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Research article

Is oil palm a threat or opportunity for Peru's forests?

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ABSTRACT

Oil palm is the world's main source of edible oil, supporting rural incomes but also driving deforestation and other impacts. As new production regions emerge, understanding the links between sustainability and governance— ranging from government regulations to market demands —is essential. We examined Peru's oil palm sector, focusing on the main producing Regions, San Martin and Ucayali. We quantified palm expansion, associated deforestation, and the role of a key land-use policy tool. Then, through 30 stakeholder interviews, we identified factors driving palm expansion and its impacts, highlighting pathways for a deforestation-free sector. We found that Peru's oil palm sector is largely supplied by smallholders, but becoming profit-oriented and industrializing quickly. Except from specific large deforestation events, oil palm has not yet been a dominant deforestation driver in Peru, but risks persist that it could become one. These risks include low yields, weak land-use governance, and land tenure issues that promote expansion over productivity gains. Furthermore, the land-use, tenure and forestry policies that could address these risks suffer from incoherencies and weak implementation and enforcement, particularly in Ucayali. Global sustainability standards are the main sustainability lever at present, but many others require stronger public-private collaboration. We propose a public-private agenda to align stakeholders towards sustainable oil palm. With sustainability becoming a competitive factor globally, Peru has an opportunity to integrate its palm sector into responsible supply chains. However, urgent action is needed to strengthen multi-stakeholder platforms and implement locally tailored deforestation control strategies before the opportunity window closes.

1. Introduction

Oil Palm is a highly profitable tropical commodity crop. Since 2015 it has become the main source of vegetable oil worldwide (Voora et al., 2020). Its high yields and industrial versatility make palm oil part of several global value chains, mostly for the processed food sector and for export markets (Voora et al., 2020), but serious environmental impacts have followed. In southeast Asia, where approximately 80 % of the world's production occurs, about half of the expansion in the last two decades is linked to deforestation (Koh and Wilcove, 2008; Vijay et al., 2016), causing the loss of several million hectares of forest (Carlson et al., 2013). Demand for palm oil is expected to keep growing. Expansion of supplies is projected at an annual rate of 1 % and, given more strict environmental regulation in Asia, larger increases in supplies are expected from emerging producer countries (Organisation for Economic Co-operation and Development, 2021), posing serious challenges to sustainable oil palm landscapes.

While Southeast Asia has had the largest environmental costs from palm oil expansion, Latin America is now emerging as an important producing region. Colombia, the main producer in the region and one of the largest in the world, increased its harvested area from 221,000 ha in 2008 to 466,000 in 2018 (Medina et al., 2019). As in other tropical regions, agricultural expansion here is a major driver of deforestation and forest degradation (Lapola et al., 2023; Pendrill et al., 2022), with critical implications for biodiversity loss and forest-dependent communities (Lapola et al., 2023). However, the impacts of such expansion are not uniform; they are mediated by the type of crop involved and the land-use governance settings in place (Kowler et al., 2016; Pendrill et al., 2022). Unlike annual or temporary crops such as soy or maize, oil palm is a permanent crop, which offers potential for alternative cultivation

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methods; pilot projects have shown that palm could be produced in agroforestry systems or mixed-use landscapes that maintain partial canopy cover, which can improve habitats for biodiversity and make producers more resilient to market shocks by promoting landscape multifunctionality (Jezeer and Pasiecznik, 2019; Khasanah et al., 2020). By contrast, the dominant monoculture plantations of oil palm are connected with severe threats to biodiversity (Mendes-Oliveira et al., 2017; Vijay et al., 2016). Furthermore, experiences in Indonesia have shown that improving the efficiency of extensive palm oil production has a strong potential of rebound effects, causing the expansion of cultivation into primary forests, undermining a land-sparing strategy of complementing intensive production with conservation areas (Dalheimer et al., 2022). In Latin-America, oil palm expansion has so far caused less direct deforestation than in Southeast Asia, with much of the growth occurring on already cleared lands (Furumo and Aide, 2017; Vijay et al., 2016). These regional and crop-specific characteristics make Latin-America an important context in which to examine how agricultural expansion can be reconciled with environmental sustainability goals.

Among Latin-American countries, the Peruvian palm sector had a later start, with only about 84,500 ha of palm in 2015 (Vijay et al., 2018). The sector is currently experiencing a fast expansion (McCarthy, 2020; Rausch et al., 2020), with a growth of more than 150 % throughout the 2010s (Rausch et al., 2020). This comparatively late development of the Peruvian palm sector offers the possibility to avoid the worst impacts seen elsewhere. In Peru, oil palm was introduced as early as the 1970s, but only experienced its first industrial 'boom' through its promotion as an alternative crop to coca in the 1990s and early 2000s as part of 'alternative development' programmes. (Borasino, 2016). As a result, the Peruvian palm sector has a high participation of smallholders, representing about 40 % of the cultivated area (Coöperatie Wolfs Company U.A. & University Amsterdam, 2021).

At present, the main producing regions are located in the Amazonian Regions of San Martin and Ucayali (see Fig. 1), containing approximately 77 % of the planted area (Ministerio de Agricultura y Riego, 2016). In both, oil palm has become an important economic motor, enhancing incomes and local livelihoods. For instance, the poverty rate of palm producers is substantially lower than that of producers of other agricultural products (Borasino, 2016). In producing regions it is also an important source of direct and indirect employment, with over 40,000 jobs created by 2021 (Junta Nacional de Palma Aceitera del Perú - JUNPALMA, 2021). Nevertheless, the economic benefits can differ among producers with different land extensions and different technical and financial capacities (Bennett et al., 2019).

After the process of decentralization of the Peruvian territorial administration in 2002, these two Regions have taken different paths in land-use governance (Kowler et al., 2016). San Martin has emerged as a leader in land-use governance and managed to control a series of environmental problems. This included large reductions in deforestation rates in the late 2000s and 2010s, which allowed San Martin to stop being the most deforested Region in Peru (Augusto Meléndez et al., 2017; Kowler et al., 2016). Ucayali on the other hand has followed a more erratic path towards environmental sustainability (Kowler et al., 2016; Zinngrebe, 2016). Here, a higher prevalence of land-use conflicts and weaker governance contribute to high and increasing deforestation rates (Direción Nacional de Prospectiva y Estudios Estratégicos, 2022). As such, the two Regions provide contrasting contexts to explore land-use governance effects on oil palm expansion impacts.

In this study we analysed the dynamics of oil palm expansion, the land-use governance elements and socio-economic contextual conditions regulating deforestation in San Martin and Ucayali. Governance elements here comprise structural (e.g., policy implementation and enforcement, institutional development, political conditions, etc.) and agency elements (e.g., stakeholders' degree and means of participation in decision making, and interactions among them) (adapted from Arts et al., 2014; Fischer et al., 2020) that influence land-use decisions at agricultural frontiers in both private and public spheres.

We mixed quantitative and qualitative methods to address two research objectives: Firstly, we explored differences in the patterns of oil palm expansion between the two Regions, the extent to which palm oil caused deforestation, and the factors to which any differences were potentially attributable. To do so, we quantified recent overall deforestation, oil palm expansion, and resulting deforestation through a series of spatial analyses. Secondly, we conducted semi-structured interviews with representatives of major stakeholder groups in the palm oil sector, as well as other related experts. Using a content analysis framework (Krippendorff, 2004) we identified the different factors and governance elements that interviewees used to explain changing patterns of palm oil expansion and related deforestation. Based on this information we extracted and discussed alternatives for sustainable palm oil. Lastly, we discussed our finding in the context of global efforts towards deforestation-free value chains for agricultural commodities.

2. Materials and methods

Here we describe the methods for the quantitative and qualitative analyses. In supplementary material 1 we provide additional contextual information about the development of land-use governance in San Martin and Ucayali.

2.1. Spatial analyses

2.1.1. Palm and deforestation dynamics

We performed geometric operations to quantify *a)* yearly total deforestation; *b)* yearly expansion of palm and *c)* forest to palm yearly transitions (i.e., pixels where forested areas were transformed to palm in the following year). We used the landcover products from MapBiomas (2024) to quantify palm expansion and forest to palm transitions for the period 1990–2020. We used the data from the Peruvian Ministry of the Environment -Geobosques- (Ministerio del Ambiente, n.d.) as well as the deforestation datasets from RAISG (Amazon Geo-Referenced Socio--Environmental Information Network - RAISG, n.d.) to quantify deforestation. Although these datasets do not cover the years prior to 2000 -so deforestation analyses only start then-we decided to use the official deforestation data whenever possible.

