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Review

Assessing Peru's Land Monitoring System Contributions towards Fulfilment of Its International Environmental Commitments

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Abstract: Land use change (LUC) is recognized as one of the major drivers of the global loss of biodiversity and represents a major threat to ecosystems. Deforestation through LUC is mainly driven by fire regimes, logging, farming (cropping and ranching), and illegal mining, which are closely linked with environmental management policies. Efficient land management strategies, however, require reliable and robust information. Land monitoring is one such approach that can provide critical information to coordinate policymaking at the global, regional, and local scales, and enable a programmed implementation of shared commitments under the Rio Conventions: the United Nations Convention on Biological Diversity (CBD), Convention to Combat Desertification (UNCCD), and Framework Convention on Climate Change (UNFCCC). Here we use Peru as a case study to evaluate how a land monitoring system enables environmental policy decisions which appear in the country's international commitment reports. Specifically, we synthesize how effective the ongoing land monitoring system has been in responding to current and future environmental challenges; and how improvements in land monitoring can assist in the achievement of national commitments under the Rio Conventions. We find that Peruvian policies and commitments need to be improved to be consistent with the 1.5 °C temperature limit of the Paris agreement. Regarding the Aichi targets, Peru has achieved 17% land area with sustainable management; however, the funding deficit is a great challenge. Even though Peru commits to reducing GHG emissions by reducing LUC and improving agricultural and land use forestry practices, it needs policy improvements in relation to land tenure, governance, and equity. Potential explanations for the observed shortcomings include the fragmentation and duplication of government roles across sectors at both a national and regional scale.

Keywords: national monitoring systems; land use; UN Conventions; national commitments; Peru

Citation: Boza Espinoza, T.E.; Salinas, N.; Cosio, E.G.; Tito, R.; Nina-Quispe, A.; Roman-Cuesta, R.M. Assessing Peru's Land Monitoring System Contributions towards Fulfilment of Its International Environmental Commitments. *Land* **2024**, *13*, 205. https://doi.org/10.3390/land13020205

Academic Editor: Francisco Manzano Agugliaro

Received: 10 December 2023
Revised: 23 January 2024
Accepted: 25 January 2024
Published: 8 February 2024

1. Introduction

Deforestation is the major driver of forest cover change in the tropics. Since 2000, 3.5 million square kilometers of global forest cover has been lost or degraded [1] and 17% of the mature forest area in the Amazonian basin has been cleared [2]. Forest degradation not only causes species extinctions [3], habitat degradation [4] and local climatic changes [5], but also affects the neighboring ecosystem structure and function long after it has taken place [3]. Different commitments and government efforts have boosted the combat of deforestation and protection of the remaining mature forests. Unlike degraded forests, the residual intact forests retain exceptionally important global environmental values, including habitat for endangered biodiversity, carbon sequestration and storage and freshwater supply capabilities, indigenous culture, and human health and welfare value [6,7].

Global initiatives, exemplified by the United Nations' Rio Conventions—Biological Diversity (CBD), Combat Desertification (UNCCD), and the Framework Convention on Climate Change (UNFCCC)—aim to strike a balance between development, wellbeing, and the planet's sustainability. While each convention has its defined goals and commitments, they are interconnected. For instance, addressing climate change can mitigate desertification and biodiversity loss, as climate plays a pivotal role in these [8] Introducing renewable energy technologies to reduce greenhouse gas emissions can alleviate pressure on land and forest biodiversity [9]. Combating deforestation can decrease net carbon dioxide emissions, land degradation, and biodiversity loss [10]. Prioritizing biodiversity conservation through restoration is crucial for reducing ecosystem degradation and countering climate change [11,12]. Collaborating and coordinating among the Rio Conventions ensures synergies that drive progress on all fronts. Since their inception after Rio 1992, countries have pledged to monitor and report the impacts of human activities, policies, and climatic pressure on their territories [12,13].

To achieve these commitment goals, land monitoring becomes an important tool for land use sustainability, in relation to the conservation both of natural resources and of the biodiversity of ecosystems [13]. The role of national monitoring systems to track land use dynamics (carbon, biodiversity, desertification) has become a key issue in the national and international environmental and development policy processes [14]. Now, more than ever, countries need to have efficient, effective, independent, and transparent monitoring systems [13] that allow them to measure and report data with the highest accuracy, consistency, and completeness possible [15]. By doing so, they promote measures and policies to redirect wrongdoing on the land [16] and help build trust among nations by transparently sharing their advances in fulfilling their international pledges. The case of Peru is a good example, where a laudable effort was made to generate REDD+ Measurement, Reporting, and Verification (MRV) systems to monitor forest dynamics [17–19], but lack of clear competencies and mandates among different governmental institutions prevented it from establishing a consistent, transparent, effective MRV system capable of surviving political shifts [20,21].

Geographic heterogeneity and climatic conditions make Peru one of the ten countries with the greatest diversity on the planet [22]. This territorial diversity represents, on the one hand, a series of vulnerable conditions such as the presence of fragile ecosystems: mountains, deserts, bays, wetlands, and cloud forests [23]. On the other hand, it represents a special wealth in terms of environmental products and services that contribute, among other things, to carbon sequestration and the adaptive capacity of populations [24]. However, Peru's natural wealth is under pressure because its dynamic socio-economic development is based on land use change and resource overexploitation, which undermine long-term environmental sustainability [25,26].

Major land use change in Peru is primarily caused by illegal logging [27,28] and agricultural activities such as palm oil monocultures [24,25], illicit crops, and migratory agriculture [26,29–31] which are rapidly and seriously affecting ecosystems and their biodiversity. Informal urban expansion into marginal lands is also causing an impact through land use change and increasing the population's exposure to potential risks from extreme weather events as a result of climate change [32,33]. All these activities cause deforestation and subsequently increase carbon emissions. The land use, land use change, and forestry sector (LULUCF) is an historically significant sector in greenhouse gas (GHG) inventories. Peru, in its GHG inventory, revealed that the country's total GHG emissions amounted to more than 205 million $MtCO_2eq$, where the LULUCF accounted for 53% of national emissions. The largest source of GHG emissions within the LULUCF was deforestation, accounting for 26.6%.

