Land Scarcity in Indigenous Territories of the Peruvian Amazon: A Dual Challenge for Indigenous Land Rights and Resource Sustainability

by

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ABSTRACT

Emerging challenges related to resource sustainability are increasingly affecting Indigenous communities in Amazonia. Although, Indigenous peoples have made significant progress in securing land rights, and Indigenous territories fulfill a critical role in preserving the forest cover in the biome, wildlife depletion, forest impoverishment and land scarcity have been recently documented in certain communities. The prospect of growing land scarcity is particularly disconcerting. Extant research suggests that a shortage of land may lead to problematic land system transitions in local communities, jeopardizing the Indigenous land management practices that sustain the anthropic forest landscapes of Amazonia.

In this thesis, I analyze the development of land scarcity in Indigenous territories of the Peruvian Amazon and the land management responses of Indigenous households to this issue, through a case study of two Indigenous communities situated in the Napo River basin. Participant observation, household land surveys, and interviews with 74 Indigenous households and 6 basin-level actors served to investigate: 1) the processes and factors contributing to land scarcity; 2) changes in community land access and property regimes; and, 3) households land management transitions associated with land scarcity.

My results indicate that inconsistent State forest control and access regimes in Amazonia can lead to community enclosure, inhibiting Indigenous peoples' access to old-growth forest in their own territories. This development was critical in exacerbating local land scarcity in one of the study communities. In response to declining land supply, Indigenous peoples in this community adopted innovative and multifaceted land management adjustments, including property communalization, accelerated individual land claiming, resource intensification and substitution strategies. Property and management regimes over secondary forest lands underwent significant transformations to make land more available, but risks undermining the sustainability of local agricultural systems and the community's social fabric. In summary, this study suggests that land scarcity in Indigenous territories remains closely linked to problematic and incomplete Indigenous land rights, and that Indigenous peoples are not insulated from the challenges of resource sustainability and its associated consequences.

RÉSUMÉ

Les défis émergeants liés à la durabilité des ressources impactent de façon croissante les communautés autochtones de l'Amazonie. Toutefois, les peuples autochtones ont fait des progrès considérables pour la protection de leurs droits fonciers, et les territoires autochtones remplissent un rôle critique dans la préservation du couvert forestier au sein de ce biome. Les pertes fauniques, l'appauvrissement des forêts et la pénurie des terres ont récemment été documentés dans certaines communautés. La perspective d'une pénurie croissante des terres est particulièrement déconcertante. Des recherches récentes suggèrent qu'une insuffisance de terres pourrait mener à des transitions problématiques des systèmes fonciers dans les communautés locales, compromettant les pratiques autochtones de gestion des terres qui maintiennent les territoires forestiers anthropiques de l'Amazonie.

Dans cette thèse, j'analyse le développement de la pénurie des terres dans des territoires autochtones de l'Amazonie péruvienne et les réponses de gestion des terres de foyers autochtones face à cet enjeu, à travers une étude de cas de deux communautés autochtones situées dans le bassin du Rio Napo. L'observation de participants, enquête auprès des ménages, et des entrevues avec 74 ménages autochtones et 6 acteurs à l'échelle du bassin ont permis d'investiguer: 1) les processus et facteurs contribuant à la pénurie des terres; 2) les changements dans l'accès à la terre et les régimes de propriété des communautés; et 3) les transitions en gestion des terres des ménages dues à la pénurie des terres.

Mes résultats indiquent que le contrôle inconsistant des forêts par l'État et les régimes d'accès en Amazonie peuvent mener à l'enclosure des communautés, inhibant l'accès des peuples autochtones aux forêts anciennes de leur propre territoire. Ce développement est critique dans l'exacerbation de la pénurie des terres locale pour une des communautés à l'étude. En réponse au déclin de la disponibilité des terres, les habitants autochtones de cette communauté ont adopté des ajustements innovateurs et multidimensionnels de gestion des terres, incluant la communalisation des propriétés, l'accélération des revendications individuelles à la terre, l'intensification des ressources et des stratégies de substitution. Les régimes fonciers et de gestion des territoires forestiers secondaires ont subi des transformations significatives pour augmenter la disponibilité des terres, mais les risques menacent la durabilité des systèmes agricoles locaux et le tissu social de la communauté. En résumé, cette étude suggère que la pénurie des terres en territoire autochtone

demeure étroitement liée aux droits fonciers autochtones problématiques et incomplets, et que les peuples autochtones ne sont pas isolés des enjeux de durabilité des ressources et de ses conséquences.

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The journey of crafting this thesis has been both challenging and pleasant, much like the winding path of the Napo river itself. Now, having reached my destination, I not only affirm my passion as a social researcher of rural lifeways but also carry with me a deeper appreciation for the intricate tapestry of human experiences I've encountered along the way.

First, I want to thank the people who make possible to conduct a successful fieldwork. I want to express my heartfelt gratitude to my fieldwork assistant, J.H.E. Her contribution went far beyond excellent work during the data collection process; she became an emotional support during our time in the communities. I am profoundly grateful to the families and authorities of the communities of Tamboruna and Solidaridad, especially those who hosted us. The warmth of their wooden doors opening to us, our shared walks to the *chacras*, their patience in answering our questions, and the joyful moments over *masato* and laughter - all these experiences I cherish deeply. Equally valuable was the support from the leaders of the Indigenous Federation FECONAMNCUA, whose insights were crucial in understanding the complex realities of the Napo basin.

My supervisor, Oliver Coomes, deserves special recognition. Oliver not only provided me with the invaluable opportunity to study at McGill, fulfilling my dream of pursuing graduate studies abroad, but also profoundly shaped my development as a researcher. Under his guidance, I discovered a new approach to scientific inquiry: one that combines the passion for research with rigorous discipline, high standards, and an unwavering professional commitment. His insightful feedback, challenging questions, and constant encouragement pushed me to exceed my own expectations. For this transformative experience, I am deeply grateful.

Finally, I want to pay tribute to my mother, Ana María Raurau. Amidst the economic turmoil that gripped Peru in the 1990s, facing the precarious circumstances typical of a high school teacher's life, she managed to bestow upon me the most precious gift: a quality education. Her unwavering determination and selfless effort laid the foundation for every opportunity I've been able to seize. As I stand at this academic milestone, I am acutely aware that every open door, and every achievement is a testament to her sacrifice and love. For this immeasurable gift that continues to shape my life and career, I am eternally grateful.

Contribution of authors

This thesis is presented in manuscript-based thesis format. The thesis is arranged around two substantive chapters (2-3) and contains an introduction and literature review (Chapter 1) at the beginning as well as a concluding chapter (Chapter 4) which discusses the main findings of my study. This is an original work by Ana Lucia Araujo Raurau. I have developed scientific questions, carried out the field research, analyzed the data and wrote the thesis. My supervisor, Prof. Oliver Coomes provided guidance and advice on the development of the research questions, on formulation of the project and on the writing of the thesis. He also gave editorial advice throughout the thesis.

List of figures and tables

Chapter I. Introduction

Indigenous territories (ITs) of Amazonia are collective territories inhabited and governed by Indigenous peoples (IPs) organized in communities. The legal recognition and titling of ITs across the Amazon, with near 7,000 communities formally established in 2022 (RAISG, 2022), have been critical in strengthening Indigenous land rights and preserving the forest cover and biodiversity (Baragwanath & Bayi, 2020; Bennett et al., 2018; Blackman et al., 2017; Gray & Bilsborrow, 2020). As territorial rights are more pervasively secured, Indigenous peoples face the challenge of sustainably managing their resources (Le Tourneau, 2015). Forest impoverishment, declining wildlife resources, and land scarcity (Coomes et al., 2017, 2020; Oldekop et al., 2012; Sirén, 2007) are sustainability issues arising together with higher resource pressure experienced by these communities over the last decades (Silva-Junior et al., 2023).

The prospect of land scarcity is particularly alarming. Within the boundaries of a collective territory in a tropical forest ecosystem, land scarcity manifests as a progressive decline in forest area available for agricultural conversion (Littleboy, 2022). This phenomenon creates a looming risk for community members, who face the prospect of losing access to new land in the coming years, potentially jeopardizing the long-term sustainability of their livelihoods (Oldekop et al., 2012). As available land diminishes, land users are typically compelled to significantly transform their land management practices and their approach to the remaining forest resources.

Precisely, recent studies conducted in Amazonian communities suggest that a decline in available land may significantly affect local land systems, leading to agricultural intensification (Coomes et al., 2011; Jakovac et al., 2016; Sirén, 2007), further individual appropriation of the forest (Coomes et al., 2000, 2011), heightened land inequality (Coomes et al., 2011), and the privatization and alienation of land through land markets (Sarmiento Barletti et al., 021). Overall, land scarcity threatens to undermine land management and governance practices which are crucial for sustaining forest ecosystems within Indigenous Territories. Of note, most of the evidence produced to date comes from cases of non-Indigenous Amazonian settlements.

In my research, I seek to understand the challenges posed by land scarcity to the way Indigenous peoples of the Amazon manage their lands. Specifically, I identify the processes that contribute to growing land scarcity within ITs and then analyze how land scarcity transforms Indigenous land management, land access and land property regimes both at a household and community level. To

address my research questions, I conducted 1) a case study analysis of an Indigenous community situated in the Napo River in the Peruvian Amazon, and 2) a comparative quasi-experimental analysis between two Indigenous communities located in the same basin. The study design and methods were approved by the Research Ethics Board of McGill University (REB # 22-06-019).

My study combines ethnographic and household survey information gathered over three months, from August to October 2022 in the study community. I conducted 74 household surveys, 74 plot observations, two focus groups with local authorities, and six interviews with key basin stakeholders. These data were subjected to multivariate regression analyses to model land scarcity as a predictor of land use and land accumulation at the household level. Ethnographic analyses were used to reconstruct how land scarcity was produced and transformed land access and property regimes in the community.

1.1 Purpose and objectives

In this thesis, I examine the development and ramifications of land scarcity in Amazonian Indigenous territories. I draw on two main ideas regarding the nature of land scarcity. First, land scarcity is a dynamic and multicausal phenomenon produced by the interaction of factors increasing the land demand (e.g., demographic growth, market forces) and constraining the supply of land (e.g., environmental hazards, property regulations) (Hartmann & Gerber, 2018). Second, I assume that land scarcity places a significant risk over users in regards to their land access in the future and increases resource rivalry, compelling individuals and communities to adjust their land management practices (Hartmann & Gerber, 2018; Oldekop et al., 2012). From this, the main objective of the study is to analyze how land scarcity transforms internal agricultural land management of Indigenous communities of the Peruvian Amazon. The specific objectives of this research are the following:

a. How is land scarcity produced in Amazonian Indigenous territories?
b. How does land scarcity transform land access and property regimes of Indigenous communities?
c. How does land scarcity transform land accumulation and land use by Indigenous households?

1.2 Literature review

1.2.1 Land scarcity in Amazonia

In a seminal work in land system science, Lambin et al. (2003) referred to land scarcity as one of the main pathways leading to land use/cover change in forest tropical regions. According to the authors, scarcity is produced by a conjugation of multiple factors, including demographic growth, the loss of soil productivity and land fragmentation. However, in this study, the various roles that these factors play in land scarcity production are not distinguished (e.g., land demand determinants, factors restricting the land supply), nor are the connections and feedback loops established between each other (Lambin et al., 2003).

Similarly, study cases conducted in Amazonia lack a systematic analysis of land scarcity production[1], often identifying a variety of disconnected factors at play in each area of study. The factors most commonly mentioned are the rapid demographic growth of Indigenous and folk[2] Amazonian populations (Bremner & Lu, 2006; Coomes et al., 2000; Lu, 2001; Oldekop et al., 2012; Sirén, 2007), and the increasing integration to food markets (Coomes et al., 2000; Godoy et al., 2009; Oldekop et al., 2012), both raising the demand for additional cropland. Other factors mentioned less frequently are the remoteness of available forest land (Sirén, 2007), and the enclosure of communities in limited territories (Coomes, 1996; Vadez et al., 2004); all of these factors restrict the supply of land. It is noteworthy that this scholarship exclusively assesses the buildup of land scarcity qualitatively, and no quantitative estimation of scarcity is provided [with exception of Coomes et al. (2000, 2011)].

More research has been conducted on the effects of land scarcity within Amazonian communities. The most observed effect is land use intensification. Numerous case studies, conducted mostly in non-Indigenous communities, show that when land availability declines, households intensify their use of agricultural lands, increasing the number of production cycles and shortening the fallow period (Coomes et al., 2011a; Jakovac et al., 2015, 2016; Putsche, 2000; Sirén, 2007; Vadez et al.,

[1] A more nuance understanding of land scarcity has been developed for African rural communities, where the available arable land is restricted in many regions of the continent (Jayne et al., 2014). Factors associated with rising land scarcity in this context are population growth, internal community disputes, war and displacement, colonial policies, land inequality distribution (Andersson, 1999; Chamberlin et al., 2014; Jayne et al., 2014).

[2] In this study, the term 'folk populations' encompasses all non-Indigenous peoples residing in rural areas of Amazonia. This category primarily includes two distinct groups: the *ribereños* and colonists, both of which are comprised of mestizos with diverse historical origins.

2004). Conversely, an increase in the land claimed -i.e., land extensification- is a less documented outcome of land scarcity. In the case of a folk community in the Peruvian Amazon, households facing scarcity rapidly claimed land over the available forest, aiming to secure their access to the last forest around the settlement (Coomes et al., 2000, 2011). More research is required to ascertain whether rapid land extensification frequently ensues from land scarcity. To date, based on existing literature, resource intensification appears to be the dominant land-use response among Amazonian communities.

The impacts of land scarcity on other elements of land systems have received limited attention in Amazonian scholarship. Exploring how land distribution is transformed by scarcity, Coomes et al. (2011) shows an indirect causal link between land shortage and higher land-size and land-use inequality. Here, land inequality emerges from asymmetrical patterns of land accumulation among households, triggered by the decline in land availability. Few studies address how land scarcity drives changes in land governance and land property regimes. Herz (2018) and Sarmiento Barletti et al. (2021) report increased privatization of household lands and the development of rental markets in Indigenous territories facing scarcity together with encroachment and indebtedness, which frays the communities' social fabric. In contrast, Oldekop et al. (2012) and Sirén (2007) documented the emergence of formal communal regulations or institutions to manage scarce forest lands under a common well-being criterion. The different trends towards individualization or communalization indicate that land scarcity may exacerbate contrasting valuations of land among resource users.