2.1.2. Palm and deforestation across the Ecological-Economic Zonifications

Zonifications are the main spatially explicit (i.e., mapped) policy instruments of territorial planning (*Ordenamiento territorial* - OT) in Peru. The Ecological-Economic Zonifications (ZEE), established in 2004, are meant to regulate land-use and harmonize competing interests across sectors under sustainability criteria. We quantified the total accumulated deforestation and oil palm cultivation in the different zones of the ZEEs of San Martin and Ucayali for the period 2017–2020. We use this time period as the ZEE of Ucayali was only approved in 2017. For this analysis we used the maps of yearly expansion of palm plantations from the Sociedad Peruana de Ecodesarrollo (SPDE) (Sociedad Peruana de Ecodesarrollo, 2020). See supplementary material 2 for information about the data used and supplementary material 3 for definitions of the different ZEE zones. [1]

2.2. Qualitative interview analyses

We conducted semi-structured interviews to understand the perspectives and motivations of the different stakeholders' groups involved in the palm oil value chain and analysed them using a content analysis framework (Krippendorff, 2004).

[1] Code for performing these analyses is available at https://github.com/dbrizuela/peru_oil-palm.

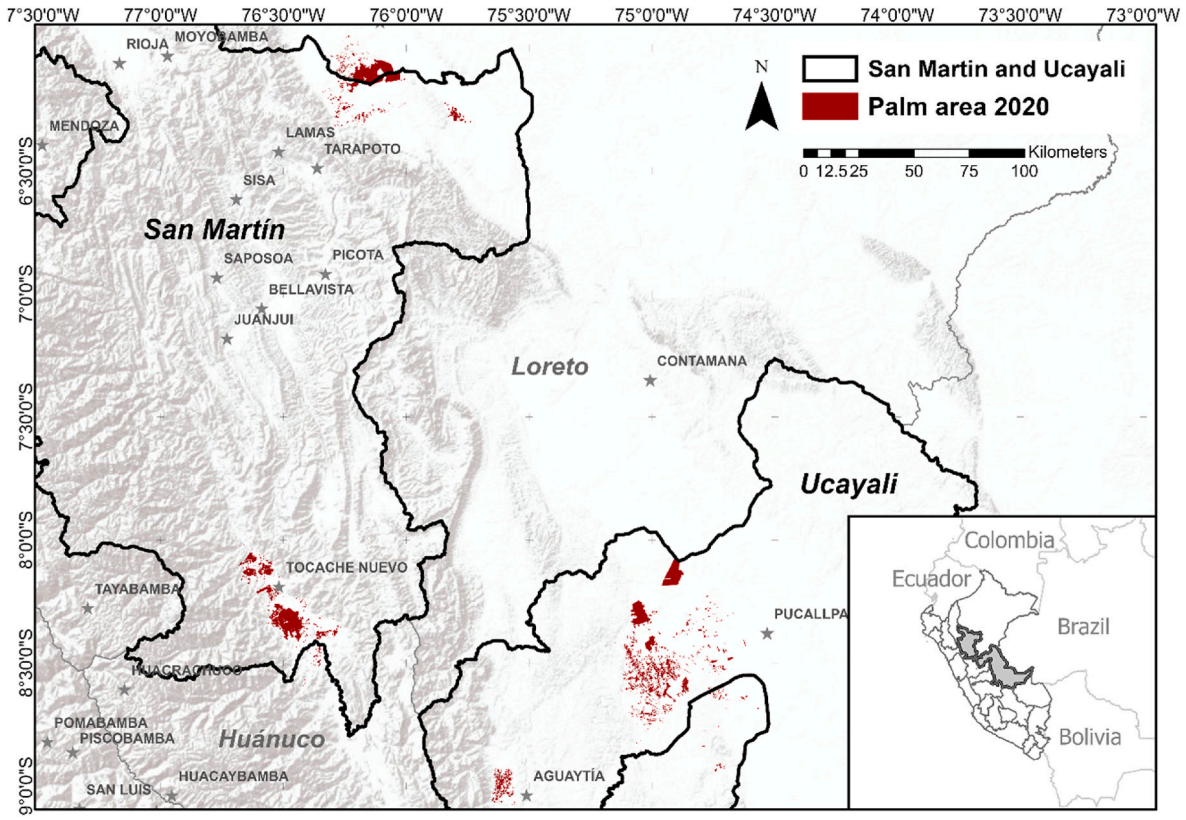

Fig. 1. Location of the study area. The map shows the locations of palm oil cultivation by 2020 in the Regions of San Martin and Ucayali, as well as in the neighbouring Regions of Loreto and Huánuco. Plantations' data from Sociedad Peruana de Ecodesarrollo (2020).

2.2.1. Sampling strategy

We conducted 30 semi-structured interviews in January 2023 in the cities of Lima, Tarapoto (San Martin), Pucallpa (Ucayali) and production areas nearby, as well as remotely with interviewees from Tocache (San Martin). We interviewed representatives of key actors in the oil palm value chain including producers' associations' leaders, oil extraction companies' representatives, national and regional government representatives, conservation activists, local scholars and other related experts (Table 1). Individuals' contact details were firstly obtained through an internet search of governmental representatives and scholars working on palm oil, as well as visible producers' associations. Then, through snowball sampling we collected further contacts provided by interviewees, aiming for a maximum theoretical variation across stakeholder groups. After 30 interviews, very little information was added by single additional interviews. Out of the 30 interviewees, 20 were men and 10 were women.

Table 1
Number of interviewees by region and type of organization. NGO-consultancy refers to organizations which provide consultancy services (related to e.g. land-use planning or sustainable agriculture) to governments or producers, whereas NGO land managers refers to organizations in charge of managing portions of the territory (e.g., protected areas).

Actors	San Martin	Ucayali	National
NGO – consultancy	2	1	5
NGO – land managers	3	1	1
Academics	1	1	–
Producers associations or companies' representatives	1	4	–
Government	1	3	4
International cooperation	1	1	–

2.2.2. Interview design

All interviews were conducted in Spanish by DBT and YZ. The base guideline consisted of eight questions, some with follow-up questions (see supplementary material 5). Interviews took between 25 min and 1.5 h. All interviewees agreed to be recorded for the purpose of text transcription and analysis.

2.2.3. Interview analysis

We transcribed, coded in Spanish and analysed the interviews' recordings using the software MAXQDA 2022 version 22.8. We firstly started open coding the text, and in a first level of reduction we identified statements about factors that explained palm expansion, its links to deforestation, factors that drive deforestation in general (regardless of palm expansion), and levers for deforestation free oil palm. Then, in a second step of reduction we grouped these into broader categories according to the sphere in which they operate (i.e., political, institutional, socio-economic, idiosyncratic, etc.). To provide contextual information of the particularities of the historical development of the Peruvian palm sector we also outlined a general chronology of its development with the information provided by interviewees.

When statements specifically referred to one Region or the other (San Martin or Ucayali) we categorized them accordingly. Results and quotes here are given in English, having been translated by the authors.

3. Results

3.1. Palm expansion and deforestation

We found that by 2020 approximately 92,842 ha of oil palm had been planted; 42,529 in San Martin and 50,313 in Ucayali. Until 2015 San Martin had a larger palm area than Ucayali, but expansion slowed down in San Martin by the end of the 2000s, whereas it accelerated in Ucayali in the early 2010s.

Throughout the study period palm has not been a major deforestation driver excepting during the two well-known large deforestation events of *Plantaciones de Pucallpa* and *Plantaciones de Ucayali*, which occurred in the early 2010s, and the case of *Barranquita* in san Martin, which occurred in the late-2000s. Fig. 3, panel b) shows how the transitions from forest to palm have typically been limited except during the years of these deforestation events. The peak of deforestation from palm in San Martin occurred in 2009, where the 2445 transitioned hectares of forest to palm represented approximately 6 % of total deforestation in San Martin that year. In Ucayali the peak occurred in 2013, where 5650 transitioned hectares represented approximately 15 % of deforestation that year.

