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PERSPECTIVE: ECOSYSTEMS RESTORATION IN LATIN AMERICA

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Transformative governance for linking forest and landscape restoration to human well-being in Latin America

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ABSTRACT

Tree planting and reforestation are currently in the spotlight as strategies for solving global environmental degradation. Many ongoing large-scale initiatives have proposed restoring millions of hectares and planting a trillion trees to solve climate change and biodiversity loss. Forest and landscape restoration (FLR) is one of the approaches most frequently employed to support these initiatives. Currently, many FLR initiatives are implemented in developing countries through a top-down approach, not fully anchored to the social-ecological characteristics of landscapes (e.g. land use and tenure, values of local peoples, local livelihoods), and sometimes relegating human well-being to a secondary concern. Therefore, issues of social equity and legitimacy might hamper the effectiveness of FLR initiatives and projects regarding their environmental outcomes. In this perspective article, we present four challenges to better link FLR and human well-being in Latin America: (1) the high dependence of local communities and countries' economies on natural resources, (2) conflicts over land tenure and access, (3) divergence in perceptions and values, and (4) the fragility of public institutions and policies. After describing these interrelated challenges, we discuss how to tackle them by implementing instruments and approaches recently organized under the concept of transformative governance. Finding an equitable and legitimate balance between global interests and urgency and increasing local well-being is the main challenge of FLR in Latin America, for which transformative governance is critical.

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1. Introduction

Global environmental degradation and the need to revert it have never been higher (Díaz et al. 2019). Tree planting and reforestation are currently in the spotlight in the political and scientific arenas as strategies for solving some of these complex environmental problems at the planetary scale (Sabogal et al. 2015; Chazdon et al. 2017; Holl and Brancalion 2020). For example, the Bonn Challenge seeks to restore 350 million hectares of degraded and deforested lands by 2030 (UN 2014), and the World Economic Forum aims to protect and restore one trillion trees by the same year (Goymer 2018). These large-scale initiatives currently occupy an important space in global discussions not only about climate change mitigation but also about biodiversity conservation and human livelihoods (Wilson and Calaganan 2016). However, the potential of large-scale tree planting and reforestation to deliver multiple socio-ecological outcomes has been highly debated and contested (Griscom et al. 2017; Baldocchi and Penuelas 2019; Brancalion et al. 2020). Many authors suggest that these ambitious restoration plans can be unrealistic, many expected outcomes not feasible to achieve, and poorly planned initiatives may result in unintended negative consequences (Brancalion et al. 2020).

The 20 × 20 Initiative, which was established in the Latin America region to support the Bonn Challenge pledges, is a multi-stakeholder arrangement that brings together governments, investors, researchers, and practitioners to restore over 50 million hectares (WRI 2014). This initiative bases its implementation on the Forest and Landscape Restoration (FLR) approach, whose primary goal is to establish multifunctional landscapes that improve the provision of ecosystem goods and services to support and enhance human well-being (Laestadius et al. 2015; Chazdon et al. 2020a). The FLR approach embodies four strategic activities: (i) participation (including stakeholders' engagement), (ii) adaptive management, (iii) monitoring, and (iv) capacity-building (Newton et al. 2012). Moreover, FLR encompasses six principles that guide its potential interventions and help differentiate it from other restoration approaches. These principles that guide FLR are: (i) focus on landscapes; (ii) engage stakeholders and support

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participatory governance; (iii) restore multiple functions for multiple benefits; (iv) maintain and enhance natural ecosystems within landscapes; (v) tailor to the local context using a variety of approaches; (vi) manage adaptively for long-term resilience (Besseau et al. 2018).

Promoting FLR in many regions of the Global South, such as Latin America (hereafter LA), is still challenging (Meli et al. 2017; Coppus et al. 2019; Romijn et al. 2019; César et al. 2020; Stanturf and Mansourian 2020; Chazdon et al. 2020b). Moreover, the promotion and effective implementation of FLR could learn from the limitations of other approaches that seek to restore forests. Within this context, in a recent review of 97 restoration projects in LA, Coppus et al. (2019) suggest that a large share of the projects, whether financed by international donors or national governments, take a top-down approach and do not explicitly seek to enhance the well-being of local communities. They found that local communities are often not included in the design and monitoring of restoration projects (Coppus et al. 2019). This has been reported for many countries, such as Colombia (Murcia and Guariguata 2014), Mexico (Méndez-Toribio et al. 2018), and Peru (Cerrón et al. 2017). Also, the development of national policies oriented towards restoration is currently lagging behind international initiatives in many countries in LA (see Schweizer et al. 2019a for a broader description of the situation in each country), and in many cases, there is no clear match among national and international objectives (Coppus et al. 2019). Hence, governance approaches that promote a better fit to the social-ecological conditions of LA and align the interests of many stakeholders operating at different levels can tackle the major challenges for FLR in the region.

