Producing nature-based solutions: infrastructural nature and agrarian change in San Martín, Peru


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Will Lock

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Producing nature-based solutions: infrastructural nature and agrarian change in San Martín, Peru

Will Lock
School of Global Studies, University of Sussex, Brighton, UK

ABSTRACT
The concept of ‘nature-based solutions’ has brought together a broad range of actors with seemingly diverse goals. This article, contributing to the forum on climate change and agrarian struggles, argues that these nature-based solutions follow a growing trend to frame the natural world as infrastructure, providing an ethnographic case study of agroforestry and reforestation projects in San Martín, Peru. It shows that as infrastructural nature claims ever more of the metaphorical space of discourse and the material space of landscapes, it becomes not just a new way of producing nature but central to the ideologies and ecologies of green capitalism.

KEYWORDS
Carbon; nature-based solutions; climate change; infrastructure; reforestation; agroforestry

Introduction
The recent rise in interest in nature-based solutions has seen carbon markets become increasingly integrated into rural politics and development strategies. In turn, carbon has become central to agrarian change in a number of contexts. As will be explored in this article, Peru is a paradigmatic case. A national drive to promote carbon-based projects has been met with regional enthusiasm to expand reforestation schemes and integrate carbon credits into export commodity production systems through agroforestry. A broad consensus of policymakers, development NGOs and private sector actors have buttressed this trend, creating a powerful development narrative in the forest frontiers of Peru’s Amazonian regions, which is producing distinct landscapes and livelihoods.

This article explores the role of infrastructural nature in these emerging carbon offsetting landscapes, contributing to the forum on climate change and agrarian struggles. Responding to Borras Jr. et al.’s (2022, 5) call to ‘situate “climate” within a wider set of environmental struggles in agrarian settings’, it analyses the narratives and strategies that frame carbon offsetting, but considers too the kind of socionatures it produces – or constrains. Engaging with an emerging literature on the anthropology of infrastructure (Star 1999; Dourish and Bell 2007; Venkatesan et al. 2018) and the production of nature...
(Ekers and Loftus 2013; Boyd and Prudham 2017; Carton and Andersson 2017), the article will show how nature-based solutions are driving a view of the natural world that ontologically and epistemologically conflates it with that of the built environment.

The logic behind nature-based solutions follows a growing trend to frame the natural world as infrastructure, reflected in both its use in practitioner and policy circles, alongside increasing academic interest (Nelson and Bigger 2022). Studies of ‘infrastructural nature’ have explored the historical tendency to treat nature as infrastructure (Swyngedouw 2007; Carse 2012) and the framing of infrastructural nature in modern iterations of ‘ecosystem management’ (Wakefield 2020). This article seeks to push these ideas further by grounding the discourse in a tangible ethnographic case study of nature-based solutions in the region of San Martín, Peru. In doing so, the article firstly explores how we might operationalise infrastructure as an analytical tool for political ecology and critical agrarian studies; expanding on the production of nature that it entails and the risks that it incurs. Secondly, it analyses the ideology that underpins infrastructural nature and its relation to green capitalism; highlighting how narratives of control and stability enrol a greater range of actors into support for nature-based solutions.

In exploring the new landscapes of nature-based solutions, the article shows how viewing the natural world as a distinct type of infrastructure attributes to it the same sense of predictability and quantifiable value that we expect of the built environment. In the region of San Martín, where landscapes are increasingly dominated by supposedly climate-friendly plantations – be they of commodity crops, agroforestry models or timber – infrastructural nature risks underestimating the unruly ecology and economic uncertainty that can arise from treating the natural world in this manner. The tendency towards simplification, technification and repetition of ecologies of control calls into question not just the well-publicised tree planting targets and net zero claims accelerated in the post-Paris governance agenda, but also the very logic that underpins nature-as-infrastructure.

The article begins with a brief summary of the concept of infrastructural nature and its connection to political ecological thought. It will then move on to describe the pursuit of carbon projects in San Martín, drawing on ethnographic fieldwork conducted in a suite of conservation and reforestation projects in the region between 2017 and 2019, to show how it has manifested in tangible policies and landscapes of production. Drawing on participant observation and 68 interviews conducted with foresters, local and international NGOs, regional government workers and cacao, coffee and cattle farmers, it will highlight how certain voices and approaches were prioritised in the region, ultimately shaping the conflicts over socionatural relations and how nature and space are produced. This is followed by a discussion of the potential consequences of this approach for local populations, the regional politics of conservation and global climate change goals.

By introducing the example of San Martín’s production of carbon to the forum on climate change and agrarian struggles, this paper situates carbon landscapes as a central axis between global climate governance and local agrarian struggles. As carbon offsetting brings together surprising coalitions of actors under new narratives of rural development, it claims ever more of the metaphorical space of discourse and the material space of landscapes. This paper thus argues that in infrastructural nature we are not just seeing a new way of producing the natural world but dominant new ideologies and ecologies of green capitalism and agrarian change.
The evolution of nature as infrastructure

The conceptual framing of the natural world as a form of infrastructure has a long history in policy, practice and academic work. Swyngedouw (2007), for example, discusses the megaprojects of Franco’s Spain in terms of their infrastructural framing of water systems, while Wakefield (2020) highlights the longer genealogy of using green spaces in urban planning and Carse (2012) discusses the ongoing integration of the natural world into the infrastructure of the Panama Canal.

The relevance to modern environmental governance has been perhaps most comprehensively elaborated by Nelson and Bigger (2022, 2), who define infrastructural nature as ‘the policy approaches, scientific practices, discourses, and investment strategies that make ecosystems legible, governable, and investable as systems of critical functions that sustain and secure (certain forms of) human life’. While Nelson and Bigger trace this ideology to the emergence of systems ecology in the 1960s and 1970s, similar logics could be traced in numerous projects to bend nature to the will of humans, to the technical and simplified structure of plantations or even to biblical tenets to master the natural world (Merchant 1982).