Meanwhile, both Regions experienced large fluctuations in overall deforestation during 2001–2020. In San Martin, deforestation peaks occurred in the late 2000s. In 2009, over 39,2000 ha were deforested. After this peak, deforestation started declining in San Martin. Ucayali had lower deforestation rates than San Martin throughout the 2000s, but this changed in 2013, thereafter consistently surpassing San Martin. In 2020, Ucayali hit a peak of about 47,280 deforested hectares. Deforestation decreased in both Regions in the mid-2010s before rising again by the end of the decade. Results given here come from the Geobosques dataset, but are relatively consistent for both datasets (see Fig. 2 where yearly deforestation from both datasets is shown).

We detected more deforestation and palm expansion in protection zones of the ZEE of Ucayali than those of San Martin from 2017 to 2020: 125,744 ha were deforested in Ucayali and 32,325 ha in San Martin. Of this protection zones' deforestation, approximately 700 ha were attributable to oil palm in Ucayali, and 117 ha in San Martin. In both cases the vast majority of palm expansion occurred in designated production zones (see Fig. 4).

3.2. Historical development of oil palm expansion

The recent expansion of oil palm in Peru has occurred in different stages. We identified three broad stages, as a national public servant outlined them:

> "There were like three big waves in palm, right? One, it is a wave of promotion, which is these years of 2000; then a stage in which the palm growers begin without the support of the Government, only support of the International Cooperation; and then, one in which they did not receive any support, which is what we are experiencing now: little support from International Cooperation and almost no support from the Government."

These stages were largely defined by the changing degree of financial, technical and political support from the national and regional governments, the increasing profitability of palm, the role of international cooperation institutions, of large companies, and the rising leadership of producers' associations. We briefly outline these stages here and provide a more detailed description in supplementary material 4.

3.2.1. First stage. Oil palm as an alternative crop

The promotion of palm in the late 1990s and early 2000s as an alternative crop to coca by the national government marked the first stage. Substantial financial and technical support was provided by cooperation institutions like the United Nations Development Programme (PNUD), the United States Agency for International Development (USAID) and the German Cooperation (GIZ), among others. The earliest project of this kind took place in 1992 in Ucayali, with the creation of the Central Committee of Oil Palm Producers of Ucayali (COCEPU). However, the most prominent programmes were the Alternative Development Programmes (PDAs), operating from 2002 to 2008, led by USAID and the National Commission for the Development and Life without Drugs (DEVIDA) on behalf of the Peruvian government. The main alternative crops were coffee, cacao and oil palm.

3.2.2. Second stage. Oil palm becomes a business

From the late 2000s and throughout the mid-2010s, the sector started consolidating. Technical assistance was still provided by international cooperation agencies, but financing increasingly relied on the producers' own resources and on some investment programs of the regional governments.

During this stage, there was a large impulse from big companies,

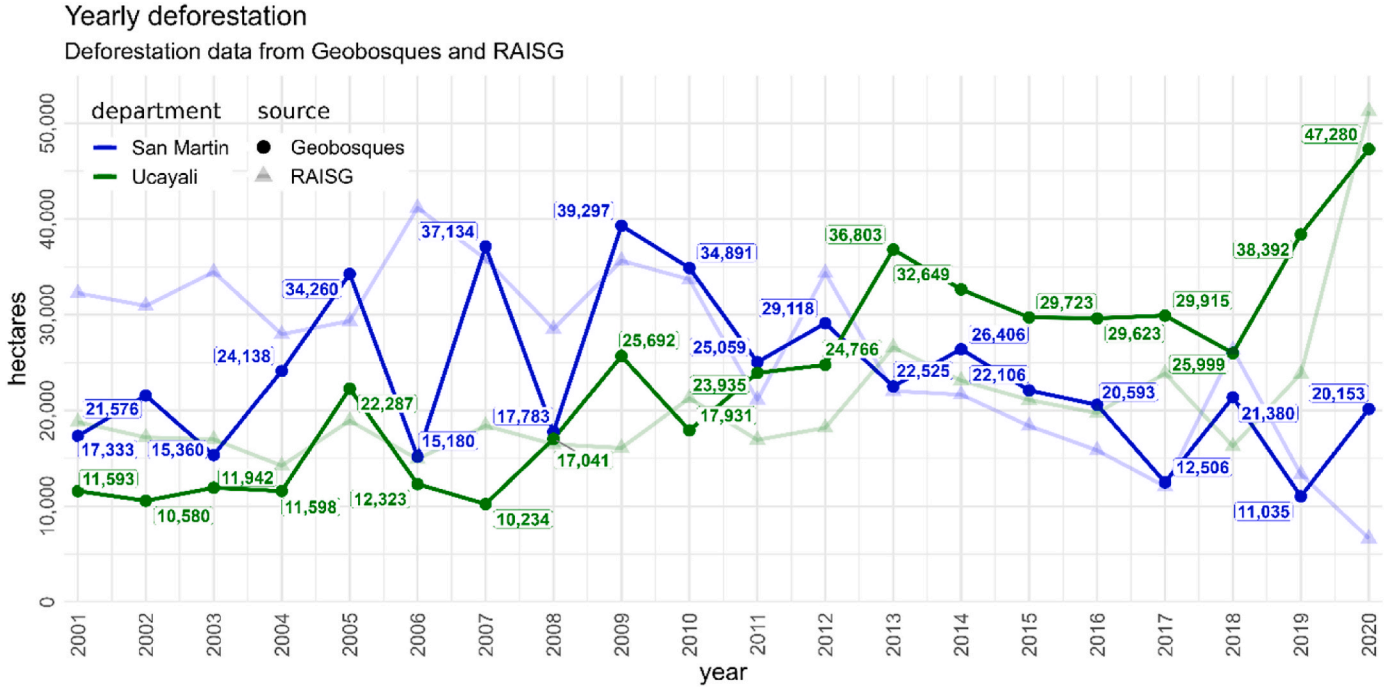

Fig. 2. Total deforestation in San Martin and Ucayali. This plot shows the yearly deforested areas for both Regions. Shaded lines correspond to data from RAISG and bold lines with labels data from Geobosques.