In this context, land monitoring efforts are essential to implement policies that can ensure sustainable development [34]. Land use policy instruments raised interest in their form of implementation and their potential effectiveness, depending to some extent on land monitoring systems to track intervention performance and forest condition [35]. Therefore, land use monitoring should focus on data collection for evidence-based policy improvement and adaptive management, as well as for securing the objective fulfilment of interventions. However, land use governance is a complex phenomenon, and its effectiveness can be explained only to some extent by the level and type of monitoring.

This manuscript evaluates how land monitoring systems in Peru contribute to the fulfilment of its international commitments based on a literature review. We seek to assess how Peru's land monitoring systems support the tracking of some fundamental land dynamics (carbon, biodiversity, desertification, restoration) and how they contribute to international reporting under the Rio Conventions. More specifically, we act on three points: 1. we summarize Peru's commitments under the three Rio Conventions (climate change, biodiversity, and desertification, including restoration pledges under Initiative 20 × 20); 2. we assess how the Peruvian land use monitoring system supports the country in monitoring and reporting its commitments; and 3. we identify the governance behind this monitoring system. To address these points, we have run a literature review, including official documents and websites. Moreover, to make this research more quantitative, we chose one numeric target for each convention and assess its performance based on the Peruvian land monitoring system. Our final goal is to help improve decision making on forest monitoring and land use management policies. As Peru faces greater challenges for the formulation and implementation of its adaptation actions and policies related to land use monitoring [36,37], our synthesis provides a basis for the best way to adequately gear these adaptation and mitigation efforts [38].

2. Material and Methods

2.1. Study Area

Peru has been recognized as one of the seventeen countries called megadiverse, for being joint owners of more than 70% of the planet's biodiversity [39], included in 6 biomes out of 14 recognized. Peruvian biodiversity is defined by the Andean Mountain Range, which runs north to south, dividing the country into three broad climatic regions (coast, Andean highlands, and Amazon rainforest) (Figure 1) [40]. Its great diversity is also due to its tropical location, the main ocean streams, and its complex orography, which defines environments differentiated by their altitude and climatic conditions [41]. The Andes create a complex of valleys, plateaus, and peaks with particular characteristics [42], which harbor 6.7% of all endemic plant species and 5.7% of endemic vertebrates, being at the top of biodiversity hotspots for conservation priorities [43]. The Tropical Andes is also important because its high biodiversity levels provide a great variety of ecosystem services, including carbon sequestration and water supply, among others [44]. Furthermore, the Humboldt marine current, with its cold water, and the Peruvian–Chilean subsurface stream, with seasonal warm waters on the north coast, provide Peru with a large diversity of climates [45] and also cause climatic variations that affect ecosystems [46].

Peru is characterized as a country with ecosystems particularly vulnerable to climate change, as it presents seven of the nine features recognized by the UNFCCC: it has (i) low-lying coastal areas; (ii) arid and semi-arid zones; (iii) areas exposed to floods, droughts and desertification; (iv) fragile mountain ecosystems; (v) disaster-prone areas; (vi) areas with high urban air pollution; (vii) economies largely dependent on income generated from the production and use of fossil fuels [47]. Peruvian mountain, rainforest, and coastal ecosystems are extremely vulnerable to climate change as they are highly adapted to specific climatic conditions that vary little from year to year [8]. Climate change has been projected to affect freshwater resources, glaciers, biodiversity, ecosystems, agriculture, infrastructure, and human health and wellbeing [48]. In particular, the availability of freshwater resources has cascading impacts on other sectors. Increased glacial melt in the

Peruvian Tropical Andes, which is associated with climate change, is projected to cause significant reductions in water flow as early as 2030 [49]. Likewise, temperature increases have several impacts on natural ecosystems. These changes are forcing lower-elevation ecosystems to shift upwards [50], encroaching upon highland-endemic species and ecosystems and increasing the risk of extinction for high-mountain species [51]. The length and severity of the dry season and rising temperatures are magnifying the impacts of fire regimes by increasing the size and frequency of fires in the Tropical Andes [52], especially by common traditional human practices such as the opening of new agricultural lands and the renewing of existing pastures [52]. Tropical forest degradation caused by fires promotes major alterations to ecosystem composition, structure, and function and is one of the main sources of carbon emissions [53]. Moreover, extreme events such as El Niño–Southern Oscillation (ENSO) as well as air movements and water temperatures in the Pacific Ocean, drive the interannual climate variability in Perú [54], having an influence on the global variation in tropical rainfall patterns [55]. Overall, tropical ecosystems are being altered at unprecedented rates by land use changes for agro-commodity expansion [56]. In 2020, primary forest loss in the Peruvian Amazon surpassed 190,000 hectares [57] and deforestation reached its highest rate in 2 years, mainly driven by agriculture, silviculture, and cattle ranching, and, in a lesser proportion, by selective logging, coca farming, and artisanal-scale gold mining, which are often difficult to detect [58]. In summary, there is an acute need to monitor (Table 1), among other issues, (1) carbon stocks and fluxes, (2) deforestation and degradation, (3) biodiversity loss, (4) forest areas and growing stock volumes, (5) changes in biodiversity status, land use, carbon stock, and ecosystem services, (6) cropland and mining expansion patterns, to improve climate change mitigation and adaptation strategies, as well as to reduce reporting uncertainties. Although the last decade has seen considerable progress in land use monitoring, there is still much room for improvement.

Figure 1. National forest inventory description: map showing the six Peruvian ecozones and selected grids. to collect information Monitoring variables being evaluated up to date.

Table 1. Monitoring needs for reporting to Rio Conventions.

