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The adoption of earth-observation technologies for deforestation monitoring by Indigenous people: evidence from the Amazon

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ABSTRACT

Deforestation monitoring is changing the nature of conservation practices in increasingly profound ways. This study illustrates how forest co-management by means of earth-observation technologies among Indigenous communities opens up new debates and perspectives on transformational actions for inclusion and equity in globalization. We analyze cases of drone adoption by the Shipibo Conibo and other Indigenous people on both sides (Peru and Brazil) of the Sierra del Divisor National Park. Our findings indicate that these technology adoptions may be inclusive and beneficial when combined with indigenous knowledge and alternative understandings of forest politics. First, we specify how counter-mapping initiatives grounded in Indigenous communities may be steered towards developing new co-participation and co-design. Second, we identify five key parameters for assessing whether co-participation and co-design during technological adoptions. Third, we assess the short- and long-term benefits, risks and threats in these technological adoption processes, drawing on indigenous perspectives.

KEYWORDS

Deforestation monitoring; Indigenous peoples; Amazon; power asymmetries; technological adoptions; drones

1. Introduction

There is a long history of global inequalities surrounding technology, which are closely tied to unequal ecological exchange and world-systemic power disparities (Hornborg, 2001). In the case of extractive technologies, there is an uneven relation between technology provided by the global North and the extraction of raw materials and loss of cultural heritage in the global South (Arboleda, 2020; Dunlap & Jakobsen, 2019). In the context of the fight for and against deforesting extractive activities, the extractors are commonly equipped with considerably more impactful tools in terms of being able to deforest ever larger areas ever faster, with longer-lasting negative effects in terms of sustainability (Delabre et al., 2020; Kröger, 2022), whereas forest defenders are just starting to equip themselves with fast-developing tools such as drones and satellite monitoring in their surveillance work. NGOs, governments and outside researchers have typically been the ones controlling and running the surveillance of deforestation in these schemes, while local communities, especially Indigenous people, are still largely excluded from active agency in monitoring activities such as in the Amazon. It is thus argued in studies on deforestation monitoring technologies that there is a need to redress these multiple power imbalances in technology access through alternative voices: more specifically, there is good reason to analyze cross-cutting counteractions between

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inclusive technology adoptions and the use of indigenous knowledge (Delabre et al., 2020; Haklay, 2013). Such analyses could also result in the inclusion of local understanding of forest politics to inform forest policy in a variety of channels (González & Kröger, 2020).

Various studies on participatory processes have focused on how technological adoptions could assist Indigenous peoples in their efforts to gain recognition of their land-use rights against enclosures and extractive devastation (Peluso, 1996; Kwaku Kyem, 2004). Other authors argue that technological development is essential in fighting climate and ecological unsustainability (e.g. Schmidt & Sewerin, 2017), a claim that merits further critical scrutiny and the division of technology use based on the needs of particular groups for particular technologies to meet specific needs. The current rapid expansion in and development of deforestation monitoring applications without transparent collective reflection on their impact could potentially hamper the long-term prospects and potential of this budding field (Arts et al., 2015). There is a need for further examination of counter-mapping[1] dynamics between local territorial knowledge and new digital deforestation-monitoring technologies that are used to resist the threat of extractive expansion (Gómez-Baggethun et al., 2010). In this article we address these broad questions concerning technology adoption in the struggle for socio-ecological justice. We show how current forest policies should integrate Indigenous valuations of forest conservation by identifying the characteristics of self-agency among actors in natural-resource politics, thereby shedding light on how Indigenous territories have been protected through technologies that facilitate deforestation monitoring.

The use of technology is also closely tied to the variety of worldviews or humans' understanding of their own environment (Clastres, 1989). Research approaches have highlighted the fact that technology use does not determine societal behaviour, and that societies rather filter its use through cultural practices that create actions of resistance (Radjawali & Pye, 2017; Scott, 1990). This reflection contributes to the debate on questions that are currently of the utmost relevance to people-oriented conservation. Who will pay for the data collection and maintenance in shared meta-datasets? What are the political aims? How will data be stored? Who will control the production of these counter-maps, and who will fill them with meaning? (Arts et al., 2015) Such a framework could underpin sponsored governance mechanisms that could serve the empowerment of marginalized social fractions (Arts et al., 2015; Hornborg, 2001; Linders, 2012; Stevens, 2014; Turreira-García et al., 2018). It is essential to avoid the expansion of data, digital, and virtual forms of extractivism (Chagnon et al., 2021) alongside more directly tangible forms such as deforestation, within communities facing these situations at the same time as adopting new processes of technology adoption.

We focus first on the Shipibo Conibo progenitor case of drone adoption. For generations, Shipibo Conibo Indigenous communities have engaged in strong forest protection, this being essential to their self-identification. An Indigenous Shipibo describes this forest ontology as follows:

> *The forest is our home, our market, our hospital: that's why we protect it. But foreigners, strangers who come, they think that the forest is like an object which can be sold, we don't allow this.* (Excerpt from the first author's interview, Patria Nueva, November 2019)

In the context of conflicts and threats within their territories, this community's collective decision to use monitoring technologies was motivated by the need for practical solutions and facilitated by allies within this struggle.