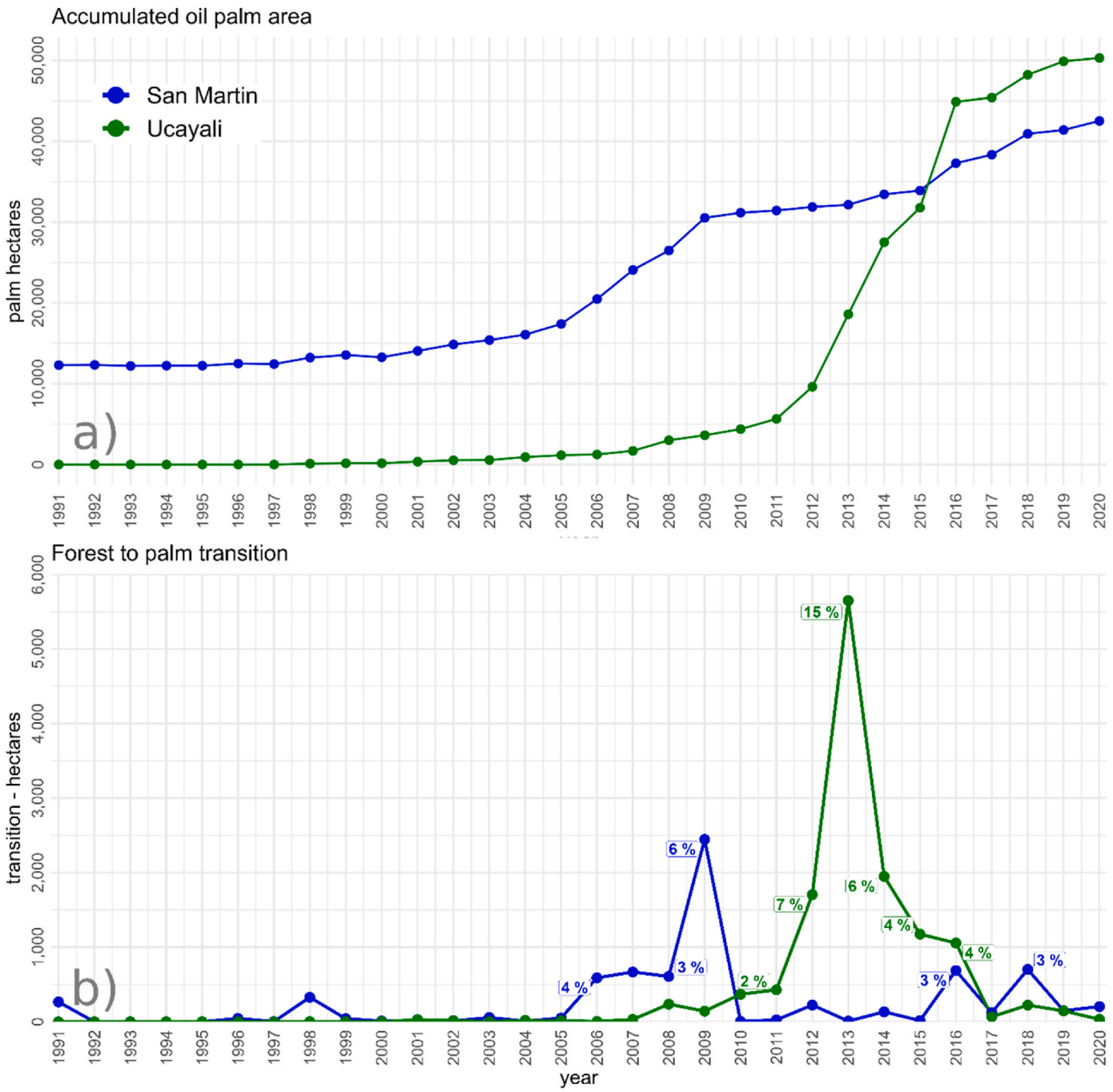

Fig. 3. Expansion of oil palm, and forest to palm transitions. Panel a) shows the total area of oil palm in San Martin and Ucayali; b) shows forest to palm transitions (i.e., where palm in a given year replaced natural forest in the previous one) and the corresponding proportion of overall deforestation in labels. palm area and forest to palm transitions were quantified with the data from MapBiomas to ensure pixel by pixel estimates. Note that the y-axes of both panels are scaled differently given the large differences in magnitude between accumulated palm area and forest to palm transitions.

mostly Grupo Palmas and the companies linked to Denis Melka, sometimes relying on aggressive land acquisition strategies. In this context, two major deforestation scandals occurred, one linked to each consortium. These cases are known as the *Barranquita* case in San Martin, linked to Grupo Romero and the Ocho sur case in Ucayali, linked to the Melka Group (these cases were described during the interviews, and more detailed accounts of these cases are available at Environmental Investigation Agency (2015) and Kowler et al. (2016)). Simultaneously, producers' associations in both Regions strengthened their technical and organizational capacities as their incomes grew due to increasing palm oil market prices.

During this period, there were some official plans and intentions to organize the palm oil sector nationally, like the publication in 2001 of the first National Plan for the Promotion of Oil Palm (*Plan Nacional de Promoción de la Palma Aceitera*) for the period 2000–2010, but the sectors' leadership kept shifting towards private actors.

3.2.3. *Third stage. A profitable, privately dominated sector*

Since the late 2010s a third stage has started, where national and to a lesser extent, regional governments have largely withdrawn from the oil palm sector as this has headed towards industrialisation. At present, most dynamics in the sector are dictated by private actors, out of which

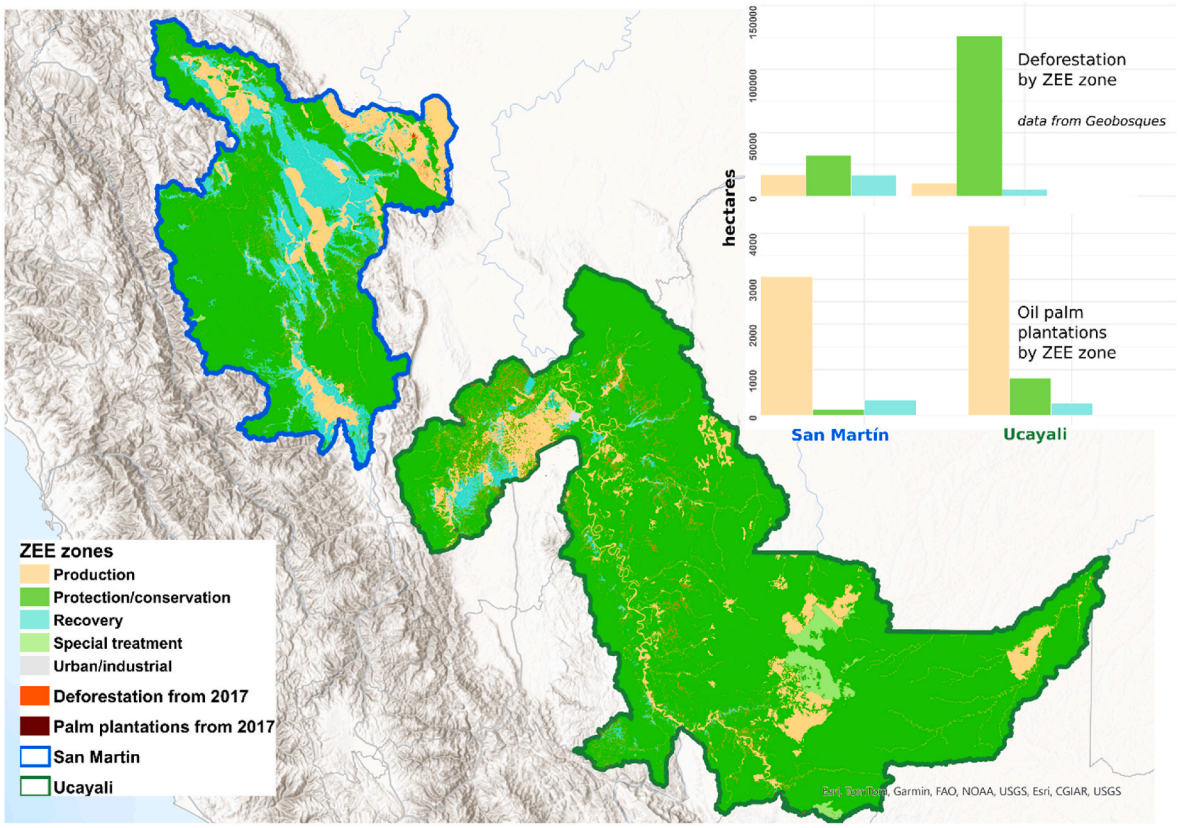

Fig. 4. Deforestation and palm across the different zones of the Ecological-Economic Zonifications (ZEEs) of San Martín and Ucayali. Note that deforestation and palm polygons correspond to the accumulated area for the period 2017–2020. Special treatment zones are areas which include archaeological sites or other sites of historical or cultural relevance. The bar plots on the top right corner show the deforested area and the palm area on the different zones of the ZEE. Bar colours correspond to the zone where deforestation or palm expansion occurred.

producers' organizations have emerged as increasingly influential actors. Extraction and refining companies owned by producers' organizations are becoming increasingly competitive and can finance their own expansion plans, although with heterogenous sustainability concerns and policies among the different organizations.

Big companies, on the other hand, have become increasingly aware of markets' sustainability demands and have adopted sustainability commitments, particularly Grupo Palmas. Yet, some interviewees were not satisfied with the compensations given from previous deforestation events.

3.3. Factors determining palm expansion and deforestation

3.3.1. Migration, poverty and local livelihoods

These factors relate to actors' economic conditions, activities, behaviours and motivations, and how these have influenced palm adoption and land-use in general.

Most interviewees shared the perception that deforestation in the Peruvian Amazon is a multifactorial process. that has been linked to low yield agriculture by poor migrants from Andean regions since the early stages of modern occupation. These migrants commonly clear patches of land to plant temporary crops with precarious practices, resulting in soil depletion and forcing them to clear new patches and repeat the cycle.

Many interviewees, mostly from NGOs and international cooperation, described that coca replacement programmes in the 1990s and 2000s also marked an important change in land-use dynamics. Palm and other alternative crops replaced coca plantations but given the few controls for deforestation that were implemented, these also caused deforestation in those years, especially in San Martin, where coca was more extensively planted. Complementary land titling campaigns further attracted people to the Amazon pursuing livelihoods and land ownership.