Agreements		
UNFCCC	**CBD**	**UNCCD**
❖ Carbon stocks ❖ Carbon fluxes ❖ Land uses ❖ Land use changes (deforestation, forest degradation, and post-deforestation land uses)	❖ Species number (richness) ❖ Threaten species number. ❖ Biological diversity status ❖ Biological diversity loss ❖ Ecosystem services ❖ Habitat degradation and fragmentation ❖ Genetic diversity ❖ Genetic erosion of species	❖ Degraded areas ❖ Land use change ❖ Agricultural soils ❖ Agricultural practices ❖ Natural and cultivated pastures. ❖ Forest fire risk ❖ Desertified, degraded, and drought-affected lands. ❖ Conserved and recovered forest areas

2.2. Material and Methods

This analysis is mainly based on a systematic literature review of official documents and websites with mapping resources (see Appendix A Table A1). To ease understanding, we chose one commitment per convention (see next section on commitments) and followed up a series of variables to characterize the monitoring systems involved, their institutional affiliations, the country's current performance in achieving the different pledges, and plausible opportunities for improvement.

We revised twenty-three national reports, strategies, action plans, and internal documents that we have gathered to capture Peru's commitments under the Rio Conventions and Initiative 20 × 20, including their temporal horizons and links to access them. We also consulted official websites with mapping outputs (e.g., INFOCARBONO, GEOBOSQUES, and GeoServidor) to follow up on monitoring achievements and their influence on reporting. From all the documents revised, we analyzed in more detail the following: Peru's Nationally Determined Contributions (NDCs), Biennial Update Report (BUR), National Communications (NC), Forest Reference Emission Level (FREL), National GHG Inventory and REDD+ safeguards, Peru's National Strategy for Biological Diversity (NBSAPs) and its Plan of Action 2014–2018, and the Peruvian National Strategy to fight against Desertification and Drought (NSCDD) 2021–2030, Peru's Land Degradation Neutrality (LDN) country report, and downloaded data and maps from geoportals.

Peru's land use monitoring and reporting efficiency were evaluated by analyzing three different indicators: forest monitoring capacities, land use change monitoring capacities, and emissions reporting capacities. The first two indicators show the capacities to implement a carbon stock assessment and to monitor forest area and land use changes. The third indicator explores the implementation of and synergies in international reporting.

3. Results and Discussion

3.1. Commitments

Since their creation after Rio 1992, the signatory countries of the Rio Conventions have committed to monitor and report the impacts of human activities, policies, and environmental pressures on their territories [12]. Therefore, the role of national monitoring systems in tracking land use dynamics (carbon, biodiversity, desertification) has become a key issue in the national and international environmental and development policy process [14]. With the ratification of the Paris agreement and the 2020 resubmission of the NDCs to advance low greenhouse gas emissions and climate-resilient development, Peru reaffirmed its commitment to conduct concrete actions to counter climate change. Last year, Peru presented an update of its NDC for the period 2021–2030 and announced it will raise its targeted unconditional reductions from 20% to 30% by 2030, and from 30% to 40% for the conditional goal. To achieve this, the Peruvian national contributions set an unconditional goal of limiting GHG emissions to a maximum level of 208.8 $MtCO_2eq$ in the year 2030 (Table 2).

However, GHG emissions in 2020 were already surpassing this rate by 89.5 MtCO_2eq. In this context, The Climate Action Tracker (2021) has rated Peru's climate targets and policies as "insufficient", pointing out that its policies and commitments need substantial improvements to be consistent with the Paris agreement's 1.5 °C temperature limit.

Regarding biodiversity conservation, Peru has committed to have at least 17% of its land area with sustainable management within the Aichi targets of the CBD. This target was fully accomplished by the country in 2020, as 17.3% of the national territory (22,645,810.5 ha) corresponds to natural protected areas, according to the National Service of Natural Protected Areas by the Peruvian State (SERNANP) (Table 2). However, the greater challenges for natural protected area performance lie in funding deficits and inefficient coordination and communication, together compounded by inadequate on-site management and logistical and technical capacities [59]. On the other hand, natural protected areas play an important role in the forest conservation strategy in the Amazonian region, where deforestation is increasing at high rates [60,61]. If this trend persists, natural protected areas may only help to reduce, rather than stop, deforestation [62,63]. Despite Peru technically fulfilling its commitment to protect more than 17% of its territory, most of the protected areas are in the Amazon. In general, it appears that forest conservation will not be sufficient to preserve its fundamental functions and biodiversity; actions must also take into consideration recovery efforts based on local populations [20]. Negative effects might be potentiated by the fact that Peru lacks a national biodiversity monitoring system, a valuable tool to generate spatial and temporal information on biodiversity and on the impacts of environmental changes.

Peru has been making progress in the development of instruments to combat desertification and drought within the framework of the UNCCD, whereby Peru recognizes the concept of Land Degradation Neutrality (LDN) as part of its environmental approach and offers the opportunity for the incorporation of planning and sustainable land use in public policies. Under this agreement, Peru commits to reduce GHG emissions by reducing land use change and optimizing agricultural and land use forestry practices. However, Peru requires policy improvements, taking into account issues like land tenure, governance, and equity and the potential environmental impacts associated with oil palm industrial-scale plantations [26,30]. On the other hand, Peru made a voluntary commitment to increase forested land titles for indigenous peoples to 5 Mha for those who hold legal, communal, or customary rights, support zero deforestation, and conserve 54 Mha of forest by 2021. Instead, the Peruvian government declared oil palm cultivation of national interest in 2000 (DS N°015-2000-AG) and in 2016 began the process of approving the National Plan for Sustainable Development of Oil Palm 2016–2026, which is a policy instrument of the Ministry of Agriculture (MIDAGRI) that will guide the medium- and long-term actions of public and private actors linked to the oil palm production chain. Fortunately, the approval of this document remains stationary until now. In this context, MIDAGRI has the authority to grant public land owned by the State to private companies for agricultural production such as oil palm if the land is classified as agricultural. Thus, land use decisions related to the distribution of large-scale agriculture play an important role in driving deforestation patterns, generating a significant challenge for the conservation of critical ecosystems [26,64].

Table 2. List of Rio Conventions—Red: target performance, Orange: target NOT achieved or unlikely to be achieved, Green: target achieved or likely to be achieved.

