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Resolving land tenure security is essential to deliver forest restoration

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Tropical countries are making ambitious commitments to Forest Landscape Restoration with the aim of locking up carbon, conserving biodiversity and benefiting local livelihoods. However, global and national analyses of restoration potential frequently ignore socio-legal complexities which impact both the effectiveness and equitability of restoration. We show that areas with the highest restoration potential are disproportionately found in countries with weak rule of law and frequently in those with substantial areas of unrecognised land tenure. Focussing on Madagascar, at least 67% of the areas with highest restoration potential must be on untitled land, where tenure is often unclear or contested, and we show how unresolved tenure issues are one of the most important limitations on forest restoration. This is likely to be a bigger problem than currently recognized and without important efforts to resolve local tenure issues, opportunities to equitably scale up forest restoration globally are likely to be significantly over-estimated.

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Dramatic claims have been made about the climate mitigation potential from the restoration of forest ecosystems[1,2], particularly in the tropics[3]. It is widely accepted that forest restoration can, at least in theory, lock up a substantial proportion of emissions needed to keep us below two degrees of warming[4]. However, while much is known about the biophysical challenges of tropical forest restoration, e.g.[5,6], recent research calling for forest restoration often fails to acknowledge the socio-legal constraints on its design and implementation[7–10].

Decades of work have highlighted broader benefits of forest restoration, including biodiversity conservation, hydrological benefits, and livelihood support[7]. As a result, tropical forest restoration is often considered as part of a landscape approach aiming to contribute to a range of sustainability goals; this has become known as forest landscape restoration (FLR). FLR is defined as "a planned process that aims to regain ecological functionality and enhance human well-being in deforested or degraded landscapes"[11], and can include forest restoration with biodiversity-related objectives, planting woodlots of fast-growing species for fuelwood, and agroforestry activities[12–14]. Many countries have made ambitious commitments to FLR, with the majority of areas pledged located in lower-income countries[15]. For example, 32 African nations have together committed more than 100 million hectares of deforested and degraded land for FLR by 2030[16]. However, there is disappointment with the speed of progress[12,17,18].

Influential global maps identifying restoration potential according to biophysical determinants, e.g.[1–3] risk erasing crucial local context[19] and so over-estimating the real potential for forest restoration[8,10]. In particular, there is increasing awareness that securing land rights is an important enabling condition for effective restoration[20–22]. Land rights not only affect who may use what resources and in what ways but also shape the incentives people have to invest in and sustain the resource base over time[20] and, therefore, could have a strong impact on where restoration can be achieved. There have recently been increasing calls for greater integration of social data into restoration science[7,8,10], and other scholars have also proposed frameworks for strengthening tenure analyses in future assessments of restoration potential[22,23]. Our study reinforces these calls by providing further evidence and nuanced insights on the extent to which the lack or weakness of rights can act as an impediment to forest restoration at scale. We draw on a mixed-method analysis, combining global-scale quantitative analysis with an in-depth analysis of what this means in practice in the social and economic context of the Madagascar country case study.

We first show that there is a substantial overlap between areas identified as being a high priority for restoration and areas with weak governance and unrecognised land rights. Moving beyond general claims that this acts as an impediment to scaling up restoration requires a deep dive into how land tenure issues impact policies and practices in a specific country. We, therefore, focus on Madagascar: a country which has committed 4 million hectares of degraded and deforested land for FLR under the Bonn Challenge. Forest restoration also forms part of its Nationally Determined Contribution to the Paris Climate Agreement, and restoration targets have high-level political support[24].

We conducted 52 semi-structured interviews with national stakeholders involved in designing and implementing FLR projects in Madagascar, including government authorities, lawyers, donors, and project proponents. Finally, we conducted 28 focus groups (including a total of 94 participants) and 17 semi-structured interviews with local communities in nine FLR sites (Fig. 1). This country case study is vital to move beyond simple acknowledgements that "land tenure matters for effective restoration" and to identify solutions to allow FLR to fulfil its potential as an important Nature-Based Solution to climate change. We use the example of Madagascar to draw out a number of ways in which tenure insecurity acts as a barrier for FLR at scale and use the wider literature to make the case that these points are likely to apply across tropical countries with governance and tenure challenges.