A theory explaining how land scarcity produces these diverse and sometimes opposing effects is pending, but some progress towards this end has been made in the research led by Oliver Coomes [in Coomes et al. (2000, 2011, 2017)], which delves into land scarcity through a long-term examination of a folk community in the Peruvian Amazon. These studies reveal that perceptions of land scarcity and the land distribution structure strongly condition the way families cope with land scarcity (Coomes et al., 2011, 2017), determining for instance, their ability to claim land in the remaining forest areas. Similar findings are echoed in the work of Oldekop et al. (2012), who analyze resource scarcity in two Kichwa communities of the Ecuadorian Amazon. They underscore the strong influence of perceptions of scarcity on the community choices to establish collective regulations. In both cases, internal land structures and local interpretations of scarcity

are key factors shaping land user's agency, and the ramifications of land scarcity (Coomes et al., 2011).

1.2.2 Drivers of land demand in Amazonia

The increasing demand for cropland is one of the main drivers of a decline of forest cover and the rise of land scarcity among Indigenous Territories in the Amazon basin. Land system science scholarship has examined the factors driving land demand across this region, with deforestation as the primary measurement of rising land pressure. In this section I review the findings regarding the three main drivers of land demand: demographic growth; market integration; and, policy regulations.

The link between demographic growth and land demand can be traced back to the ideas of Malthus, which posit that a rise in population results in an increasing agricultural production, thereby leading to land expansion and eventual resource depletion (Malthus, 2015 [1798]). Extensive research carried out in the Amazon has largely scrutinized the association between population and land, with findings often challenging or moderating the Malthusian hypothesis. For instance, López-Carr (2004) and Aide et al. (2013) show that population size and growth in Amazonian folk settlements is not consistently associated with land expansion, and the link is only strong in certain contexts, such as the early years of settlement. Moreover, the population-land association weakens with the expansion of off-farm economic sectors and the diversification of household livelihoods beyond agriculture (Wright & Muller-Landau, 2006). This is especially relevant among folk and Indigenous communities, where livelihoods can vary significantly, and in many cases, structured by other activities such as fishing, timber extraction or seasonal labor (Coomes et al., 2016).

Interestingly, a special concern has arisen regarding Amazonian Indigenous peoples, who have experienced a demographic surge in recent decades due to high fertility rates (C. Gray & Bilsborrow, 2020; McSweeney, 2005; McSweeney & Arps, 2005). Nonetheless, studies by López-Carr et al. (2006), Pan & López-Carr (2016), and Sellers (2017) found no direct association between fertility rates and increased deforestation in Amazonian Indigenous communities; again, tempering the simplistic causal link between population and land.

Other population variables have more diverse and not linear associations with land demand in Amazonia. First, given that land is typically managed by family units in local settlements,

household dynamics are anticipated to influence land demand (de Sherbinin et al., 2007; Perz et al., 2006). Several study cases (e.g., (López-Carr, 2009; Perz, 2001a; VanWey et al., 2007) demonstrate that the household life cycle determines the size of their land holdings, indicating that the land individually accumulated is driven by the family's consumption needs and labor endowments [(Chayanov (1987) cited by (Ellis, 1993)]. This association is particularly robust in remote areas of the basin, where food and wage labor markets are not fully developed (Perz, 2001a). Second, migration dynamics are also associated with land demand, in at least in two ways. On the one hand, in-migration to forest frontiers, usually motivated by the high availability of land, has proven to be an important determinant of deforestation and agricultural land expansion (Bennett et al., 2018; López-Carr, 2009). On the other hand, out-migration from Amazonian settlements can alleviate pressure over the forest by reducing the demand of land (Aide et al., 2013; Rudel et al., 2005), or incentivize deforestation through the impact of remittances (López-Carr, 2009; McSweeney & Jokisch, 2007).

There is a growing consensus in the literature that demographic factors are not strong determinants of land demand (de Sherbinin et al., 2007), because the relationship between population and land is indirect and typically mediated by other variables (e.g., population growth leads to more food demand, which in turn, leads to land expansion) (López-Carr et al., 2005), Moreover, land pressure driven by population dynamics could be offset through specific economic responses (e.g., greater food demand could be met by increasing crop productivity), and not necessarily through land expansion (Bilsborrow, 1987; Lambin et al., 2003).

In contrast, market integration is a more robust predictor of escalating land demand. Numerous case studies consistently show that a better access to agricultural markets correlates with a greater expansion of the cultivation area within local Amazonian settlements (Coomes et al., 2016; Godoy et al., 2009; C. L. Gray et al., 2008; Vadez et al., 2004). Furthermore, market integration also stimulates the exploitation and depletion of other wild resources, such as timber, non-timber and game (Abrahams et al., 2017; Coomes et al., 2016, p. 201; Hallwass et al., 2020; López-Carr et al., 2005), potentially increasing the dependency on agriculture and land expansion among Amazonian forest dwellers (Coomes et al., 2016).

Public policy also plays a critical part in shaping land demand dynamics in Amazonia|. Policy regulations can directly affect land demand and exacerbate deforestation by fostering incentives -

such as credit, agricultural inputs or titling - to support commercial agricultural and cattle-ranching (Bennett et al., 2018; Chavez & Perz, 2012, 2012; Coomes, 1996). Other policies aiming at fostering regional development also have considerable impact on land demand. For instance, infrastructure projects such as road construction or colonization promoted by Amazonian governments have led to massive frontier in-migration and accelerated land expansion (Almeyda Zambrano et al., 2010; Alvarez & Naughton-Treves, 2003). In contrast, conservation and land tenure policies have inhibited and confined land expansion over the forest (Angelsen, 2010; Assunção et al., 2020; Chávez et al., 2014; Nepstad et al., 2006). Nonetheless, government policies often yield uncoordinated and sometimes contradictory State interventions; a feature attributed in part to the considerable instability in Latin American democracies (Chavez & Perz, 2012; Silva-Junior et al., 2023).

1.2.3 Land management in Amazonian Indigenous and folk communities

The internal structures of a land system - i.e., the patterns of land access and property, land use, and land distribution - define the ramifications of land scarcity in a territory (Coomes et al, 2011). In this final section of the literature review, I summarize the literature describing Indigenous and folk land management systems in Amazonia. In doing so, I draw from a multiplicity of scholarship, including ethnography, economics, and land system science.

Amazonian Indigenous and folk peasants typically live within collective territories governed under communal/collective arrangements. In that sense, Indigenous and folk territories can be categorized as forest commons: "...forests for which the boundaries of the resource, the identity of the user group, and property rights to benefit from the resource are well defined." (Chhatre & Agrawal, 2008: 13286). Over the past few decades, these commons have gradually gained formal recognition from the State, obtaining their legal inscription and, in many instances, a collective property title (Bremner & Lu, 2006; Larson et al., 2018; Monterroso et al., 2017).

States have played a significant role in demarcating collective territories and defining the extent of community's property rights, but are contingent upon the evolving legislative frameworks in each country (Constantino et al., 2018). Concerns have been raised over the limited amount of land

allocated to Indigenous and folk communities[3] (Barclay & Santos Granero, 1983; Constantino et al., 2018), along with the restrictions imposed over resource access within their own territories (Larson et al., 2018; Monterroso et al., 2017). In Peru for example, Amazonian Indigenous communities are allowed to hold agricultural lands only in areas where soil fertility is sufficient (ibid). In addition to challenges in community design, territorial rights are weakly enforced by States in the Amazonia, leaving communities frequently exposed to land encroachment and dispossession by private actors (Sarmiento Barletti et al., 2021; Silva-Junior et al., 2023). In sum, Indigenous and folk communities of the Amazon manage their lands amid considerable resource constraint and tenure insecurity.

Indigenous and folk households practice shifting cultivation, an agricultural system in which land is accessed by claiming a patch of forest and cultivation transitions through phases of short-term swidden to long-term fallow (Denevan et al., 1984). This transition allows land users to manage the nutrient poverty of Amazonian soils, and to increase their control over secondary forest succession; the two major ecological challenges of agricultural production in tropical forest ecosystems (Denevan et al., 1984; Denevan et al., 1988). A remarkable diversity of species has been documented within shifting cultivation plots. Cultigens commonly found across the Amazonia include manioc or yuca (*Manihot esculenta),* plantain (*Musa sp.*), maize (*Zea mays*), rice (*Oryza sativa*), sugar cane (*Saccharum officinarum),* guayaba (*Psidium sp.),* umarí (*Poraqueiba sericea*), uvilla (*Pourouma cecropiaefonia*), caimito (*Poutena caimito*), barbasco (*Clibadium asperum*), pona (*Iriartea sp.*), cedar (*Cedrela odorata*), among dozens of others (Denevan et al., 1984; Pinedo-Vásquez et al., 2012).

Amazonian shifting cultivation occurs on two different landforms. The floodplain, *várzea* or lowland is comprised by mudflats, dried lakes beds, levees, and sand, and is subject to various levels of flooding during the year. Floodplain soils are typically fertile, being nourished by riverine sediments (*Floodplain Or Várzea | AGUAS AMAZÓNICAS*, 2022). In contrast, the upland or *tierra firme* comprises soils that are considerably more acidic and less fertile, but secure against floodings, riverbank erosion and other riverine hazards (Coomes, 1992; Hiraoka, 1989).

[3] In Peru the recognition of Amazonian Indigenous communities occurred without sufficient consideration for Indigenous territoriality or livelihoods, leading to the establishment of small and fragmented territorial units (Barclay & Santos Granero, 1983; Larson et al., 2018; Varese, 2005). A similar critique has been made of Indigenous territories design in certain regions of Brazil (Constantino et al., 2018).

Indigenous and folk households practicing shifting agriculture allocate lands both in the upland and lowland, usually achieving a balance between agricultural productivity and asset security (Coomes, 1992; Hiraoka, 1989). Across the landscape, the alternation of forest cover and agricultural fields creates a dynamic mosaic of patches in different stages of forest succession (Denevan et al., 1988; Pinedo-Vásquez et al., 2012).

There are two major features of small-scale shifting cultivation as practiced in Amazonia. First, the utilization of external agricultural input (e.g., fertilizer) is limited, consequently, land productivity relies primarily on intrinsic soil fertility (Jakovac et al., 2016). Typically, the fallow length (i.e., the years in which the land is 'resting') has been considered as the main predictor of soil fertility reproduction (Denevan et al., 1988). However, recent studies in folk communities show that the number and duration of cropping cycles are stronger determinants of the fertility status of agricultural soils (Coomes et al., 2000; Coomes & Miltner, 2017; Jakovac et al., 2016; Lawrence et al., 2010; Wood et al., 2017). Second, shifting cultivation systems in the Amazon are path-dependant (Coomes et al., 2011a). Land-use decisions (e.g., vegetation species choices, duration of cultivation phases) condition the sub-sequent land-use/cover dynamics. Overall, the sustainable and effective management of agricultural land in Amazonian communities depend heavily on specialized anthropic management (Denevan et al., 1984).

Typically, Indigenous families hold individual possession rights over the agricultural lands they opened in the forest, having significant control over the usufruct, management and transferring of their plots to others (Bremner & Lu, 2006; Coomes et al., 2011; Lu, 2001). Only alienating the land to outsiders is prohibited, as the community is widely recognized as the sole owner of the territory (Coomes et al., 2011). Interestingly, communal authorities in Amazonian settlements usually exercise limited regulation over household land management, intervening only in specific issues of land access (Summers & Pinedo, 2002). Cases have been documented where community leadership adjudicates agricultural areas to land-poor families in need (Brisson, 2003; Summers & Pinedo, 2002) or grants formal land access permission to people considered to be outsiders (such as *mestizos* married to local women, Indigenous members of other communities or *colonos*) (Araujo Raurau, 2022; Coomes, 1996). The significant independence with which households manage their lands can be attributed to the deep sense of autonomy that marks Indigenous

sociability patterns in Amazonia, a cultural norm that has been found to persist even within contemporary Indigenous communities (Gow, 1991; Sarmiento Barletti, 2016)

Traditionally, land property/possession rights are derived from the act of converting forest into productive land, and secured in time through the continuous production of the plot (Bremner & Lu, 2006; Cronkleton & Larson, 2015; Lu, 2001a, p. 200). Through these practices, land use is exercised, thus demonstrated to other relatives and neighbors, revealing the highly relational nature of possession rights in Amazonian communities (Cronkleton & Larson, 2015; Descola, 1994). The duration of possession rights depend on customary agreements in force in each community: for the Huaorani in Ecuador, a plot abandoned by a family can be appropriated by other community members (Lu, 2001), whereas for the Bora, land possession is recognized by others after many generations (Alvarez Del Castillo, 2012). In communities facing higher land pressure, households may combine more intense social networks (e.g., arrange *mingas* more frequently) and formal possession recognition (e.g., State land certificates) to demarcate "unofficial individualized boundaries" over their plots (Cronkleton & Larson, 2015). However, relational mechanisms are still predominant in securing land. Thus, despite the minor institutional collective regulations, individual land possession in Amazonian communities is strongly anchored in common senses, tacit moral mandates and social networks (Cronkleton & Larson, 2015).

Claiming agricultural land by slashing-and-burning a patch of old-growth forest is the classic mechanism for accessing land in Amazonian Indigenous and folk communities (Brisson, 2003; Brown, 1984; Descola, 1994). As households typically have a limited workforce, they depend heavily on shared cooperative labor to undertake highly demanding and mostly manual agricultural tasks (Brisson, 2003; Takasaki et al., 2014). Overall, labor endowments determine the capacity of households to access to land. Land claiming is a generalized practice in a context of high land availability and low population density (Descola, 1994; Lu, 2001a); one could anticipate that access mechanisms may diversify in the face of rising resource pressure.

Land transferring between households has become a common practice in local Amazonian settlements and occur with considerable dynamism (Brisson, 2003). Full property/possession land rights are traditionally transferred at any stage of the household life cycle, between not only nuclear but extended relatives or even neighbors or friends (Araujo Raurau, 2022; Brisson, 2003; Coomes et al., 2017). Land are characterized as gifts rather than inheritance or temporary transfers (Brisson,

2003). Finally, land markets have rarely developed in Amazonian communities, except in cases of acute resource crisis and/or community disintegration due to dispossession processes (e.g., encroachment, indebtedness) (Herz, 2018; Sarmiento Barletti et al., 2021).