We explore whether and how counter-mapping initiatives grounded in Indigenous communities may be steered toward developing new co-participation and co-design approaches in the context of forest governance. We assess whether and how the co-management of earth-observation technologies among Indigenous communities around the Sierra del Divisor National Park in Peru and the

Serra do Divisor National Park in Brazil have readdressed power asymmetries. Lastly, we explore how Indigenous technology adoption may equalize power disparities and support sustainable forest governance.

2. Methods and data

The observations and analyses were collected via a mix of ethnographically-oriented field research visits, interviews, focus-group workshops, a review of primary sources, and a review of secondary literature. The first author carried more responsibility for the Peruvian analysis, whereas the second author conducted the multi-site ethnographical study, including interviews, in several parts of Brazil and among their Indigenous people (in 2017, 2019 and 2022, each visit lasting several months). Our interpretative analysis is built on one policy-relevant objective, namely to provide a more nuanced picture of the realities that Indigenous communities face (Tuhiwai Smith, 2013) in their interaction with monitoring technologies, in accordance with Indigenous and decolonizing methodologies (Kovach, 2010; Nadasdy, 2005). The joint aim of the two authors was to scrutinize Indigenous monitoring experiences in processes of technological adoption in varied Amazonian contexts, ranging from Peru to Brazil's Acre and Pará states, where field research was conducted.

The data analysis, based on the initial empirical evidence, was steered by the theoretical focus: namely the technological adoption processes that could result in equalizing multiple types of power relations, as well as the possible pitfalls to be averted and the social changes to be expected as Indigenous monitoring capacities expand. The authors were not involved in the NGO processes, but rather studied them as outsiders: collecting information from different entities involved in various settings, making field visits entailing the observation of Indigenous people utilizing drones in controlling deforestation, conducting in-depth interviews, and conducting participant observation in communities as well as expert interviews. The interviews were recorded, transcribed, translated and analyzed for key words, to capture the points at which key issues were discussed. We start the analysis by presenting the key site of the case study.

2.1. The first case study site: Shipibo Conibo monitoring deforestation

The Indigenous Shipibo Conibo peoples live in Peru's Ucayali province, around the Sierra Divisor National Park. In the case of Shipibo Conibo, technology adoption was facilitated by Rain Forest Foundation – USA (RF-US). It is a progenitor case in the Amazon, hence its selection. On the political level the case has attracted widespread media and global policy attention The case-study approach (Lund, 2014) is adopted to explore the use of forest-monitoring technology among Indigenous communities, and the implications.

Extractivists constantly challenge the *de facto* means of the Shipibo Conibo, as well as of many other Indigenous communities in Latin America (Kröger & Lalander, 2016), to govern their territories in practice, in spite of a progressive national constitution giving them *de jure* rights.

The forests are seriously threatened by rising levels of logging and gold mining. Moreover, the region has experienced increasing violence and illegal activity, having become a major corridor for drug trafficking to Brazil: organized crime has taken over large territories in both Peru and Brazil during the past five years (based on the authors' field research, 2022).

Rampant deforestation reached historically record levels between 2009 and 2010, after outsiders opened an illegal forest path that crossed through the villages of Patria Nueva and Nuevo Saposoa.

In 2011, the Shipibo Conibo authorities (communal assembly) decided to take collective action against illegal loggers. Figure 1

In 2011 and 2012 the communities requested the conversion of this illegal path into a buffer zone (belonging to the National Park) to avoid extractive activities by outsiders. Native communities of the region (Matsés, Asheninka, Huambisa, Isconahua and Shipibo Conibo) acquired the right to prior consultation through the Supreme Decree of 2014–2015 established by Peru's Ministry of the Environment (MINAM). (MEP, 2011, 2018) Tensions remained high, however. It is at this conjuncture of rising deforestation, new *de jure* rights, and the need for new tools and ways of governing deforestation, that we situate our analysis of how the communities started to use monitoring