Results

Global maps showing restoration potential ignore tenure and governance issues. Our analysis finds that 78% of the land identified by Strassburg et al.[2] as being in the top 20% of restoration potential is in countries with below median scores on the World Governance Indicators rule of law indicator[25] (Fig. 1a). In addition, 42% is in countries where more than 20% of the land is used or held by indigenous and local communities and is not formally acknowledged by the government[26] (Fig. 1b). For Brancalion et al.'s top 20% of global restoration priorities, the respective figures are 85% (the low rule of law) and 43% (high unrecognised land tenure) (see Supplementary Fig. 1). Interestingly, Bastin et al.'s analysis of global tree restoration potential, which has been criticised for not incorporating socio-economic factors[7,27], has more limited overlap (57% and 27%, respectively, see Supplementary Fig. 2).

Focusing on Madagascar, we see how global analyses such as Strassburg et al.[2] may overstate reforestation potential once tenure complexities are taken into account. Of the 27 Mha identified as being high potential for restoration (46% of Madagascar's total land area), 10% is in protected areas. Much of the non-forested land in protected areas is claimed by local communities and used by them, including for agriculture[28]. However, land in Malagasy protected areas is currently under "unspecified" tenure[29], and neither local communities nor protected area management agencies can obtain state-recognised tenure under Malagasy law due to a long-lasting legislative impasse[29]. Overall, no more than 15% of Madagascar's land is formally titled, so at a minimum, 67% (see "Methods") of the land identified by Strassburg as having high restoration potential must coincide with areas without a formal title, much of which is claimed by local people through customary tenure. The true figure is likely much higher since land tenure is disproportionately formalised in urban areas and intensively farmed croplands like irrigated rice fields[30] (which were more likely to be excluded by Strassburg et al.).

Contested land tenure has been a substantial barrier to scaling up FLR in Madagascar. The Malagasy government has identified large areas as targets for FLR[29], but most of these areas have not been physically demarcated and in many cases, overlap with lands that are customarily or formally claimed by local people. Several restoration projects across Madagascar have intended to use these target lands to carry out large-scale restoration interventions but had to step back or work with smaller land parcels when confronted with on-the-ground realities of land occupation by local people. This is illustrated by comments from one project proponent:

> *"Our efforts are currently hindered by severe land tenure issues, with most of the target areas being already occupied by locals. This means we will either have to negotiate with individual landholders—which makes upscaling more challenging—or abandon our plans altogether."* Project Proponent 11 (PP11).

Lands targeted for restoration in Madagascar are often considered by project implementers as "*marginalised*", "*degraded*" or "*barren*" but are often seen very differently locally. While these lands are often formally state-owned and are frequently within or adjacent to protected areas, they are, in practice, regulated by customary or informal tenure arrangements[29]. Some project