While such presentations and simplifications of the natural world have long been a focus of political ecology and critical agrarian studies, the language has spread beyond the world of ecology to politicians, non-governmental organisations (NGOs), activists, practitioners and more. Calls to manage the ‘earth system’ or even to marshal ‘spaceship earth’1 have proliferated in recent years in response to the threat of climate change and form the basis of the nature-based solutions promoted by figures as diverse as Greta Thunberg and Donald Trump, George Monbiot and the executives of Shell.

The growing use of the language and logics of natural infrastructure reflects not just the growth in an interest in ‘rebuilding’ the natural world but how a whole semantic field connecting architecture and construction is being integrated into environmental governance. The Executive Secretary of the Convention on Biological Diversity, for example, has noted how ‘biodiversity is the “infrastructure” that keeps our planet going’ (Hance, 2018), while the Nature Conservancy argues that we should view nature as ‘green infrastructure’ to leverage investment (Tercek 2017).

The idea of Green Infrastructure – as opposed to the blue infrastructure of water or more general natural infrastructure or ecological infrastructure – has perhaps pushed this logic furthest in policy circles. While the term has its roots in urban studies, often relating to green spaces within cities or that join the urban with the rural, definitions have been expanded by conservation practitioners and policy makers. The European Union’s Green Infrastructure Strategy (EC 2013, 7), for example, refers to it as ‘a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services’, clearly connecting the emerging policy focus on ecosystem services to the discursive logic of infrastructural nature.

While to date the concept that has mostly been applied to trees, parks and other providers of ‘green services’ in urban settings or managing water systems, this article centres

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1A term coined by architect Richard Buckminster Fuller. Fuller notably linked his vision of spaceship earth to a time when we wouldn’t need the ‘distraction’ of politics (Murphy 2015).
its role in the growth of nature-based solutions in rural contexts. Green infrastructure in particular has been seen as synonymous with nature-based solutions (Nesshöver et al. 2017), with a common focus on the creation, control and optimisation of ecosystems. Some proponents frame this as a move away from previous extractive approaches with nature ‘no longer solely seen as a source of commodities’ but inspiring ‘more systemic economic solutions’ as ecosystems ‘evolve to diverse but locally optimal equilibriums between productivity, adaptability, and resilience’ (Maes and Jacobs 2017, 122).

Rather than synonymous, infrastructural nature can be seen as an ideological underpinning of nature-based solutions as they are emerging in practice. As noted by Nelson and Bigger (2022), nature is not simply treated as infrastructure and allowed to ‘evolve’ but *made* to function as such. Wakefield (2020, 776), for example, shows how oysters are discursively produced as infrastructure in New York as a ‘risk management solution’. Here, the biological processes of oysters are ‘tamed’, so as to be used as a plannable, predictable and scalable ‘solution’ to coastal management and disaster mitigation. Nature, in the words of Carse (2012, 540), must ‘be built, invested in, made functional, and managed’ in the service of human needs. This requires both a view of human mastery over nature and a view of nature itself as a stable, predictable system to build upon.

While I concur with Wakefield’s (2020, 763) assertion that this ‘question of how living beings are made to be infrastructure has not been explored’ on a biopolitical level, I argue that we must go further than analysing how actors make ‘nature do what it does’ (776), to analyse how it *produces* very specific types of socionatures. Carse (2012, 551), for example, examines the processes by which ‘watershed forests became infrastructure through the purposeful work that went into linking them with the existing water management system’. Here too, further nuance could be developed. Rather than looking at how ‘a landscape becomes infrastructure for one system of production’ (Carse 2012, 540), approaching this question from a critical agrarian perspective allows us to analyse the overlapping narratives and infrastructures that exist in these landscapes. The contestations that occur, and the processes of negotiation and negation that alter the dynamics of production.

The production of carbon for nature-based solutions reflects this complexity and deserves greater focus as infrastructural nature. A range of literature has built on Henri Lefebvre’s ([1974] 1991) concept of the production of space and Neil Smith’s (1990) theory of the production of nature to analyse the rise of carbon and nature-based solutions in recent years (Ekers 2015; Boyd and Prudham 2017; Carton and Andersson 2017). The production of nature thesis, in particular, draws our attention to the specific ways that economic relationships can shape socionatural systems, which can be usefully applied to these new markets. As noted by Neil Smith (1990, 86): ‘It is not merely that different production processes have different “space requirements”; rather, in the process of building productive forces into the environment, space is produced according to the spatial properties of this set of productive forces’.

While criticisms of Smith’s work point to the potentially prescriptive or reductive framing of a ‘singular’ production of nature (Andueza 2021), a more nuanced reading will explore the different productions of nature that co-exist – or could exist. Following Ekers and Loftus (2013, 237) ‘the key is to historicize the specific forms that the making of natures takes, and to be able to do this in geographically situated ways’. As will be shown below, the production of nature for carbon markets in San Martín is neither as totalising as an ‘historical nature’ (Moore 2015) nor as clear as state territorialisation (Ballvé...
2012), but a reflection of the narrative politics of different groups co-constituting and spreading specific productive regimes.

As this article will go on to show, the infrastructural logic and narratives behind interventions in the Peruvian Amazon are more than marketing rhetoric used by diverse groups but a critical reframing of the natural world in need of investigation and analysis, particularly as carbon markets and nature-based solutions are scaled up. I argue that such dynamics call for a combination of the insights of economic geography with those of ethnography, and specifically the ethnography of infrastructure to interrogate the (re)structuring of socionatural relations in agrarian settings. Viewing the way power operates through the production of nature-based solutions in San Martín highlights a novel ideological approach that is embraced by politicians, practitioners and activists across the spectrum, and one that requires greater focus in academic work.