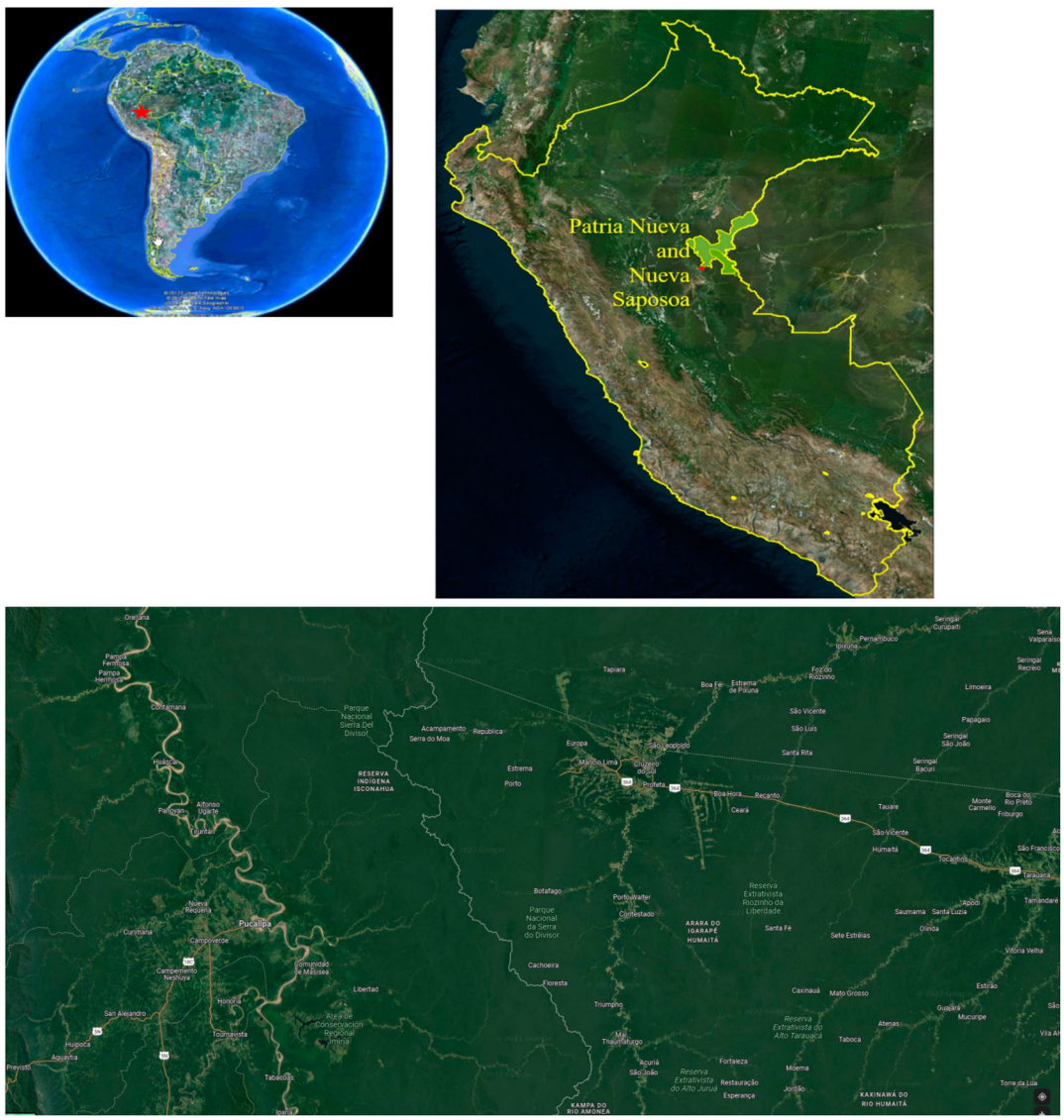

Figure 1. Location of the Patria Nueva and Nueva Saposoa, Sierra del Divisor Natural Park, Peru. Google Maps: satellite image of the National Park of Sierra de Divisor between Brazil and Peru, downloaded 2022, 4 April.

technologies. What was this process like, and what were its consequences? What are the current views on monitoring expansion among different Indigenous peoples in various parts of the Amazon, facing similar extractivist expansions as the Shipibo Conibo?

2.2. Data collection

The primary data for Peru was gathered through Participatory Workshops (PW) with focus groups (Kowalski et al., 2009), and for Peru and Brazil through both interviews and participant observations carried out between 2015 and 2022. Additional primary sources include policy documents, official Global Land Analysis and Discovery (GLAD) alerts and related documents, and reports related to this project. The authors triangulated the transcriptions of all interviews with satellite data analysis and the contexts of the historical threats.

Interviews were conducted with key social actors and institutions involved in the process in 2019, 2020, and 2022: Table 1 lists these interviews conducted partly online, partly during the fieldwork visits, by both authors (each with different people).

During the conversations with stakeholders and external actors in Peru, the first author focused on gauging the impact of new institutional relations in national forest policies, in accordance with Peru's Constitution and with international agreements and policies on climate change. During 2022 in Brazil, using the peer reviewer's comments following the first submission of this article for publication (regarding a critique of these schemes, for example) author 2 asked Indigenous people, government officials, civil society organizations and others how they perceived the expansion of indigenous monitoring. These replies are presented and analyzed in section 5. Next, we describe and analyze the progenitor case in Peru.

3. A progenitor case: deforestation monitoring driven by the Shipibo Conibo in Peru

Technology for monitoring indigenous deforestation was introduced in Peru among Indigenous people in 2012, framed as providing them with tools, information interaction, and technological mechanisms through which they could directly monitor their territory. None of this would have materialized without initial help with hardware and training, however. According to our interviewees, the RF-US NGO and the Indigenous communities decided to try using a larger variety of new technological tools to advance their territorial-protection agenda. Given that internet connection is

Table 1. Interviews conducted by the research team with Indigenous Shipibo Conibo communities, stakeholders and experts between 2019 and 2020, and in Brazil in 2019 and 2022.

Institution	Position of the interviewee(s)	Dates	Number of interviewees
Specialized Public Prosecutor's Offices on Environmental Matters	Officials	December 2019	2
Regional Agriculture Office	Official	December 2019	1
Peruvian Ministry of the Environment	Officials	December 2019	3
Pronaturaleza	Officials	February 2020	2
NGO Proamazonia	Co-founder	February 2020	1
Residents of Nuevo Saposoa	Locals	January 2020	4
Residents of Nueva Patria	Locals	January 2020	3
Several Indigenous peoples in Acre, Brazil	Indigenous leader	March 2022	5
Several Indigenous peoples in Pará	Indigenous leaders	November 2019	6
NGO and government officials, Brazil	Officials	March-April 2022	9

hard to come by in the field, RF-US developed data hubs from its regional base in Lima through which they could pass the satellite information, so that Indigenous monitors do not need to connect online: they can download the information using smartphones. Community monitors are then able to follow up on weekly GLAD alerts from Global Forest Watch, and they have been able to identify deforestation activities at a 30-metre resolution. All data is first received and filtered by the community, given that the system was structured in such a way that Indigenous monitors see the data first. They then decide whether or not to share it with RF-US, or with other external actors such as Peruvian governmental institutions. The data is and remains Indigenous property, which was an innovative aspect of this project. Hence, the project carries potential as an example of a transformative alternative to digital extractivism (see Chagnon et al., 2021).