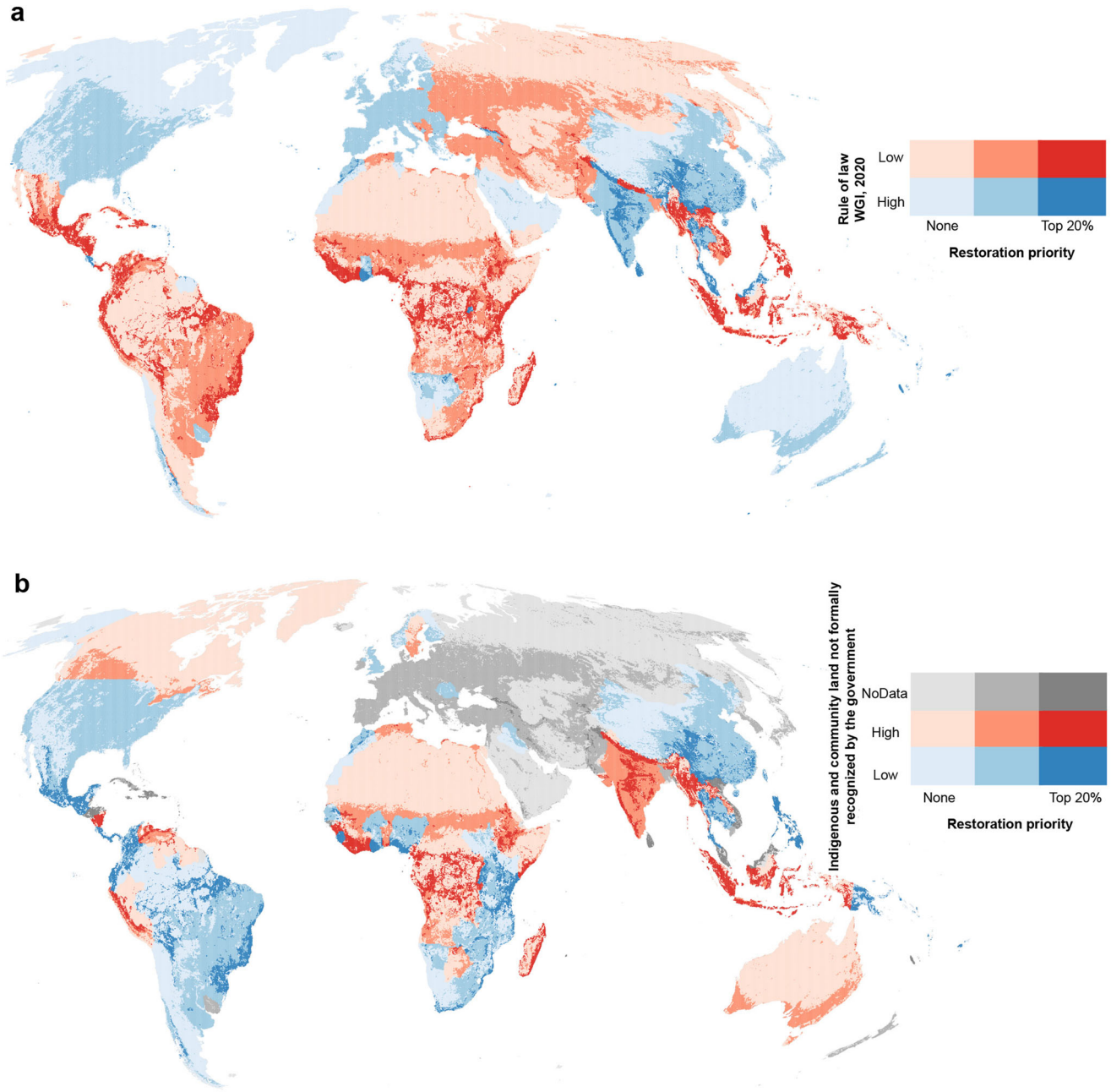

Fig. 1 Overlap between restoration priority area scores, governance indicators and land tenure. a Overlap between restoration priority area scores (from[2]) and the World Governance Indicators rule of law indicator[25] (countries scoring below the median are classified as Low and those with a higher score than the median as High). **b** Overlap between restoration priority area scores (as defined by Strassburg et al.[2]) and the distribution of indigenous and community lands not acknowledged by the government (from[26], countries with >20% of indigenous and community lands not recognised by governments are High, <20% are Low).

proponents ignore customary claims and emphasise the legal situation to justify the removal of people from these lands in the name of restoration, as echoed by the following quote:

> *"These are state-owned lands and need to be restored, and by rights, these people were not meant to be there in the first place"* (PP9).

Even if this succeeds in restoring land, it comes at high social costs and is unlikely to result in effective restoration long-term[31].

These tenure disputes can continue for many years. For example, large-scale pine plantations were established by the Malagasy government in the 1970s, but conflicting claims have emerged, with local people threatening the sustainability of the plantations. Project proponents had to yield to communities' claims in one case, as a project proponent stated:

> "*Following a court ruling, we were compelled to hand back a large area of tree plantations to legal owners who had overlapping land claims.*" (PP27).

Tenure affects expectations of benefits and thus local motivation for FLR. There are many different activities included in FLR projects in Madagascar, and the land tenure context varies

between these activities. Across Madagascar, particularly in the periphery of protected areas, forest restoration is typically carried out for biodiversity objectives. Currently, there is no prospect for consumptive use (of timber or tree fodder) being allowed in this context. There is a common view among project proponents that the non-consumptive ecosystem services from restored sites on lands formally owned by the state (but used customarily by local people) should provide enough incentives to motivate local support, as a government official (GO) attested:

> *"Forest restoration brings several benefits to local wellbeing, if we only mention water regulation, carbon sequestration, pollination, etc. These benefits alone should attract local participation, if that's not the case, we need to work harder at educating them."* (GO2).

However, local people question whether they will benefit from these restored areas. While the legal framework makes provision for local communities to benefit from carbon credit sales on state-owned land (although, in many cases, they are yet to materialise), "carbon rights" belong exclusively to the State[32].

Local communities prefer woodlots of fast-growing (often exotic) species to restoration of native forests on their lands because of the short-term profits from wood sales or consumption. They also expressed stronger motivations for investing labour in exotic tree planting on their individual lands compared to communally managed lands because of the perceived greater security of the benefits in the long run:

> "*As opposed to on common land, we have greater control over trees on our land in the long term. Also, other community members might change their minds in the future, and this risks jeopardising our efforts."* (LC19).