Indigenous and folk households accumulate land conditioned by a set of ecological and economic factors. As mentioned previously, families accumulate land in relation to their stage in household life cycle (López-Carr et al., 2005; Perz, 2001a; Perz et al., 2006), following the classic Chayanovian pattern whereby households increase or decrease their land endowments according to their income/consumption needs (Ellis, 1993). In addition, Coomes et al. (2011) found that the households' initial land endowments (i.e., the land possessed in the first year of household constitution) play a significant role in subsequent land accumulation, with families starting with greater land holdings having a distinct advantage in expanding their land holdings. Conversely, there are factors that slow/moderate indigenous households land accumulation. The exploitation of lowland areas, where soils are naturally more fertile for agriculture has been shown to reduce the need for land expansion in upland old-growth forests; thereby, exerting a substitution effect on upland accumulation (Coomes et al., 2022b, 2022a). Moreover, the increased remoteness of old-growth forest available for land conversion significantly increases the opportunity cost of agricultural production, potentially inhibiting households from expanding their land holdings inland (Coomes et al., 2022a; Sirén, 2007)

As no central authority oversees household land allocation, the distribution of land in Amazonian Indigenous and folk communities is commonly an aggregate expression of land access, land accumulation and land use patterns. Coomes et al. (2011) demonstrate that land distribution can be highly unequal in these settlements, as both land accumulation and land use trajectories can differ among segments of households. Because of internal land inequality, land-poorer families in these communities experience considerable constraints in land management. Nonetheless, there are certain communities where land distribution is organized into *parcelas* (large blocks of forest area individually assigned to households for agriculture) and where land is more equally held (Coomes et al., 2000). Of note, no systematic research has been conducted about land distribution structures and their evolution in local communities of the region.

1.2.4 Balance

The scholarship addressing land scarcity in Amazonia is limited and consisting primarily of case studies conducted in folk settlements (i.e., non-Indigenous communities). This research often overlooks the social production of land scarcity, instead, it focuses on the material manifestation of land scarcity (i.e., the decline in the forest lands) and its differential impacts on Amazonian local land systems, with a clear emphasis on the effects on land-use change. Despite these limitations, the available research on land scarcity in the region yields three valuable insights. First, it reveals that land scarcity is a complex phenomenon driven by multiple factors, including factors determining the demand for land and/or the supply of land. Second, previous studies show that land users and communities cope with land scarcity differently and sometimes in contrasting ways. And finally, research suggests that the framing processes and internal features of local land systems shape the particular outcomes of land scarcity within a given territory.

Amazonian scholarship on land dynamics has centered mostly on explicating deforestation and land use/cover change patterns and determinants. The scholarship reviewed suggests land demand in the region is strongly influenced by external determinants. The varying configurations of market forces and policy frameworks have been critical in promoting agricultural land expansion within local territories. Population dynamics have been found to have more moderate and indirect effects on land demand, with the diversification of livelihoods outside agriculture being one the main reasons of the weak population-land association in the Amazon. Further, knowledge regarding internal Indigenous and folk land management is dispersed and not systematic, possibly due to the focus of scholarship on external pressures and dispossession processes in community territories. The literature reviewed indicates that ecological dynamics of forest ecosystems, peasant household economics, and relational forms of communal regulation shape Indigenous and folk land access and management. Thus, land supply constraints may be explained by specific dynamics in these three dimensions.

My thesis intends to address the research gap identified above, by contributing an Indigenous case study to land scarcity scholarship in Amazonia. Further, factors shaping land use transitions beyond land demand drivers and outcomes other than deforestation are explored. Finally, the thesis presents an in-depth analysis of internal Indigenous land management in Amazonia.

1.3 Conceptual framework

Drawing on Hartman & Gerber (2018), land scarcity arises when "...limited resources are confronted with demands (or needs) that outreach the available supply" (p.3). For this study, the available supply is delimited both by the factors conditioning the land quantity and quality (e.g., floodings, soil fertility), and the land control and access regimes in force within a territory (Scoones et al., 2019). In that sense, my conceptualization of land scarcity incorporates both neo-classic and Marxist economics perspectives. This approach has two major strengths. First, it conceives land scarcity as a socially produced phenomenon, and second, land scarcity is understood to result from an interaction in which a diverse array of factors increasing the resource demand and delimiting/organizing its supply are confronted.

Land scarcity materializes in space through a decline in land availability. In forest landscapes, land scarcity occurs when the forest area available for land conversion declines within a territorial unit (Littleboy, 2022). As such, land scarcity constitutes not only an issue of resource shortage, but it is also an expression of progressing deforestation. Further, land scarcity is perceived by land users as a risk of potential deprivation of additional resources (Oldekop et al., 2012), producing a spiral dynamic (Hartmann & Gerber, 2018). As land availability declines, the perception of growing land scarcity drives up the value of land and intensifies the rivalry for this resource which in turn, exacerbates the perceived scarcity. Importantly, the severity of the perceived land scarcity varies across contexts and land users (Coomes et al., 2011), with the perceptions of scarcity escalating rapidly in communities or users accustomed to land abundance.

The risk posed by land scarcity often prompts land users to adopt major shifts in how they govern and manage land (Oldekop et al., 2012). The way land users cope with land scarcity depends greatly on the internal land system structures (e.g., land use, land access, land distribution patterns) (Coomes et al., 2011). Still, two notional land system transitions can be distinguished. First, a Neo-Malthusian hypothesis linking land scarcity to the further individual appropriation of remaining resources, contributing to eventual land depletion (Fairhead & Leach, 1995; Galaty, 2016; Hardin, 1968). In contrast, from neo-classical and institutional economics, it is hypothesized land scarcity may lead land users to over-exploit the land already in use - among other resource substitution strategies - (Boserup, 1965) or to articulate stronger collective regulations over land access and

management (Oldekop et al., 2012; Schlager & Ostrom, 1992); overall preserving the remaining resources.

This conceptual development is graphically summarized in Figure 1.1.

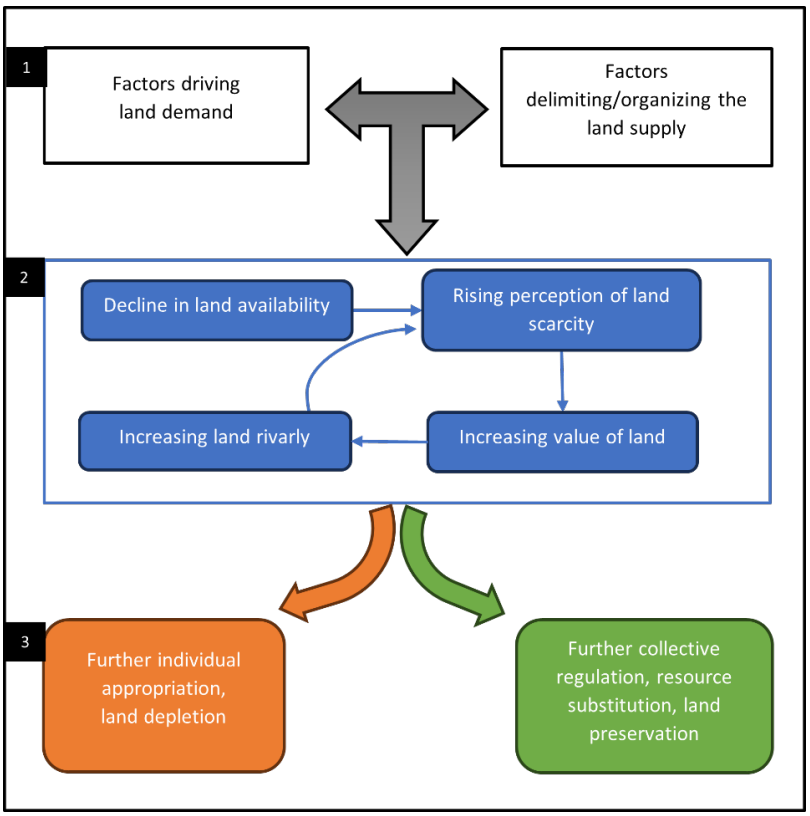


Figure 1. 1 Conceptual framework of land scarcity in three stages
(1) Land scarcity production; (2) Land scarcity spiral; and (3) Typology of responses driven by land scarcity.

1.4 Methodology

1.4.1 Study area

The Napo River is one of the eleven hundred tributaries of the Amazon River. It originates on the eastern slopes of the Ecuadorian Andes, flows 885 kms eastward across Ecuador towards Peru, then turns southeastward until merging with the Amazon River, about 80 kilometers from Iquitos (*Napo River | Amazon, Ecuador, Peru | Britannica*, n.d.). The Napo basin encompasses approximately 101,000 km^2, with 60% of the basin (upper Napo basin) situated in Ecuador and the remaining 40% (middle and low Napo basin) in Peru (*Napo Basin | AMAZON WATERS*, 2022).

On the Peruvian side, the Napo is described as a meandering and murky river, intersected by numerous blackwater tributaries, such as the Curaray River (*Napo Basin | AMAZON WATERS*, 2022). Extensive wetlands and floodplains are found across the basin, covering around 700 km^2 (Celi, 2014, p. 65). On average, the Napo experience an average annual fluctuation of 8.5 meters in the middle and low downstream, with the flooding season often taking place between April to August (*Napo Basin | AMAZON WATERS*, 2022). Hydrological research shows water-level fluctuations and flooding are highly variable and unpredictable in the middle and low basin (Celi, 2014), a finding that is consistent with the local characterization of the Napo river as being 'erratic'.

Approximately 65 Indigenous territories are situated along the Napo basin, between the districts of Mazán, Napo and Torres Causana (IBC, 2016). Indigenous communities are concentrated in the middle sectors of the basin. According to the last national census, 26,137 people inhabit the rural areas of the Napo basin, predominantly self-identifying as mestizo, Kichwa del Napo and Arabela peoples (INEI, 2017).

Many Indigenous communities in the basin originated as rubber extraction and agricultural states, where Indigenous kins worked under servitude relationships to a boss (*patrón*) during the Amazonian rubber boom between 1890 to 1910 (Coomes, 1995). Over the rubber geographies constituted, the Peruvian government formally recognized these settlements as Indigenous territories. Although community recognition can be traced back to 1919 in Peru, most of Indigenous territories in the Peruvian Amazon were formalized broadly in two later waves. The first took place in the 1970s, during the nationalist dictatorship of the Military Board and in frame of the progressist Agrarian reform implemented in the country during that decade. The second occurred between 1980 and 2000, with the emergence of national and international Indigenous movements and their fight for land rights (Larson et al., 2018; Monterroso et al., 2017). In the Napo basin, many communities obtained their legal registration and, in many instances, the collective title of their territories along these two waves (Instituto del Bien Común (IBC), 2016). Moreover, the establishment of the Federation of Native Communities of the Middle Napo, Curaray and Arabela basin (FECONAMNCUA, acronym in Spanish) in 1987, marked a significant milestone in the advocacy for the formalization of Indigenous territories in the area.

The recognition and titling of communities has considerably slowed in the Peruvian Amazon since the 2000s; instead, other forms of private resource management and exploitation have been prioritized by the State in the last two decades (Larson et al., 2018; Monterroso et al., 2017). In the Napo basin, since 2009, the primary forest area (2,230,375 Ha) surrounding Indigenous territories has been categorized as Forest in Permanent Production (BPP, acronym in Spanish). Under this public property regime, the State administers and regulates the sustainable exploitation of timber and non-timber resources by private actors, who are granted usufruct rights over blocks of forest denominated forest concessions (Figure 1.2). According to public records, forest concessionaries in the Napo are primarily dedicated to logging, and in few cases, to conservation and carbon markets (Gerencia de Desarrollo Forestal y de Fauna Silvestre Loreto n.d.). Additionally, in the last decade, there has been a considerable expansion in illegal alluvial gold mining in the Loreto region, with the Napo basin and its affluents becoming one of the newer sites for this activity (Mongabay Latam, 2023). It is expected that communities in the Napo have important interactions with both timber extraction and illegal economies.

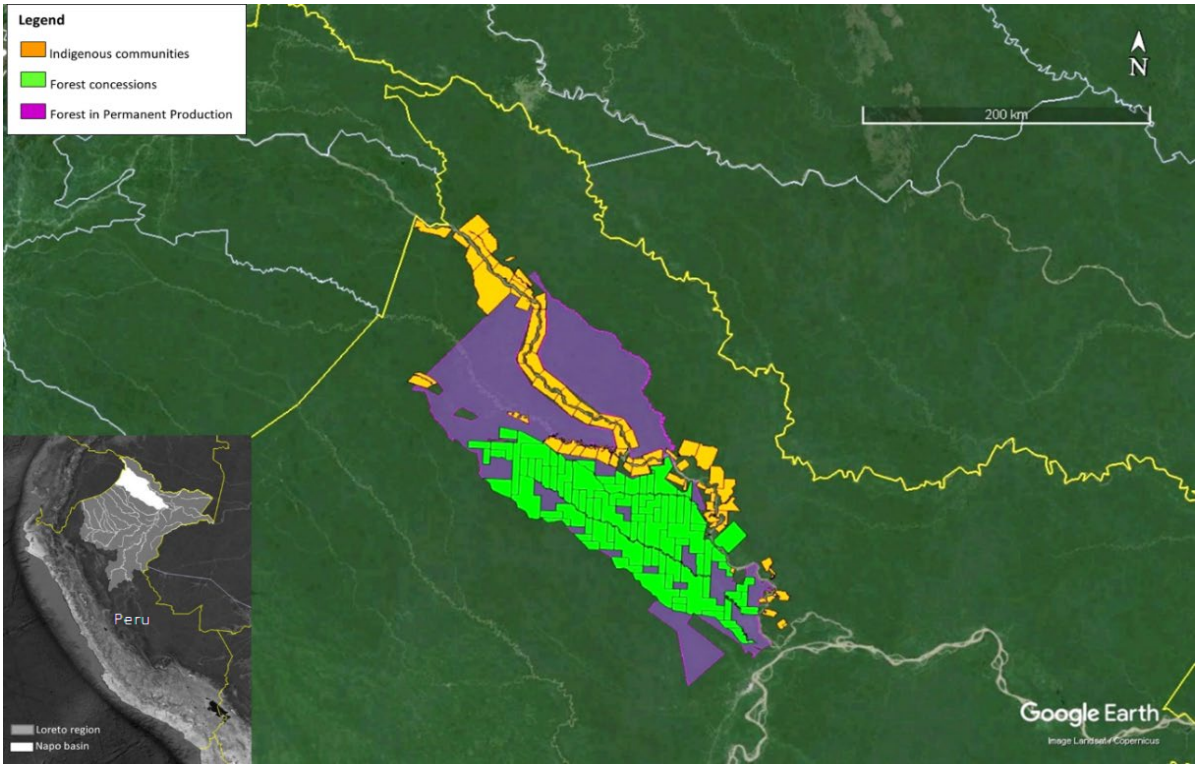


Figure 1. 2 Land tenure regimes in the Napo basin
This figure shows the areas occupied by Indigenous communities, private forest concessions and forest in permanent production. Satellite imagery from Google Earth (2023), Indigenous territories polygons from Instituto del Bien Común (2016), forest concessions and forest in permanent production polygon from GEO GPS Perú (2020).