Indigenous monitors played an active role during the processes of ideation, design, training, reporting to institutions, and evaluation. The words below from an involved Indigenous monitor illustrate transformation on the level of agency and in relation to technology:

> *We never imagined that we, the Shipibo, could also handle this little plane (drone). At the first training I thought: this is too difficult. At first, the government said that the Shipibo were not capable of using technology, but it was not like this. Now I can send images to the competent authorities. I know that these large trees are important to my community and to everyone. There is no contradiction in combining the tools that science gives us with what we know after living so many years here. Thanks to the satellite we can inform the authorities of the threats we face, using facts.* (First author's interview, Pucallpa, December 2019)

Monitors also learned how to use technical tools and to socialize the information in two distinct ways: presenting legal claims formally by filling out official documents for the legal authorities, and communicating the meaningful data informally, in simple words, to the other community members. Periodically, monitors counter-map official territorial boundaries by combining advanced GIS maps with their traditional surveillance activities (prioritizing their patrols' territorial surveillance routes), so that they can provide regular updates to their community and make collective decisions on which information to communicate further.

Even though the system was originally designed to protect their territories, communities have adapted the information-gathering system for other uses during the Covid-19 pandemic, sending images of clinics without doctors and documenting difficulties at health-service points in the area.

This shows that there may be potential positive wellbeing-related spinoffs from introducing monitoring capacities in Indigenous areas. Indigenous people seem to adapt elements of these technologies that serve their goals, based on their own premises. Being able to retrieve territorial information from satellites frequently ignited lively policy discussions on land use and resource allocation. In this regard, the key point was identified by a male Indigenous leader: '*The idea of bringing science to communities is interesting, particularly in seeing how we take that Western science and combine it with local science*' (First Author's interview, Lima, January 2020). This community leader emphasized how the new maps and tools allowed for the communities and their new allies jointly to pay more attention to a host of important issues related to environmental degradation and development in a broader sense.

During 2016 and 2017, having made their collective decisions, the communities filed irrefutable evidence of illegal activities in their territories. The Specialized Prosecutor's Office on Environmental Matters was able to halt, protect against, and denounce illegal activities in these territories, as did other governmental institutions including the Specialized Public Prosecutor's Offices on Environmental Matters and the Regional Agricultural Office. The government officials and

community representatives have recognized each other as allies against deforestation in a remote area of the Peruvian rainforest, where previously there was a marked absence of state presence.

Figure 2 details the steps indicating how technological adoption functioned in this process. It seems that the communities were key actors from the beginning, and that new knowledge and capacities have been shared and created.

There are currently different initiatives of local participatory monitoring in Peru: some entail the collection of information on biodiversity in fish, bird, and floral species, while other projects monitor oil pipeline infrastructure (Dourojeanni, 2019). This model has developed a dialogue between two actors with two completely different worldviews, the communities and the Peruvian state. Both, for the first time in their history, have started to cooperate to combat deforestation The differences in this specific case study are: first, this counter-mapping exercise is focused on significantly increasing Indigenous people's *de facto* control of their territories, and self-determination regarding their own collected data; second, communities have adopted novel uses of the digital monitoring system, such as those mentioned above during the Covid-19 crisis; third, the system has demonstrated that communication between local communities and NGOs aimed at saving the Amazon biome may represent an effective mechanism for local forest conservation. This kind of state embedding by civil society actors, while retaining community autonomy, facilitates the introduction of sustainable forest and resource policies and the redressing of imbalances in power and agency (Haklay, 2013; Kröger, 2013; Turreira-García et al., 2018).

In April 2017, deforestation documentation paved the way for the communities, in alliance with the Ucayali regional authorities, to reach agreement with individuals who were illegally settling and burning the rainforest for agriculture. With the support of regional law enforcement, this resulted in the expulsion of those who did not respect communal rules in the forest (Mongabay Latam February 16, 2017). On the national level, the Indigenous communities were recognized by the Peruvian government in 2018, named as the best custodians of forest heritage for their work as a