However, the restoration of native forestlands in Madagascar is usually initiated on land where the government has tenure and where there is no intention to strengthen individual tenure, such as in and around protected areas (such land may be co-managed by community groups and local authorities, but individual tenure is not possible under current laws). The lack of interest in community restoration on communal lands might be an obstacle to upscaling forest restoration on a scale larger than individual plots since many areas identified as priorities for restoration are currently managed in common (e.g., for grazing).

Local people worry FLR will reduce tenure security. Some local people associate forest restoration, especially that carried out with native species for biodiversity objectives, with strict forest protection by the state and expressed fears of being disenfranchised and displaced, as two interviewees from local communities expressed:

> "*Enroling our lands in a native tree planting project is akin to handing our lands back to the government."* (LC3).

> "*We fear that the state or other more powerful entities will claim the newly restored lands later*" (LC8).

This has even led to people actively vandalising restoration efforts. In several cases, the land was burned soon after saplings were planted, and the restored parcels returned to agriculture. Along with fires, incidents of destruction of seedlings were widely reported across the project sites. This highlights the risks to reforestation where de jure state ownership overlaps with local customary tenure.

Tenure securitisation can be a tool for incentivising FLR. Formalising local people's tenure can facilitate local willingness to invest in restoration, and local people may engage in planting fast-growing trees (mostly exotic species) as a way of strengthening their claims:

> "*Our expectation is that our investments in Eucalyptus tree planting will increase the recognition of our land claims, despite the lack of formal proofs."* (LC18).

Several respondents reported that successful projects in Madagascar, mostly under the domain of the Ministry of Agriculture, have combined technical support for tree planting activities and processes to increase tenure security through the formalisation of participants' individual rights to trees and lands (PP10, PP22, PP23, PP26). However, this might be more difficult to achieve for larger-scale or communal initiatives on formally state-owned lands or in the peripheral zones of protected areas.

Discussion

Global analyses overstate the potential for forest restoration. It is not surprising that areas prioritised globally for reforestation overlap disproportionately with countries with a weak rule of law and unsecured indigenous/local tenure. Both Strassburg et al.'s[2] and Brancalion et al.'s[3] analyses aim to minimise costs by favouring areas with low agricultural yields and, therefore, low opportunity costs. This will tend to push restoration into regions with the weaker rule of law and land tenure, likely partly driven by the fact that secure tenure is a known determinant of agricultural productivity[33]. Strassburg et al. also prioritise areas with lower labour costs (i.e., poorer regions) where the welfare consequences of displacing marginalised people from their land are likely to be more severe[8]. On the benefits side, Strassburg et al. prioritise areas with higher biodiversity (biodiversity hotspots heavily overlap with severe poverty[34]) and carbon sequestration potential (which tends to be higher in the tropics). Bastin et al.'s analysis, which largely ignored costs (aside from excluding croplands), shows less overlap with the weak rule of law and unrecognised tenure.

Therefore, attempts to prioritise restoration on some metrics—low land and labour costs—will tend to increase other costs and risks[8,10]. Strassburg et al.[2] extrapolate restoration costs from Brazil by adjusting for lower labour costs elsewhere but not accounting for changing governance risks: Brazil scores relatively well (48th percentile) on the rule of law indicator and has relatively less unrecognised indigenous and local tenure. There is a risk that the true costs of equitably achieving restoration in other countries like Madagascar, with lower labour costs and yields but greater governance challenges, could be underestimated. Just as global conservation priority setting has favoured poorer countries for their apparently lower opportunity costs, leading to high welfare and human rights concerns[35], so efforts to prioritise restoration towards cheaper areas carry high risks for project failure, equity, and human welfare. Where priority areas for restoration overlap with insecure tenure and weak governance, there is a risk that people with less secure rights are disenfranchised or displaced in favour of large-scale native tree plantations or carbon trading schemes, whose benefits accrue to more powerful stakeholders[36,37].

This is not to argue against implementing forest restoration in such places but rather that the true costs of doing so need to be acknowledged. This will include the costs of resolving tenure conflicts, which will also be necessary to achieve the yield improvements on the remaining land, which Strassburg argues can replace lost agricultural productivity from restored lands. More than 1.4 billion people globally live in areas identified by Strassburg et al.[2] as having the top 20% of restoration potential, and countries identified as having higher restoration potential are

also more likely to have lower Human Development Index values[9]. Implementing restoration projects in these countries without adequate consideration of land tenure and governance carries high risks for the world's poorest people, and because influential analyses ignore these factors, they are likely to significantly overstate global restoration potential.