Infrastructural nature from global ideal to local policy

What are nature-based solutions? What does it mean to produce nature as a solution? And how does it change how we relate to the natural world when it is a solution to our – or society’s – problems? The following sections draw on research conducted over the space of three trips between 2017 and 2019, working and living amongst communities involved in a suite of for-profit nature-based solutions projects run by a French carbon vendor in the Western provinces of Mariscal Cáceres and Huallaga in San Martín (see Figure 1). While much of this time involved working with local farmers to understand how international schemes and regional goals were translated into policies and demands, analysis also focused on project and policy documentation, as well as government geodata, to assess how landscape planning had evolved over time, and how nature-

![Figure 1. San Martín with provincial borders in the context of Peru.](image-url)
based solutions were now being integrated into it. Interviews were conducted across these spaces in local villages and regional towns, alongside numerous informal conversations with farmers, foresters, and planners.

On my first visit to one village involved in a nature-based solutions project in San Martín run by a collaboration between an international for-profit company and a local NGO set up to manage a number of projects, I was given a tour by one of the members of the local cacao association, Eduardo. Our walk around the project area took in various sites: areas of cacao plantations, a (failed) fish farm and a plantation of *capirona*, a rapid-growth tree species favoured by farmers in most reforestation projects in this valley. On requesting to see some of the forest (‘bosque’) I was taken to another vast plantation of *capirona*, with very few other species of tree and limited undergrowth.

While I grew used to the eerie quietness of the cacao plots and plantations, the sheer lack of life in these new forests was, on first impressions, striking. The trees were planted in uniform rows and the long bare trunks of the *capirona* provided no habitat for local birdlife, which was normally so abundant in the forests of this valley. The soil was dry and tough to break by hand, with little sign of insect life above or below it.

My tour of the village concluded with another cacao farmer, Julián, taking me to his newly cleared plot on the side of a large hill, ready for planting a new *capirona* plantation. As we climbed up the land, with all vegetation cut back and then burned to clear the early growth and prepare the soil, Julián explained that in a few short years the area would be a profitable timber plantation funded by carbon credits. As we sat overlooking the village and the wider valley, he pointed to one of the overgrown areas to the bottom of his parcel of land and explained the process of clearing such land, as he had the very patch on which we were sitting. In contrast to his great pride in the reforestation plots, the weedy growth of returning forest was deemed ugly and worthless.

The plantations were a source of pride and the seemingly unproductive forest was seen simply as waste. Subtle changes in language, such as the use of the word timber (*madera*) rather than trees (*arboles*), were replicated by community members in many villages. When I highlighted the diversity of shrubby areas growing back naturally and slowly, I was told they were ‘poor’ – when I enquired about areas that looked particularly dense with undergrowth, I was told they were worthless, as there were no timber species present – or needed to be turned into plantations. In a local protected area, a conservation worker even suggested to me that they should reforest the already recovering jungle, to help speed the process along with rapid-growth trees. Nature-based solutions had not just changed the material landscape but the local discourse, and produced landscapes were seen as preferable to wild.

The sections that follow explore how this framing of the natural world developed and the ideas and ideologies that have helped to shape it. It shows how narratives of nature-based solutions tend towards infrastructural framings of the natural world, tracing how a specific production of nature has resulted from a national pursuit of global carbon funding and how this translated to regional goals and local practices.

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2Literally, ‘This forest is poor, there’s no timber’ (*es pobre este bosque, no hay madera*).
Capturing the carbon market

The Government of Peru has actively pursued opportunities to expand nature-based solutions in the country, designing a range of laws and rules to facilitate the abstraction and legal ownership of carbon. The country’s carbon strategy is specifically geared towards the growth of a carbon offset economy through ‘improving’ agricultural and forestry productivity, REDD+ projects, and new land management systems (Government of Peru 2016).

The strategy of the National Forest and Wildlife Service (Servicio Nacional Forestal y de Fauna Silvestre, SERFOR), reflects this focus on the development of forests for new green economies through the ‘promotion of the sustainable use of forests’ and the ‘incentivising of forest plantations for recovering degraded areas and increasing forested areas’ (SERFOR 2016). This fits with a wider approach to conservation in Peru, which places it within sustainable development plans and prioritises its profitable aspects (Shanee et al. 2020).

The national strategy for climate change and the work of establishing the national carbon market is the responsibility of two key bodies – the Ministry of the Environment (MINAM) and the National Environment Fund (FONAM). FONAM specifically manages the ‘National Carbon Portfolio’ (which includes registered projects in voluntary markets, the Clean Development Mechanism and the development of state-based REDD+ projects) and promotes environmental investments in Peru to state and non-state actors globally. This includes forestry management and reforestation, which at a local level have additional supervision from the Ministry of Agriculture, SERFOR and from Regional Environmental Authorities, as well as the National Park Service for those that fall in state protected areas.

The scale of ambition for carbon credit-funded projects in the country can also be seen in the marketing of protected areas or reforestation land as a means of investment throughout the country, by both private groups and government bodies. On an international level, FONAM takes these proposals to carbon trade fairs and conferences to engage with investors around the world, producing investor booklets which boast of the potential for forestry production in the Amazon and advertise vast areas of land ‘available’ for reforestation. Private companies are often also in attendance at Amazonian investment events, producing similar booklets advertising reforestation models of intensively designed plantations that promise spectacular returns from the combination of carbon credits and sustainable logging.