As documented across the Amazon basin, the relationships established between legal or illegal private actors and Indigenous communities often lead to contention and divison among locals (Sarmiento Barletti et al., 2021; Silva-Junior et al., 2023), and potentially, to their engagement in criminal activities (Sarmiento Barletti, 2016). This issue is particularly sensitive in the Napo basin: in the 2010s, 38 Indigenous communities in this area were fined by the Peruvian State for their involvement in timber laundering organized by public officers and informal logging companies, totaling 10 million soles (about 2,500,000 USD) in penalties. As in most parts of the Peruvian Amazon, Indigenous communities in the Napo basin face intense external pressures over their territories, both from legal and illegal sources.

Within this intricate regional context, Indigenous peoples living in communities rely heavily on the forest to secure their livelihoods. Indigenous households practice a mixed economy, engaging in subsistence and market-oriented activities. Shifting cultivation agriculture is typically the primary source of food and monetary income, with upland cultivation as a predominant agricultural practice due to the unstable flooding regimes in the Napo basin. According to the IV National Agrarian Census (INEI, 2012), plantain and yuca are the primary agricultural outputs in the basin; followed by coffee, maize and peanut as secondary cultigens. In certain communities, cattle-ranching replaces shifting cultivation as the main occupation of households. In general, land is still the most important asset for Indigenous families (Coomes et al., 2011). Other activities such as fishing, timber and non-timber extraction, and hunting complement Indigenous forest-based livelihoods (Coomes et al., 2016). Among exclusively market-oriented activities, seasonal out-migration for wage labor, predominantly involving males, is increasingly relevant for income generation. In addition, Indigenous families also count on conditional cash transfers (CCT), bonuses and other types of State monetary/food assistance.

Indigenous peoples of the Peruvian Amazon are affected by a conjunction of inequities, including monetary poverty, food and nutritional insecurity, limited access to public services (e.g., water, education and health) and precarious exercise of their rights (Abizaid et al., 2020; Correa et al., 2018; INEI, 2023a, 2023b). This inequality trap (Modrego & Berdegué, 2016) explains the profound marginalization experienced by Amazonian Indigenous peoples in Peru, and the persistence of their exclusion (Correa, 2020).

1.4.2 Sample communities

The study was conducted in two Indigenous communities, Tamboruna and Solidaridad (pseudonyms), located along the Napo River, in the Department of Loreto, in the northeastern Peruvian Amazon (Figure 1.4). These communities are situated approximately 6 to 7 hours from Iquitos by riverboat, the capital city and primary market of the region. The nearest secondary urban center in proximity to the communities is Santa Clotilde, reachable within two hours from Tamboruna and one hour from Solidaridad by *peque-peque*, a motorized wooden canoe widely used by locals across the Peruvian Amazon.

The first criterion used to narrow down the population of potential communities for study was the relative abundance of upland and lowland. Indigenous communities which have most of their territory situated in the lowland, where land endowments are unstable due to seasonal floodings, were excluded from the study. By this, I aimed to select cases where land scarcity is not produced primarily by environmental hazards and could be representative of the conditions in the majority of Indigenous territories in the Peruvian Amazon. To operationalize this selection, I utilized the dataset of the PARLAP project (https://parlap.geog.mcgill.ca/) which provided a categorization of upland and lowland Indigenous communities.

An exploration of the degree of land scarcity, the second criterion, across upland Indigenous communities of the Peruvian Amazon was conducted to identify specific regions of study. Drawing from Littleboy (2022), I estimated land scarcity by measuring the potential available cropland (PAC) in each community territory, defined as the forest area (Ha) still available for agricultural land conversion. A gross calculation of PAC (Ha) was obtained by subtracting the total agricultural area (land already in use) from the communities' territory. To account for different levels of population density, the potential available cropland was divided between the number of households [PAC/hh (Ha)] dwelling in each community. The 10% of communities with the lowest PAC/hh were identified, representing communities with more acute levels of land scarcity were selected. To produce this estimation, I utilized the datasets of the Institute of Common Goods (IBC) (https://ibcperu.org/) to obtain the areas of Indigenous territories, and of the PARLAP project to account for agricultural areas and the number of households per community. From this analysis, the Napo basin was recognized as a probable hotspot of land scarcity in the Peruvian Amazon (Figure 1.3).

Lastly, communities in the Napo basin where land scarcity is perceived as being acute by locals were identified with the help of Indigenous leaders of FECONAMNCUA. The final selection took into account leaders' recommendations, community's interest in the research, and logistical conditions for the research team such as access to water for consumption and cellphone signal availability. A second community with similar features but with more abundant land was additionally identified to meet the requirements of my research design. Tamboruna was selected as the focal community for analyzing land scarcity, and Solidaridad as the case for comparative analysis purposes.

Figure 1. 3 Location of communities potentially experiencing land scarcity in the Peruvian Amazon
Estimation of land scarcity done according to the area of PAC/hh. Satellite imagery from Google Earth (2023).

(1) Tamboruna

(2) Solidaridad

Figure 1. 4 Indigenous communities of study
Satellite imagery from Google Earth (2022), community territory boundaries from Instituto del Bien Común (2016).

a. Tamboruna

The community of Tamboruna was formally recognized as Indigenous territory in 1919 and obtained its collective title in 1976. Its territory encompasses 2,447 Ha and is situated between the Napo river and the Tamboryacu river. By 2022, 79 households and 369 individuals dwelled in the

community. Most of them self-identify as Kichwa del Napo, but a few community members are mestizo or from other Indigenous ethnic groups. As documented across Amazonian Indigenous communities (Gray & Bilsborrow, 2020; McSweeney & Arps, 2005), Tamboruna presents a pre-transitional demographic structure: minors (under 15 years old) represent almost half (49%) of the population and elders (65+ years old) only the 5%. Tamboruna is an upland community, with most of its territory (1,694 Ha, 69%) located above 130 masl. The estimated agricultural area comprises 515.6 Ha, representing one fifth (21%) of the community's territory. Upland soil fertility is low, consistent with regional descriptions, i.e., a low cation exchange capacity (conductivity 0.8 ds/m), high acidity (pH 4.3), nutrient deficiency [moderate concentrations of organic matter (2.8%), low phosphorus and moderate potassium levels (9.7 ppm, 62.3 ppm)] and moderate aluminum toxicity (1.4 cmol/kg $Al^{3+} + H^{+}$) (see section 1.4.5 for detail on soil data collection). Families based their livelihoods primarily on shifting cultivation and seasonal wage labor, but engage in other supplementary activities such as fishing, timber and non-timber extraction and rarely hunting. Maize, yuca, plantain and sugar cane are the main crops produced in the community.

A detailed assessment of land scarcity, conducted with data that I gathered in the field, revealed that only 5.2 hectares of PAC per household are available in the Tamboruna. This estimation accounted for various areas not accessible for land conversion besides the agricultural area, including the settlement zone, conservation areas, and annex territories. Overall, this figure confirms that Tamboruna experiences acute land scarcity.

b. Solidaridad

The community of Solidaridad was formally recognized in 1952 and obtained its collective title in 1976. Its legal territory encompassed 969 Ha; however, the community had historically occupied the upland beyond the boundaries recognized by the State. In 2022, the community obtained an extension of 1000 Ha, finally formalizing the actual usufruct area of local land users (1,969 Ha). In the same year, 34 households and 158 individuals resided in Solidaridad. In contrast to the pattern found in the basin (where Kichwa are the dominant ethnic group), Solidaridad is home to the Murui-Munuane people, previously known as Huitoto. As in Tamboruna, half of the community members of Solidaridad are minors under 15 years old, whereas elders represent only 8%; indicating a pre-transitional demographic structure. Solidaridad is also an upland community, with 1264 Ha (64%) of its territory situated in the upland (>130 masl). The agricultural area

comprises 620 Ha, representing a 31% of the community's territory. However, as in Tamboruna, the upland soil fertility in Solidaridad is very low. Upland soils have an average low cation exchange capacity (conductivity of 0.9 ds/m), high acidity (pH 4.1), a certain nutrient deficiency [moderate concentrations of organic matter (2.7%), sufficient phosphorus levels (15.1 ppm) and low potassium levels (56.1 ppm)] and very high aluminum toxicity (4.5 cmol/kg $Al^{3+} + H^{+}$). Similar to Tamboruna, families in Solidaridad are dedicated mainly to shifting cultivation, raising of African buffalos, and seasonal wage labor. Fishing also plays a relevant role in their food intake, whereas timber and non-timber extraction, and hunting are supplementary activities. Besides the typical crops such as maize, yuca, plantain and sugar cane, Solidaridad is well-known in the middle Napo for the production of pineapple, yuca *brava* (*Manihot carthaginensis*) and manioc flour (*fariña*).

Land pressure is considerable in Solidaridad, but it is notably less severe compared to Tamboruna. After deducting the agricultural area of the community, the estimated PAC per household is 38.7 Ha.

1.4.3 Data collection

A reconnaissance trip was made in July of 2022 to present the research to the basin-level Indigenous Federation FECONAMNCUA and the potential communities of study. The approval of both FECONAMNCUA and the assemblies of Tamboruna and Solidaridad was obtained.

Data were gathered over three months between August and October of 2022 by the author with the assistance of J.H.E, a Peruvian social scientist. We spent seven weeks working in Solidaridad, and following that, six weeks working in Tamboruna; in both cases, hosted by local families. Bi-weekly trips to Santa Clotilde and monthly trips to Iquitos were made to purchase basic goods, and to interview key actors at a basin level.

In Tamboruna, a sample of 40 households from the five neighborhoods of the community was selected using a non-random snowball sampling method. The number of households per neighborhood was defined based on the total number of families in each quarter, and the households ultimately surveyed were chosen based on their availability. In Solidaridad, a census was conducted of all the 34 households practicing shifting agriculture. In addition, 4 authorities

per community and 4 basin-level actors were interviewed, including leaders of the Indigenous Federation FECONANMCUA and NGO officers.

A structured questionnaire was administered to the households practicing shifting cultivation in each community. The topics of the questionnaire were the following: household demographics, kin size and composition, participation of the household in community governance, income, land management, labor endowments, the availability of land and other natural resources. For each of household's plots, I documented their size, land cover type, distance in minutes from the home, years under land cover type, and the form of land acquisition (claim or transfer) in two points in time: the year of the fieldwork (2022) and the first year of the household constitution. A small number of open-ended questions was included in the questionnaire to specifically explore the occurrence of land disputes in each community. Respondents were given the space to freely discuss the reasons behind these conflicts, their progression, and their impact. By including this qualitative approach, we documented household discourses on land access and possession rights.

A field history survey was conducted in one plot from each household participating in the study, resulting in 40 fields documented in Tamboruna and 34 in Solidaridad. The plots were selected using a non-random sampling method based on the distance to the plot and the availability of the respondents. The respondents reported the long-term land cover history (type of cover and duration of the cover) of each selected plot.

One focus group was conducted with community authorities in each settlement. The primary topics discussed included the community's history, organizational structure, the provision of public services, the occurrence of environmental shocks, and shifts in the regional economy. Additionally, informal conversations were held during the fieldwork to delve into the issues of land scarcity and land conflicts. Moreover, structured interviews were conducted with Indigenous basin-level actors to explore the case of the environmental crime involving the communities of the Napo basin, as well as the implementation of Program of Ecosystem Services (PES) and other conservation projects in Indigenous territories. These discussions, as elaborated in the thesis, emerged as crucial for understanding the dynamics of land scarcity production.

The Research Ethics Board Office of McGill University approved this investigation's research design and data collection tools (REB# 22-06-019).

1.4.4 Methods and data analysis

This study adopts a mixed methods approach, integrating both quantitative and qualitative analyses. In the first chapter, ethnography is used to understand the production of land scarcity and its impact on land access and property regimes in Tamboruna. The primary methods employed include oral history analysis and discourse analysis. Complementarily, archival research of international and local journalism, and State policy and legal documents were used to contrast historical information collected in the field. In the second chapter, I use a quasi-experimental design to compare the effects of land scarcity on household land management in two upland native communities with varying levels of land scarcity. The main methods employed for this comparison include hypothesis testing and Ordinary Least Squares (OLS) regression analysis. These methods are used to explore significant differences in household land management among communities and ascertain the role of land scarcity in producing these contrasts.

Quantitative data collected in the field were coded compiled in an integrated database using Microsoft Excel. Statistical analysis was performed with STATA™ 17. In turn, qualitative data was transcribed in Microsoft Word and subsequently processed using Atlas Ti.

1.4.5 Community compensation

The mandate for compensation was established in the research design aiming to return the families and communities for the time given to the study. I arranged with each Community Assembly that every participant in the survey will benefit from a NPK pH test to assess the fertility status of their soil. Soil sample collection was conducted in parallel with the field survey, and the data were later analyzed by technicians in the Soil Laboratory of Agricultural La Molina National University in Lima, Peru. Finally, a local agronomist was hired to analyze and prepare individual and community reports on soil fertility. A final trip to the communities took place in December of 2022, where the agronomist and I presented the results to the community assemblies and distributed the individual reports to the families (See Appendix).

1.4.6 Positionality

I identify myself as a mestizo, descendant of Quechua Indigenous peoples, assigned woman at birth, lesbian and queer person. I was born in Lima, the capital city of my country, Peru, and although growing up in a precarious condition, I have not experienced poverty or food insecurity

in my life, and I had the opportunity to receive university education in prestigious institutions. My race and my educational, economic and cultural background put me in an immediate privileged position regarding the people I worked with during my fieldwork, who have been affected by systematic racism and exclusion over generations. In addition, my position as a scholar grants me the opportunity to represent the reality of the communities in national and international academic spaces. Even more, I will benefit from this process, by gaining a degree and increasing my academic status.

To avoid privileges leading to abusive practices during data collection, my research assistant and I strictly adhered to the approved McGill ethics protocol for this research. Among the many processes established, I note that oral and written information about the research was provided to most of community members in both settlements; the right to decline participation at any moment was firmly respected, and coding protocols were followed to guarantee anonymity and data privacy. Additionally, my research assistant and I engaged in daily dialogues about our work and any challenging situations that arose, which served to further reinforce our commitment to upholding ethical standards throughout the research process.