Lessons from the Madagascar case study. The Madagascar case study provides insights into what it means in practice to say that scaling-up of forest restoration will not be possible without resolving land tenure security issues. Our analysis suggests that complex tenure issues are one of the most important reasons that FLR has been so limited in scale in Madagascar. The broader literature suggests these issues apply much more widely.

We demonstrate that in Madagascar, the large disconnect between statutory and customary land tenure systems[22] poses fundamental challenges to achieving the desired ecological and social outcomes from the restoration. A multi-million dollar native-tree-planting project in Madagascar struggled because of land tenure insecurities and undelivered carbon revenue[31]. Wherever restoration is implemented in contexts with a lack of clarity over land tenure and a history of land tenure conflict, identifying restoration sites without an understanding of competing claims and customary and statutory tenure relations has met local resistance. Such lack of acceptance by the local communities ultimately puts the restoration project at risk[36].

The fact that local communities with insecure tenure will be unlikely to invest in or give long-term support for restoration efforts from which they perceive little benefit applies well beyond Madagascar[12]. Restoration initiatives are often based on a belief that restoration activities cannot fail to be beneficial locally, echoing simplistic "win–win" discourses[38] in conservation[35], yet initiatives often generate local social costs[12,39], and decision-making is mostly driven by external entities[40], while local communities are displaced in favour of large-scale tree plantations or assisted regeneration[39]. Degraded areas are not necessarily uninhabited or unused[41]. When these degraded lands are "restored", they acquire material and other values that can result in local communities, and particularly their most marginalised members, being dispossessed of their rights to use, access and benefit from these resources[31,36].

Local people in Madagascar often worry that forest restoration will further undermine their land rights, but it can be a tool to help secure tenure. Tree planting has been found to be an effective way to establish informal claims to land in Nepal, Vietnam, Nicaragua, Bolivia, and the Philippines[21,42,43]. For example, smallholders may plant trees to delimit and assert rights to lands and later use or commercialise the trees[21]. Secure tenure has often proven more important than other motives for restoration investments (such as cash subsidies) and has been more effective at sustaining the participation of local communities[41].

However, there is evidence that these exotic-tree plantations (often on individually used lands) can conflict with ancestral or communal rights and generate social costs[44]. In some situations, upholding private user rights might undermine the rights of those who claim ancestral rights, such as pastoralists and less advantaged groups who rely disproportionally on access to the commons[44].

Policy implications. Land tenure considerations are clearly a much wider problem in the tropics than is often recognised by those arguing for ambitious targets for restoration. While FLR has an explicit focus on livelihoods[7], there has been insufficient attention paid to how the land tenure context will influence who wins and who loses from an FLR initiative and the success of the FLR. Restoration implementation at scale will inevitably require efforts to resolve contested land claims. However, any changes to land rights are extremely challenging and can result in appropriation of lands by elites, exclusion of historical landholders and conflict[36,39]. Scaling up forest restoration across the tropics will require targeted efforts to resolve problematic tenure issues, and this can be done in a number of ways.

First, it will be important that restoration includes processes to explicitly recognise the rights of affected local people in a way which is clear under national law. A priority should be resolving competing claims between local users appealing to customary or traditional tenure arrangements, on the one hand, and governments, NGOs or private investors relying on national legal codes, on the other[42,45]. Securing user rights is not simply a matter of formalising customary tenure (through land titles or certificates), which in some cases can undermine tenure security[46,47], but involves the legal recognition of the underlying norms and principles that they are based upon and the design of institutional frameworks for administering lands[47]. Restoration also has much to learn from the critics of REDD+ initiatives ("Reducing emissions from forest degradation and deforestation") by supporting participatory and accountable planning processes and securing free, prior, and informed consent on the part of affected rural communities before forest restoration projects are approved and funded[40]. Adequate time, technical resources and funding are essential to support these broader processes of tenure resolutions if they are to be fair and equitable[48].

Second, effective implementation of restoration requires recognising its potential social costs and understanding that alternative livelihoods, compensation, or both may be required to ensure that restoration occurs and is sustained[12,37]. Rigorous and independent social impact assessments of restoration projects and regular monitoring of social and economic impacts will be essential[36]. Adequate social safeguards will be needed to offset any negative impacts on the livelihoods and well-being of smallholders.