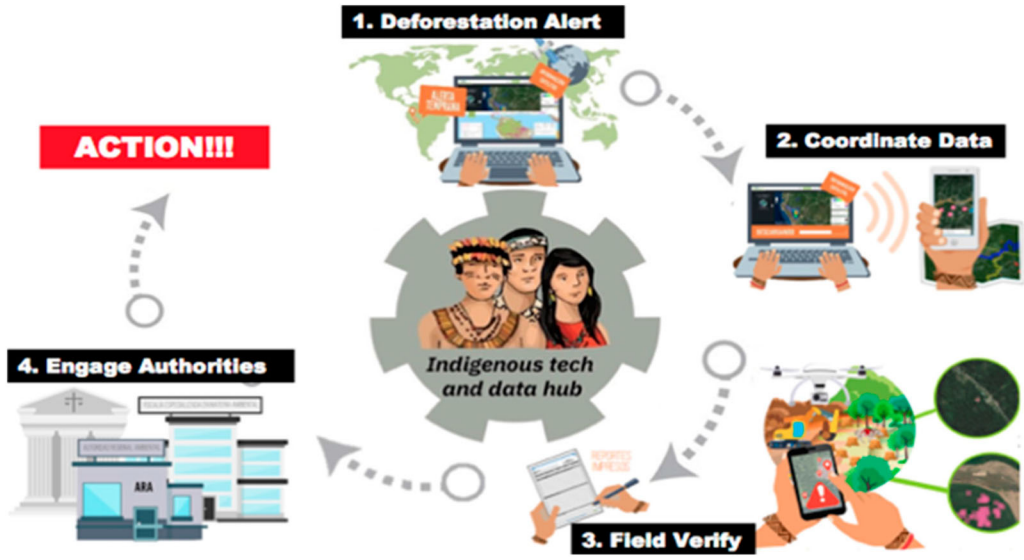

Figure 2. The Training Process and external interaction, according to the NGO: Communities' adoption of UAV, GPS, GLAD and other technologies for monitoring their territories.

Source: RF-US Peru team.

vigilance committee and as forest trustees (La República, Agencia Andina, Inforegión November 14, 2018). These natural reserves became part of the National Programme for Forest Conservation after 2018, which officially awarded conservation status to 8,320 hectares of the Nuevo Saposoa territory and 6,763 hectares of the Patria Nueva territory. Next, we analyze in more detail the political impacts and connotations of this process.

4. Consequences: the political relevance of the Shipibo Conibo peoples' participation

Our discussion herein reflects an understanding of neoliberal tendencies in expanding monitoring capacity to individuals, which may be counterproductive in the bigger picture if the new generated data is not used by the authorities to counter deforestation, and if problematic extractivist policies are not heavily curbed. This said, one cannot deny the local and place-based importance of these schemes, based on our evidence, especially given that regimes such as Bolsonarós Brazil are openly hostile to curbing deforestation, and locals' livelihoods may depend on expanded deforestation capacity. Thus, although these are not the key solutions, they could be a part of the bundle of required solutions in real-world (not ideal) politics.

By comparison, the Peruvian side has fared far better than neighboring Brazil's Acre state from GLAD-related territorial changes. The Brazilian territories of Serra do Divisor National Park, which border Sierra del Divisor Park and which are managed by the Instituto Chico Mendes de Conservação e Biodiversidade (ICMBio), do not have as advanced initiatives such as those implemented by Indigenous Peruvian communities to support the prevention of deforestation on the political level (based on the interviews and field research including community and national park visits by the second author in Peru in 2017 and Acre in 2017 and 2022).

Moreover, Brazilian frontier areas show evidence of increased deforestation, unlike the areas inside Peru's territorial boundaries. Until now, therefore, the pressure to accumulate capital through extractive projects in Peru's Sierra del Divisor is weaker than in Acre in Brazil, where illegal land grabbing for the purpose of speculation, ranching, and road building is a formidable political economic force driving large-scale clear-cutting (Kröger, 2020). There is currently an ongoing project to link Perús Pucallpa with Brazil's Cruzeiro do Sul by means of a major highway, which would cut through several Indigenous peoples' lands and the National Parks (Salisbury et al., 2014). The current government in Peru does not support the road project, but this could quickly change with a regime change. The very idea of having a road has put the area under very heavy deforestation and land-grabbing pressure. There is a marked difference in deforestation between the Brazilian and the Peruvian sides, which is aligned with the adoption of Indigenous monitoring: there is more monitoring and less deforestation in Peru.

There are at least five short-term lessons to be learned based on the progenitor case of Peru (longer-term implications are examined in the next section), which shows how technological systems can be adopted to benefit Indigenous communities in a way that is relevant to forest preservation on the global level.

First, technology-adoption processes served as a means of protecting Indigenous territories based on the co-production of knowledge, whereby Indigenous monitors were treated as equal players and agents of active forest conservation. These monitors were actively engaged in all phases of the project, appropriating technology to produce their own information in support of their own claims (Benyei et al., 2017; Haklay, 2016; Ministry of Environment Peru, 2011). They were able to communicate their claims independently before government authorities.

Second, the agency of Indigenous people and their perception of themselves and others are transformed in this case, reducing power asymmetries between state representatives and the communities. The monitors have become representatives of the communities in their claims upon state authorities. They have thus become 'agents of change,' guiding administrative and judicial complaints against the invaders. Technology has become a key means of forging agency in this setting, the fostering of agency being crucial in addressing dire socio-environmental conflicts connected to extractive projects (Kröger, 2013). Community monitors also learned the standard technical language through which to communicate satellite territorial data, which means that they became interlocutors mediating between their communities and technical specialists. Furthermore, they caught the attention of state authorities when using official measurements and tools (communicated in a language that technical bureaucrats understood and accepted).