On the subnational level, the expansion of the carbon portfolio has been aided by ongoing processes of decentralisation in Peru. Regional governments are able to register plantations for reforestation or circumvent lengthy application systems for protected areas by establishing regional conservation areas or ‘conservation concessions’ and REDD+ working groups operate on a regional level to promote opportunities and share best practice, with San Martín a leader in these processes.

The creation of privately protected areas3 has also been key to the growth of REDD+ projects in Peru, as the designation of legal ownership is the basis of creating a saleable asset in carbon and an essential element to listing with certification groups such as Verra.

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3 Private conservation in Peru is largely facilitated through three types of official park designation – private conservation areas, ecotourism concessions and conservation concessions.
In total, privately protected areas now total almost 2 million hectares of the country (Shanee et al. 2020) alongside an ever-expanding number of regional conservation areas. Responsibility for these areas falls to regional bodies, rather than the more bureaucratic national groups (Piu and Menton 2014), allowing carbon investment opportunities to be identified and applied for through regional or local governments.

Peru’s enthusiasm for REDD+ has made it a leader in both ‘REDD readiness’ projects for the nascent compliance markets and voluntary market projects. As of 2017, the National Carbon Portfolio included 50 REDD+ projects covering more than 6 million hectares (6,412,082), of which over 4 million fall outside of national parks (FONAM 2017, plus author’s analysis) and 41 afforestation/reforestation projects covering just 195,441 hectares but with the potential to generate almost 60 MtCO2e in 20 years (FONAM 2017).

The country’s private sector projects have been even more dynamic, driven in particular by the boom in interest in nature-based solutions from 2016. Analysis from Ecosystem Marketplace (2019) suggests that between 2016 and 2018 over half (57%) of the overall global increase in voluntary market credits came from Peru – accounting for 86% of the overall 22.8 MtCO2e increase in volume from Latin America. Without Peru, global REDD+ volume would have been virtually unchanged in the 2016–2018 period (Ecosystem Marketplace 2019) and while other countries have made progress since, nature-based solutions continue to supercharge the market (Ecosystem Marketplace 2021).

While the rapid growth of projects in Peru in this era reflects a wider rise in interest in nature-based solutions, it was also a result of the proactive attempts to translate this global interest into national strategies and regional policies, as well as the integration of green and natural infrastructure into Peruvian law (Tomateo 2021). The region of San Martín was at the forefront of this trend. Reforestation, REDD+ and climate smart agriculture – and their promotion alongside increasing ties to global markets – have combined to create a powerful new narrative of agrarian development that appeals to diverse groups. These new initiatives, and the ideologies on which they rely, reflect the top-down solutions to climate change, deforestation and biodiversity loss promoted by global bodies (and markets) but are also inscribed in local landscape planning through processes of ‘zonification’, which segment areas of land for their greatest delivery of goods and services.

**Optimising the landscape**

The ‘ecological and economic zonification’ (‘Zonificación Ecológica y Económica’, ZEE) of areas at a macro, meso and micro scale has been pursued by successive national governments in Peru and has been supported by and developed in tandem with regional governments as well as through bilateral aid and international NGOs (Augusto 2018). San Martín is a national leader in this regard, having pioneered a strategy to organising its territory from around 2008. In this strategy – termed ‘Production, Protection and Inclusion’ – areas are designated for (intensive) agriculture, strict exclusion zones or areas of low intensity use or agroforestry production.

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59,826,569.68 tCO2e.

5Also referred to in international reports as the ‘production protection compact.’
The core of the argument behind zonification in San Martín is to optimise the landscape to meet the needs of both agricultural production and biodiversity protection. In doing so, it is assumed that local farming communities will have the tools and support to produce sufficient crops on their current land, without needing to expand or claim new areas to farm from the region’s forests, thus stemming deforestation. Put simply by a representative of the regional government in an interview for this research: ‘we realised that we can’t protect, without producing. We can’t ensure the protection [of forests], without ensuring the production [of crops].’

The strategy of using increased commodity production to avoid the expansion of the agricultural frontier into forested areas is, in itself, not new. Land-sparing ‘proposes that increased productivity will satisfy crop demands without extending production area, allowing other areas to be set aside for “strong” conservation, largely protected from all human use’ (Oliveira and Hecht 2016, 269). The concept of land sparing is commonplace to the point of received wisdom for development and environmental practitioners (Angelsen and Kaimowitz 2000) and Peru is no exception. The current approach in San Martín, however, is not only rooted in conservation thinking, but inextricably tied up with the work of private organisations and new opportunities to profit from international offsets and nature-based solutions. This brings together a broader coalition of actors, from cacao exporters to conservation NGOs and carbon groups to politicians, under the narrative of zonification, further integrating the logic and funding of sustainable development into conservation projects (see also Chambers et al. 2020).

Before moving on to discuss the types of nature produced, it is worth detailing the success of the scheme in terms of headline figures of production and protection – and why it is so attractive to policymakers and development funders. Land sparing has resulted in an enormous growth of productive activity in San Martín, with agricultural production soaring while the regional government pursued its conservation agenda in the early 2000s. Between 2001 and 2009 the agricultural sector in San Martín grew by 80%, while from just two official protected areas in 2001, protected areas now cover a total of 1.95 million hectares in the region (almost 40% of the total area), not including the numerous buffer zones (Shanee et al. 2020).

Reforestation has also boomed with multiple projects around the region. Vast areas have been designated ‘suitable for reforestation’ and millions of trees planted. From 2013 to 2018, for example, 441 certificates for forest plantations were authorised covering an area of 1758 hectares. Forestry is a key focus of private involvement with the state with many buffer zones and wider areas planning large plantations. Agroforestry has also been widely promoted, with the sustainable intensification of commodities such as cacao, coffee and cattle combined with replanting schemes to generate carbon credits while attempting to regenerate ecosystems.