Third, forest restoration entails trade-offs at different scales and requires attention to the way global and national restoration agendas frame tenure arrangements in local restoration projects[49]. For instance, while the introduction of monocrop exotic tree plantations such as Eucalyptus across Africa may support little biodiversity, these fast-growing species can strengthen land tenure claims and thus incentivise investments in restoration while sustainably meeting wood fuel demand and generating income for local communities. If countries that have committed to large restoration targets are to achieve restoration that favours biological diversity, restoration initiatives must consider not only land tenure but also the flow of short-term benefits to local communities.

Finally, forest restoration requires the equitable inclusion of local people in decision-making processes[8,9]. This will require the design of effective governance mechanisms to ensure that affected people and communities are able to negotiate with proponents and governments in a fair and equitable manner and that all parties to any agreement can be held mutually accountable.

All major global or pan-tropical studies[1–3] highlighting the potential for restoration (or related concepts) ignore governance and tenure issues. Social issues, including land tenure, are much more substantial than currently recognised in the discourse surrounding large-scale forest restoration efforts. Proponents of tropical restoration must recognise that relatively low opportunity costs and cheap labour do not necessarily indicate low overall costs once the governance and tenure risks are taken into account and adequate funds are allocated to address them. To ensure that nature-based solutions such as FLR achieve their potential to tackle both the climate and biodiversity crisis while also contributing to sustainable development, we stress the urgent need for restoration

actors to acknowledge and act on these land tenure constraints both in restoration design and implementation.

Methods

Overlap between reforestation potential, governance indicator and land tenure. We overlaid the Strassburg et al.[2] datasets with global datasets of the rule of law and land tenure status. We used the rule of law indicator from the World Governance Indicators' Rule of Law Dimension for the year 2020[25], which is highly correlated with another rule of law indicators in cross-sectional comparisons. For the land tenure data, we used the percentage of land held by Indigenous and Local Communities but not formally recognised by the government[26]. The governance indicators are published at the national scale because they are, to a large degree, inherently national. While tenure status may vary spatially within a country, a spatially explicit dataset is not available for many countries, including Madagascar. The dataset used here, while not permitting us to ascertain the precise degree of overlap between restoration priorities and unrecognised indigenous tenure, provides an indication of the likely significance of tenure issues.

We made a bivariate choropleth map on a global hexagonal grid in Mollweide projection with a cell size of 10 km side[9]. Then, we used the Zonal Statistics in QGIS to summarise the value in each cell within the hexagonal grid. We used the MAJORITY for categories of restoration priority and MEAN for both the tenure dataset and the governance dataset, as these two datasets are published at the national level (an approach used by studies overlaying restoration potential with country-level datasets such as income[7] and human development index[9]).

We classified the restoration priority area into three categories: no restoration priority (identified as lacking priority by Strassburg et al.), intermediate (the lower 80% of the areas identified as having restoration priority by Strassburg et al.) and high restoration priority (the areas with the top 20% of restoration priority). Both the tenure and the governance datasets were classified into two categories: Low and High. The rule of law dataset was divided using a cutoff with a score of (−0.107), equivalent to the median score. Countries with 20% or less of their lands held by

