number of possible outcomes (i.e., the total number of predefined choices in the questionnaire) per domain. We normalized the ratio for each domain to a 25-point scale and summed these scores to derive an overall performance metric, with possible scores ranging from 0 (no performance in any domain) to 100 (full performance, n22 subdomain level options, across all four domains). This metric does not reflect all of the outcomes potentially achieved by an ILI or the magnitude of the outcomes; neither does it account for the fact that each ILI may have a different number of intended outcomes at the outset. Nevertheless, it serves as a useful proxy for understanding the relative breadth of outcomes of each ILI across the domains and the level of multiple outcomes (or "inter-sectorality") of the ILIs across the typology. The Kruskal-Wallis test and the post hoc Dunn's analysis (dunn.test package)[80] are appropriate for unbalanced sample sizes and were used to test for statistical difference among performance at the domain level and across types. Pearson's (continuous) and point-biserial (binary) correlations assessed associations between the linking mechanisms employed and overall performance (the sum of the domains). We used the R packages ltm, ggcorrplot, and stats.[76,81,82]

Caveats

Our analysis must be qualified against the limitations of the data. Notably we report on outcomes and actions perceived by ILI implementers (rather than quantified measurements or assessments by independent third parties), an approach used in performance assessments yet one that has potential for bias since proponents engaged with projects perhaps sense an obligation to present a favorable view of the intervention.[83] Another limitation is that the survey design aimed to capture the breadth of ILI actions and outcomes rather than an exhaustive inventory and thus may omit particular activities (e.g., livestock related and access to credit), outcomes (e.g., non-material subjective and relational livelihood outcomes) and the extent that impacts were differentiated between stakeholder types. Finally, we have data from a single time-step for ILIs with diverse historic legacies and varying ambitions that demand different amounts of time to mature—a process we cannot address here.

DATA AND CODE AVAILABILITY

The full dataset is available at Harvard Dataverse at https://doi.org/10.7910/DVN/DVKMKH.

SUPPLEMENTAL INFORMATION

Supplemental Information can be found online at https://doi.org/10.1016/j.oneear.2020.01.009.

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AUTHOR CONTRIBUTIONS

Conceptualization, Methodology, Validation, Formal Analysis & Interpretation, Writing – Original Draft, Writing – Review, and Visualization, R.C. and N.E.-C.; Project Administration, R.C.; Data Curation and Funding Acquisition, N.E.-C.; Conceptualization, Funding Acquisition, and Writing – Review, D.A.C.; Writing – Review, F.A.J.D., A.K.H., C.A.H., J.M., and J.R.; Conceptualization and Funding Acquisition, B.V.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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