UNFCCC										**Performance**	
Commitment	**Baseline Year**	**Horizon Year**	**Indicator**	**Data Available as**	**Temporality**	**Competent Institution**	**Institution in Charge of Reporting**	**Reported under**	**Report Frequency**	**Indicator in Baseline Year:**	**Indicator in Horizon Year:**
Reduce 30% of GHG emissions linked to LULUCF sector	2010	2020	$MtCO_2eq$	National Estimation Reduction potential ($MtCO_2eq$)	1 year	NDC Working Group	MINAM	NDC	5 years	170.6 $MtCO_2eq$	298.3 $MtCO_2eq$
CBD											
At least 17% of the land area with sustainable biodiversity management	2013	2021	land area with sustainable biodiversity management	Percentage of area under Natural Protected Areas	--	MINAM	General Directorate of Biological Diversity	NBSAP	20 years	12.04%	17%
UNCCD											
3.5% of agricultural soils of intensive use recovered	2015	2030	Agricultural soils of intensive use degraded	NIR AGRICULTURA Prorest Censo agricola	--	MIDAGRI	Directorate General of Agricultural Environmental Affairs (DGAAA)	National Action Program to Combat Desertification and Drought 2016–2030 (PAN)	LDN	No data	No data
Initiative 20 × 20											
2 million hectares of reclaimed land will be productive forest plantations where exotics are allowed	2008	2024	Plantations areas (ha)	Map of priority sites for restoration	1 year	MIDAGRI	SERFOR	National Reforestation Plan	--	15,500 ha	909,500 ha

In Latin America, Initiative 20 × 20, created at the Conference of the Parties in Lima (COP20), derived from the Bonn Challenge. It establishes that member countries prioritize the recovery of degraded lands as a strategy to achieve sustainable development for the benefit of rural populations. Initiative 20 × 20 aimed at restoring 20 million hectares by 2020, expanding to 30 million by 2030. Its current pledge includes 52 million hectares [65]. In 2015, Peru began the planning process for the restoration and recovery of degraded lands; and in 2016, Forest Landscape Restoration was implemented, supported by the International Union for Conservation of Nature (IUCN), with the Restoration Opportunities Assessment Methodology (ROAM) as a basis for the planning process at the three levels of government (national, regional, and local) [66]. Peru committed itself to restore 3.2 million hectares of degraded land by 2030 [67]. From those, 2 million hectares of reclaimed land will be for productive forest plantations where exotics are allowed, and 1.2 million hectares will be recovered for agriculture, including the restoration of land subject to overgrazing (200 kha) or salinization (300 kha) (Table 2). Under this scenario, the Peruvian government implemented the National Strategy for the Restoration of Degraded Ecosystems and Forest Lands (ProREST 2021–2030) as a programmatic and guidance tool for management implementation actions. ProREST included broad and diverse participatory mechanisms. The actions consider various land uses with different approaches to soil management and conservation and the use of agroforestry systems, including the management of secondary forests. Agroforestry usufruct concessions (AFUC) could make a potential contribution to restoration; however, the fundamental attributes of the program need to be made clear in order to secure its contribution to national restoration targets [68]. The analysis showed that ProREST represents, in general, a substantive advance in terms of restoration, since it will be a fundamental instrument to develop, guide, and implement restoration initiatives in the coming years.

3.2. Monitoring Systems and Support to NDC Pledges

Land monitoring has become a key issue in the environmental and development policy process at the domestic and international scales [69], especially in tropical countries where rates of deforestation and cattle expansion are high, are growing [70], and have global consequences for planetary budgets (e.g., 11 percent of global GHG emissions in 2020, respectively) [71]. The significant role of forests in climate change mitigation, as recognized in the Paris agreement (2015), makes it increasingly important to develop and evaluate methods for monitoring, evaluating, and reporting emission levels and mitigation efforts.

The UNFCCC recommends a stepwise method for emission reduction estimates. It allows flexibility in using the available data (as a starting point), while improving capacities and reducing uncertainties over time (moving up in different tiers of estimating carbon stock changes)—a pathway that may vary depending on a country's circumstances. National forest carbon inventories form an essential part of fulfilling a country's international pledges. As Peru's national forest inventory has not yet been fully implemented, MINAM, through its National Forest Conservation Program (NFCP), invited private institutions, governmental and non-governmental organizations, public institutions, and academic institutions to collect and provide forest inventory data to estimate carbon stocks at the national level (only Peruvian Amazon) for FREL. In this respect, Peru currently does not have Tier 2 level estimates for carbon stocks in non-forest categories and lacks spatially explicit information on these categories for the years included in the historical reference period of the proposed FREL (2001–2014). In contrast, Peruvian BUR 2019 has used a Tier 1 level because only basic activity data is available, taking default factors in most of the calculations. However, for all change categories, national carbon stock values have been used for forests' carbon stocks prior to conversion to other land uses. In 2009, it was pointed out that Peru had medium engagement in the UNFCCC REDD process, with an advanced completeness of the GHG inventory and a very good forest area change monitoring capacity; however, there were national forest carbon inventory needs to be established for moving to Tier 2 [72]. Nothing has changed; Peru needs to develop some more steps to move to Tier 2, such as implementing field sample plots to derive allometric data for biomass and to identify key categories of national carbon stocks. In addition, coastal dry ecosystems are clearly under-monitored, as only the Peruvian Amazon has been monitored and reported (Figure 2). The tropics also host some of the largest peatlands on the planet (Cuvette Central in the Congo River, the Southeast Asian Peatlands, and Pastaza Marañon in Peru) [73], whose degradation by draining, future fragmentation, and fire have global consequences [74]. Tropical peatlands' key role in the global carbon cycle as significant carbon storage sites [75,76] makes their monitoring, sustainable management, and conservation of extreme importance. However, their management in Peru is very limited and only carried out by local populations/stakeholders. Despite the peatlands' importance as an important potential carbon source, they are still not included in national carbon stock estimations.