The power of this logic – promising protected areas with increased production – has had profound outcomes on power relations in the region, bringing together an eclectic range of small and large actors under a broadly shared goal of landscape management. In officially demarcating the land, new rules and regulations were standardised in a way that makes land more investable for the private sector (rendering it legible, see Scott

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6These figures were quoted in a presentation by a Regional Government representative on 01/06/2018 which also highlighted the potential profits of these schemes.
[1998]), something highlighted by the aggressive marketing of reforestation in regional trade fairs. This provided fertile ground for groups looking to establish projects through voluntary carbon markets but also produced specific natures that could provide the seeming stability and predictability of this planning process.

**Producing infrastructural nature**

The zonification process in San Martín made the region a national leader in nature-based solutions, it also resulted in a specific production of nature pursued by state, private and non-governmental actors hoping to achieve goals of social development, conservation and agricultural production, previously seen as contradictory. While these goals were formalised from 2008, the introduction of carbon credits and nature-based solutions became the catalyst that helped to spread the model across the region. Three core aspects of the infrastructural nature of the landscapes created through the combination of zonification and nature-based solutions will be explored in this section: the simplification of social systems, the intensification of production and the expansion of specific productive regimes across the region.

**Simplification**

In seeking to optimise and rationalise the landscape, the zonification process creates areas of specialisation, simplifying potentially diverse landscapes to prioritise ways in which they can achieve their optimal value. Detailed maps designate zones of rice production, cattle farming, maize or broader designations for agroforestry systems such as coffee or cacao. Agricultural extension activities and incentives can then be targeted to encourage local farmers to convert to certain crops or follow best practice methods – in turn strengthening local supply chains and infrastructure for delivering these crops to market.

While the zonification process seeks to optimise and rationalise the landscape, the simplification of ecosystems emerges as much out of the models prescribed and local practices. Plans are not simply imposed on areas (nothing is to stop a farmer planting avocados in a maize zone, for example), but the incentives and subtle processes of rationalisation, promotion and celebration tend to reinforce certain crops. For example, in certain areas of San Martin, farmers who do not have secure land tenure have been offered titles for a 40-year lease on their land by the regional government if it is entered into micro-zonification programmes. These ‘cesión en uso’ contracts encourage farmers to impose strict separation of crops on their land in a bid to promote the intensification of certain crops alongside areas of conservation or reforestation at the most local level.

With cacao, preferred varieties are promoted (often the globally favoured CCN51) and agroforestry plantation designs are shown to farmers in events and workshops across the region. One NGO even proudly displays these standards on their office walls by a model plantation, with farmers asked to sign the poster to declare that they will adhere to specific modes of production. The preferred methods promoted means that a single species and plantation style dominates the local landscape.

The gradual reduction in diversity in favour of ecosystem simplification is most clearly seen, though, in the timber species in reforestation and agroforestry plantations around
San Martín. Typically, plantations are optimised to meet minimum forest definitions under Peruvian and UNFCCC accords,7 the plantations can be harvested sustainably in a rotational system to allow for the sale of timber, while also accruing carbon credits. In accordance with these rules and the demands of the markets, plantations are designed to contain a combination of trees of short, mid and long-term growth to ensure the greatest returns in carbon and timber in the space provided.

In reality, however, many of the farmers in San Martín prefer the rapid growth species of tree, which can be matured, cut and sold in 5–7 years. While original designs might show semi-diverse grids of different tree species, most plantations are largely – or entirely – composed of one of these species, such as capirona and bolaina. These two trees alone account for 84% (54% and 30% respectively) of all trees planted in regional government schemes, with the remaining 16% representing just four other species (GORESAM 2022).

The processes of simplification were reiterated to me by a local reforestation group which predominantly integrates timber into coffee agroforestry. From 2010 to 2015 work had focused on a minimum of eight species of timber in any plot but had since reduced to a maximum of two or three. As noted by the head of reforestation, Jorge, this was for ‘reasons of business, of economics, logistics’ but often meant a focus on a single species which ‘could be capirona, it could be bolaina, or it could be another species, purely eucalypts’. Jorge explained that while diverse plots were better for environmental reasons, the number of species was reduced because for farmers the ultimate goal is the extraction of as much timber as possible. Another reforestation project manager noted that even where they tried to promote more diverse plots and insisted on three species per parcel minimum, farmers continued to almost exclusively plant capirona or bolaina. The actual diversity of species in plantations thus rarely goes further than some fast-growth trees and, perhaps, plantain, leaving vast areas of smallholder agroforestry in virtual monocultures.

**Intensification**

Plantations are not only simplified, but being asked to deliver more through intensification. The intensification of production is promoted by a number of groups – and notably across a consensus of national and regional politicians, international development funds (such as USAID), exporters and private companies, and a range of local and international conservation NGOs and carbon groups pushing for the ‘sustainable intensification’ of production to support the land-sparing strategies. The drive for intensification is manifested locally in the call for technical ‘improvements’ and the ubiquitous concept of ‘aprovechamiento’,8 through which local NGOs and regional officials criticise local farming practices that do not produce commodities for export or take advantage of technology such as striimmers, increased fertiliser use and high-yielding seed clones.

The push for intensification extends to the production of numerous crops across the region. State incentives such as the aforementioned ‘cesion en uso’ contracts encourage

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7 A minimum area of 0.5 hectares; A minimum tree crown cover of 30%; And a minimum tree height of 5 meters.