Many studies have proposed principles and conceptual frameworks that might be useful to guide FLR, including ecological restoration (Suding et al. 2015), landscape planning and stewardship (Sayer et al. 2013; Reed et al. 2016; Bieling and Plieninger 2017), FLR (Brancalion and Chazdon 2017; Besseau et al. 2018; Molin et al. 2018; César et al. 2020), tree planting initiatives (Brancalion et al. 2020) and forest restoration (Strassburg et al. 2019, Di Sacco et al. 2021; Pandit et al. 2020). These principles might be challenging to apply in the complex social-ecological situation of LA, where the dialogue among multiple stakeholders is limited and large power imbalances characterize decision making. Although FLR principles are useful for designing and implementing restoration, reforestation, and tree planting initiatives, they might be more useful in the LA region if adapted and anchored to its specific social-ecological conditions. However, understanding the multiple and interconnected linkages between ecological and societal factors is commonly known as wicked problems (DeFries and Nagendra 2017; Edwards et al. 2017), and demands integrative approaches that incorporate both local needs and vulnerabilities (Melo et al. 2021). These problems generally do not have a clear-cut solution; conversely, the complexity that they encompass means that they should be tackled in an integrative manner by employing a set of approaches that can increase the likelihood of obtaining better socio-ecological outcomes. Recently, many of these approaches have been grouped under the concept of *transformative governance*, defined as "an approach to environmental governance that can respond to, manage, and trigger regime shifts in coupled socio-ecological systems at multiple scales' (Chaffin et al. 2016; Razzaque et al. 2019). Contrary to other approaches that have been developed within a political vacuum (Blythe et al. 2018), transformative governance explicitly considers that values, interests, and power are fundamental issues for promoting policies for socio-ecological transformation that are not only effective but also legitimate and equitable (Blythe et al. 2018; Razzaque et al. 2019).

In this perspective article, we aim to (1) describe the social-ecological conditions of LA that pose challenges for leveraging and enhancing FLR and, (2) identify how different options (approaches and instruments) recently grouped under the umbrella of transformative governance can help FLR initiatives contribute to promoting ecological integrity and human well-being in LA. This perspective article presents our viewpoints and experiences in different LA countries, supported by the current scientific literature. In the following section, we describe the social-ecological context of LA and how its characteristics are particularly challenging for leveraging FLR.

2. The socio-ecological context of Latin America and implications for forest and landscape restoration

Latin America constitutes a heterogeneous region in terms of its biophysical and ecological aspects, harboring huge biodiversity (Balvanera et al. 2012) and carbon stocks (Erb et al. 2017). It is one of the regions of the planet where the biocapacity (41% of global ecosystems) is higher than the human footprint (23% of global footprint) or, in other words, where the supply of natural resources is higher than its domestic demand (Rice et al. 2018). Latin America contains most of the global land reserves, that is, agriculturally suitable lands that have not been converted yet (Lambin et al. 2013). In the last three decades, the conversion rates of native ecosystems to anthropogenic land in LA countries have been among the highest globally (Hansen et al. 2013; Sloan and Sayer 2015). This conversion is due to their position

in the international division of labor as major food, fiber, and bioenergy exporters (Rice et al. 2018).

The high biocapacity, ecological diversity, and increasing pressure on natural resources in Latin America determine that feasible and successful FLR have to consider the social-ecological context where they are implemented (Brancalion et al. 2019; Meli et al. 2019a; Fischer et al. 2020). This context includes biophysical, economic, socio-cultural, and governance factors that may operate as barriers or facilitators for FLR implementation (e.g. Guariguata and Brancalion 2014; Huber-Stearns et al. 2017). In LA, the interplay of these factors determines four particular challenges for implementing FLR initiatives: (1) the high dependence of local communities and countries' economies on natural resources, (2) conflicts over land tenure and access, (3) divergences in perceptions and values, and (4) the fragility of public institutions and policies (Figure 1).

2.1 The high dependence of local communities and countries' economies on natural resources

LA countries' economies are highly dependent on the currency derived from commodity exports (Ocampo 2017). Several LA governments are also indebted and thus may be constrained by international financial institutions or commitments to engage in policies requiring market liberalization and increasing exploitation of natural resources (Svampa 2019). Besides, 81% of the farms and 23% of the agricultural area in LA are smallholder family lands (Leporati et al. 2014; OECD/FAO 2019) which rely on subsistence or semi-subsistence farming, hunting, and gathering (Haggblade et al. 2010). Although rural areas represent demographically only 18% of the population in LA, they contribute to 29% and 41% of the total number of people living in poverty and extreme poverty, respectively (Vakis et al. 2016; FAO 2018). The remaining 19% of the farms and 77% of the agricultural area comprises medium-size and large commercial farms (Leporati et al. 2014). Thus, in many LA rural areas two contrasting models coexist, an export-oriented production model with many local social-ecological negative consequences but considerable importance for countries' economies, and a local semi-subsistence farming model with low surpluses to trade in national and international markets, but with a critical contribution to local well-being (Hecht 2010). The coexistence of these two models is under frequent tension (Hecht 2010; Reboratti 2012; Aguiar et al. 2016).