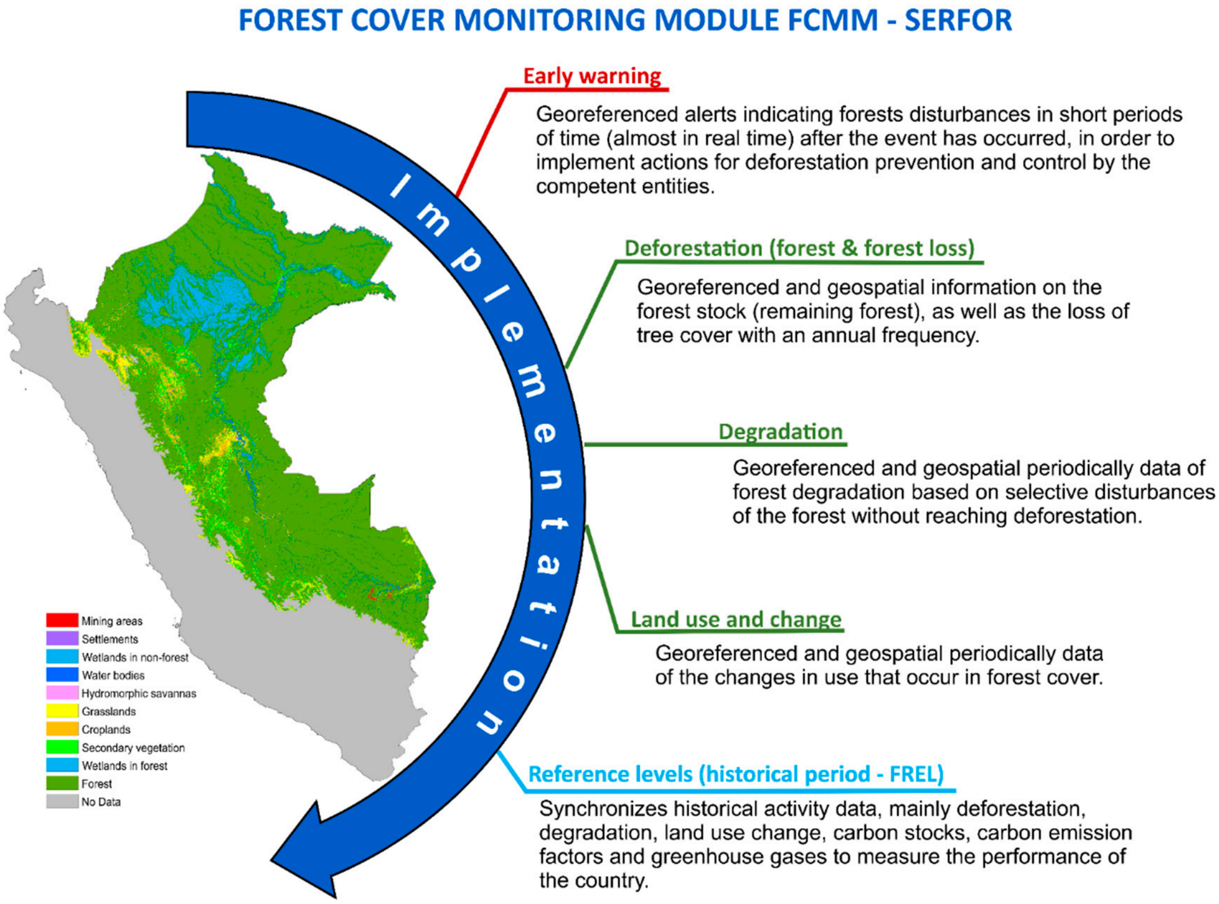

Figure 2. Peruvian land use change monitoring system.

The Peruvian REDD+ mechanism has been developed in distinct phases (preparation, implementation, and payment for results) and under different levels of implementation (national and subnational). At the subnational level, there are multiple REDD+ initiatives and projects that result in greater dynamics in relation to the other levels of implementation. Even if considerable improvements were made by subnational-level initiatives, further efforts are needed at the national level [77]. Based on an X-ray of the REDD+ context in Peru [78], the need to develop and strengthen capacities around MRV for REDD+ and its relationship with INGEI USCUSS was identified. In this sense, REDD+ strength the methodologies and technical capacities of land uses and changes in land use measurement and monitoring, mainly due to deforestation, without forgetting forest degradation, post-deforestation land uses, and forest carbon stocks and fluxes estimations [79].

In addition, REDD+ activities in Perú are also targeting biodiversity conservation, because they can provide additional benefits to promote payments for ecosystem services (PES) (hydrological services in special) schemes as an immediate benefit for people [18,80]. The PES became an advanced method to maintain forest cover in protected areas and among indigenous communities, implemented by the NFCP [81].

Peru needs to invest more in climate action, and that poses two major challenges: (i) improving the conditions that ensure the efficient use of existing public climate financing, and (ii) mobilizing financing to scale climate action to the level required for NDC compliance. In this sense, Peruvian regulations do not establish an exact definition of what is meant by climate finance, referring to flows of resources destined for mitigation and/or adaptation measures [82].

In the case of CBD reporting, data to prepare the Sixth National Report (2014–2018) are not based on information provided by NFI, even though it gathers biodiversity data on their plots and reports. Numbers and updates presented in the National Report are based on information of biodiversity published in books, scientific journals, and official publications and on the opinion of experts. Therefore, consistency in the data collection methodology is unlikely. Thus, there are research gaps, which prevent estimates of the species number for seven Phylla of animals present in the country. This gap prevents detection of changes in the diversity and species composition of these taxa. Along with this, to be able to correctly direct conservation efforts it is important determine the level of threat to species classified as "Insufficient Data".