From the late 2000s, profit-motivated migration has become an important underlying motor of palm expansion. Interviewees from producers' associations related how migrants with economic resources from Regions like Huanuco, Cusco or Cajamarca started planting palm and, in some cases, bought plantations from former local owners. One employee of a producers' company told us:

> "Almost 40 percent of those people have retired, and later others have come, saw an opportunity, due to the issue of the land … and developed the crop."

Yet, interviewees did not always directly link the establishment of plantations by migrants to deforestation, as the plantations were commonly established over areas formerly deforested.

3.3.2. Market factors

Market factors consist of the influence that the global fats and oils market signals and demands have had on palm expansion and land-use dynamics.

Interviewees shared the perspective that the profitability of palm has remained the main motivation for expansion since global prices of palm oil increased in the early 2010s. This has also motivated numerous producers to reconvert areas with other crops into palm, especially during periods of elevated prices.

At present price booms seem to have a larger effect in Ucayali, due to the availability of unoccupied suitable flat land and to recent increases in installed capacity of extraction plants. A producers' company employee referred to this expansion:

> "In 2010 the price of palm reached 280 dollars per ton. That was a boom, the issue of the price that made people go crazy and began to plant …
>
> Right now, here in Pucallpa there are 21 nurseries. These 21 nurseries are adding up to more than 8,000, 9000 ha of plants that will be ready for the field."

Although exports have increased in recent years, domestic demand is likely to keep accommodating a large share of the production, and hence strongly influencing palm expansion dynamics in the near future. A regional government public servant told us:

> "Peru has a deficit in oils and fats, it will continue to have it. In fact, according to experts, we should have about 300,000 ha of palm oil to cover Peruvian demand."

3.3.3. Infrastructure

Roads infrastructure is a necessary condition for palm expansion. Fresh fruits need to be transported quickly to extractions plants before they start degrading. Interviewees, particularly from producers' associations described how at present the expansion of small producers is somewhat limited by infrastructure availability as they depend on public roads. In contrast, large companies can establish private road networks, eliminating accessibility issues to forested areas. At the same time, roads construction increases the accessibility of forested areas to immigration, potentially triggering deforestation.

3.3.4. Policies, institutional and political factors

This group includes policy development, integration and application, institutional integration, enforcement capabilities and resources, as well as the influence that politics (i.e., power struggles) exercise over the former.

Many interviewees, especially from academia and NGOs, shared the perspective that public agricultural investment programmes have historically driven deforestation. Many interviewees also mentioned that in Ucayali, the regional government was largely responsible for the expansion and economic consolidation of the palm sector through large investments. One academic described the effect of investment programs in deforestation:

> "For Ucayali, as in all regions, for all crops, the common denominator was public investment projects. So, the number one in promoting deforestation in Peru, at least in the rainforest, has been using state money."

The 2001 national palm promotion plan was followed in 2016 by the National Plan for Sustainable Development of Oil Palm for the period 2016–2025. In 2016 the regional government of Ucayali also published its own sectorial development plans. Additionally, in 2003, the Biofuel Market Promotion Law sent palm producers a signal to increase production, including area extension. In the end, soy oil was imported for biodiesel production, further distancing the relations between palm producers and the national government.

Despite such plans and strategies, one former national government servant considered that these had little effect, as they lacked the legal instruments to actually be implemented:

> "In 2001, a decree was made, something that promoted palm, but they did not provide any instrument. It was, 'I promote palm, we must plant palm.' But where are the instruments that make that effective, right?".

Other interviewees expressed concern that commonly, palm expansion programmes do not provide financial support for enough time while new plantations mature, forcing producers to look for other incomes meanwhile, commonly involving deforestation.

Regarding the use of the ZEE, to many interviewees ZEEs largely lack effectivity for several reasons. Firstly, the requirement for compliance across sectors recently became downgraded and limited only to the environmental sector. The ZEEs were not yet finished for all regions when this happened, and new zonifications, utilized by different institutions (e.g., agro-ecological zonification, forest zonification) were mandated. These different zonifications are slow to produce and difficult to articulate with each other, slowing down and complicating the completion of effective OT across government levels. Secondly, there is a poor enforcement of land-use regulations in general (e.g., Forestry and Wildlife Law, Land Titling law, etc.) as there is not enough political will to verify its compliance and prosecute faults. Additionally, different land uses (e.g. agricultural, forest, rural, etc.) are regulated by different, poorly articulated, institutions.

Most interviewees thought that zonifications do not really influence the patterns of palm expansion, as the sector responds more to market incentives for conservation than land-use regulation. One consultant said:

> "In the context of palm oil, there is almost no mention of the ZEE.… they have entered into the logic of market requirements to be able to define where they are going to grow or not."

Aside from palm, interviewees thought that zonifications seem to have been used to some extent to orientate land-use in San Martin and seldomly in Ucayali.

Other legal instruments have recently been created. The Contracts for Assignment in Use of Agroforestry Systems (*Contratos de Cesión en Uso para Sistemas Agroforestales* - CUSAF) allow irregular occupants to stay in public land and implement agroforestry systems. CUSAFs were thought of as an incentive for the illegal occupants to regularize their situation and be permitted to perform economic activity legally in the occupied land. Many interviews thought that CUSAFs were a good idea, but were critical about some aspects of their implementation which have disincentivised adoption. These include a cumbersome application process and the payment of administrative fees, which occupiers refuse to pay, as they see no benefits in applying to a CUSAF in comparison to informal occupation.

3.3.5. Management factors

This group includes management and technical aspects specific to oil palm cultivation that have contributed to its expansion and to palm-induced deforestation. Interviewees from the production sector agreed that many farmers have adopted palm, or even reconverted plantations from other crops to palm as it is easier to manage and less prone to diseases than cacao or coffee. As technical and financial assistance now mostly comes from private actors, many interviewees, especially from the production sector and NGOs, shared the perspective that producers' organizations play an increasingly important role in the expansion dynamics of palm, as the extent to which assistance for expansion or reconversion is conditioned on no-deforestation commitments is largely at their own criteria.

Some interviewees expressed concerns that some associations are supporting area expansions without sufficient deforestation control in Ucayali. Moreover, regardless of the lower productivity, Ucayali has also had large increases in installed extraction capacity, raising concerns that the demand for fruit might be satisfied at the expense of forests. One private consultant described this situation:

> "Productivity is lower in Ucayali than in Tocache (in San Martin). We talk about 10, 12 tons, in Tocache we talk about 30, 28 tons, right? And these producers in Ucayali, with that productivity, want to expand"

On the other hand, some private companies, like those from, or working with, Grupo Palmas, despite formerly being involved in deforestation scandals, have at present adopted no-deforestation commitments. Some interviewees, especially from NGOs and producers' associations, perceived that these companies were careful to provide technical support only to complying producers and were optimistic

about their effectiveness for controlling deforestation. These commitments have as well been pushed by other large actors from the food processing sector which buy oil from Grupo Palmas. These companies include the largest individual buyer, Alicorp, and other international companies like Nestlé, Cargill and Bimbo.

Obtaining certifications, mostly via the Roundtable on Sustainable Palm Oil (RSPO), was also seen by many interviewees as an important step to meet markets' sustainability demands. At present several producers' organizations are in the process of obtaining these certifications, commonly supported by NGOs. Although some interviews perceived that buyers' policies and certifications have indeed influenced producers' behaviour towards sustainability, others were more sceptical about the actual degree of implementation.

3.3.6. Illegality and corruption

These factors comprise illegal activities like drug trafficking, land trafficking (illegal grabbing of land for selling and speculating) or money laundering, as well as institutional corruption and misbehaviour. Corruption was commonly mentioned as an important underlying factor behind several failures in the implementation of land-use policies and illegal deforestation. Deforestation scandals involving major palm companies were seen as being facilitated by significant legal oversights, likely by authorities participating in misbehaviour. On the other hand, interviewees did not attribute expansion among small and medium size producers to corruption in the form of bribes or illegal benefits. The rarity of sanctions was also seen as an incentive for illegal behaviours.