The high dependency of LA economies and societies on natural resources will continue driving major and widespread losses in biodiversity and ecosystem services, with consequent negative impacts on local human well-being (Lapola et al. 2014; Barral et al. 2020). Recent trends in reforestation and the creation of protected areas are insufficient to countervail the impacts of ecosystem conversion for the expansion of commodity production frontiers (Curtis et al. 2018). The increases in forest cover in some places of LA do not compensate for widespread and significant forest loss in commodity production frontiers, nor are necessarily persistent trends of net forest cover increase, and in some cases are explained by forest plantations (Aide et al. 2013; Nanni et al. 2019). Some areas where forest cover initially increased but later decreased are present, indicating

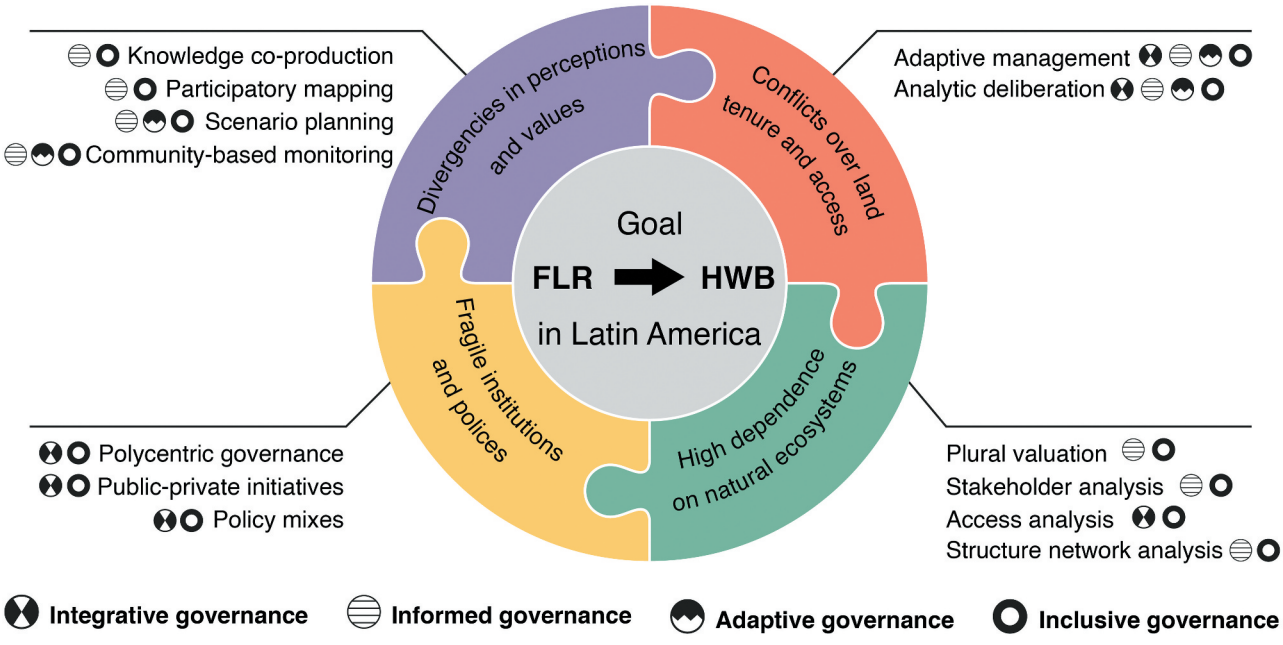

Figure 1. Four challenges (puzzle circle) and potential instruments and approaches for linking forest and landscape restoration (FLR) to human well-being (HWB) in Latin America. Icons show the four dimensions of transformative governance (see main text).

that some or all gains in forest cover in the early 2000s have been subsequently lost, even ten times more often than the sustained increases in forest cover (Schwartz et al. 2020). Also, the extent and representativeness of protected areas are still far from those suggested by international conservation targets (Baldi et al. 2019), and complementary public policies for reducing the conversion of natural ecosystems (e.g. land-use planning) are generally weakly enforced (e.g. Brancalion et al. 2016; Nolte et al. 2017; Aguiar et al. 2018).

FLR includes among its principles the promotion of multifunctional landscapes, where it is possible to reconcile food production and nature conservation, through agroforestry, mixed species plantations, natural regeneration in areas of low agricultural suitability, among others (Chazdon and Guariguata 2016). Despite that these systems are widespread through LA (Estrada-Carmona et al. 2014), and that their promotion and adoption are increasing (Peri et al. 2016; Tschopp et al. 2020), in many flat humid, and sub-humid areas, forest conversion, and degradation exceed by far forest cover increase and restoration (Curtis et al. 2018; Rosa et al. 2021). Therefore, it is challenging to increase tree cover in a region where there is a high pressure to convert forests into cropland and pastureland or where the human activities that underlie forest degradation (e.g. timber extraction, livestock production) are still widespread. Thus, the expansion of FLR is contingent on the decisions of multiple stakeholders to move towards national economies that rely less on the exploitation of natural resources. A precondition for FLR is to have a net positive impact on the balance among food production, nature conservation, and human well-being.

2.2 Conflicts over land tenure and access

Concerning the governance of LA rural territories, anarchic land use planning has been generalized, and access to land is often unequal and insecure (Rudel and Meyfroidt 2014; Guereña 2016). Postcolonial LA has been characterized by a weak implementation of centralized land-use planning by governments and the existence of a large share of land under insecure forms of land tenure schemes (Rudel and Meyfroidt 2014). In terms of land distribution, Latin America remains the most unequal region in the world (Gini index of 0.79), which also largely affects economic inequality since non-financial assets account for 64% of the total wealth (Guereña 2016). As a result, land grabbing and social-environmental conflicts are frequent and growing in LA (Borras et al. 2012; Rulli et al. 2013; Reboratti 2012; Scheidel et al. 2020). Besides, social-environmental conflicts in many cases lead to physical violence. For instance, the annual killings of environmental defenders have increased over the last fifteen years (Butt et al. 2019; Scheidel et al. 2020), many of them involved in agribusiness and mining conflicts (Haslam and Tanimoune 2016). Colombia illustrates how these issues present a challenge for restoration, as the current peace agreement includes ecological restoration and economic programs in areas with illicit crops (Suarez et al. 2018; Etter et al. 2020).