Representing scarcity in Indigenous communities is a highly sensitive enterprise. Land scarcity in forest ecosystems has been attributed to population growth, a Neo-Malthusian narrative frequently utilized to feed fortress conservation policies, condemn Indigenous and folk forest peoples (victim blaming) and even legitimize territorial dispossession (Fairhead & Leach, 1995). This study design was attentive to a simplistic Neo-Malthusian analysis of scarcity, and evolutionary approaches to forest history (from pristine to scarce). I analyze land scarcity as a phenomenon produced by multiple factors beyond population and leading to multilinear land system transitions. The results of this research show that land scarcity in Amazonian communities is produced by decreased access of Indigenous peoples to the forest and not by forest depletion. Moreover, I show that Indigenous peoples are capable of innovative land use and land property adjustments in the face of scarcity, preventing further advancement into old-growth forest.

In the Peruvian policy context, characterized by significant institutional weaknesses and the cooptation of the State by illegal or informal mafias, particularly in the realm of resource extraction, the potential impact of my thesis on the welfare of Indigenous communities is likely to be limited. The highly unequal benefit obtained from the research process could lead to

reproducing academic extractivism and coloniality. Following decolonial ethics, a compensation process was implemented to offer a tangible benefit to the families participating, and to fulfill the need of short-term reciprocity. However, once the thesis process is completely finished, I am committed to connect with regional and national stakeholders to diffuse the results of my research and pursue further impact.

Finally, despite our privileges, some elements of our identity put my research assistant and me in a vulnerable position during the fieldwork. Our condition as women, and in my case, of homosexual and non-binary person was difficult to manage in communities with more binary and misogynist gender systems. Personally, despite the burden resulting from suppression, I chose to withhold my queer identity to avoid possible scenarios of physical or psychological abuse from community members. The constant dialogue between my research assistant and me was crucial to protect each other from any unsafe context and to mutually support or mental health status. In the future, I will consider having more sources of psychological support during the data collection process.

Chapter II. Land scarcity in Indigenous territories of the Amazon: origins and ramifications in land access and property

2.1 Introduction

Indigenous peoples (IPs) of Amazonia have made significant inroads in securing their territorial rights. Approximately 7,000 Indigenous Territories (ITs) span the Amazon (RAISG, 2022), covering more than 241 million hectares, and accounting for 29% of Amazon biome (RAISG, 2023). As territorial rights are to some extent secured, Indigenous peoples increasingly confront the challenge of how to better manage their resources (Le Tourneau, 2015). While Indigenous territories have proven effective to preserve forest cover (Bennett et al., 2018; Blackman et al., 2017; C. Gray & Bilsborrow, 2020; Nepstad et al., 2006), sustainability issues such as forest impoverishment, wild resources depletion, and land scarcity (Coomes et al., 2017, 2020; Oldekop et al., 2012; Sirén, 2007) have emerged in association with growing population and progressive market integration.

The prospect of rising land scarcity among ITs is of special concern. Recent studies among folk communities in Amazonia point to potentially significant impacts linked to land scarcity, including agricultural intensification (Coomes et al., 2011; Jakovac et al., 2016; Sirén, 2007), further land appropriation into the remaining forest (Coomes et al., 2000, 2011), higher land inequality (Coomes et al., 2011a), and the privatization and alienation of lands through rental markets (Sarmiento Barletti et al., 2021). Overall, land scarcity may erode land management practices that sustain the reproduction of forest landscapes within these communities. The evidence accumulated to date exclusively almost comes from studies in non-indigenous communities, partially due to the fact that research on Indigenous territories has focused preferentially on the impacts of land invasion and resource capture by outsiders, over local land scarcity and internal land management.

The objective of this chapter is to analyze how land scarcity is produced in Indigenous Territories in Amazonia, and to explore how Indigenous peoples confront this issue by transforming their land access and property regimes. To this effect, I conducted a case study in the community of Tamboruna (pseudonym), a Kichwa Indigenous territory of the Peruvian Amazon affected by a severe decline in land availability. Land surveys, interviews and participatory observation with

Indigenous households, focal group and informal conversations with community authorities, and structured interviews with Indigenous federation leaders and NGO officers provide the basis for this ethnographic analysis of land scarcity and its outcomes. Oral history analysis, discourse analysis and descriptive statistics are the main methods used to examine the data collected. Complementarily, archival review of international and local journalism, and public legal documents were conducted to contrast historical information on recent events.

In the first section of this chapter, I develop an analytical framework for custom-based land access and property regimes drawing on key concepts of Access Theory. Next, I present a characterization of land access and property regimes in Indigenous communities based on the scholarship available to date. In the third section, I navigate through the history of the community to understand how land scarcity was produced in its territory, accounting for factors increasing land demand and factors restricting the supply of land. Following that, I characterize the land system in Tamboruna, focusing on the access and property regimes in force in the community and the land distribution structure. In the fifth section, I analyze internal land contentions between Indigenous households related to land scarcity, focusing on the discourses around conflicts. I conclude the chapter by discussing the nuances of land scarcity production, the evolution of indigenous land and forest access and property regimes, and the potential political and environmental implications of these transitions.

2.2 Conceptual framework

The conceptual point of departure of this article is the Theory of Access developed by Ribot & Peluso (Ribot & Peluso, 2003) and its further development by other authors. The decision to conduct access analysis in this research stems from the particular nature of economic relationships in Amazon rural communities, where customs and convivial/moral conventions often supersede formal rules and institutions in defining the access and ownership of resources (Cronkleton & Larson, 2015). In the following paragraphs, I will summarize and interrelate the concepts of access, property and appropriation developed by Ribot & Peluso (2003), Sikor & Lund (2010) and Kronenburg & van Dijk (2020) respectively, giving especial attention to the elements in the theory that are relevant for analyzing Indigenous societies.

Ribot & Peluso (2003) broadly define access as the ability to benefit from a resource. By this, the authors widen the scope of analysis beyond the rules, norms and formal institutions sanctioning

property rights (Schlager & Ostrom, 1992) to encompass "a larger array of institutions, social and political-economic relations, and discursive strategies" (Ribot & Peluso, 2003: 157) that determine the flow of benefits from resources. Further, access is conceptualized as a dynamic in which actors in different *loci* of power engage in a continual interplay, disputing and negotiating their position with respect to the flow of benefits. Thus, rather than a synchronic picture of a structure of rights (Kronenburg García & van Dijk, 2020), access is depicted as a "bundle of power relationships" framed in a historical context (Ribot & Peluso, 2003). Three types of access relationships are distinguished by the authors: gaining access, maintaining access -keep the flow of benefits opened-, and controlling the access of others (Ribot & Peluso, 2003).

According to Access Theory, property is categorized as a rights-based access mechanism (Ribot & Peluso, 2003), which occurs "when the ability to benefit from something derives from rights attributed by law, custom or convention" [McPherson (1978) cited by Ribot & Peluso, (2003: 162)]. Drawing from Ribot & Peluso (2003), Sikor & Lund (2010) defined property as "legitimized claims, in the sense that the State or some other form of politico-legal authority sanctions them" (p. 4). Nonetheless, whereas the authors narrow their definition of authority to institutions or actors holding power positions, Ribot & Peluso (2003) acknowledge that the legitimacy and enforcement of rights can derive from customs and conventions: the "social acceptance of a given practice by which people gain benefits" (Ribot & Peluso, 2003: 162).

Property is not a completed nor a static stage of access (Kronenburg & van Dijk, 2020). Despite being sanctioned by an external authority or convention, property "needs to be continuously asserted and actively affirmed" to the society [Busse and Strang (2011), cited by Kronenburg & van Dijk (2020:170)]. To acknowledge the processual and relational nature of property, Kronenburg & van Dijk (2020) introduce the concept of appropriation, defined as the continuous act of making property. According to the authors, appropriation takes place through a variety of claiming practices, including grounding claims (e.g., altering the landscape with visible markers as fences), talking claims (i.e., using speech strategically to make or contest property), or representing claims on material objects as maps (Kronenburg & van Dijk, 2020). As a result of the process of appropriation, a symbolic identification between the subject and the resource takes place [also showed in (Peluso, 1996), and (Li, 2014)], by which the features of the landscape intervened are associated with the subject's identity and vice versa (Vidal & Pol, 2005).

It is relevant to remark that the legitimacy of access, property, and appropriation practices are strongly subjected to a diverse set of social mandates and conventions: to the complex and different valuations of a resource, to kinship obligations, or to ethics of a higher order such as the right to subsistence of every human (Ensminger & Rutten, 1991; Peluso, 1996; Scott, 1976). As observed by Peluso (1996), the conventions framing access and property practices (what she denominates "ethics of access") become more explicit when the imbalance among society segments increases. Overall, in my view, these ideas are better encompassed by the concept of moral economy coined later by Edelman (2005), which refer to economic relationships (in this case, access and property relationships) strongly embedded in morality arenas, where class (or strata) struggles are expressed and disputed.

In summary, this conceptual framework expands our understanding of access and property beyond the domain of formal institutions. Moreover, it highlights the conventional and dynamic nature of property, which may be established by customs and conventions, and must be continually asserted through claiming practices. Finally, it shows the morality and legitimacy of these conventions can be disputed, especially in context of high inequality. Overall, this conceptual development enables us to analyze contexts in which access and property dynamics are 1) independent from central authority or formal institutions; 2) upheld through relational validation rather than enforced through coercion; and 3) embedded in multiple social spheres, all of which are typical features of Indigenous societies.

Whereas access and property dynamics within a territory may vary in space and in time, it is possible to identify characteristic, stable and self-sustainable dynamics composing a land use regime (Kull et al., 2018; Ramankutty & Coomes, 2016). Similarly, property scholarship establishes a typology of four categories of property regimes according to the source and intensity of property rights: open access (free-for-all and absence of ownership); common property; individual private property and public/State property (Vaccaro & Beltran, 2019). Regimes can experience shifts, defined as abrupt, systemic and long-lasting transformations that engender a new access and property dynamics (Kull et al., 2018; Ramakutty & Coomes, 2016). In practice, different types of access and property practices (i.e., individual, collective, open access or public) can be nested within the same territory, especially among peasant and Indigenous communities (Agrawal, 2007; Schlager & Ostrom, 1992). Moreover, the dynamics of change of property

regimes are not necessarily linear (e.g., from commons to individual regime) and enduring, but multilinear and context-dependant (Ensminger & Rutten, 1991; Galaty, 2016).

2.3 Land access and property regimes in Indigenous territories of the Amazon

Indigenous territories of Amazonia[4] are collective properties owned and inhabited by Indigenous families belonging to one or multiple ethnic groups. These territories are ruled by a local communal governance, which partially incorporates elements from traditional chiefing and democratic politics -e.g., an assembly, an elected leadership - (Sarmiento, 2016). In that sense, Amazonian Indigenous territories are unquestionably forest commons: "...forests for which the boundaries of the resource, the identity of the user group, and property rights to benefit from the resource are well defined." (Chhatre & Agrawal, 2008: 13286).

The livelihoods of Indigenous households within Amazonian ITs are quite diversified[5] but still depend considerably on shifting cultivation (Coomes et al., 2016). Shifting cultivation is an agricultural system traditionally practiced in forest ecosystems through which plots are created by cutting-and-burning patches of forest, and land cover is rotated cyclically from short crop/orchard phases to longer forest fallows (Denevan et al., 1988). Multiple plots belonging to a household are typically in different phases of rotation, producing a mosaic of alternated crop, fallow, and old-growth forest patches across the landscape. Among other functions[6], the management of land rotation facilitates the control over the fertility and productivity of Amazonian soils which are naturally poor in nutrients (Denevan et al., 1984; Denevan et al., 1988; Jakovac et al., 2016). The duration of the fallow stage (i.e., years under fallow cover) has been considered the primary factor in recovering soil fertility, but recent studies show that the number and extension of the cropping stage is a stronger predictor (Jakovac et al., 2016; Wood, 2014; Wood et al., 2017). Overall, the sustainability of dynamic shifting cultivation in Amazonian Indigenous territories depends greatly on anthropic management.

[4] Their denomination varies across Amazonian countries: "Native communities" in Peru, "Indigenous lands" in Brazil and Venezuela, "Community land" in Ecuador, and Indigenous territory in Bolivia (RAISG, 2023)
[5] Including timber and non-timber extraction, fishing, hunting, and seasonal wage employment, among other activities.
[6] Land rotation also allows an anthropic control over the natural forest succession process. Indigenous households typically seed a diversity of shrubs and trees together with crops that are later profit during the fallow stage (Denevan, 1984; Denevan et al., 1988).

Agricultural land in Indigenous and folk communities of the Amazon is typically managed at the household level, as documented by numerous case studies (Coomes et al., 2000; Cronkleton & Larson, 2015; Holland et al., 2014; Lu, 2001; Ocampo-Raeder, 2008). This stands in stark contrast to other resources gathered from the forest and from the rivers (such as non-timber and timber products, game and fisheries), which are usually governed under an open-access or common-pool regime: available to all community members without any individual ownership or possession rights granted [as defined by Vaccaro & Beltran (2019)]. In contrast, agricultural land is produced and maintained by human intervention. As such, exclusive management and possession rights are typically recognized for the household or kinship unit working in the land (Cronkleton & Larson, 2015; Lu, 2001a; Ocampo-Raeder, 2008).

It is noteworthy that Amazonian Indigenous households have significant autonomy for acquiring, transferring, and usufructing their land. However, alienating the land (i.e., selling or renting a plot) to outsiders is strictly restricted[7], a prerogative exclusively granted to the community as holder of the territory (Cronkleton & Larson, 2015). In addition, community authorities are shown to have a punctual role in adjudicating agricultural lands to asset-poor families or incoming in-migrants requiring plots (Araujo Raurau, 2022; Brisson, 2003; Coomes, 1996; Summers & Pinedo, 2002). Otherwise, strong communal regulation over land management is unusual in these communities[8] (Cronkleton & Larson, 2015), possibly due to the strong sense of autonomy that prevails in Amerindian societies [widely documented in ethnographies among Indigenous groups as in Gow (1981), Brown (1984) or Sarmiento (2016)].