Many interviewees agreed that the prevalence of corruption and acceptance of illegal practices is higher in Ucayali than in San Martin, and that this in turn has made the agricultural expansion and deforestation harder to control in Ucayali. Across stakeholder groups, interviewees also agreed that land trafficking is an increasingly important deforestation driver. Although land is trafficked for different uses, many also perceived that the importance of palm as a driver of land trafficking has increased in recent years.

The production of coca has been an important indirect driver of land-use change in this region of Peru. Many interviewees based in production regions were familiar with the historic land-use dynamics coca planting caused in the past, and thought that at present the fluctuations of the price of coca still contribute to land-use dynamics although less than in the past.

3.3.7. Idiosyncrasy

These factors refer to dominant narratives and perceptions that influence people's behaviour towards palm expansion and land-use.

One of the most dominant narratives driving deforestation is the idea that by clearing patches of land, occupiers will get property rights. Although in the past this was indeed the case, it is no longer - but this still attracts migrants to work in agriculture, including palm. A private consultant described it:

> "palm is explained by: one, by the perception of the producers that there are lands available to occupy and convert them into palm cultivation. Two: this is also linked to migratory processes, both in Ucayali and San Martin."

According to some interviewees, the production of palm has been established and locked-in to a monoculture production system because of the dominant narratives of what best practices for profitable palm production are. During coca substitution policies, a minimum of 5 ha was advised for profitable palm cultivation. This idea -that long continuous extensions are needed-has made palm producers dubious of agroforestry production systems or combining palm with other crops or economic activities.

Some interviewees from regional governments and international cooperation agencies thought that producers' interactions, as well as their interactions with other stakeholders were different in San Martin and Ucayali due to different regional idiosyncrasies. Whereas in San Martin producers were more organized and had better communication among themselves and with authorities, in Ucayali they were more dispersed and less organized, which makes it difficult to build common visions for the territory. One employee of an international cooperation agency described it:

> "[Producers in San Martin] *are more transparent and more collaborative. Here* [in Ucayali] *you have little collaboration, they are not so collaborative. They are less transparent, they are more distrustful, so the idiosyncrasies of each people, of each region, are very different.*"

On the institutional side, some interviewees thought that the ministries of agriculture and the environment are captured by excessively legalistic and technical mentalities, which has made the implementation of land-use policy instruments overly complicated.

3.4. Towards deforestation free oil palm

The interviewed stakeholders identified several potential levers for preventing existing and future palm induced deforestation. Some levers aim to improve general land-use planning and management, as well as the implementation capabilities of institutions, whereas others were more specific to oil palm, such as plantations' management or value chain traceability. Many interviewees, particularly from producers' organizations and national government, thought that general levers require strong participation of governments and imply larger land-use legal reforms, whereas those specific to oil palm have been pushed by private actors largely on their own. In Table 3 we provide a summary of these factors -palm specific factors and factors tackling general deforestation-grouped in the same way as the expansion and deforestation factors in Table 2. Overall, interviewees thought that market demands for sustainable palm oil and their adoption by large companies in the processed food sector are at present the main levers for deforestation free palm rather than national or local policy instruments.

4. Discussion

Land-use changes linked to palm oil in Peru since the 1990s can be differentiated into different periods with diverging dynamics. These dynamics were initiated by external forces, particularly international cooperation and anti-drug programmes, and were later amplified by strong market demands in the late 2000s. Over time, internal factors, such as management practices and land-use governance have played a growing role in shaping sustainability outcomes of palm in Peru. Since the late-2010s, global initiatives on certification and no-deforestation commitments began influencing Peruvian palm oil management.

The spatial analyses on palm and deforestation provide multiple insights on the diverging dynamics of palm expansion and deforestation between both departments. Firstly, that in line with the faster development of land-use governance (both structural and agency elements) in San Martin throughout the 2000s, overall deforestation was largely reduced by the end of that decade and has remained comparatively low. In Ucayali meanwhile, deforestation has increased throughout most of the last two decades. Secondly, that palm has not been a major deforestation driver, excepting the two well-known large cases linked to industrial palm cultivation, which also emerge in our analyses. Although these were atypical events, they highlight the potential threat of large-scale oil palm investment.

We identified several other factors that increase the risk of palm becoming an important deforestation driver in the future, as well as factors with potential to ensure deforestation-free oil palm. In the next sections we discuss these factors, how they differ across both Regions, and the role of key actors for each factor. Lastly, we describe limitations of our study.

Table 2
Summary of factors driving palm expansion, palm related deforestation and general deforestation.

	MARKET	MIGRATION, POVERTY AND LOCAL LIVELIHOODS	INSTITUTIONAL, POLICY AND POLITICAL	MANAGEMENT	ILLEGALITY
Factors that drive oil palm expansion	· High global market prices of palm oil. · Peru's fats production deficit.	· Legal income opportunity as coca substitute. · Attractive source of income for small and medium producers. · Profitable reconversion crop from cattle pastures and other crops. · Adoption of oil palm by migrants. · Development of roads.	· Alternative development programmes to combat coca production. · National and regional public investment policies and credits. · Public national and regional sectorial promotion plans. · Biodiesel promotion policies.	· Easier to manage and less prone to diseases than cacao or other cash crops. · Technical and financial support provided by producers' associations, governments -mostly regional- and big private companies.	· Illegal land acquisition operations and institutional misbehaviour, allowing the establishment of large continuous areas of palm plantations.
Factors that make oil palm deforest	· Producers expanding palm area over forest looking to increase their income, commonly co-motivated by high commodities' market prices.	· Deforestation and palm planting to pursue land rights. · Poverty and migration as underlying factors for settlers to adopt palm oil and to manage it inefficiently. · Aggressive expansion strategies of big companies.	· Technical and financial support to palm producers as part of short-term programmes. · Poor institutional capacities for enforcing land-use regulations. · Poor intersectoral coordination for controlling palm expansion. · Insufficient political support for deforestation free palm oil initiatives. · Insufficient financial support and intercropping training to provide income to producers while new plantations mature.	· Producers' organizations promoting expansion without deforestation controls. · Low yields make producers expand over forests to satisfy demand. · Insufficient technical and financial support for implementing deforestation control interventions in palm production. · Oil palm managed as a monoculture.	· Illegal deforestation by big companies on land acquired irregularly. · Illegal occupation of forests by settlers who obtain titles and then sometimes sell to palm producers (i.e., land trafficking).
Factors that drive deforestation	· Global demand of cash crops.	· Poverty, Migration and resulting land-use dynamics. · Settlers' pursuit of land rights through agricultural occupation. · Agricultural expansion. · Failure in demonstrating (economic) value of forests. · Pasture expansion for cattle grazing. · Roads' infrastructure construction. · Lack of finance for improving farming practices · Invasion of poorly managed forestry concessions.	· Ineffective land-use change laws mostly due to a) poor institutional capacities and political will for enforcement, b) incomplete or unclear zonification maps across scales, c) overcomplexity to apply some of the legal instruments, d) zonifications being poorly integrated across institutional realms. · Lack of a general, nationwide regulatory frame to govern land-use change. · Public investment policies for agricultural development lacking effective deforestation controls. · Weakened institutional capacity due to the frequent rotation of trained personnel. · Lack of political will to push deforestation control agendas. · Lack of a regulatory instrument for the specific management of secondary forests.	· Poor traceability in forestry operations.	· Illegal logging for timber. · Non-sanctioned mismanagement of forestry concessions, which drives settlers to illegally clear and occupy land inside concessions. · Authorities and private actors not complying with land-use regulations without sanction. · Land trafficking (i.e., clearing land, obtaining rights and then selling).

4.1. Lessons learned and pathways towards deforestation free oil palm

4.1.1. Market demands can directly and indirectly induce sustainability commitments along the value chain

At present many actors see market-driven voluntary commitments as the most effective means for developing a deforestation-free oil palm sector (see section 3.3.5). Global market demands of deforestation free agricultural commodities -in turn driven by sourcing policies of importing countries or supranational entities like the European Union- have led major global companies to adopt no-deforestation commitments. Companies like Nestlé, Cargill or Bimbo, which are among the main buyers of Peruvian palm oil, have adopted such commitments. Specific policies differ among companies, but generally consist in avoiding sourcing from recently deforested areas, ensuring supply chain traceability, and differentiated technical and financial support to producers according to compliance. If broadly implemented, these commitments could be a powerful lever given the high proportion of Peruvian oil these companies purchase from other major actors in the national processed food sector in Peru, such as Grupo Romero.