These decreasing power asymmetries between Indigenous and outside state actors may have come at a price in some cases, however. For example, some informants claimed that internal power divisions would widen as some learned to use the technology, and were paid for monitoring, whereas others did not. First, among the potential negative impacts is the potentially growing inequality between community members who use the new technology and those who do not. An Indigenous woman resident in Nuevo Saposoa explains these dynamics:

> *Many Indigenous people also want to have a better life, and that often means having a western lifestyle like what they see from those that come from outside, and that's an irreversible thing.*
>
> *On the positive side, the project gave people formal employment, and this has prevented loggers from entering the area. But I am concerned about the cultural loss, the old generations are going to die. With a cellphone and an application young monitors make a call and talk to the officials, managers, mayors, etc., they also know what they should send. Those who are not receiving anything from the process are the elders, those who hold the ancestral beliefs, they are isolating themselves.* (author's interview Nuevo Saposoa, December 2019)

Third, in terms of governance, the collected data facilitated the development of interaction strategies with governmental and international institutions to combat the drivers of deforestation. The Sierra del Divisor experience also resulted in effective territorial control, and even in new policy approaches in the Amazonian biome: this has strong political implications because it demonstrates that we do not need forests without people (i.e. uninhabited) (Arts et al., 2012), as forests are social-ecological systems shaped for millennia by people in the Amazon. This is an equally significant development because all countries in the the Amazon Basin committed themselves to saving the rainforest as part of the 2015 Paris Agreement and the Nationally Determined Contributions (NDCs). In comparison to other cases (Ansell & Koenig, 2011; Stevens, 2014; Vitos et al., 2013), this one represents a particularly compelling counter-mapping model based on co-participation and co-design.

Fourth, this seems to be a case of continuing to create an alternative knowledge-production system, in which non-Western actors are key in producing the knowledge, and increasingly do so as they please. In terms of forest governance, power transformation means not only having open access to smart tools, but also changing the underlying understanding of what forests and nature-human relations are on a more profound onto-epistemic level (González & Kröger, 2020; Schroeder & González, 2019). Next, to situate this case from Peru in a broader Amazonian setting, we make comparisons with Brazil, providing fresh evidence on the currently budding Indigenous monitoring processes there.

5. Broader lessons: findings on the Brazilian Amazon

The second author conducted ethnographic field research among indigenous populations, NGOs and state authorities in the Brazilian Amazon in 2017, 2019 and 2022 to verify whether similar dynamics and viewpoints are present in Brazil as in Peru. The findings illustrate that Peru is more advanced in terms of the expanding use of drones by indigenous populations, whereas these projects are just starting on the other side of the frontier in the state of Acre, which shares the Sierra del Divisor / Serra do Divisor National Park with Peru. The Indigenous leaders, the NGO personnel, and the state authorities who were interviewed all supported the initiatives. The interviews were conducted in March-April 2022, with a view to giving the Indigenous people themselves the opportunity to reflect on the critiques raised by some about the possible risks of adopting indigenous technology for deforestation monitoring, for example.

In response to the question of whether these were good projects, Francisco Ashaninka, the coordinator of the Ashaninka people, replied (translated from Portuguese by the second author): 'Yes, these are important. We are anyway denouncing the ongoing invasions. We have a monitoring project in our territory [already].' The Ashaninkas living on the border of Peru and Brazil, and under much pressure, did not yet have or use drones, but they were working with 'satellite images, looking, observing, and also making field visits.' Extending this monitoring by different technological means was seen as having many benefits:

> '*Well, the benefit is that you have to live knowing your house, you know, how can you live in a site where you don't know your territory? So this is already a great benefit. […] Getting to know your territory, knowing the potential, this is a strategy that is not new, it is very old, the great first world countries are even monitoring other countries. […] The more you master, the more you know, the easier it is to take care of your territory, so the world today is all connected. And in our territories, we have to activate the State to fulfill its role, so we are monitoring.*'

When asked about risks, Franciscós reply was: 'What risks?' Risks in the communities were specified, to which the reply was: 'First, there were people who didn't want an Indian to use a phone.' This kind of focusing on risks was seen as a problematic stance, especially when voiced by non-Indigenous people, as Francisco explained:

> '*This is backwardness, you preventing someone from using a tool like that, a drone, any equipment, the internet, to which you have access. Those who think it shouldn't be, that this can't be equipment that the Indians can master, are backwards, you know? This thinking has to end. Now, it can't be that others are dominating, using [the technology and drones] and come at us and we can't defend ourselves, that's a way to defend ourselves too. So we're going to have to acquire, buy everything we can buy that will help give us the means to communicate.*'

Similarly, in November 2019 the second author also documented the effective use of drones by the Munduruku people on the Tapajós river in Pará in Central Amazon, in their struggle against deforestation and invasion by loggers, miners, and land grabbers. In this context, young women with families were using the drones, and they saw this as a major step in advancing equality on many fronts, inside and outside the community. Aldira Munduruku, for example, talked about her experience with drones in a village south of Itaituba:

> '*The reason for learning to use the drone is to monitor, monitor our territory, everything that is happening, to show out there not only in Brazil, but in the countries out there that we want show the Pariuá [the Munduruku word for non-Munduruku people] who want to help us and who can know about our reality. So, our job is just to show reality, everything that's happening to us and with our forest.*'

There is no mention in the recorded Indigenous accounts about risks, or problems associated with using drones, although they had been using them for a number of years. Francisco Ashaninka explained that the projects needed to be expanded to 'put *pressure on the State to recognize its flaws*': their reports were not currently respected as they did not have proof of invasion, which their drone images could provide. Francisco was aware that internal community organization was extremely important in this adoption process, and that it could build up existing surveillance committees by equipping and training them in the use of new equipment and in communication skills.