Land possession rights in Indigenous and folk communities are not sanctioned by local authorities; instead, they are typically anchored in custom and conventions acknowledged by all community members (Cronkleton & Larson, 2015; Lu, 2001a). The primary convention in these communities recognizes the work invested in the land is the font of possession rights (Cronkleton & Larson, 2015; Lu, 2001a). Therefore, the cutting-and-burning of the forest and the continuous use of a plot are critical appropriation practices utilized by households to ground and demarcate their possession to other community members (Cronkleton & Larson, 2015; Lu, 2001a). The resultant land rights

[7] Land rental markets have developed in communities undergoing context of indebtedness and subsistence livelihoods crisis (Herz, 2018; Sarmiento & Barletti, 2021).

[8] This marks a radical contrast with Indigenous communities of the Andes, which are characterized by strong communal regulation over the land access, land allocation in space, land distribution and even land use.

are usually enduring, although their duration varies among ethnicities and communities: possession may endure until the household leaves the community (Coomes et al., 2000; Lu, 2001), or can be passed down through generations within the same kinship group regardless of residency status (Alvarez Del Castillo, 2012; Pinedo-Vásquez et al., 2012).

Households gain access to land through two main mechanisms: claiming land in old-growth forest and land transfer (Brisson, 2003; Brown, 1984; Descola, 1994). A household claims land by cutting-and-burning a patch of old-growth forest, usually undertaken by collaborative labor provided by nuclear and extended relatives. Thus, labor endowments are a first determinant factor in the ability of households to access to land (Abizaid et al., 2015; Brisson, 2003; Takasaki et al., 2014). In turn, land is also transferred between relatives, neighbors or friends with an impressive dynamism (Brisson, 2003; Araujo Raurau, 2022). Patterns of land transfer may depend on the particular kinship and convivial obligations across communities and ethnic groups.

The amount of land a household accumulates in time is conditioned by economic and ecological factors. In most of Indigenous and folk communities, household land holdings vary in correlation to the life cycle (López-Carr et al., 2005; Perz, 2001b; Perz et al., 2006); that is land is accumulated according to the families' income/consumption needs (Ellis, 1993). In addition, the land held during the first year of households' constitution - i.e., initial land endowments - also are influential in accumulation trajectories (Coomes et al., 2011). Other factors slow or moderate asset growth. For instance, long distance to plots (i.e., poor land accessibility) and the availability of high fertile soils in the lowland reduce the drive of households for increasing the size of land portfolio (Coomes et al., 2022b, 2022a).

In some Amazonian communities, land is distributed under a *parcela* structure, i.e., large blocks of forest area of equal size are individually allocated to community members for their agricultural use (Coomes et al., 2000). However, more typically, the land distribution within Amazonian Indigenous and folk communities is not formally structured, and results from the aggregation of household land acquisition, land accumulation, and land use. Significant disparities in land distribution (both in terms of land size and land use) among households have been documented in communities of the Peruvian Amazon, suggesting that land inequality is a more common reality in these settlements than expected (Brisson, 2003; Coomes et al., 2011).

In sum, in Amazonian Indigenous and folk communities, agricultural land is an individually managed resource nested within forest commons, a pattern largely documented in forest ecosystems (Agrawal, 2007; Li, 2014). Despite the absence of a communal control over the land, customs and conventions anchor individual land access and possession practices within "shared rules, common understandings, and social networks" (Cronklenton & Larson, 2016: 509), suggesting a particular form of diffused collective regulation. However, there is growing evidence to indicate that these traditional land access and property regimes are undergoing significant transformation. In contexts of high scarcity and land rivalry, communities may institute institutional control over access to the remaining forest (Oldekop et al., 2012). In other cases, households may seek to strengthen individual land possession (Cronklenton & Larson, 2016) and engage in a rush to appropriate the last available land (Coomes et al., 2011). These case studies suggest opposing trends towards increasing communal control or further individualization of land in communities facing resource contention.

2.4 The production of land scarcity

In this section I analyze the processes leading to land scarcity in the community of Tamboruna. Drawing on the definition of scarcity of Hartman & Gerber (2018), the narrative of this section addresses the factors driving land demand and constraining the land supply in the community. After presenting a basic description of Tamboruna, I examine the significant demographic growth experienced in the last decades as a process framed in the community's modern constitution. Next, I demonstrate how the land supply in Tamboruna became significantly constrained for the community members. Besides, I revisit the contentions over Indigenous Territories land rights, the rising of environmental regimes, and territorial fission between indigenous kins. The section finalizes by providing an estimation of the level of land scarcity in Tamboruna.

2.4.1 A brief profile of Tamboruna

The native community of Tamboruna (2,447 Ha) is situated between the basins of the Napo River and Tamboryacu River, up to 7 hours travel by riverboat to Iquitos (capital city of the region of Loreto), in northeastern of Peru (Figure 2.1). In 2022, the community was home to 79 households and 369 residents. Dwellers of the community identify predominantly as Kichwa del Napo or *Naporuna*, the majoritarian ethnic group found both in the Peruvian and Ecuadorian sides of the

Napo basin. Mestizo and Indigenous peoples from other ethnic groups also reside in the community.

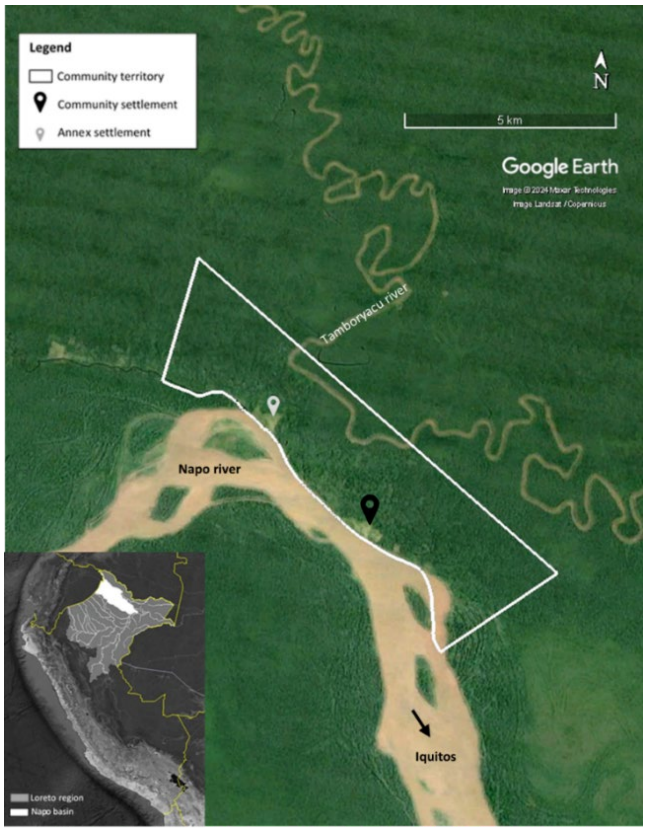


Figure 2. 1 Community territory of Tamboruna
Satellite imagery from Google Earth (2022) and polygon of community boundaries from Instituto del Bien Común (2016).

Tamboruna can be categorized as an upland community: 1,739 ha (71%) of its territory is in the upland, and the remaining 708 Ha (29%) are in the lowland. The estimated agricultural area within the community territory spans 572 Ha, representing around a fourth of Tamboruna's territory. Further, most of the working area (526 Ha) is located in the upland, and only a minority (46 Ha) is in the lowland, an area that has been significantly affected by riverbank slumps (*barrancos*). Of note, not all the lowland working area held by community members lies within Tamboruna's legal boundaries: it is estimated that 257 Ha of agricultural lowland is situated in the opposite right bank of the Napo and in the southeast of the community, in both cases, areas of State lands.

Households are the main economic unit, and their livelihoods are based on subsistence and market-oriented activities, features of peasant economies elsewhere [following the definition of Ellis

(1993)]. Shifting cultivation and other complementary farming/extractive activities - cattle ranching, fishing, hunting, timber, and non-timber extraction - represent on average 65% of the household income. State cash transfers[9] and seasonal wage labor - in most of the cases to work in oil palm plantations elsewhere in the Peruvian Amazonian - are the second and third income sources, respectively. Despite the diversification of income sources, income poverty[10] is common in the community. In 2022, the household mean annual income was 5,594 USD (median of 4,635 USD), more than 40% of the inhabitants lived with less than 2.36 USD per day per capita (i.e., total poverty), and nearly 10% lived with less than 1.43 USD per day per capita (i.e., extreme poverty)[11].

2.4.2 Becoming a (populated) community

Over the past three decades (1993 to 2022), Tamboruna has experienced remarkable population growth, doubling the number of households from 36 to 79, and increasing the resident population from 200 to 369 (Figure 2.2). The community is also undergoing an important development transition, with a functional communal governance increasingly recognized in the basin, and the growing presence of State services and infrastructure not commonly found across the rural Peruvian Amazonia (i.e., cellphone antenna, high school, sceptic toilet system). Indeed, Tamboruna is considered by Indigenous Federation leaders as a community that is a gaining prominence in the middle Napo basin, appealing for cooperation with the government, NGOs and other agencies that seek stable partnerships and large impacts among Amazonian Indigenous territories.

The rising status of the community strongly contrasts with most of its history. As many other Indigenous communities of Loreto, Tamboruna originated by the end of the 19th century as a rubber extraction estate. Some hundred and thirty[12] Kichwa Indigenous peoples were brought forcibly from the Ecuador by a mestizo rubber boss (*patrón*), to work as tappers in the extraction of rubber

[9] State cash transfers have become a highly relevant income source for indigenous households in Peru and elsewhere in the Amazonia (Coomes et al., 2016; Hecht, 2014); even more so since the pandemic of COVID-19, when the Peruvian State increased the number of bonuses transferred to rural households.

[10] Household income was measured adding the monetary value of all agricultural and forest products produced/extracted by the household (for subsistence and for sale), salary from wage labor, cash from State transfers received, and remittances received (in cash or assets).

[11] Poverty lines for the Peruvian rural Amazonia calculated by the National Institute of Statistics and Information of Peru (INEI, 2023).

[12] As documented by PARLAP community survey conducted in the Peruvian Amazon.

and other similar products (e.g., balata) in servitude and debt-peonage. Despite the exploitative labor arrangements, a certain feeling of moral indebtedness to the rubber boss is still expressed in the local people's memory, recalling that Indigenous families were allowed to use the lowlands (more fertile soils) and had access to clean water for consumption in the bricked wells built by the *patrón*, and which are still in use to date. Interestingly, it is in those late years of the rubber boom, specifically in 1919, that Tamboruna was recognized as an Indigenous community, during the first wave of Indigenous Territories recognition in Peru's Republican era[13][14]. According to local testimonies, the legal recognition process was arranged by the boss, in an effort to secure his territorial rights over the area and to bring school services for Indigenous children. As such, Tamboruna existed *de jure* as an Indigenous community, controlled *de facto* by a rubber boss - a situation apparently typical at other communities in the Napo basin[15].

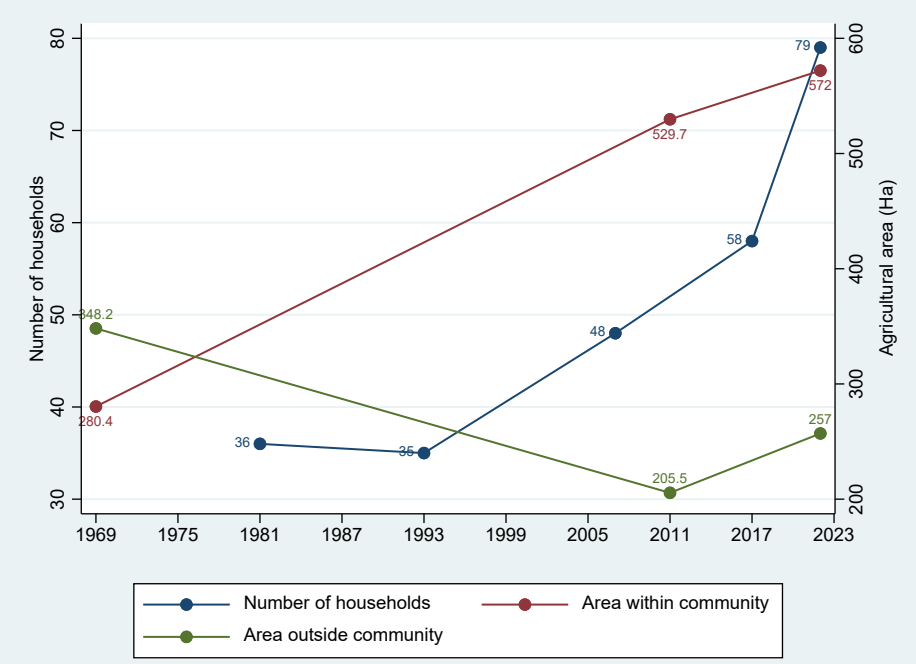


Figure 2. 2 Demographic growth and agricultural land expansion in the community of Tamboruna

[13] This finding is particular given the fact that only few Amazonian community were recognized during this time, as the legislation of the time was primarily focused on Andean communities. However, the leadership in Tamboruna have a legal document proving this early recognition supported by local historical narratives, indicating this community is one of the exceptions.

[14] This wave took place in the broader context of the inclusion of Indigenous Peoples into the national constitution, a significant development that unfolded during the eleven-years dictatorship of Augusto B. Leguía (1919-1930).

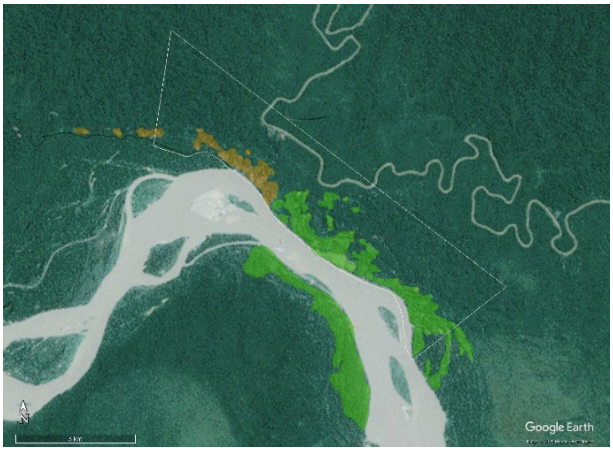
[15] I documented two other cases in the Napo basin where the recognition of communities as Indigenous territories was arranged by the boss ruling the settlement.