8 There is a notable similarity between the term aprovechar (literally, to make good use of or to take advantage of) as it is being used in San Martin and the discourses of improvement in the English Enclosures, wherein: ‘making land productive – that is, improving it – was becoming the basis for property rights; and more particularly, the failure to improve could mean forfeiting the rights of property’ (Wood 2017, 157).
practices to rapidly increase the yield and productivity of key crops, such as coffee and cacao. The intensification of livestock in San Martin is equally instructive in its ambition. Current plans for support for cattle-farming communities located within a restricted conservation concession area, for example, were described to me by local residents and NGO workers as intensifying production to reduce land use – to have ten cows per hectare where farmers currently have two. One long-time conservation worker in the region highlighted the paradoxical nature of expanding the number of cattle within conservation areas and the inherent contradictions of ‘sustainable cattle’, even as they explained their own organisation’s shift in recent years towards ‘productive’ conservation that focused on livelihood opportunities and agricultural support.

The intensification is notable too in the approach to agroforestry and reforestation projects. Within plantations, despite being planted at ‘optimum’ distances as stated in project plans, trees are still densely planted. Clones are produced in nurseries around San Martin to grow straighter, higher and faster. Promotional materials for reforestation groups promise ever-taller trees, grown in ever-denser blocks, with increased carbon sequestration and quicker turnaround for sustainable logging cycles. The trees themselves in these models are assumed to be consistent, stable and machine-like in their production and are being planted in vast numbers by private and public groups alike. The emerging productive regime thus seeks to deliver ever more yield through pushing nature to work harder, particularly at the margins and frontiers.

Massification

As production is intensified to deliver ever more goods and services, it also leads to its expansion across geographies. Multiple groups, including within the regional government, the local business community and local farmers, spoke of plans to expand the production and intensification of strategic commodities in the region. Amongst these productive goods that are being promoted, few are discussed with as much enthusiasm as tree-planting, a potential value-add to previously unproductive land, exhausted crop plantations and providing economic diversification for farmers across the region.

One international reforestation organisation has even formed a new company to deal with the sale of timber from its numerous small-scale plantations. The aim of the company, as expressed by one project leader was to allow farmers in the valley to have access to ‘the best technology to take advantage of the most timber possible’. The company – and its promises of scaling to ever more areas – began to dominate the topics of many meetings and discussions with reforestation workers in 2018, and even more so in 2019, as the timber industry became the focus of ever greater claims of intensification and profitability.

One regional government head of conservation even considered a functioning timber trade to be their ‘dream’ for the future of the area and NGO reports talk of plans for the planting of millions of trees across the San Martin region to turn it into a ‘forest power’. In 2019, this dream took a step towards reality with the first REDD+ -funded reforestation plantations obtaining certification by the Forest Stewardship Council. Conservation and government workers enthused about this possibility, placing it at the core of multiple projects and the regional productive strategy of one valley. Project designs were shared, plantation layouts replicated and models of ‘success’ promoted.
At a regional level, many groups have a stake in the success of the reforestation and agroforestry projects, from the organisations directly involved in the project to local companies and regional politicians keen to show that the model of agriculture and carbon can deliver benefits for communities across San Martín. While this was something reproduced and reiterated to me by a wide variety of actors in the region, events were an especially instructive example of how (and whose) success is communicated to wider audiences. In both 2017 and 2018, the San Martín Regional Government held large events celebrating the food, farming and future of the forests of the region – with both years receiving visits from the incumbent President of Peru. These events provided an opportunity to see how the projects and plantations were made infrastructural, woven into wider ideals of development for the region, and marketed as investment opportunities.

In presentations, agroforestry and reforestation were presented as simple models of neat lines of trees, with carbon sequestration and potential profits highlighted. Having worked amongst these largely monocultured plantations, the gap between rhetoric and reality at the events was notable. The hype created however, made competing visions of socionatural relations seem risky, uncertain and even wasteful, as they are outperformed in the metrics collected and targeted by the regional government and development organisations. A leader of one local project regenerating soils through gradual processes of biochar creation and production for self-sufficiency told me that funding or support from the regional government was increasingly difficult as their approach did not measure carbon or provide opportunities to scale up in a profitable manner.

As I will go on to argue, what works and spreads reflects not just a drive for profit, however, but a specific ideology of the natural world that assumes the possibility of optimisation, predictability and stability. While there has not been the top-down drive for monoculture production systems of old, the optimisation of the natural world for its delivery of ecosystem services has led to specialised zones of production and decreasing diversity. Thus, despite proposing an alternative green economy, landscapes of small-scale producers tend to specialise in a single crop, in some cases a single variety, with nature-based solutions beginning to resemble the agroindustrial models they claim to supplant. This is hard to ignore when travelling anywhere in the region, with areas dedicated to cacao production often spreading across vast quantities of fields, where a combination of success-stories and state-based incentives see an increasing number of small-scale producers turn to cacao production. The new assemblages that make up infrastructural nature, however, overestimate nature’s capacity, underestimate its instability and narrow the development pathways for local communities.

Understanding infrastructural nature

The production of nature-based solutions in San Martín has resulted in distinct landscapes and emerging socionatural relations. But what exactly is produced? What are these ecologies of green capitalism? Perhaps more pertinently for this forum on climate change and agrarian struggles, how do they differ from previous top-down models and plantation systems? Connecting the literature on infrastructural nature with nature-based solutions highlights how ‘forested landscapes’ are not just ‘assigned an infrastructural function’ (Carse 2012, 552), nor simply made to function as such (cf. Nelson and Bigger 2022); certain aspects of nature are emphasised discursively and promoted materially. This
section will elaborate on these aspects, and the potential issues with them, through the infrastructural framing of nature as stable, as repeatable and as a carbon sequestering solution to climate change.

**Nature-as-stable**

The framing of nature-based solutions makes a familiar assumption about the natural world: that its processes are manageable and controllable. Infrastructural nature pushes this further however, assuming stability and predictability akin to the inert materials that make up the grey infrastructure of cities. On regional planning maps, plantation models and statistical summaries, trees, plants and other lifeforms are treated as building blocks of human-designed ecosystems.