This reflects our findings on the Peruvian side concerning the importance of the internal community process of technology adoption, which should avoid the pitfall of creating inequalities, as some noted. In Acre, Lindomar Padilha from CIMI (Conselho Indigenista Missionário) (the second author's interview, March 18, 2022) was highly critical of the introduction of so-called Indigenous Agroforestry Agents, who are given a payment within the REDD+ (Reducing Emissions from Deforestation and forest Degradation) compensation scheme to control deforestation within Indigenous territories, also by drones. He argued that this would have introduced internal division within the communities, whereby locals are forbidden to clear the forest for food production. We were not able to verify these claims, however, and Indigenous leaders who were interviewed did not bring up these problems in Brazil. The takeaway from these findings is that Indigenous groups, like all groups, seem to start to use the new technologies quickly, based on existing and new cultural-political patterns, and that inequalities are likely to surge if the adoption is not done equally among community members and neighboring communities. We assess these potential pitfalls next.

6. Long-term risks and threats in Indigenous monitoring

We have identified the merits of Indigenous monitoring in previous sections, as well as some potential risks and problems. In the following we assess these aspects for deeper, in-built power imbalances in the long term.

The adoption of powerful external technologies through processes that affect many aspects of community life may also introduce new dependencies, as an external project collaborator explained:

> *But in the end, the technological process is already irreversible, it is happening, it can no longer be stopped, we are part of it and this means that you can no longer contradict yourself. […] We have already generated dependencies, we have fulfilled the objective of the project, we have responded to our financials, but it is already done. It is important to start analyzing contingency co-management, how it is applied, and we have inadvertently been part of that problem.* (First author's interview, Lima, January 2020).

The long-term effects may thus be fragile if outside support is withdrawn. Communities may have no money to pay for technology maintenance or data hubs when key technology breaks down or a key NGO and government agency withdraw their support. However, the risks need to be counterbalanced with the urgency of protecting the rainforest. Dependencies such as those acquired by Indigenous communities also need to be assessed equally with any Western community or person who uses drones or mobile phones, and is in a similar dependency situation, although typically with easier access to tool maintenance.

Another aspect to consider is whether the time that young monitors spend daily on monitoring and using new technological tools is time that is taken away from their established livelihood

practices. These transformations mean that traditional lifestyles and livelihoods may be put at risk, and it is good to keep this in mind. It seems from our interviews, however, that using drones and satellite monitoring, as well as the new forms of communication, seemed to leave more time for other important tasks: daily and weekly patrolling routes could be shortened, and the time saved by using aerial monitoring could be spent on maintaining food gardens, for example (based on the second author's interviews, 2022). Further discussion concerning the plural understandings and the uses of technology and local needs is required to better understand these dynamics (Turnhout et al., 2014).

Despite these initial successes, the repercussions are uncertain in terms of how much of the success makes its way back to the communities and the mid- to long-term effects of this institutionalization. The Peruvian state has been exploiting the success of the progenitor case since 2018, for example, and it has included this case study as part of the REDD+ mechanism (CIFOR, 2018). It is worth pointing out that the Peruvian Indigenous leaders who were interviewed by the first author in December 2019 did not report having received any incentives or remuneration from the central government. Furthermore, in the first author's interviews with several RF-US officials, they declared that they did not have information about the transition of the institutional frame of this process from an NGO-led initiative (Rainforest Project) to a global governance initiative (REDD+). The mixing of REDD+ with the budding indigenous monitoring schemes should be avoided based on these findings, as the recorded types of REDD+ insertions may harm the adoption processes.

NGO personnel working in both the Brazilian and the Peruvian areas of this border zone also identified other risks in the technology spread. One was the rising threat of violent robbery within Indigenous communities. The areas concerned are largely beyond the scope of police protection, controlled by organized crime and drug traffickers who might be lured in to steal equipment, both for its value and to prevent the tracking of their drug routes (the second author's interview with Malu, Comissão Pró-Indio, Acre, March 21, 2022). The drug cartels could also co-opt locals, being aware of the potential of Indigenous people with drones and other ways of supporting the trafficking. According to Malu, fear of such consequences has prevented some communities from adopting the technology in spite of its recognized potential benefits, the border area having been infested with drug-related violence in recent years. On the other hand, all the FUNAI (Brazilian Indigenous Agency) officials who were interviewed and most NGO officials were wholeheartedly in favour of monitoring Indigenous deforestation, giving examples of currently unfolding success stories. For example, Moacyr Silva from Brazil's WWF (interviewed by the second author, March 30, 2022) claimed that WWF-supported projects were proving to be 'very useful' in the state of Rondônia: the Indigenous people learned fast and used a lot these tools effectively to counter encroachers.

These schemes have however also been criticized for the possible negative impacts in terms of monetizing the valuation of nature among locals who have not thus far put a monetary value on forests (Leach & Fairhead, 2002). The monetization of incentives could pose increasingly dangerous threats to the acculturation of these millenary cultures (Polanyi, 1944). An expert on the monitoring of Indigenous deforestation from RF-US in the studied area reflected on their role in these transformations as follows:

> *There is one reason why we invest our time, our resources, our connections in Indigenous communities: they have the best long-term conservation, while simultaneously, they are just as capable as anybody to access technology and make informed decisions. They are equal players and not just beneficiaries. There is*

> *a misconception in conservation. Forest conservation is an active behavior, for this, these communities do need money. People are doing their work for conservation, they are walking the territories, they are the ones who should get direct benefits. Governance forest systems should be able to incentivize people directly. The entire planet depends on facilitating these traditional protection efforts.* (First author's interview, 2020).