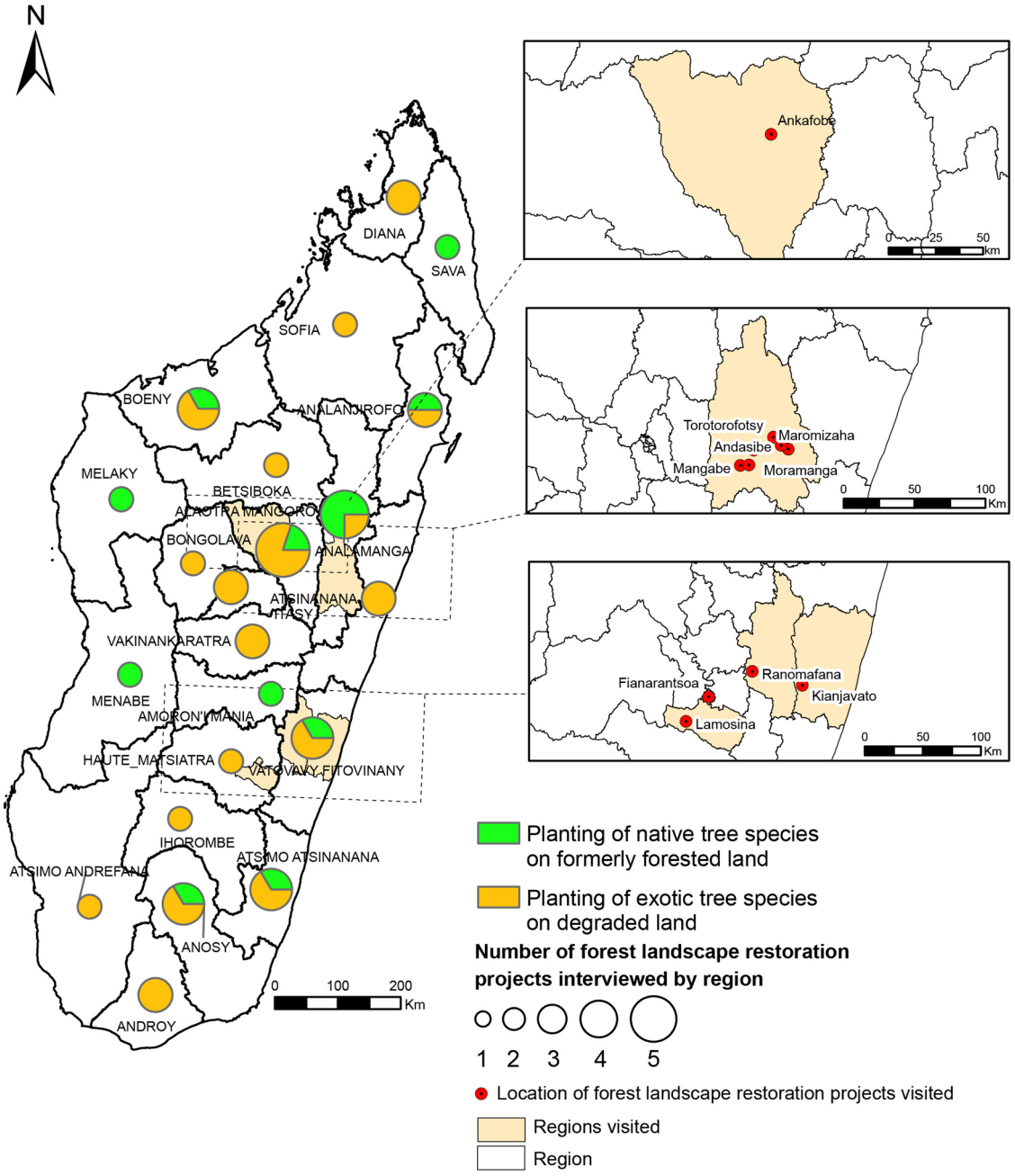

Fig. 2 Study sites in Madagascar. We conducted 52 stakeholder interviews with project proponents, donors and government representatives from 30 organisations involved in Forest Landscape Restoration projects from all 22 regions of Madagascar. We visited nine FLR projects in 5 regions, where we conducted 28 focus groups and 17 key informant interviews with community members and local representatives. This sample is illustrative of the type of FLR projects ongoing in the country.

indigenous or local communities but not formally recognised by the government were categorised as Low, and those with more than 20% were categorised as High, and those with no data available on tenure were classified as NoData. The 20% threshold was informed by the distribution of the land tenure datasets. Almost half of the countries with land used or held by indigenous and local communities that are not formally acknowledged by the government were below this threshold. We then combined the three categories of restoration priority with the classes of the land tenure and governance datasets. The resulting map was produced in ArcGIS.

We used the same classification of restoration priority for the case of Madagascar (Fig. 2) and extracted the protected area layers of Madagascar (Systeme des Aires Protegees de Madagascar, 2017) using the Zonal Statistics function to calculate the proportion of high restoration potential areas that lie within protected areas (10.2%). No more than 15% of Madagascar's land area is believed to be formally titled (Ratsialonana Rivo Andrianirina pers com, 23rd February 2022), and Strassburg et al. identifies 46% of Madagascar's land area as being in the top 20% of global restoration potential, the absolute minimum proportion of this high potential land that must lie on untitled land is 67% ([46–15]/46), but this is likely highly conservative.

National stakeholder interviews. We conducted semi-structured interviews with national stakeholders who influence FLR strategies, practitioner experts on FLR-related land tenure, or those involved in designing and implementing FLR projects in Madagascar. These included government authorities, lawyers, donors, and project proponents. We targeted individuals who have a decision-making role in their organisation and those who have intimate knowledge of FLR in Madagascar or are engaged in land tenure and FLR implementation.