The Peruvian ecosystems' conservation status has not been fully studied, and their inclusion in the protected areas system is more suitable to enhance biological conservation [83]. Their study would help to improve conservation decision making. Some ecosystems are under-represented within protected natural areas: for example, the Meso-Andean relict forest (only 275 ha in protected areas), the coastal wetlands and hills, and the seasonally dry riparian forest. A similar situation occurs with ecosystems located in coastal regions. There is no information concerning official initiatives to establish priorities for endangered species and communities, for wild species related to domestic species, medicinal or agricultural species, or other key species. For some wildlife taxa and endemic species, only estimates of their numbers are available, but no detailed record is available, or there are old lists or preliminary lists that may contain synonyms or errors. The list of threatened species of flora and fauna is not up to date; thus, the Peruvian IUCN red list lacks information on individual species' population trends and there is also an under- or overestimation of the species conservation status [84]. Being a megadiverse country, Peru will have to cope with the difficulty of preserving natural landscapes, while sustaining economic growth under an agriculture- and resource-based economy [3,85]. Therefore, there is a need to reduce the conflict between economic development objectives and biodiversity conservation by enhancing the spatial–temporal planning of resource concessions. Socio-ecological conflicts display competition between land use interests and also encompass divergent political strategies and weak coordination between conservation activities and other development interests [86].

Peru currently does not have a standardized methodology for measuring the degradation of terrestrial ecosystems at the national level, nor are there any statistics that allow the degradation to be quantified in surface units. Within the UNCCD convention, no national report has been submitted yet, although there is an urgent need to generate improvements in the monitoring systems. Cases evaluated as part of a previously published study raised observations of this type [87]; there were no reports of their level of compliance or their inclusion in the monitoring systems. Therefore, it is a key challenge to implement an active and consistent monitoring system to examine land productivity and its degradation [88]. This is particularly challenging, because it also requires to assess desertification and restoration future trends by identifying how much of the desertified land is likely to be restored [89]. In this context, Peru has information on restoration experiences in the country, executed under the names of recovery, rehabilitation, restoration, or simply reforestation, which have had, as a common factor, recovering the forest cover, improving it, or enriching it; however, they are scattered, little publicized, and less systematized. For this reason, it is important to collect the information or evaluate the experiences and document them, to know what the enabling conditions and key factors have been that allowed the success or generated the failure of these experiences, as well as to know their progress and achievements.

3.3. Governance

Land use decisions involve a complex network of actors, from which questions emerge about how interests and power levels, often conflicting, influence land use change. In this context, the Peruvian decentralization process redistributed responsibilities in the forestry, environmental, and agricultural sectors, and thus expanded the powers of regional governments in making decisions about land use and areas with forest cover. Although the policies and laws that dictate such reforms were created to be applied uniformly across all regions, they have been implemented differently and have had different effects, according to the distinctive governance and land use contexts of each region in the country. Actions such as the Land Use Plan (LUP) process and ecological–economic zoning (EEZ) are essential to achieving better land use management policies and practices; however, the units responsible for these processes are the weakest environmental offices in the government at both the national and regional levels.

Countries in Latin America, such as Brazil, are encouraging improvements towards implementing suitable legal instruments to explain institutional obligations associated with National Forest and Land Monitoring Systems that have shown their effectiveness in promoting national change and inspiring the rest of the world along the process [90,91]. The real-time system for the detection of deforestation, DETER, the detection of degradation, DEGRAD, monitoring the trend of deforestation, PRODES, and the detailed mapping of deforested areas, TERRACLASS, developed by the Brazilian Institute for Space Research (INPE) enabled a reduction in deforestation by 35% during the 2005–2012 period [92,93]. Brazil's experience with the satellite monitoring of tropical forests through the TerraAmazon system serves as an encouraging example of how innovation can enhance policy. The science-driven TerraAmazon system in Brazil, backed up by a political will to separate science from policy, inspired a new generation of MRV systems in the south. TerraAmazon not only showcased how good science could promote good policy and early action on the land through a well-coordinated response chain, but also created a list of committed state governors that honestly wanted to promote sustainability in their lands. However, between 2018–2022, all these efforts collapsed, and this remains as an example of submission to political will and the absence of global social crisis events, as occurred with COVID-19. In the same way, Brazil's reduction of deforestation through good public policy implementation and intervention in the beef and soy supply chains [94,95] could be a model for the governance and policy changes necessary for Peru. Once Brazil began to apply the soy moratorium (SoyM) as a first voluntary zero-deforestation agreement, soy expansion in newly deforested areas was reduced considerably, expansion taking place entirely on land cleared before the agreement [95]. Brazil's beef industry (major meatpacking companies) signed the G4 Cattle Agreement, which involves a range of commitments concerning their sourcing and requiring them to ensure proof of zero deforestation by not buying animals from farms or sourcing cattle involved in deforestation [96]. The intervention in beef and soy supply chains used by Brazil reduced deforestation and provided important lessons on the value of public policies and supply chain interventions in slowing the advance of the agricultural frontier.

Other good examples are actions taken by Mexico that might help to reduce carbon emissions from deforestation and forest degradation, even though land use cover change processes differ across the country [97]. These actions included strong environmental institutions, payments for maintaining natural forest, protected areas that successfully restrict certain land uses, support for community and indigenous forest management, and macroeconomic and agricultural policies that make it less cost-effective to clear additional forest land for livestock and crops [98]. Mexico has a Forest Monitoring Satellite System (SAMOF, Spanish acronym), a wall-to-wall approach which aims to generate spatially explicit information, with greater spatial and temporal resolution, on the dynamics of the country's forest cover [99]. In addition to this system, a review and feedback strategy has been implemented that incorporates expert knowledge on the country's forest ecosystems, with the support of technicians from the operational areas of the National Forest Commission and state governments. However, long-term monitoring programs to reduce uncertainty in the estimates and achieve a robust and transparent MRV system are needed [100].

Similarly, Peru has moved policy implementation forward through the Peruvian forestry law (No. 29763) in 2011 and later in its National Strategy ProREST 2021–2023, which contains an innovative provision called agroforestry usufruct concessions (AFUC) already mentioned in the UNCCD framework analysis section, that consists of providing a 40-year renewable lease to farmers committed to conserving forest remnants to establish sustainably managed agroforestry systems [68]. The AFUC has achieved significance due to Peruvian national commitments to land restoration, including the target of 3.2 M ha under the 20 × 20 Initiative.