Nevertheless, independent producers or smaller companies and organizations risk being excluded from high value markets, if the high costs of compliance are transferred to smallholders (Hasan et al., 2022). This situation is not exclusive to Peru. Low inclusion of small producers is a general problem of deforestation-risk commodities' voluntary sustainability commitments, and require complementary support by industrial and governmental actors (Lambin et al., 2018). Hence, the scope for producers' associations and small producers to comply with global markets' sustainability standards will be crucial in determining the

Table 3
Levers for controlling deforestation caused by palm oil and in general.

	Palm specific levers	General deforestation levers
MARKET	· Market demands for deforestation-free palm oil. Big oil buyers have started implementing no-deforestation commitments. · Access to higher value sustainable palm oil markets. Certifications are being pursued by producers' associations to access these markets. High conservation value and high carbon storage (HCV-HCS) studies have also been performed on behalf of some producers' organizations and local governments.	· Promotion of regional sustainability labels. Ucayali has created the 'Ucayali label'.
MIGRATION, POVERTY AND LOCAL LIVELIHOODS	· Diversify the economic activities of producers to control palm area expansion by providing alternative incomes. · Obtain financial and technical support for the production of added value products. Rather than mostly crude oil, small producers' companies could produce and commercialize added value products like refined oil, soaps, and other derivates of palm oil. This could increase incomes without area expansion.	· Make conservation of forest economically competitive against oil palm through non-timber products, tourism, or payments for conservation, carbon or ecosystem services. · Formalize land tenure of migratory peasants so they establish at a site and break the migratory agriculture cycle.
INSTITUTIONAL, POLICY AND POLITICAL	· Facilitate the processes to access public deforested land for palm expansion to reduce pressure on forests.	· Improve the coordination of the palm sector with other economic sectors and with authorities, to build a common vision of the use of the territory. · Improve the design of public incentives for rural development to include safeguards to prevent deforestation. · Design financial programmes to support the transition of agricultural production to sustainable practices across entire landscapes. · Harmonize and strengthen land-use planning policy instruments. · Strengthen the institutions in charge of enforcing land-use policies and improve their coordination.
MANAGEMENT	· Increase yields to satisfy demand with less area expansion. · Design technological packages for the specific biophysical conditions of production sites. · Provide seedlings for area expansion only to producers that have high yields and available area to grow without deforesting. · Implement and improve extraction plants' providers' traceability systems to ensure no-deforestation compliance. · Provide targeted financial support to producers with new plantations to ensure an income while palms start producing fruit.	· Focus private and governmental technical and financial support according to producers' economic conditions. · Strengthen small producers' associativity to increase yields and further accessing higher value markets (e.g., European Union).
ILLEGALITY		· Mitigate land trafficking by increasing the capabilities of the institutions in charge of dealing with this conflict and by educating communities in the importance of not taking part in land trafficking operations. · Control institutional corruption.

direction the Peruvian sector takes in the following years.

4.1.2. *The potential of certifications*

Most interviewees' opinions indicate strong potential for RSPO and similar certifications for controlling deforestation as producers aim to increase exports to higher value markets. For instance in Colombia, the main producer in Latin-America, credible commitments were not undertaken until the domestic demand was saturated and surpluses had to be exported (Furumo, 2020) to markets that required certifications.

On the other hand, experiences in other countries attest limited effectiveness. In Guatemala, an emerging oil palm exporter, where more than 60 % of plantations are RSPO certified, deforestation reduction appears insignificant (VanderWilde et al., 2023). The experiences in Indonesia and Malaysia also attest limited effectiveness of RSPO, in this case mostly due to the low adoption caused by the high cost and difficulties for compliance (Carlson et al., 2018; Meijaard et al., 2017; Purnomo et al., 2023). As a response, both countries have created their own national certification programmes (Sylvia et al., 2022; Yap et al., 2021) which, despite becoming mandatory, face limited market credibility (Hidayat et al., 2018; Rahyla Rahmat et al., 2021). The promotion of the 'Ucayali label' -a sustainability standard for agricultural products from Ucayali promoted by the regional government (Gobierno Regional de Ucayali, 2021)–about which some interviewees from this Region were hopeful could face similar credibility issues.

These experiences show that national and regional contexts mediate the success of certifications for controlling deforestation from oil palm. In the case of Peru, some interviewees were less optimistic about certifications because there is still a large domestic demand to fulfil. Yet, Peruvian oil palm exports have risen sharply (Agencia Agraria de Noticias - Agraria.pe, 2023), whereas RSPO certification has been slow (Earthworm, 2023; Roundtable on Sustainable Palm Oil - RSPO, 2023).

4.1.3. Improving and diversifying producers' income decreases expansion pressures

Diversifying and boosting the incomes of smallholders are important levers for decoupling economic development from land-use change. Some interviewees revealed that producers are dubious of agroforestry systems or combining palm with other crops. Yet, evidence indicates that on-farm diversification can increase the resilience of small producers towards price-shocks of volatile markets (Ivanova et al., 2020; Sánchez et al., 2022). Price shocks mostly affect small producers' incomes and might force them into other economic activities that imply deforestation. This is particularly important in Peru given the large proportion of smallholders, and has been acknowledged in previous sectorial strategies (Ivanova et al., 2020). However, many interviewees perceived that progress has been slow. The production and commercialization of added value products by producers' associations –rather than pure oil-could also boost producer's income without increasing planted area. Although the majority of the producing land and extraction revenues still belong to small and medium producers in Peru (Ivanova et al., 2020; Ministerio de Agricultura y Riego, 2016), the increasing influence of global capital and large producers in the Peruvian palm sector could change this condition. Hence, in an increasingly competitive sector, products with added value could offer significant protection to producers.

4.1.4. Palm management

Among management levers, increasing yields was deemed key, as many interviewees associated low yields with the inclination of producers to expand area for satisfying demand, particularly in Ucayali. At present most of the technical support both for increasing yields, and for increasing area comes from private actors, particularly producers' organizations. Hence, the form of increasing productivity that these organizations prioritize (i.e., yield increase or area increase) will play a key role in the land-use impacts of palm production, once again highlighting the relevance of producers' organizations as key actors.

4.1.5. Deforestation and land-use governance

The levers for developing a deforestation-free palm sector that we identified - particularly those for which most interviewees were particularly optimistic - can only reach their full potential when implemented under strong land-use governance conditions. For instance, no-deforestation commitments from global companies need to be supported by policies in production countries such as land-use plans or indicators serving as monitoring baselines to ensure implementation, credible compliance, and access equity among producers (Grabs et al., 2021; Lambin et al., 2018). Increasing yields also require strong land-use governance to effectively control deforestation from commodity crops (Byerlee et al., 2014; García et al., 2020).

Our results show that governance conditions for deforestation-free oil palm are more prevalent in San Martin than in Ucayali. The reductions in overall deforestation throughout the 2010s were attributed by many interviewees, as well as by previous studies (e.g., Augusto Meléndez et al., 2017; López, 2015) to the creation and strengthening of environmental institutions. According to many interviewees, these structural elements of governance in san Martin are also complemented by more inclusive and articulated means for land-use decision making, more capable and better organized producers' organizations, as well as more effective channels for producer-government interactions (i.e., stronger agency elements of governance).

In Ucayali, on the other hand, the weaknesses of many of these governance elements contribute to the growth of overall deforestation and increase the risk of deforestation from palm. This, in addition to the recent acceleration of palm expansion, as well as the suitable landscape conditions for further expansion over forests, exacerbate this risk. The deforestation models of Vijay et al. (2018) indeed show that large areas of Ucayali are at risk of deforestation from palm expansion. Plus, in line with earlier studies (Shack et al., 2021), the higher prevalence and tolerance of corruption in Ucayali mentioned in our interviews was deemed key for slowing down the development of environmental institutions (also see e.g., Bennett et al. (2018) and Fischer et al. (2020)) and the implementation and enforcement of land-use policies.