Land availability is critical for implementing FLR, particularly because most of the area is currently under agricultural use (Latawiec et al. 2015; Stanturf et al. 2015) and is expected to increase in the future (Lambin et al. 2013). Within this context, lands occupied by indigenous peoples and local communities are targeted for implementing restoration programs. However, external pressures, including tree planting, have triggered the appropriation and privatization of indigenous and local peoples´ lands (Ceddia et al. 2015, 2019; Brancalion et al. 2020), posing a threat to local livelihoods. For example, the Cerrado in Brazil and the Chaco in Argentina are experiencing increasing rates of large-scale agriculture-driven deforestation associated with the privatization of forest and savanna lands formerly occupied by indigenous and local communities (Faingerch et al. 2021; Jepson et al. 2010). Other examples are those areas of low agricultural suitability or abandoned where the natural regeneration of forests can be the most cost-effective strategy for increasing forest cover (Chazdon and Guariguata 2016). However, in many cases, the ownership of regenerating forests is contested (Chazdon et al. 2017), and they are often considered legally abandoned and therefore susceptible to squatters (Chazdon and Guariguata 2016). Thus, considering that a critical issue for FLR implementation is land availability, careful land planning and management are needed to accommodate additional tree/forest cover. Nevertheless, this accommodation should occur without bringing serious setbacks for people and the environment across different scales (Grau et al. 2013; Latawiec et al. 2015; Brancalion and Chazdon 2017), or even the conversion of native non-forest ecosystems by afforestation (Brancalion et al. 2020). Therefore, governments should consider ways to make enough land available for restoration without compromising livelihoods and land tenure security of local communities (Latawiec et al. 2015) by developing adaptable packages for farmers and landowners which do not constitute 'green land grabbing' (Perring et al. 2018).

2.3 Divergences in perceptions and values

In LA landscapes, a large diversity of social actors, including agribusiness and forestry companies, peasant farmers, and indigenous peoples coexist, often in conflict (Ellis et al. 2010; Hecht 2010; Reboratti 2012). The divergent perceptions, narratives, and values,

rooted in different cultural understandings of human-nature relationships, along with power asymmetries among these social actors are generally associated with disputes on natural resources management, with substantial impacts on poverty, environmental degradation, and social justice (Jacobs et al. 2020). For example, at least three contrasting sets of values and beliefs coexist in commodity production frontiers of the Dry Chaco forests, each of these supporting environmental discourses of development that are in conflict and underlie permanent social unrest (Seghezzo et al. 2011; Zepharovich et al. 2020). In Chile, restoration priorities diverge among different stakeholders; local communities give greater importance to ravines and creeks, experts to landscape connectivity, and experts and government managers to restoring areas of greater biodiversity (Castillo et al. 2020). In the Brazilian Atlantic Forest, similar narratives across different social actors and scales suggest that a focus on improving the economic benefits can aid in upscaling forest restoration. However, discrepancies among the narratives of different social actors highlight that negotiation is key for enabling FLR interventions (Schweizer et al. 2019b).

The recent entry of extra-local economic actors (e.g. transnational corporations) into once remote and unappealing rural areas might add another layer of complexity to social relations in LA forest landscapes (De Castro et al. 2016; Bartley 2018). The arrival of these new social actors is promoted by local and national governments, who often support policies that require the liberalization of markets and the privatization of public assets, using fiscal policies that finally favor investment rather than incomes and security for the poor (Fairhead et al. 2012). In this context, it is not clear whether and how transnational corporations bring challenges or opportunities for environmental sustainability in general (Folke et al. 2019), and FLR in particular (Brancalion et al. 2017). Hence, the implementation of FLR in LA and the definition of why, where, and how to restore forests and landscapes requires the negotiation among many social actors with contrasting values, knowledge, and power not only to ensure the effectiveness of interventions but also to embrace the potential conflicts and distribute benefits evenly (Guariguata and Brancalion 2014; Mansourian 2017; Sunderlin et al. 2017; Djenontin et al. 2018).

2.4 Fragility of public institutions and policies

The multidimensional nature of FLR, with its social, economic, and environmental goals (Sabogal et al. 2015), requires institutions to deliver coherent policies that are effectively, sustainably, and equitably enforced in the long term (Mansourian 2017). Public institutions and policies in LA are often fragile (Levitsky and Murillo 2009) and therefore present a central challenge for implementing FLR and increasing its contribution to human well-being. This fragility is expressed in at least five dimensions (Levitsky and Murillo 2009; Brinks et al. 2019): (1) *non-existence*, when there are no specific rules within public policies for affecting actors' behavior; (2) *insignificance*, when rules are legally enforced but do not affect social actors' behavior; (3) *non-compliance*, when actors (generally the powerful ones) chose not to enforce or accomplish the rules; (4) *instability*, when rules change at high temporal rates; and (5) *coherence*, when enforced rules are not well integrated among the different sectors (e.g. environment, agriculture, forestry), administrative levels or spatial scales. Many of these characteristics currently hamper restoration programs in LA and the Global South (Chazdon et al. 2020).