We developed an initial list of individuals and organisations we wished to interview based on our extensive reading in this area and information available online. When selecting national stakeholders, we used a relatively broad definition of FLR, including any participants who are involved in implementing forest restoration projects that either aim to improve human well-being and/or ecological integrity and that are intended to be implemented at scales larger than individual plots. We built on this list as those approached for interviews often suggested additional contacts. In total, we attempted to contact 60 stakeholders for interviews. Some of them did not respond, declined, or suggested other names. Some participants from the same organisation were also interviewed in a group of 2–4 people as they felt that they were better qualified to answer our questions in a group setting. In total, we interviewed 52 people from 30 organisations. Interviewees are listed (anonymised) with their characteristics (such as organisation and other relevant information where applicable, such as FLR type, size, location, and type of tenure addressed) in Supplementary Notes 2. Interviews were conducted between June to September 2020, mostly over Skype, Zoom or on the phone due to COVID restrictions.

Interviews covered how FLR is conceptualised by various stakeholders, the characteristics of the FLR activities they are involved in, how land tenure is perceived and considered in the design of FLR projects, both from the social and biophysical perspectives (e.g., any tenure interventions they carry out, any changes in land tenure from FLR establishment, any land conflicts caused by the FLR project, who owns the land and trees, who maintains trees and has access, their interpretation of tenure laws and any tenure challenges they face) (see Supplementary Notes 3 for interview guides). All interviews were conducted in either French or Malagasy by OSR and/or HMR.

Site visits and interviews with local communities. We also conducted 28 focus groups and 17 key-informant interviews with local communities in nine FLR sites, mostly located in the eastern part of Madagascar (Fig. 1, see Supplementary Notes 3 for interview guides). Fieldwork took place in October and November 2020. The semi-structured questions covered local involvement in FLR design and implementation, local perceptions of tenure, and of the effect of FLR and tenure considerations on local livelihoods and ecological outcomes of FLR (in terms of hectares restored or reforested). Interviews and focus groups are listed in Supplementary Notes 2, with anonymised characteristics.

Ethical considerations. This research was approved by the College of Environmental Sciences and Engineering, Bangor University's ethics committee (#COE-SE2020JJ02). Informed consent was obtained from all research participants. Interviewees were informed of the aims of the research, how data would be treated and that all information would be anonymised. We made it clear that participation was voluntary and that they could leave an interview or focus group at any time. We provided a short leaflet in Malagasy and French explaining this, with contact details and photographs of the field team. For the interviews with local communities, we gave small donations (e.g., oil sugar, soaps and face masks) to community participants to thank them for their time. We did not compensate national stakeholders. We operated under a regularly updated covid policy; following (and going beyond) national guidelines at all times.

Qualitative data analysis. Interviews were recorded and transcribed (except on a few occasions where consent for recording was withheld and we relied on notes). We conducted thematic coding using NVivo 12.0 to analyse open-ended responses. Coding was conducted iteratively (by the lead author) to generate codes and themes that summarised and captured the essence of the responses. To validate the coding scheme, a second coder (HMR) used the draft coding scheme to independently code all responses. The coded text generated by the primary and secondary coder was then examined for reliability, i.e., the reasonable expectation that coders with similar topical familiarity would assign the same codes to the same unit of text[50]. We calculated alpha statistics for each code, and codes with an alpha value of 0.66 or higher were considered reliable[50]. Codes that did not meet this threshold were jointly reviewed, and the coders resolved conflicting interpretations by either merging codes or refining code definitions. Interviews were transcribed and analysed in their original languages. Only selected quotes were translated into English. We do not give information which allows individual quotes to be attributed to our respondents.

Data availability

The data of land tenure, governance indicators and restoration priority area scores used to create the global maps in Fig. 1 are derived from published papers and can be found in the Supplementary Data files. The interview and focus group discussion transcripts cannot be sufficiently anonymized to prevent deductive disclosure, and our ethical committee approval and respondent consent do not, therefore, allow sharing them.

Code availability

The analysis scripts used in the global overlay analyses are archived at https://doi.org/10.5281/zenodo.7844505.

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Author contributions

O.S.R., H.M.R., J.P.G.J. and N.H. designed the research; M.R. performed the global overlay analysis with input from O.S.R., J.P.G.J. and N.H. O.S.R. and H.M.R. conducted the interviews and focus groups, and SR contributed to the interpretation of the results. O.S.R. drafted the paper, and all authors participated in the paper editing.

Competing interests

The authors declare no competing interests.

Additional information

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