The assumption of stability is a particular issue for a region that is subject to environmental stresses (such as the constant erosion of waterways and conversion of forest to wetland) and shocks (such as frequent floods and droughts), not to mention political change and the shifting population dynamics driven by local population growth and migration. The patchwork of small farms of densely packed trees and specific commodity crops has left producers increasingly vulnerable to market swings and crop failure, but also created the perfect breeding ground for pests and plagues.

In the cacao sector, for example, disease has particularly come in the form of the cacao pod borer, *mazorquero*, and, the fungus, frosty pod rot, both of which have decimated harvests for some farmers in recent years. Moreover, as the model of production creates ever more problems, more time, money and expertise are invested in it, with numerous projects seeking to prop up ailing commodity crops such as cacao, often in the form of Western expertise that prescribe the same solution of further intensification to make up for shortfalls. The density of cacao plots in itself is a challenge for these farmers. While clearing a plot of diseases and pests may be possible, various farmers complained of them quickly spreading back from neighbouring plots. The simplification and intensification of plantations has thus created new geographies of risk in San Martín as they have been confronted by the ‘inherent unruliness in ecologies, trees and therefore carbon’ (Leach and Scoones 2015, 14).

Infrastructure provides a lens to understand not only the unruliness that causes projects to fail but, critically, how this is ignored in plans, maps and market strategies. In San Martín, the continuous struggles with pests and diseases threaten outright ruin for farmers, yet these threats fail to register in the regional planning documents that assume stability. This provides some insights into the ‘insistence on “technical fixes” that do not work’ in the region (Paredes and Kaulard 2022, 5).

Where Osborne (2015, 67) has noted ‘the uncooperative nature of carbon commodification’ and Prudham (2015) points to the always contested nature of commodification, infrastructural nature can focus our analysis on the narratives that frame unruly nature as stable, manageable and commodifiable, and how failures and crises in turn are compensated for by success stories and expansion.

**Nature-as-repeatable**

The infrastructural approach treats the natural world as not just stable, but repeatable. This leads to unique – and at times stark – landscapes of production. The mapping and
titling of land, for example, is seen as both a prerequisite for investment and as critical to producing commodities in sufficient quantities to tap into high value global markets, whether that be carbon and timber markets or through niche superfoods such as the locally produced nut *sacha inchi*. This logic is pervasive in San Martín and leads to specific commodities, seeds and clones being incentivised, spreading ever further across the region.

Locally, the repetition of certain crops leads to the geographic centralisation of production (Smith 1990), in many cases locking in landscape uses. While a *campesino* in San Martín may be able to secure a form of land tenure thanks to agroforestry projects (and this is no minor accomplishment), communities may be tied into specific crops promoted by regional support and infrastructure or limited in expansion or rotational cropping practices by strictly delineated areas of use or protection. As favoured models and varieties spread ever further across the region, entire valleys of small-scale producers begin to resemble industrial plantations. Over time, this reinforces a logic that favours intensively grown export crops at the expense of diverse production systems and crops for self-sufficiency. While not without its positive aspects, the landscape planning and zonification in San Martín therefore has the potential to disadvantage alternative development pathways (as detailed in this forum by Paredes and Kaulard 2022).

Here, an important contrast with traditional plantation systems is emerging in the practices of green infrastructure. Where plantations are typically ‘large-scale agricultural operations characterized by their intensive use of capital investments as well as the exploitation of wage labour’ (Perfecto, Jiménez-Soto, and Vandermeer 2019, S236), infrastructural nature involves the integration of smallholders into similar systems of production. Such dynamics have been noted in corn production in Myanmar by Franco and Borras Jr. (2019, 195), in which they observe ‘the ongoing transformation of much of Northern Shan State’s once-biodiverse and variegated land uses into an increasingly uniform small farm-based corn monoculture subordinated to merchant capital’. Equally, Pye (2019) has pointed to processes of ‘accumulation by inclusion’ in certified palm oil production, as increasing numbers of small-scale farmers in Southeast Asia switch to industrial methods of palm oil production.

Infrastructural nature provides a lens to understand these new waves of accumulation occurring under the banner of ecosystem services and nature-based solutions, in which the machine-like structure of the plantation becomes the infrastructure-like structure of produced landscapes. In nature-based solutions, we can observe and analyse this process as not simply driven by large operations of capital accumulation, but by the emerging narratives, models and goals of climate change mitigation and how diverse groups coalesce around them.

**Nature-as-solution**

Nature-based solutions make an explicit connection between goals of climate change mitigation and landscape management. Applying the logic of infrastructural nature to this dynamic can highlight not only the ways that ecosystems are being optimised to offset carbon emissions and deliver ever-greater benefits, but the wider implications of valuing specific socionatural systems.

The reality of plantations of nature-based solutions are far removed from the marketing and original plans of many projects, with ideals of forested landscapes being replaced
with select fast growth species in semi-monocultures. Even in contexts where agroforestry may have been promoted as a way to boost biodiversity within agricultural systems and diversify production, it has resulted in a few profitable species of timber, chosen for their rapid growth to ensure quicker turnaround times for logging and carbon sequestration. In San Martín, this reflects a growing conflation between development and conservation goals under the auspices of regulated and ‘greened’ production (Chambers et al. 2020).

While agroforestry systems promise to increase production in conditions that ‘more closely mimic natural forest’ (Clough, Faust, and Tscharntke 2009, 197), the resulting ‘reforested’ plots are not what many would recognise as a forest or jungle. Trees may well be planted to match official definitions of forest in height, crown coverage and area, but rapid-growth species planted in neat rows with trimmed undergrowth provide an eerie silence in place of the normal competing sounds of the wildlife of the Peruvian Amazon. From a purely sensory perspective they seem devoid of any sort of life beyond the hulking trees which rapidly stretch up to the light.