Most countries in LA lack national policies oriented towards restoration backing up international initiatives, although they count with some legal frameworks in the jurisdiction of either the agriculture or the environmental sectors that are useful to support FLR interventions (Schweizer et al. 2019a). Some countries have developed efforts to improve cross-sectorial communication and legislation and to develop innovative financial mechanisms to support FLR. Others have national programs or plans (e.g. Brazil, Colombia, Guatemala, Costa Rica, Ecuador, Mexico, see Méndez-Toribio et al. 2017); but some still claim for an urgent need for a national long-term strategic plan for FLR (Bannister et al. 2018).

Beyond legal frameworks, weak implementation capacities, insufficient funding, sectorial and social conflicts, political instability, and lack of transparency are critical impediments for effective policy implementation (Schweizer et al. 2019a; Stanturf and Mansourian 2020). Such levels of institutional fragility are not generally present in countries of the Global North (Levitsky and Murillo 2009) where FLR frameworks emerged (Mansourian and Parrotta 2019). Hence, it is necessary to adapt them to the messy social-ecological context of LA and its idiosyncrasies. The ability of LA countries to implement FLR is partially contingent on enabling legal frameworks that can promote such large-scale interventions, connecting national and international restoration aspirations adequately integrated and nested within national and sub-national programs (Meli et al. 2017), and partially on those initiatives and efforts based on local socio-political contexts and needs.

FLR has emerged as a social-ecological solution to promote desired features of altered landscapes like productivity, resilience, and sustainability (Brancalion et al. 2019). However, it requires transformative governance to overcome the barriers for implementing

FLR arising from the complexities of LA social-ecological contexts. In the following section, we discuss some potential approaches and instruments to tackle these challenges.

3. Transformative governance for leveraging forest and landscape restoration in Latin America and its contribution to human well-being

Transformative governance encompasses four intimately connected dimensions, namely integrative, informed, adaptive, and inclusive (Table 1, Chaffin et al. 2016; Razzaque et al. 2019; Visseren-Hamakers et al. 2021). In the following, we describe how each of these dimensions is associated with the challenges that FLR faces in LA and describe different potential approaches and instruments to address them and adapt current programs and policies, whether they are market-based, government, or mixed. We present different examples where these instruments and approaches have been used in restoration or conservation initiatives (Table 2).

Transformative governance needs to be integrative to jointly address social-ecological problems that involve many scales, locations, and issues (e.g. poverty and biodiversity conservation) (Visseren-Hamakers 2015). Regarding scales and locations, the spatial decoupling of the supply and demand of financial resources for restoration generally determines disputed interests between national and international funding agencies and local communities that participate in restoration initiatives (Brancalion et al. 2020). In addition, public policies are generally designed and implemented in fragmented silos (e.g. different ministries, market sectors, type of agricultural commodity), where synergies and trade-offs are not addressed. Many examples exist of missed opportunities to take advantage of potential synergies due to a lack of policy integration. For example, when policies aiming to control deforestation and those promoting conservation and restoration are designed or implemented separately (Ceccon et al. 2015; Meli et al. 2017; Schweizer et al. 2019a), and when restoration programs fail to contribute to the land tenure security of indigenous and local communities in charge of implementing them (Larson 2011; Larson et al. 2013; Notess et al. 2018). Although carrying forward restoration actions on lands with insecure tenure is generally not included in the conditions for an acquisitive prescription (i.e. usucaption), governments could promote public policies on this topic to consider restoration actions, in addition to residence time and other economic activities, as a condition for remedying titling defects. Overall, multi-level, cross-sectoral programs and policies are needed for balancing multiple goals in a region where the local dependence on ecosystem services is often in conflict with the national dependence on the exploitation and export of natural resources.

Many options have been described and used for conducting integrative governance, such as polycentric governance, public-private initiatives, and policy mixes, which could be combined for designing and implementing FLR programs and policies (Visseren-Hamakers 2015). The Atlantic Forest Restoration Pact in Brazil is a good and successful example of integrative governance in a public-private initiative (Table 2). This coalition, formed by over 260 stakeholders from different sectors of society (i.e. governmental agencies, private sector, NGOs, and research institutions) aims to restore over 15 million hectares in 17 states of the country (Brancalion et al. 2013; Ball et al. 2014; Pinto et al. 2014). Polycentric governance is another useful approach, frequently implemented in fisheries (Table 2). For instance, co-management approaches may allow the incorporation of multi-level institutions in the decision-making processes, by granting exclusive territorial user rights to artisanal fishers to manage benthic resources (Ebel 2020) or producing management plans that can operate at different geographical scales and different species or multiple species (Gelcich 2014). Agregar algo acá de como la

Transformative governance needs to be informed so that decisions and solutions regarding social-ecological problems are based on legitimate and credible knowledge. Although environmental decision-making is increasingly relying on scientific evidence, it primarily relies on biophysical or monetary valuation of nature through conceptual frameworks and models that do not account for other forms of valuation and knowledge (Turnhout 2018). These forms of highly technical approaches are generally conducted exclusively by practitioners with a scientific background. Therefore, the design, implementation, and monitoring of conservation and restoration initiatives generally exclude a significant fraction of stakeholders with other values and knowledge systems and consequently hamper the legitimacy of these interventions (van Oosten et al. 2019). Moreover, many scientists argue that a gap exists between research and implementation, where evidence-based solutions from the scientific sector are rarely applied successfully (Higgs 2005; Toomey et al. 2017).