One of the greatest governance challenges for Peru is the fragmentation of government functions across sectors at the national and regional levels [33]. As has been previously discussed, the separate, uncoordinated, authority of MIDAGRI and MINAM creates loopholes that allow the conversion of forest lands to large-scale agriculture. In addition to this, institutional changes brought about by regionalization/decentralization have resulted in poor capacity building in the specialized technical agencies at the regional level and in further confusion and conflict, mainly due to a lack of clarity regarding the roles of government entities and poor coordination between the different regional agencies regarding decision making on the use of water and soil [101]. These challenges are evident in a duplication of functions and in the conflict that exists in practice over authority and requests for land use. Overlapping land claims caused by a complex land use classification and land titling process are one of the main challenges Peru faces in order to achieve sustainable land use, economic growth, and poverty reduction [3,33].

4. Conclusions

Our analysis highlights the fact that forest monitoring is becoming essential for biodiversity assessments, carbon stock estimations, and sustainable forest management. Reporting for international commitments needs robust, long-term, and up-to-date information on other land uses, non-productive forest functions, and on the conservation of biodiversity. A recent advance in this regard is that NFIs are being used to estimate the forest standing volume of wood and to indicate changes in stand structure, growth rates, and species composition. That should help Peru to move to the Tier 2 level in carbon pools reporting.

Data from research observational studies, collected over long time periods, may effectively complement forest inventories and monitoring. Such data will provide the empirical basis for growth models and a spatially explicit diversity analysis. Models developed from these studies are essential for generating reasonable scenarios at landscape level, including carbon modeling and projections of climate change. These more elaborate and accurate methodologies would help Peru to move even to Tier 3 level. Progress in the development of systems for land use monitoring illustrates the difficulties of linking local activities to national outcomes and including them in a seamless structure of reporting across levels. Despite much financial and institutional investment, progress has been only partial, and several issues remain to be resolved. Peruvian advances in the reporting function have been limited. There are no official reports or official databases of the country's climate action outside of the information sent to the UNFCCC.

Clearly communication and dialogue between actors and sectors is a crucial step towards better planning. In theory, it could allow the negotiation of both development and conservation activities in a transparent discussion of advantages and disadvantages, as well as explicit planning for the needs of multiple actors under a low-emission or sustainable future paradigm. Coordinated actions can simultaneously address the drivers of land degradation and biodiversity loss, while protecting ecosystems and supporting climate action.

At the systemic level, there are important advances such as the National Strategy for Climate Change, the National Strategy for Biological Diversity, and the National Program to Combat Desertification. Intersectoral coordination tasks and national commissions have been formed on three topics: climate change, biological diversity, and desertification and Drought. However, despite them having been operational for many years, a continuous trend towards systemic improvement cannot be reported; the capacities formed are more individual than institutional.

The implementation of REDD+ requires a clearly defined forest management approach and forest governance capable of controlling and directing its goals towards sustainable development. Peru should look for ways to integrate findings from local level monitoring into their national reporting systems, since REDD+ impact depends on land use decisions on the ground. Land classification is a sensitive and controversial issue but is currently a legal requirement prior to the issuance of property titles (or permits). The lack of soil or territorial planning laws only adds to an already complicated situation. Apparently, few people are familiar with MINAGRI's methodology and criteria for use in interpreting and managing soil classification. In particular, the lack of clarity about the classification systems gives an impression that they are subjective and open to manipulation.

The weak institutional framework generates a fragile governance in the management and administration of the forest heritage, particularly in the face of deforestation. There is no leadership by an institution with full autonomy and a strong political presence within the state apparatus, which incorporates as a public policy objective the reduction of deforestation and forest degradation rates. The forestry sector is part of the agriculture sector, where it occupies a third or fourth level within the organization of MIDAGRI. Additionally, poor coordination between agencies has resulted in overlapping land use concessions. These overlaps, and a political lack of will to resolve them, have generated and are the basis of constant conflicts that hinder progress towards an effective fulfillment of the national environmental commitments. In the same way, policy implementation can play an important role in facilitating adaptation and mitigation strategies for addressing climate change effects and achieving Peruvian international commitments.

Overall, this revision suggests that Peruvian commitments and policies require significant progress. It is worth reiterating that GHG emissions in 2020 exceeded their conditional goal for 2030. Natural protected areas' performance may help to reduce deforestation; however, their performance needs financial sustainability, better management for an effective conservation of biodiversity, and a working biodiversity monitoring system. There is a clear need for policy progress, considering issues such as land tenure, governance, and the potential impacts of oil palm industrial scale plantations. In terms of restoration, Peru has made significant progress by developing an important restoration guide for the coming years. The scenario seems to reflect some advancements in land use monitoring; however, there is more room for improvement. Contrasting with the advancement made, Peru's forestry and wildlife law (Law N° 29763) has recently been modified by making the MIDAGRI the regulatory body for land use in forested areas, instead of MINAM, and enabling land use change by removing requirements for forest and agricultural companies to change them to farming.

Author Contributions: T.E.B.E. and R.M.R.-C. conceived the idea for the present study, T.E.B.E. collected the data, T.E.B.E. and R.M.R.-C. analyzed the data and led the writing of the manuscript. All authors have read and contribute to all versions. All authors have read and agreed to the published version of the manuscript.

Funding: This work was supported by CONCYTEC (Peru)—World Bank grant (Contract 011-2019-FONDECYT-BM-INC-INV).

Data Availability Statement: Data is contained within the article.

Conflicts of Interest: The authors declare no conflicts of interest.

Appendix A

Table A1. List of Rio Conventions action plans and 20 × 20 Initiative, time period and access.