The aim of this reflection was to demonstrate the urgent need to conceive of self-sufficient and transparent financing mechanisms that would sustain counter-mapping initiatives in forest monitoring. In sum, although some power asymmetries have been reduced, and a host of other benefits achieved, at a broader level there is still a risk of commoditization of both forests and livelihoods when this technology is adopted in global environmental politics of climate compensation (e.g. REDD+). Next, we provide five key parameters for assessing the success the technological adoptions more generally, based on our comparative analysis.

7. Five key parameters for assessing the democratic adoption of technology

Initiatives concerning the implementation of digital technology for forest monitoring have been developed in many places around the world. Radjawali et al. (2017) explain the conditions under which drones were effectively used to make counter-maps and solidify community land claims. In the 2010s, Latin America represented the region of the world with the highest incidence of participatory mapping by Indigenous communities (Vargas-Ramírez & Paneque-Gálvez, 2019).

Given that most of these technological initiatives were driven by external agents and community allies, it is necessary to develop clear definitions of global agreement on data collection, the maintenance of meta-datasets, and the international agreements that guarantee the co-participation and co-design of counter-mapping initiatives in threatened regions (Arts et al., 2015). The control of Indigenous data should be verified in these cases to avoid digital extractivism in its different forms, including risks connected to open data, which extractivists could use virtually or physically to harm or exploit the land or data sovereignty of the communities (see Kukutai & Taylor, 2016).

Taking the above benefits, risks, and processes of facilitating counter-mapping efforts for forest sustainability as a basis, we identify five key parameters for assessing whether co-participation and co-design have been achieved in technological adoptions, and longer-term risks averted or at least diminished.

(1) The adoption of technology is based on the bottom-up co-production of knowledge as meeting core community concerns and needs.
(2) Forest governance needs to establish massive external support mechanisms to ensure transparency and self-determination among forest dwellers and in the entire process (e.g. who controls, pays for, benefits from, or is negatively affected by the process).
(3) The allies and external actors who collaborate with communities should also distribute the more difficult tasks, thus creating new agency and power vis-à-vis outsiders.
(4) Indigenous and other technology adopters are recognized as equal players by the state and the global community, as capable of handling technology and participating actively in conservation policies.
(5) Processes are based on knowledge co-production that results in the creation of alternative and/or interdisciplinary systems, giving space for new capabilities and innovation.

8. Conclusions

Sixty-eight percent of Indigenous lands and protected natural areas in the Amazon region are under pressure from roads, mining, dams, oil extraction, and forest fires and deforestation (RAISG, 2020). It is essential to protect and expand monitoring in accordance with the conditions of the Amazon forests, including the forest-dwellers' knowledge of drones and other things that allow for the implementation of an early-warning platform for risks. We have explored new schemes within which Indigenous monitors of forests have been trained as key actors in detecting and reporting to the authorities illegal loggings on their territories, and in stopping deforesters on the evidence of drone and satellite data they collect. We have also discussed the potential and risks included in these transformations. In the observed progenitor case in the Peruvian Amazon, deforestation in the communities was reduced in the short term from over five percent annually to technically zero, and community power grew. The process enabled remote Amazon Indigenous communities to become political actors participating in the crafting of national forest policies

There are several undeniable short-term benefits, such as the halting of deforestation and the acquisition of new *de facto* skills and access to technology among the inhabitants of the forests. There were also several longer-term and deeper exposures and risks associated with the increased adoption of externally produced monitoring technologies, however, such as dependency on outside technology and funding to continue the monitoring. There may also be unexpected impacts, depending on the context, such as an increased risk of violence or co-optation along drug-trafficking routes.

In the cases we studied in Brazil and Peru, Indigenous communities have become key agents of monitoring deforestation in their territories. However, equalizing all power relations that are problematic in conservation by means of technological processes is challenging (Büscher et al., 2014), and requires further study. We identified five key parameters for assessing the success of these schemes.

This case showcases how technology can help in fostering interconnectedness, feedback, and adaptive capacity between people and institutions (Blok, 2017; Simondon, 2010). The twenty-first century developmental processes need to be based on capability-enhancing governance (Evans, 2010), in which Indigenous peoples need to achieve more encompassing embeddedness within states, and in global and national civil society (Kröger, 2021; Kwaku Kyem, 2004). One of the main challenges related to co-participation and the co-design of digital technological data to counter deforestation is the engagement of disparate people to connect, interpret, and collaborate through pluriversal ontologies and politics (Kusumasari, 2018). This process is necessary on the global and local levels to overcome dire sustainability challenges, such as Amazon deforestation. It entails learning and engaging in a shared process as Indigenous communities and state and global actors work toward similar goals, but from distinct epistemological perspectives. However, further studies and actions are needed to assess the longer-term impacts of this transformation.

Note

1. In this regard, Nancy Peluso (1995, p. 384) defines counter-mapping as the practice by which Indigenous communities map their customary or ancestral lands to back up legal claims to their territory. The potential of the counter-mapping movement to enable intensified spatial surveillance of their own territories in the courts has brought significant implications related to equal political participation, human rights, and legal acknowledgment (Radjawali & Pye, 2017; Wainwright & Bryan, 2009; Bryan, 2011).

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