Evidence is only one of the factors influencing decision-making (Pielke 2007) and is perceived differently among stakeholders according to their beliefs and experiences (Matzek et al. 2014; Newell et al. 2014). Therefore, it is necessary to include other factors such as values and local knowledge in decision-making and reconceptualizing science-policy interfaces. Thus, the linear model where science provides answers and solutions that are converted into interventions by practitioners and decision-makers

Table 1. The four dimensions of transformative governance and their characteristics based on Chaffin et al. 2016 and Razzaque et al. 2019.

Dimension	Characteristics
Integrative	It results from addressing the incoherence, trade-offs, and synergies between different societal goals that are generally reflected in governance structures, policies, and programs designed or implemented in different ministries or market sectors.
Informed	It results from addressing the different knowledge and information systems that are the basis for societal change by encompassing multiple values and forms of scientific and non-scientific knowledge that are credible and legitimate for all relevant stakeholders.
Adaptive	It results from addressing the continuous learning about social-ecological systems dynamics and adjusting their responses by enhancing resilience and capacity to adapt and cope with change and uncertainty.
Inclusive	It results from addressing the governing mechanisms that enable the participation of different stakeholders, improving the quality of the decision-making processes, and securing the equity and legitimacy of the decisions that are taken.

Table 2. Examples of case studies from Latin America using some instruments and approaches that may contribute to the transformative governance of Forest and Landscape Restoration. Integrative governance. Informed governance. Adaptive governance. Inclusive governance.

Instrument/ Approach	Transformative governance dimension	Case study	Description
Knowledge co-production		Garzón et al. (2020)	In this study, a group of local people was trained in ecological restoration by researchers from social sciences and biology to become "local scientists" and contribute to an education program in which local peasants restore landscape connectivity. This program helped to organize the propagation of native forest species and outplantings by the program participants.
Participatory mapping		Delgado-Aguilar et al. (2017) Uribe et al. (2014)	After identifying the most important ecosystem services used by the communities in the study area, their members indicated on a 3-D map where they access the different services (food, wood, water, tourism, hunting). The map showed the ecosystem services hotspots, identified priority protection areas, and provided guidance for developing specific forest management strategies, including restoration. Local communities were only willing to contribute information to the research if they were informed of the goals and results, and the community council had previously agreed with the objectives and activities of the research. The preferences of four different stakeholder groups were considered: general public, academic, non-governmental organizations (NGOs), and governmental officers were spatially modeled to identify their priorities. The final result was a map that identifies the preferable sites for restoration, where resources and efforts should be concentrated.
Scenario planning		Otero-Rozas et al. (2015)	This study assesses the understanding of the social-ecological system, its dynamics, and future management challenges by different stakeholders (e.g. women, men, young, old, local people, researchers) through participatory scenario planning. For this, it analyzes 23 case studies conducted in a wide range of social-ecological settings and concludes that participatory scenario planning has enriched environmental management and scientific research through building common understanding and fostering learning about the future planning of social-ecological systems.
Community-based monitoring		Ortega-Álvarez et al. (2018)	In this study, community-based monitoring was used to engage communities in identifying particular habitat traits that are ecologically relevant and important for their productive activities. Thus, it helped communities and stakeholders to design plausible and effective management guidelines and measure outcomes for sustainability
Polycentric governance		Ebel (2020) Gelcich (2014)	In this study, the authors analyzed the outcomes of a decentralized governance scheme through a co-management of benthic resources by granting exclusive territorial user rights to artisanal fishers. This decentralization allowed for integrating multi-level institutions with decision-making processes, empowering communities, and addressing uncertainty and complexity to foster resilient socio-ecological systems and create more equitable management outcomes. It created locally agreed-upon fishery management plans that can operate at different geographical scales and for different species or multiple species fisheries. It highlights the importance of having transparent and deliberative knowledge co-construction arenas as a condition to achieve more polycentric strategies.
Public-private initiatives		Brancalion et al. (2013) Ball et al. (2014) Pinto et al. (2014)	The Atlantic Forest Restoration Pact is a coalition of over 260 stakeholders. This initiative has allowed different sectors of society (i.e. governmental agencies, private sector, NGOs, and research institutions) to create a forum for public and private concerns regarding forest restoration. The initiative adopts a set of governance tools so multiple actors can implement key processes to achieve long-term restoration goals: (1) a national council, (2) an executive committee that establishes norms, rules, principles, and policies for the initiative operationalization, (3) six thematic work teams (i.e. scientific knowledge, policies, economics, financial resources, technical capacities, and divulgation), and (4) 18 regional units that evaluate and help to consolidate the restoration chain.
Adaptive management		Sims et al. (2014)	Adaptive management was employed to progressively redesign policies according to feedback from stakeholders and evaluations of these policies' functionality and impacts in a National Reforestation Program in Mexico. The guidelines of this program were revised each year by a multistakeholder committee. Also, adaptive changes in the program's criteria for eligibility and selection led to an increase in enrollment of lands for restoration.
Plural valuation		Arias-Arévalo et al. (2017)	A plural valuation to assess the environmental motivations (i.e. egoistic, biospheric, altruistic) and values that people attributed to the ecosystems and showed that environmental motivations and socioeconomic factors are associated with the expression of different value domains. The multiple values of ecosystems expressed by stakeholders helped tackle social conflicts and consider the diverse needs and interests of different social actors.
Structure network analysis		Alvim Sanches et al. (2021)	Network analysis was employed for understanding interactions of multiple social agents, governmental and non-governmental organizations, engaged in the restoration and protection of common resources. It showed that indigenous people have a fundamental role in questioning and advancing the outcomes of restoration efforts and monitoring the environmental impact on water quality of rivers and conditions of forests and other ecosystems surrounding indigenous lands. This participation strengthened the institutional arrangements and increased the chances of forest restoration efforts.