With the end of the second rubber boom, during the 1940s, it is likely that the social and economic organization of Tamboruna transitioned to a *hacienda* system, where agricultural and non-timber forest products replaced rubber extraction as the primary activity (Coomes, 1995). Under this regime, Indigenous families exploited their agricultural lands as tenants, and benefited individually from commercializing their products. In exchange, they were required to provide labor, agricultural products and other contributions to the *patrón* (Coomes, 1995; Gow, 1991). Some testimonies suggest that rosewood (*palo rosa*) extraction also became a relevant economic activity in Tamboruna along the same decade. Under the *patron* ruling, Indigenous workers extracted and carried the *palo rosa* timber to a rustic processing plant set up along the Tamboryacu River, where rosewood oil was distilled before being sent to Iquitos. It is probable that in the last decades of boss ruling, Tamboruna constituted as a hybrid agricultural and non-timber extraction estate.

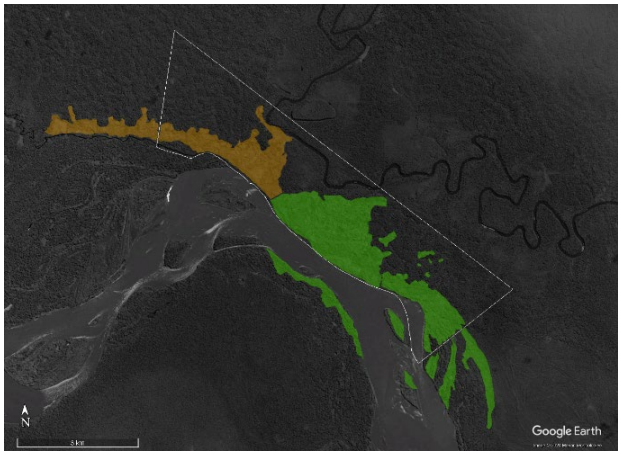
The era of *patrones* ended with the arrival of the National System to Support Social Mobilization (SINAMOS) in the Napo basin, an organization created in the 1970s as the political arm of the nationalist dictatorship regime of the Military Board (1969-1980) in Peru. SINAMOS, which promoted the progressive agrarian reform policies of the regime, dissolved estates and expelled several bosses from settlements across the Peruvian Amazon[16] and specifically in the Napo region, likely including Tamboruna. Overall, the political agitation generated by the end of boss domination led to a second wave of recognition and titling of Indigenous territories in the basin, and the constitution of the firsts Indigenous basin-level federations representing these settlements. In 1976, Tamboruna formalized its legal status under the new legislation, changing its designation from "Indigenous community" to "Native community," and its territory (2,447 hectares) was finally titled.

[16] 331 native communities encompassing 1.5 million ha were titled in the Agrarian reform period in the 1970s (Larson et al., 2018). Historical research highlights the relevance of SINAMOS in marking the end of boss era, and for community recognition and titling in Amazonian basins. See historical analysis by Gow (1991) for the Urubamba river, and (Barclay & Santos Granero, 1983; Santos Granero & Barclay Rey de Castro, 2014) for the central Peruvian Amazon, in Oxapampa, Satipo, and Ene rivers.

(1) December 1969



(2) July 2011



(3) September 2022

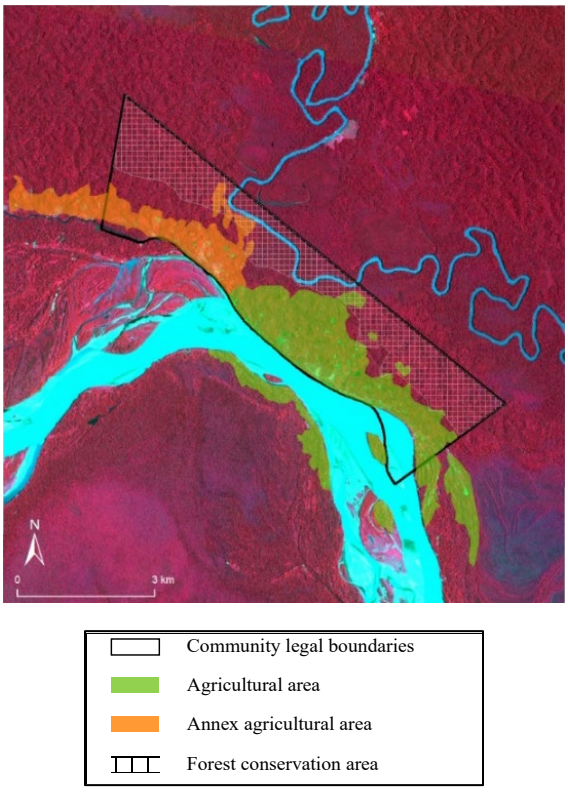


Figure 2. 3 Agricultural area in Tamboruna in 1969, 2011 and 2022[17]

[17] I used the methodology of Coomes et al. (2022) to manually identify agricultural areas. The two first maps were digitized with Google Earth Pro using aerial a high resolution aerial photograph taken in 1969, and a satellite image of 2011 in black and white. The last map was digitized in ArcMap with a satellite image of 2022 from Planet Scope. Given the difficulty to distinguish old-growth forest from secondary forest lands, false colour pattern was used to identify agricultural area. The raster file of the conservation area was provided by ORPIO during my fieldwork.

The first decade of autonomy (roughly, between the 70s and the 80s) was marked by a consolidation of farming-based livelihoods. Approximately 40 households lived widely scattered in the area, in many cases outside the community's legal territory, as was typical during the time of *patron*. They relied primarily on small livestock raising (pigs and chickens) and floodplain agriculture (rice, maize), and rice commercialization for regional markets became relevant source of monetary income[18]. An aerial photograph from 1969 confirms the presence of an extensive area under cultivation (an estimated of 348 Ha) in external *varzea*, most of it situated on the opposite riverbank. In contrast, the extension of cultivated area within the community territory, approximately 280 Ha, was comparatively small (Figure 2.3).

This changed around the late 1980s, when an exceptionally high water on the Napo river - attributed to a massive riverbank slump or *barranco*[19] on the Ecuadorian site of the basin - flooded most of the lowlands, causing critical economic losses to Tamboruna's families: animals drowned, crops were lost, and houses were devastated. In the search of security, most of the households moved permanently to the upland within the community legal territory. This event marked several milestones for the people of Tamboruna. The first conglomeration of houses in a neighborhood was built around the elementary school and shifting cultivation in old-growth forest on the upland replaced floodplain agriculture as the main livelihood, pushing families to learn how to manage poorer and more difficult soils. Further, community chiefs started to play a bigger role in organizing the families, paving the road for the implementation of participatory decision-making instances[20] - e.g., community assembly, leadership -. In testimonies from elders, the big flood is recalled as a 'civilizational' event, when life patterns prevailing in the era of rubber bosses were finally gave away to a new life in a modern community[21]:

[18] Some elder families reported having participated in a State agricultural credit program promoting rice cultivation implemented in the late 1980s, a process documented by Coomes (1996).

[19] Riverbank slumps are a product of lateral fluvial erosion, and in the Amazon, are one of the most common environmental hazards affecting people and infrastructure (Bandeira et al., 2018).

[20] A communal governance structure with democratic traits was introduced in Indigenous territories in 1974, by the Law of Native Communities and Agrarian promotion of Selva and Ceja de Selva (Law N 20653). In this law, the organization of a community assembly and the election of community chief was mandated. In 1978, the new law of Native Communities and Agrarian Development of Selva and Ceja de Selva (Law N 22175), and specifically, the regulation of the law, installed a community leadership (*junta directiva*) directed by the Indigenous chief. However, in many communities the actual implementation and functionality of this governance was a long-term process.

[21] When analyzing historical narratives of Indigenous and *ribereño* peoples of the Urubamba basin, Gow (1991) showed that a 'civilizational moment' was consistently recognized by locals to distinguish the current life in communities from the era of the rubber boss (when people lived in ignorance and dispersed). This is a common historical construct along settlements articulated to the rubber economy.

…**like a jungle,**[22] **(we lived all) spread out**. […] (After a new *barranco*) then (the leaders) **have ordered us to move in front of the school**. […] (The community) was only from that hill until here, after it everything was just bush (*monte*). […] **There were no people, nothing,** (the community encompassed) only until my grandfather's house. (M.V., male, 34 years oldy)

Yes, (we had our plots) in the lowland most of all, and then in the year 91' the flooding came, all the restinga was flooded and since that moment, I started to open plots in the upland. […], **then (in that way) we protected ourselves** […] We used to lose our plantain, all our plantain trees were rotten. After that **we had to learn how to work in the upland.** (C.V., woman, 48 years old)

Since the beginning of the new century, Tamboruna has experienced significant urban development, largely due to the active involvement of the community in District and Indigenous federation politics. The community's transformation began in 2007 with an intervention by the District mayor, a mestizo teacher who had received support from Tamboruna members during the election. Under his leadership, Tamboruna was selected to receive public solar panel-based electricity. Three years later, in 2010, the regional government of Loreto initiated a major infrastructure project by constructing a new modern elementary school and officially converting the old primary school into a high school. During the same period, a towering cellphone antenna was installed to provide signal coverage to the entire community. Additionally, at the time of our fieldwork, the Ministry of Housing was on the verge of implementing a sceptic toilet system for every household. It is noteworthy that individual access to State infrastructure, such as electricity, is contingent upon permanent residency in the community, which has incentivized families to fix their settlement in Tamboruna, contributing to the community's growth.

Indeed, Tamboruna has experienced a considerable increase in population during this period; interestingly, resulting from in-migration due to marriage. Similar to other rural settlements, Tamboruna sees substantial out-migration of young people to urban centers, particularly to Iquitos, the regional capital, with an average of 4.4 adult children leaving per household, and only 1.6 adult children remaining as residents. However, the loss of locals in Tamboruna is to some extent compensated by the practice of exogamic marriages. Indeed, whereas only 13% of the households are constituted from a marriage between locals, the vast majority of the households (82%) are

[22] The respondent is using the word jungle (*selva* in Spanish) in its negative connotation, associated with disorder and chaos.

marriages of mixed origins (local-migrant) (62% of the cases the wife is in-migrant, and 38% the husband is in-migrant), and the remaining 5% are fully in-migrant families. In the foreseeable future, with increasing State presence, authorities anticipate that the influx of residents into Tamboruna will continue:

> Most of all (it is due to the) electricity that the people have come to urbanize, **most of them used to live spread like water**[23] **rising their pigs, their chickens** […] and when electricity came, it has attracted the people so they urbanize, even more, with the cesspool toilet project that is going to come, even more people are going to settle here. (L.V., male, 31 years old, authority of the community)

Not surprisingly, both the resettlement of families on the upland and population growth have impacted agricultural landscape around the community (Figure 2.3). By 2011, a noticeable shift in the extension and concentration of agricultural land had occurred. The working area within the community territory nearly doubled in relation to 1969, reaching an estimate of 529.7 ha and increasing by an annual rate of 2.1%[24]. While the exploitation of lowlands outside the community continued, there were notable differences. Across the Napo River, on the opposite riverbank, the working area significantly contracted (-219.4 Ha). In constrast, the agricultural lowland area situated in the southeast of the community, between Tamboruna and the adjacent community, saw an increase to the area cultivated (+76.7 Ha), becoming another hotspot for lowland agriculture for Tamboruna locals.

By 2022, the agricultural area had stabilized within the community (572 Ha, +42Ha), growing by 0.7% annually and indicating a decoupling between the rhythm of population growth and land expansion. This stabilization coincides with general patterns of land cover across Indigenous territories elsewhere in Amazonia, in which waves of land expansion take place after initial settlement, followed by land cover stability (Coomes et al., 2022b; Gray & Bilsborrow, 2020). In Tamboruna, land cover stability may be also related to the recent implementation of a forest conservation area within the community territory (a process addressed in the following section).

[23] The respondent used the word 'regados' coming from the verb 'regar', which means to pour or spray liquid over the ground. Thus 'regado' (adjective) can be translated as poured or sprayed. In Peruvian Spanish, to adjectivize something as "regado" has a negative connotation, usually associated with lack of organization, order or structure.
[24] This rate was calculated from 1990 to 2011. I chose 1990 as a point of departure as it was the year of the resettlement in the upland. An annual land cover estimation conducted by MapBiomas Perú (https://plataforma.peru.mapbiomas.org/) confirms a significant agricultural expansion within community territory occurred in Tamboruna started in 1990.

Interestingly, in this recent decade, the agricultural expansion has been more considerable in areas outside the community boundaries (257ha, +52ha and 2% of growth annually), especially across the river from the community, suggesting a spill-over effect in the face of restrictions on upland crop expansion. Whether the prospect of more families settling in the community will lead to new periods of agricultural expansion remains to be seen.

In this section, I narrated the history of Tamboruna from formal recognition to its social constitution, focusing transversally on the evolution of the use and expansion of agricultural land. I suggested that in the last three decades, the formation of a modern community on the upland and its insertion in development trajectories have driven increased population and a concurrent period of land expansion. The larger agglomeration of people has put greater pressure on the land base, but challenges the arrangements, customs and conventions under which Indigenous households traditionally convive and deal with conflict related their lands.

2.4.3 The rising of conservation regimes over the forest

Since 2020, Tamboruna has participated in a Payment for Ecosystem Services program (PES) implemented by US Rainforest along the Napo basin. In this inititative, 1193 Ha or nearly half (48.7%) of its territory have been placed under a conservation regime (Figure 2.3), becoming the main cause of land access constraint for local families. Interestingly, the engagement of Tamboruna in this intervention was not entirely voluntary, but resulted from a complex environmental crime case in which members of the community were implicated.

In the 2010s, 38 communities in the Napo basin, including Tamboruna, were involved in a timber laundry scheme organized by forest regents and informal logging companies (*'madereros'* in local dialect). Forest regents are certified private officers recognized by the National Forestry Law who are responsible of enabling the regulated extraction of timber by private actors (Ley Forestal y de Fauna Silvestre, 2011). To engage in commercial agreements with *madereros*, Indigenous communities should engage with forest regents, who have the function of designing timber exploitation plans (PGMF[25], acronym in Spanish) and of supervising its implementation by logging companies according to law. Nonetheless, investigation by journalists have revealed the involvement of forest regents in criminal organizations. In the case of the Napo basin, forest

[25] Plan General de Manejo Forestal

regents complotted with logging companies to register 'ghost trees' in the PGMF's of Indigenous communities of the basin, and through that, laundry timber illegally extracted from other areas (Mongabay Latam, 2018, 2019a, 2019b).