While these risks emphasise the need for improving land-use governance in Ucayali, the poor performance of existing governance elements, emphasised during our interviews, suggests that further changes are required. For instance, whereas land-use planning is a key factor for controlling land-use change - as acknowledged in the Global Biodiversity Framework of the Convention on Biological Diversity (Convention on Biological Diversity - CBD, 2022) - the substantially larger deforestation and palm expansion we detected in protection zones of the ZEE of Ucayali compared to San Martin reveals ineffectiveness of this important land-use policy tool. Furthermore, after finishing our interview process, changes to the Forestry and Wildlife Law (Law Num. 31,973) were introduced that further lowered the capacity of zonifications as effective instruments for planning sustainable land-use (Dávila and Canelo, 2024; Martel et al., 2024). We argue that this is to the detriment of forest conservation and sustainable land-use. Existing evidence shows that zonifications can indeed contribute to protecting forests at agricultural frontiers in developing countries and that -contrary to these changes-zonifications should be strengthened (Bruggeman et al., 2015; Lwin et al., 2020; Nolte et al., 2017). For instance, east of Ucayali, the Brazilian state of Acre has improved its land-use governance through the implementation of a zonification (Tovar et al., 2021).

The overcomplexity of implementing some legal instruments also weakens land-use governance. This situation seemed to particularly affect land tenure regulations. For instance, the adoption of Contracts for Assignment in Use of Agroforestry Systems (CUSAFs) by irregular occupants was low because of the complicated application process (and the payment of rights). Although securing land rights was deemed important for controlling deforestation by many interviewees, there are also important considerations, both in the context of palm expansion and deforestation in general. In Ucayali, Bennett et al. (2018) found that titling campaigns might be biased towards migrants and districts with palm production rather than native irregular occupants with staple crops. Also, there is evidence that securing land rights does not necessarily control deforestation but could promote it under weak land-use governance conditions (Agrawal et al., 2014; Ceddia et al., 2014; Fischer et al., 2020), further emphasizing the need to improve land-use governance for reaching all levers' potential.

Governmental support is also key for a deforestation-free palm sector, even more as it is linked with official plans for rural social and economic development (Potter, 2015). Most stakeholders indeed believed national and regional governments could play a leading role towards this aim and perceived that the progressive withdrawal of governments (see section 3.2), particularly national, impedes progress towards deforestation-free palm oil in Peru. Nevertheless, we also observed that some regional public servants, mostly in Ucayali, thought that the palm sector does not need governmental support anymore because, in their opinion, it has reached financial self-sufficiency. We are not certain how prevalent this view is among regional public servants, but it shows a poor level of communication and convergence among public and private stakeholders (i.e., weak agency elements of governance) which need to be solved to reduce further risk of deforestation as the oil palm sector expands. Although not free of failures, improvements in the social and environmental outcomes of the palm sectors of the largest producing countries of Latin-America -Colombia and Ecuador-would have not been possible without governmental support (Boyd et al., 2018; Furumo, 2020; Furumo et al., 2020; Ministerio de Agricultura y Ganadería et al., 2020; Rueda-Zárate and Pacheco, 2015).

4.2. Study limitations and outlook

Our interview process helped us draw a general picture of the

dynamics of Peruvian oil palm landscapes, the factors driving their expansion and to identify potential levers to control palm induced deforestation. While lessons can be learned from the experiences of countries with a developed oil palm sector, effective strategies for controlling deforestation - from palm and in general-need to be tailored to local contexts based on a solid knowledge of the governance conditions in place (Seymour and Harris, 2019). Several studies have assessed the development of land-use governance in San Martin, given its reputation as a jurisdiction that managed to significantly reduce its deforestation rates, but much less is known about Ucayali. Although our work identifies some of the governance elements in place - or missing-in Ucayali, other than Kowler et al. (2016), no thorough studies of land-use governance in Ucayali seem to be available. Further studies would increase the evidence basis for improving land-use governance in this rapidly transforming Region.

Poor monitoring and data availability also hamper the evaluation and design of interventions on deforestation-risk commodities worldwide (Lambin et al., 2018). In Peru, the existing data on the size and spatial distribution of palm plantations is limited and uncertain (the data used for our transitions analysis come from remote sensing, not from a thorough mapping of plantations in Peru). While some extraction plants have spatial data of their providers' plantations, creating national, public, spatially explicit data of oil palm expansion remains a substantial challenge. This is key to accurately weight the effects of RSPO and other private incentives in land-use dynamics and adjust when needed, in Peru and globally.

Lastly, a complete picture of land-use change in this region of the Peruvian Amazon would include the dynamics of other crops and economic sectors like forestry or extractive industries. However, thorough studies of these land-use change drivers in this region of the Amazon are currently insufficient to build a complete landscape dynamics picture.

5. Conclusion and Outlook: Governing future palm expansion

Palm cultivation in Peru will very likely keep growing in the coming years as market demands and economic incentives for expansion continue to exist. The key question is how this growth will unfold. Despite encouraging signs within the sector, where private actors and governmental institutions are willing to adopt international sustainability practices, alarming signs also exist: big companies and producers associations are rapidly increasing their production capacities, and only few are establishing new plantations according to land-use regulations or private standards. In order to distinguish themselves from this non-sustainable trajectory it is paramount that key stakeholders in the palm sector -public and private, large and small-collaborate to create and implement a pre-competitive agenda towards a sustainable and deforestation-free Peruvian palm oil sector. Based on the results of our interviews, literature and our experience in the sector, we propose the following characteristics and elements of a pre-competitive agenda for deforestation-free palm oil:

- A long-term vision beyond political cycles that is connected to local contexts.
- A landscape perspective that includes the network of public and private actors that shape land-use dynamics and need to be engaged for deforestation-free oil palm.
- Long-term financing for the sustainability transition of the sector including public and private support for yield improvements, certifications and renewal of plantations.
- Incentives to preserve forest patches inside plantations, as exist in other producing countries like Brazil (Jezeer and Pasiecznik, 2019).
- A standard measurement, reporting and verification (MRV) system for consistently evaluating avoided deforestation from palm production sustainability practices under private and public incentives.
- Traceability systems based on visual characteristics of palm plantations (e.g., by easily accessible remote sensing data).
- Advance land titling for correctly assigning responsibilities.
- Apply and enforce land-use planning tools such as ZEEs or high conservation value – high carbon storage (HCV-HCS) maps through participatory planning processes to assure uptake.
- Coordinate and harmonize local standards with market demands and value chain reporting to be able to use sustainability as an added value and for improving the public image of palm oil.

The successful implementation of a sectorial sustainability agenda over entire landscapes requires a general territorial planning (OT) regulation as a key reference for strengthening land-use governance and controlling deforestation (e.g., see Target 1 at Convention on Biological Diversity -CBD, 2022). The difficulties in the design and implementation of land-use policies have not been exclusive to Peru (Postigo de la Motta, 2017) but rather common in developing countries, largely because of institutional underdevelopment (Hartter and Ryan, 2010; Schönenberg et al., 2015). Hence, it becomes necessary to find innovative ways of articulating and complementing regional and local governments capacities with private deforestation control initiatives (Furumo and Lambin, 2020) and to bring stakeholders, academics and other knowledge holders together to build common visions of the territory and strengthen land-use governance (Schönenberg et al., 2015). Evidence shows that improving land-use governance can indeed reduce deforestation in developing countries (Fischer et al., 2020). Furthermore, existing deforestation-free national agreements for main commodities (i.e. coffee, soy, palm oil, cocoa, etc.) have resulted in a good basis to promote the first steps of pre-competitive agendas involving the public and private sectors (i.e., palm oil zero deforestation agreement in Colombia) (Ministerio de Ambiente y Desarrollo Sostenible de Colombia et al., 2017).

Finally, although recent global sustainability commitments, including entry requirements for deforestation-risk products in entire markets like the European Union (European Commission, 2023) represent a step forward for increasing global responsibility for deforestation driven by commodities' global demand, without a robust monitoring component it is difficult to fully understand their effects (Lambin et al., 2018). Complementing land-use governance improvements and sustainability commitments with robust monitoring is still an area of improvement for deforestation-free value chains, for oil palm in Peru as for other developing countries with emerging agricultural commodities sectors.

CRediT authorship contribution statement

Diego Brizuela-Torres: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Calum Brown:** Writing – review & editing, Supervision, Resources, Funding acquisition, Conceptualization. **Yves Zinngrebe:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jenvman.2025.127462.

Data availability

Link to code for analyses and hyperlinks to public data used are provided in the main manuscript and supplementary material

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