should be replaced by another (Toomey et al. 2017). A new model of interaction should account for multiple values and knowledge systems and be anchored on research-implementation spaces (Toomey et al. 2017) or hybrid forums (Callon 2009) where scientists, practitioners, decision-makers, and local communities interact (Horton and Brown 2018). There are many alternatives for approaching these interface spaces, among which post-normal science is one of the most well-known (Funtowicz and Ravetz 1993).

Many opportunities and options could aid research-implementation spaces. In LA most people working in restoration are related to science – civil – policy interfaces, being an excellent opportunity for better integration of science and policy (Meli et al. 2019b). The common presence of NGOs working on restoration in the region may also help bolster and strengthen these interfaces. Knowledge co-production is one of the increasingly promoted approaches for addressing contemporary sustainability challenges (Norström et al. 2020). A successful program in Colombia used knowledge co-production to plan, implement, and monitor forest restoration through training local people in ecological restoration by researchers from social and natural sciences to become 'local scientists' and further contribute to an education program in which local peasant farmers restore landscape connectivity (Table 2; Garzón et al. 2020).

There are also many instruments for bridging or weaving indigenous and local knowledge and science for conducting collective decision-making regarding the design, implementation, and monitoring of interventions. Among them, participatory-action research, participatory mapping and scenario planning, and community-based monitoring are some of the most widespread (Johnson et al. 2016; Tengö et al. 2017). For instance, participatory mapping may help to reveal and include the preferences of different stakeholders during the design phase. It has been used to define areas where restoration efforts should be focused (Table 2; Uribe et al. 2014), the ecosystem services that will be restored (Delgado-Aguilar et al. 2017), or even the future management challenges (Oteros-Rozas et al. 2015). Concerning implementation, the participation of Indigenous and Local Communities in restoration initiatives can lead to successful projects when the projects have a co-management approach and when customary institutions are recognized (Reyes–García et al. 2019). Finally, regarding monitoring, a recent review suggests that local people can accurately collect many kinds of data, which are impossible to gather through remote sensing (Evans et al. 2018). Moreover, they can do this at one-third the cost of professionals; thus, community monitoring can be a cost-effective strategy for increasing accountability, learning, and therefore, potentially enhancing legitimacy. Other reviews suggest that mixed-gender groups are more prone to participate in collaborative forest monitoring (Mwangi et al. 2011; Basnett et al. 2017), indicating that FLR might also contribute to inclusion and equity.

Transformative governance needs to be adaptive to cope with change, conflict, and uncertainty, especially those resulting from climate change and other global phenomena (e.g. COVID-19 pandemic). Adaptive governance includes processes of experimentation and learning to adjust responses to changing social-ecological conditions and under situations where the outcomes of interventions are highly uncertain (Folke et al. 2005; Chaffin et al. 2016). High political instability and social conflicts are widespread across rural landscapes in LA, making it necessary to design flexible and adaptive strategies for FLR in these contexts. The ideas and solutions designed for developed countries might not be easily implemented in LA countries, and more flexible, inclusive approaches are needed to cope with its context.

For FLR strategies to be adaptive, a mix of governance arrangements are needed, which include inclusive dialogue between stakeholders (analytic deliberation); complex, redundant, layered institutions (nesting); mixed institutional types (e.g. market- and state-based); and institutional designs that facilitate experimentation, learning, and preparation for change (adaptive management, Dietz et al. 2003). For example, in a National Reforestation Program in Mexico, a multistakeholder committee revised annually its guidelines, the criteria for eligibility, and the priority areas to restore, so adaptive management allowed progressively redesign policies, their functionality, and impacts (Table 2; Sims et al. 2014). Also, for deliberative methods to be effective, building trust and shared understanding among stakeholders is crucial. Functional redundancy among institutions is a crucial dimension since the political instability of LA determines that government changes might determine large financial cuts for actions that the previous government implemented. Therefore, the participation of NGOs and diversifying the funding sources might be a good strategy for coping with institutional instability, such as Brazil's current situation where the previous government made ambitious reforestation commitments, and the current is promoting deforestation (Da Cruz et al. 2020).

Transformative governance needs to be inclusive so that decisions and their outcomes are legitimate, accountable, and equitable. Inclusive governance enables the participation of stakeholders so that decision-making processes adequately address power relations due to class, ethnicity, or gender. For this, it is necessary to include multiple ethical (Bieling et al.