In being framed as a solution to environmental and developmental ills, infrastructural nature not only works as a technology of land management, but as noted in the literature on the production of carbon, is ‘(re)made to work harder, faster and better’ (Boyd and Prudham 2017, 877). There is a move from the formal subsumption of nature, the expansion of commodity production based on the commodification of existing carbon, to the real subsumption of nature, trees planted for their specific ability to capture carbon and ease of control (Smith 2007; Carton and Andersson 2017). Here, it is no longer enough to hem nature in and tame it, but ecosystems must be made and optimised. Infrastructural nature can take our understanding of this real subsumption of nature further to probe at the ideological underpinnings that it represents and how it draws new actors into practices of accumulation.

While the production of nature as stable, as repeatable and as a solution reflects longer processes of landscape management and control in San Martín (Augusto 2018), nature-based solutions have provided a narrative that internalises previous critiques. The changing language to describe the wealth of plantations and the poverty of the natural forests or overgrown land, or the subtle use of the term ‘timber’ to discuss trees, reflects a changing narrative politics being driven by climate change. This allows for expanded (assumed) control over the forest frontiers and leads to novel forms of inclusion and exclusion under the banner of the green economy.

The socionatural poverty of nature as infrastructure

This article has expanded on the concept of infrastructural nature and highlighted some of the intended and unintended consequences of this logic when framed as a response to climate change. Responding to this forum’s call to interrogate the ‘combinations of narratives and strategies [that] frame climate change and the institutionalised responses to it in agrarian settings’ (Borras Jr. et al. 2022, 17), it has shown how groups in San Martín have coalesced under the idea of nature-based solutions to extend ongoing processes of rural commodification and control. The evidence presented here builds on papers in this forum analysing the narratives and appropriations associated with carbon offsets (Schwartzman 2022) and the emerging assemblages of actors in agrarian contexts responding to climate...
change goals (Hernandez and Newell 2022), to interrogate too the types of nature being produced and the ways in which they reflect infrastructural ideologies.

The narrative of infrastructural nature holds a seductive logic for many and has helped to create a coalition of actors under a stated mission of optimisation and land-sparing, rather than simply privatisation and profit. In doing so, it has managed to enrol actors that may well disavow neoliberalism – including local conservation groups, ‘ethical’ brands and progressive policymakers – into an approach that ultimately still enables expanded capital accumulation. It can be summed up with a response to the role of conservation by one informant from the regional government, ‘conservation for me is a way of protecting resources and at the same time exploiting them’. Infrastructural nature is, as such, both a core narrative in ongoing agrarian transitions in response to climate change and a critical pillar in an emerging ideology of green capitalism.

Infrastructural nature is not only reflected in changing discourses and desires at the global level, but in tangible changes to landscapes, lifestyles and livelihoods, such as in San Martin. Where previous utopian projects to produce artificial natures ‘attempted to come to terms with the chaos of the natural world, by defining it as something apart from human reality, something completely “outside”’ (Murphy 2015, 210), current attempts seek to remake it as a repeatable, stable, and service providing system, which humans must manage to avert climate disaster.

Sullivan (2009, 23) has highlighted the ‘cultural poverty’ in Payments for Ecosystems Services, in which ‘the non-human world in all its diversity and mystery becomes the provider of services’. I argue that in applying the logic of infrastructural nature to nature-based solutions we can see too the ‘socionatural poverty’ of the landscapes produced. Strolling through the densely packed trees of carbon-credit funded plantations, devoid of bird life and biodiversity, one can reflect on a new nature being produced in the name of sustainable development. This is the natural world through the lens of infrastructure: a discreet, simplified, technified, manageable unit designed to deliver optimal services.

Pointing out the failures of infrastructural nature and the emerging risks from ‘unruly nature’ in this article is not to call for a hands-off approach to the natural world that would reinforce similarly stark dichotomies between nature and society, but to highlight the specific production of nature it entails and the alternative approaches it obscures. Cloaked in a language of optimisation and stability, the green infrastructure paradigm reinforces specific spatial relations and structures of power in San Martin.

While some progressive actors may seek to reclaim an infrastructural view of nature, or even claim that it could have decolonial dimensions (Tomateo 2021), the ontological view of the natural world that it relies on fails to account for the uncertainty or humility that these complex, contextual and changing systems require. By failing to engage with the holistic, but messy, political work of what truly diversified landscapes may look like, natural infrastructure can but only continue to reproduce the inequalities and failings of extractivist policies elsewhere.

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ORCID

Will Lock  http://orcid.org/0000-0003-2782-1602

References


Will Lock is a Lecturer in International Development and Anthropology at the University of Sussex and his research focuses on the emerging world of for-profit conservation and reforestation – tracing carbon market value flows, the production of nature and the dynamics of green capitalism. His work covers the voluntary carbon market, the use of market-based instruments in conservation and the political ecology of forests more broadly. Will carried out ethnographic fieldwork of a REDD + conservation and reforestation project in the San Martín region of Peru in 2017-2019, working primarily with cacao farmers implementing agroforestry models and producing Fair Trade and organic certified beans for largely European chocolate consumers. Subsequent research has analysed the link between sustainable supply chains and conservation/deforestation at forest frontiers and possible avenues for re-framing ecosystem restoration, beyond carbon plantations and the sustainable intensification of commodity crops. Will is currently researching conflicts between carbon plantations and local food production in Wales and his broader research interests include political ecology, the production of nature, neoliberal nature, ethnographies of development and conservation, agroecology and environmental justice.