Conventions	Report	Time Period	Access
UNFCCC	Intended Nationally Determined Contribution (**iNDC**)—2015	2010–2030	https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Peru%20First/iNDC%20Per%C3%BA%20castellano.pdf, accessed on 20 October 2020
	Grupo de Trabajo Multisectorial de naturaleza temporal encargado de generar información técnica para orientar la implementación de las Contribuciones Nacionalmente Determinadas (**GTM-NDC**)—2018	2030	https://www.minam.gob.pe/cambioclimatico/wp-content/uploads/sites/127/2018/12/Informe-final-GTM-NDC_v17dic18.pdf, accessed on 2 February 2021
	Nationally Determined Contribution—Update Report (**NDC**)—2020	2021–2030	https://www4.unfccc.int/sites/ndcstaging/PublishedDocuments/Peru%20First/Reporte%20de%20Actualizacio%CC%81n%20de%20las%20NDC%20del%20Peru%CC%81.pdf, accessed on 15 January 2021
	Second Biennial Update Report (**BUR**)—2019	2015–2016	https://unfccc.int/sites/default/files/resource/Segundo%20BUR-PERU.pdf, accessed on 20 January 2021
	Third National Communication (**NC**)—2016	2010–2015	https://unfccc.int/resource/docs/natc/pernc3.pdf, accessed on 12 March 2021
	Forest Reference Emission Level (**FREL**) for reducing emissions from deforestation in the Peruvian Amazon—2021	2010–2019	https://redd.unfccc.int/files/nref_peru_final.pdf, accessed on 22 October 2021
	National Inventory of Greenhouse Gases (**GHG**)—2021	2000–2016	https://unfccc.int/sites/default/files/resource/INGEI_2016_Junio-2021_Final.pdf, accessed on 14 Mayo 2022
	REDD + Safeguards—2020	2012–2019	https://redd.unfccc.int/files/resumen_de_informacion_salvaguardas__1_.pdf, accessed on 1 August 2021
	National Strategy for Climate Change (**NSCC**)—2015	2021	https://www.minam.gob.pe/wp-content/uploads/2015/09/ENCC-FINAL-250915-web.pdf, accessed on 14 July 2021
	National Strategy on Forests and Climate Change (**NSFCC**)—2016	2030	http://www.bosques.gob.pe/archivo/ff3f54_ESTRATEGIACAMBIOCLIMATICO2016_ok.pdf, accessed on 27 May 2021
	Adaptation Measures Catalog—2019		https://cdn.www.gob.pe/uploads/document/file/571780/Cat%C3%A1logo%20MACC-NDC%202021.pdf.pdf, accessed on 7 January 2021

Table A1. *Cont.*

Conventions	Report	Time Period	Access
	Mitigation Measures Catalog—2019		https://sinia.minam.gob.pe/documentos/catalogo-medidas-mitigacion#:~:text=El%20Cat%C3%A1logo%20de%20Medidas%20de,Determinadas%20(GTM%2DNDC), accessed 5 April 2021
	Strategic Elements of REDD+ Implementation in Peru—2014		http://www.bosques.gob.pe/archivo/fbbfcc_strategic_elemnts.pdf, accessed on 20 February 2021
CBD	National Biodiversity Strategy and Action Plans (**NBSAPs**)—2014	2014–2018	https://sinia.minam.gob.pe/documentos/estrategia-nacional-diversidad-biologica-2021-plan-accion-2014-2018, accessed on 27 February 2022
	Sixth National Report on Biological Diversity Management Report (**CBD**)—2019	2014–2018	https://cdn.www.gob.pe/uploads/document/file/360830/Informe_de_Gestion_final.pdf, accessed on 25 January 2021
	Sixth National Report on Biological Diversity in Numbers (**CBD**)—2019	2014–2018	https://cdn.www.gob.pe/uploads/document/file/360831/La_Biodiversidad_en_Cifras_final.pdf, accessed on 22 January 2021
	REDD-plus and Biodiversity—2011		https://www.cbd.int/doc/publications/cbd-ts-59-en.pdf, accessed on 26 May 2021
UNCDD	National Strategy to fight against Desertification and Drought (NSCDD)—2022	2016–2030	https://sinia.minam.gob.pe/documentos/estrategia-nacional-lucha-contra-desertificacion-sequia-2016-2030, accessed on 27 May 2021
	ProREST National Strategy for the Restoration of Ecosystems and Degraded Forest Lands	2021–2030	https://cdn.www.gob.pe/uploads/document/file/2039629/Estrategia_ProREST_vf_21_07_2021FF_1F_2.pdf.pdf, accessed on 26 May 2021
	Peru—Land Degradation Neutrality (LDN) country report—2020	2030	https://www.unccd.int/sites/default/files/ldn_targets/2020-05/Peru%20LDN%20TSP%20Country%20Report%20%28Spanish%29.pdf, accessed on 27 July 2021
Initiative 20 × 20	Guidelines for the Restoration of Forest Ecosystems and other Wild Vegetation Ecosystems—2018		https://www.serfor.gob.pe/portal/wp-content/uploads/2019/01/Orientaciones-para-la-restauraci%C3%B3n-de-ecosistemas-forestales.pdf, accessed on 15 January 2021
	Forest landscape restoration experiences with the application of ROAM in Peru—2018		https://www.iucn.org/sites/dev/files/content/documents/flr_peru_experiencias_roam.pdf, accessed on 15 January 2021
	Restoration of Landscapes in Peru—Priority sites and evaluation of opportunities—2019		https://cdn.www.gob.pe/uploads/document/file/1662872/Restauraci%C3%B3n%20de%20Paisajes%20en%20el%20Per%C3%BA.pdf, accessed on 26 May 2021

Table A1. *Cont.*

Conventions	Report	Time Period	Access
Geoportals	GEOBOSQUES—Forest Cover Changes Monitoring Platform		https://geobosques.minam.gob.pe/geobosque/view/index.php, accessed on 15 October 2020
	GEOSERVIDOR—technological platform with specialized geospatial information		https://geoservidor.minam.gob.pe/, accessed on 15 October 2020
	INFOCARBONO—National Inventory of Greenhouse Gases		https://infocarbono.minam.gob.pe/, accessed on 15 October 2020
	GEOSERFOR—SERFOR Spatial Data Infrastructure Geoportal		https://geo.serfor.gob.pe/geoserfor/, accessed on 15 October 2020

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