2020) and valuation perspectives (Zafra-Calvo et al. 2020), particularly of minority groups who are actually or potentially affected, directly or indirectly by interventions. Power and values are usually highly asymmetrical among stakeholders in LA, and FLR projects are not exempt from this situation (Mansourian and Parrotta 2019). Being transparent about underlying power relations and value systems and accommodating plural values and knowledge systems in decision-making widens collaboration and might increase the equity, effectiveness, and legitimacy of interventions (Pascual et al. 2014; Calvet-Mir et al. 2015; Wells et al. 2021). Therefore, it is necessary to define and monitor multiple indicators related not only to the biophysical effectiveness and efficiency of FLR interventions but also to its equity and legitimacy (Adger et al. 2005; McDermott et al. 2013; Pascual et al. 2014; Mansourian 2017). The collaborative definition and monitoring of these multiple outcomes can contribute to enhance synergies and reduce trade-offs among them (Pascual et al. 2014; Calvet-Mir et al. 2015; Evans et al. 2018). Conversely, not accounting for these issues can have undesirable consequences that can contribute to worsening pre-existing local conditions of inequality, injustice, conflict, and prejudices regarding government and NGOs interventions and motivations (Sikor 2013), and ultimately hamper ecological objectives (Von Kleist et al. 2019).

Accounting for inclusive governance for enhancing the contributions of FLR to human well-being can be guided by the four dimensions of social equity (McDermott et al. 2013; Pascual et al. 2014). These dimensions are *recognition* (accounting for diverse knowledge and value systems), *procedural* (inclusion of all stakeholders in decision making), *distribution* (addressing the distribution of costs and benefits of interventions), and *contextual* (surrounding conditions that affect the other dimensions). There are many helpful instruments for including these dimensions in the different phases of the programs and policies (Berbés-Blázquez et al. 2016). For example, stakeholder analysis (Reed et al. 2009), access analysis (Daw et al. 2011), and analysis of the structure of social networks (Buckingham et al. 2020) can be employed for assessing the knowledge and value systems of different stakeholders and the relationship among them and with nature. Deliberative processes (e.g. citizen juries, consensus conferences, and focus groups (Lienhoop et al. 2015; Dryzek and Pickering 2017) can be implemented for assessing the distribution of costs and benefits of interventions and for reaching minimum agreements that enable action and contribute to better social and ecological outcomes. Plural valuations are gaining importance to reveal the diverse values that people attributed to the ecosystems and thus helping tackle social conflicts and consider the diverse needs and interests of different social actors (Table 2; Arias-Arévalo et al. 2017; Jacobs et al. 2020; Zafra-Calvo et al. 2020).

Forest restoration is a cutting-edge area of policy-driven, solution-oriented research (Chazdon et al. 2017; Goymer 2018; Fischer et al. 2020). Many researchers (e.g. Bastin et al. 2019) and organizations (e.g. United Nations' Trillion Tree Campaign) have suggested ambitious objectives, such as planting a trillion trees worldwide (Goymer 2018). Although this simple solution seems attractive, its feasibility and potential social-ecological outcomes are uncertain and controversial (Brancalion et al. 2020). FLR is gaining momentum as an alternative, holistic strategy to tackle these global challenges but is not yet fully anchored to local social-ecological conditions and, therefore, may fail to promote multiple benefits for human well-being. Since the outcomes of FLR (as so do other restoration initiatives) depend on the complex interplay among their design, implementation, monitoring, and social-ecological context, the definition of what, where, and how to restore forests and landscapes requires specific approaches. Transformative governance is an umbrella under which many of these approaches and instruments have been grouped. Many of these approaches and instruments have proven to be useful in contributing to the success of conservation and restoration programs. For these approaches and instruments to yield expected outcomes it can take many years or even decades, as the transformation of institutions and behaviors is a slow process that adaptively redefines its goals as it proceeds. Despite this, their progressive inclusion will undoubtedly contribute to better outcomes of FLR implementation in LA. Although our article has its focus in LA, other regions of the Global South have a similar social-ecological context and challenges for the successful implementation of FLR (Chazdon et al. 2020, Stanturf and Mansourian 2020). Therefore, the instruments and approaches we present may be useful for FLR initiatives in other regions of the Global South.

4. Conclusions

Nature conservation and restoration are critical if humanity seeks to mitigate the current and projected adverse outcomes of climate change, biodiversity loss, and local livelihoods deterioration. Promoting FLR in LA will require innovative governance systems that embrace the region's ecological, social, cultural, and political idiosyncrasies, leveraging to revert historical degradation through large-scale reforestation, sustainable farming, conservation of both forest and non-forest native ecosystems, and valuing the human cultures that have historically developed in association with these ecosystems. Transformative governance has the potential to tackle these

idiosyncrasies and challenges and promote more effective, equitable, and legitimate solutions.

At the core of transformative governance is the idea that there are no panaceas, silver bullets, or simple solutions to tackle wicked problems such as the restoration of ecosystems in LA. Conversely, there are many options to increase the effectiveness, social equity, transparency, and legitimacy of interventions. Although these options seem complex and challenging to implement, many of them have proven to enhance restoration programs' social and ecological outcomes and similar initiatives worldwide. Each landscape might have unique socio-ecological conditions that require a proper diagnosis before the intervention. Here we contribute to identifying the components of the social-ecological systems where governance interventions can trigger desired changes towards linking FLR and human well-being in LA landscapes. The approaches and instruments of transformative governance require long-term shifts, something that might contrast with the urgent need to revert environmental degradation. However, the definition of where and how to restore and protect forest ecosystems should avoid the environmental pragmatism of short-term fixes that ignore local social-ecological conditions and the inherent complexities associated with the broad-scale, long-lasting transformations of land uses and practices. Finding an equitable and legitimate balance between global interests and urgency on the one side and increasing local well-being, on the other, is the main challenge of FLR in LA, for which transformative governance is critical.

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