The role of Indigenous community chiefs in the criminal scheme is contested. Their participation is critical to fulfill the bureaucratic requirements for timber extraction: in approving and sign documents elaborated by the regent; in leading the community assembly to consider legal agreements; and in collecting the signature of every consenting community member as required by law. There is a consensus among State and NGO officials that Indigenous chiefs of Amazonian communities tend to have limited legal knowledge to be able to follow the complexity of the process, which make them vulnerable to being scammed by criminal actors (Mongabay Latam, 2018). In the Napo basin, cases have been reported where chiefs knowingly engaged in criminal arrangements after being offered lucrative compensations (e.g., portable chain saw, motorized canoes also known as *peque peque*); rewards that often were not even materialized (Mongabay Latam, 2018). The liminal role of Indigenous chiefs, between being tricked or intentionally criminal, resembles what occurred in Tamboruna, where the chief in this period reportedly forged the signature of some community members in legal documents after being misled by the forest regent. As a result of the direct implication of Indigenous communities of the Napo basin in this environmental crime, they were fined by the State Forest Supervision Agency (OSINFOR, acronym in Spanish) to a total of 10 million of Peruvian soles or about 2.5 million USD. Tamboruna specifically was penalized with a S/ 60,000 or 15,000 USD fine. As suggested by Sarmiento Barletti et al. (2021), the considerable legal power local chiefs have within Indigenous communities in the Peruvian Amazon is leading to significant imbalances, conflicts and indebtment.

In this critical situation, the role of the Federation of Native Communities of the Middle Napo, Curaray and Arabela (FECONAMNCUA), and specifically of its female president during this period Betty Rubio, was highly relevant to collectively confrontig the criminalization of Indigenous communities. Under the leadership of Rubio, FECONAMNCUA criticized the criminalization of Indigenous communities which have protected the forest for decades without any support from the State, and further, which have not been properly informed of contemporary environmental legislation (Mongabay Latam, 2021). According to Rubio's interpretation, the case

resembled the era of rubber bosses, when indigenous families were tricked into deceptive arrangements (currently, with illegal actors), which resulted in scant compensation for their labor and resources, and in long-term indebtment and servitude (this time with the State). After several protests and negotiations with OSINFOR representatives in Loreto, FECONAMNCUA reached an agreement for establishing conservation areas in the fined communities as a mechanism to pay the fines imposed by the State. US Rainforest, a US based NGO already working with the communities in a forest monitoring program, intervened as guarantor of the agreement, and since then has acted as the implementer of the PES program in alliance with FECONAMCUA.

At this point, it is relevant to mention some details on how the US Rainforest intervention works. First, besides offsetting payment of the fine, the PES program allocates a sizable compensation to Tamboruna: S/10 or 2.8USD per hectare under conservation, equivalent to S/10,120 or 2,8000 USD per year; an amount the community is committed to utilize for benefit of all. For instance, funds are used to support community leaders in traveling to Iquitos to pursue meetings and negotiations (*hacer gestiones*) with regional authorities, a critical strategy to secure State support in any community (Killick, 2008). Another popular proposal among community members is to purchase a peeling rice machine that can be used by every household. Overall, the financial compensation received is highly valued by Tamboruna residents.

Second, the NGO aims to consolidate community forest governance and community control over its own territory. To that effect, US Rainforest has implemented a parallel intervention for community forest monitoring, through which indigenous monitors are trained to receive deforestation alerts and patrol the territory (Slough et al., 2021). Based on the information collected from the monitoring efforts, the intervention requires community leadership to address the deforestation alerts together with the assembly of families.

Whereas the monitoring is intended primarily to warn the community of encroachment attempts, the approach of US Rainforest to signaling internal deforestation is more ambiguous. According to NGO officials interviewed, the intervention does not prohibit Tamboruna's dwellers from claiming land in the area under conservation, but such clearing requires approval by the community assembly, subjecting *de facto* individual land access to a collective evaluation. Moreover, in their discourse, NGO officials relegate the practice of opening plots in upland old-growth forest (*monte alto*) and promote instead the re-utilization of fallows (*purmas*) as an ideal land use practice.

Having the incentive of the PES compensation and the pressure of indebtment, the community have opted for adopting a strict conservation approach. Following the NGO's unofficial view, the community assembly approved a prohibition on opening plots in old-growth forest and mandated the re-use of secondary forest plots instead. Moreover, the deforestation alerts have become a critical technology (in the Foucauldian sense) in enforcing this new rule with severity. For instance, despite not being old-growth forest, an alert was emitted when a *comunero* decided to clear his 30 year old *purma* (a plot with a considerable canopy cover), leading to some controversy in the community on how to deal with his case. Overall, with support in the forest monitoring, the community has been capable of rigorously invigilating land expansion driven by local families:

> Now they (informal loggers) do not come in anymore. We are (successfully) protecting our boundaries, the alerts always warn us. **Now what it is coming up more in the (deforestation) alerts is our own people who are opening plots**. (R.T., male, forest monitor, 31 years old)

Further, a punishment discourse elaborated by the community leadership appears as another coercive element supporting the community control over old-growth forest:

> What you can not touch is *monte alto*, **that it has been prohibited to us, so we can protect it** […]. We can only clear our purmas, the ones that are ours; monte alto we can not clear because it has been said it is punished. **If we clear *monte alto* or a tree that is endangered, we will be punished**. That is what the Apu told us. (I.P., female, 40 years old)

> Because of the agreement we have with Rainforest **it is prohibited to touch *monte virgen***. We simply have to do our plots in our purmas, because that area is in recovery [conservation] because of a debt that the community has. […] Only through an assembly somebody can posit to the community "I want to clear a plot in *monte alto*". Then we redact a minute, and we have to send it to the enterprise [referring to US Rainforest] **so we do not have problem when they come to supervise us**. (L.V., male, member of community leadership, 31 years old)

These testimonies coincide in part with the evaluation of US Rainforest's monitoring program in the Peruvian Amazon conducted by Slough et al. (2021). The study shows that, whereas the impact on decreasing tree cover loss is considerable but moderated in time, the intervention is very successful in constituting a conservation bureaucracy (i.e., forest monitors) in the communities, and elevating it to the status of local authorities (Slough et al., 2021).

The US Rainforest program is not the first conservation interventions in Tamboruna. Several other programs implemented by the State or civil organizations (including public schools or churches)

have largely introduced the conception of forest as environment in this community, as well as all over the Amazon. However, by setting up a functional and legitimate control system, the current intervention enforces an 'environmentalist' land use regime over old-growth forest (Dobler-Morales et al., 2020), significantly constraining access to new agricultural land on the upland within the community. The case of Tamboruna resembles multiple cases documented among Amazonian Indigenous territories where resource government based on an environmental rationality ['environmentality' as labeled by (Agrawal, 2007)], has been implemented by the intervention of external actors [see Palacios & Sarmiento Barletti (2021)].

By 2022, the community had requested and obtained an expansion of the conservation area from 80% to 100% of all the remaining old-growth forest available. Moreover, some authorities expressed their willing to extend in time their engagement in the PES program, all in order to increase the monetary and other benefits received from the intervention.

2.4.4 Fractures within the community

It remains unclear when the Annex of Tamboruna was formally constituted, but as advanced, an early settlement in the northwest of the community can be traced back to 1969. Local historical narratives, however, are consistent in indicating that its creation is related to increasing family disputes, which led few kin groups to relocate far north, crossing the Tambomayu ravine, which divides the community in two. Despite not being formally recognized by the State, the Annex has functioned in practice as an independent community with its own appellation, governance structure, port of entrance and elementary school. Moreover, the agricultural area used by Annex families is significant. I estimated an area of 384 ha in 2022 was in use, of which approximately 276 ha lay within the community's territorial boundaries. Even in the face of land scarcity, the agricultural area of the Annex families is spatially separated from the area typically worked by Tamboruna residents. The social frontier between Tamboruna and its Annex is recognized by members in both sides, contributing to the reduction of the actual territory available in the community of Tamboruna.

The relationship between Tamboruna and its Annex has been contentious for years, but reached a critical point in 2011, when Tamboruna applied for a legal extension of its territory into the

adjacent forest on public property[26]. In the process, Tamboruna authorities discovered that the Annex had been formally recognized as a native community by the regional government of Loreto, despite the settlement despite the settlement being located within the titled territory of Tamboruna. This obvious breach of the Native Communities law was achieved with the help of an outsider mestizo of initials E.M.T., already known on the Yaquerana river for its implication with Indigenous communities in arranging pirate carbon bonds schemes (Wiesse & Saravia, 2012). E.M.T. also led the Annex to formally organize a Community Forest Surveillance and Control Committee[27] and to co-constitute a Forest Management civil association with two other communities, a platform which allowed him to obtain legal management rights over public forest in the area where Tamboruna aimed to expand. Until 2022, E.M.T. still physically occupied this zone and even put armed private security to impede any local from crossing or even navigating near that sector. As remarked by the local press in the Napo basin (Carrasco, 2023; Nolazco, 2012), the ease with which external actors claim formal possession over the forest, even affecting the land rights of long-standing Indigenous communities, is quite striking[28].

With the legal support of basin and departmental-level Indigenous organizations (FECONAMNCUA and ORPIO), Tamboruna has gone through an extensive legal battle to recover the integrity of its territory. In April of 2023, after the dispute reached the court of the Forest National Authority (SERFOR), SERFOR declared the nullity of all previous resolutions of the Regional Government of Loreto, including retiring the status of native community to the Annex. However, the conflict seems to have more long-term consequences. The expansion of Tamboruna's territory was paralyzed along the 10 years that this conflict was latent and is still

[26] As established by law, Native Communities can ask for an extension of their territories if the area recognized is not sufficient for their sustenance. In the fieldwork, I documented that many communities of FECONAMCUA have initiated the process of extension, in an effort to appropriate of the adjacent forest areas not yet concessioned to private actors by the State.

[27] Legally, a committee conformed within a native community responsible of the surveillance, monitoring and control of forest resources and wildlife within the community's territory. By law, the creation of these committees is incentivized, and their activities are supported by the State.

[28]Later, it came to light that all the legal moves of the Annex were part of a bigger scheme led by E.M.T. This mestizo had convinced two more native communities in the Napo to establish their own Forest Surveillance Committees, and later to join all three committees in a civil association directed by himself. According to local sources and local press of the basin, E.M.T. made false promises of rewards to the families, and even falsified documentation -signatures, and minute books of the communities- to get the legal registration of this association. The regional government of Loreto even funded the elaboration of the strategic plan of the supposedly indigenous-led civil association (Resolución Ejecutiva Regional N 370 - 2013-GRL-P, 2013). Some leaders interviewed presumed the goal of E.M.T. was to facilitate illegal actors access to timber and other resources. Other sources indicate that E.M.T. could be possibly linked to the selling of pirated carbon credits, given his previous antecedents.

pending to date according to local sources. More importantly, the fracture between the community and its Annex continues to deepen.

2.4.5 Land scarcity: an estimation

After accounting for all the processes constraining the access to old-growth forest…how much land is actually available to members of Tamboruna? Deducting the estimated agricultural area already in use (572 ha), the urban area (29 ha), the area under conservation (1193 ha), and the estimated territory occupied by the annex (239 ha)[29], the remaining forest area available for agricultural conversion in Tamboruna stands at 414 Ha[30]. Considering the population density in the community (79 households), each household has access to only 5.2 hectares of remaining land, indicating an acute level of land scarcity.

2.5 Land system in Tamboruna

In this section I characterize the land access and property regimes, and land distribution structures in Tamboruna, aiming to set the context for understanding the ramifications of land scarcity in the community.

2.5.1 Access and property regimes

Within the collective property of the community of Tamboruna, land is managed by households individually. Families have the freedom to acquire, transfer, and utilize land with considerable autonomy. As typically in Amazonian communities, there is a common understanding between *comuneros* that alienating the land - i.e., transferring plots to outsiders - is prohibited, a mandate well acknowledged and respected by all members. Communal authorities, including the community leadership or the assembly do not exercise any significative regulation over agricultural land access, distribution or use, but with certain exceptions[31]. Contemporarily, with

[29] Area of Annex occupation within the community that does not overlap with the conservation area.
[30] This estimation is based on the methodology developed by Littleboy (2022). The author measures land scarcity by calculating the potential available cropland (PAC) -i.e., the land available for agricultural conversion within a given territory after subtracting (1) the area under urban use, (2) the agricultural area already in use -including secondary forest plots-, (3) the area under conservation regimes, and (4) other not profitable or accessible area (all the land farther than 2 hours of walk).
[31] When the land users are fully in-migrant families (Indigenous households of other communities or ethnic groups) or members of other neighboring communities, the community chief or the leadership have played a regulationg role, granting permission and allocating specific areas to usufruct.

the presence of conservation programs and the implementation of the PES, the community is assuming a new role in restricting the access to the potential agricultural land in old-growth forest.

The recognition and maintenance of land possession rights are strongly subjected to custom and conventions. It is widely recognized by community members that land possession is derived from the work a family invests in clearing-and-burning the forest and creating a productive plot. Historically, the possession rights established when creating a plot are long-standing in time, even along extensive fallow periods, allowing households to retain their rights to *purmas* as long as they remained in the community. In the recent years these property conventions are being challenged by land-poor segments in the community, a development I analyze in the next section.

Like in most Amazonian Indigenous and folk communities, families in Tamboruna gain access to land through land claiming and land transferring. Families open patches of old-growth forest with the support of collaborative labor. Land transfers refer to the circulation of plot among community members. In Tamboruna, land transfers take place primarily from parents to adult children who just married, as a way to support the new couple. Of note, I registered plots which have had several owners of different degrees of kinship or friendship along the productive life of the plots, confirming the dynamism of land transfers in Amazon communities.

As mentioned above, a considerable area of agricultural land is situated outside the community territory. The working area located in the islands and opposite riverbank, historically used by families in the settlement, are used under a public-private usufruct regime. This regime was adopted in the 2010s, after the categorization of all forested area surrounding Indigenous territories in the Napo basin as public property. In this period, the Ministry of Agriculture of Peru required small holders to regularize their land holdings by obtaining a usufruct certificate granted by the State. Currently, only families having a State-issued certificate can access and use these lands; typically, they are elders who inhabited and worked the land in this area from several decades ago.

2.5.2 Land distribution

Tamboruna exemplifies a traditional agricultural community in Amazonia. Families are small holders who practice shifting cultivation as the dominant agricultural system. On average, households in Tamboruna posses 8.5 plots with a mean area of 6.4 ha. The predominant portion of households' holdings are in the upland (a mean of 4.7 ha, 64% of the household's area), whereas

only 1.8 ha (36%) lies in the lowland. Within the lowland, the working area per household is evenly distributed between high levees (*restinga alta)* (0.8 ha on average, 55%) and low levees (*restinga baja)*[32] (0.9 ha on average, 45%). Lastly, the average area per plot per household is 1.1 ha, reflecting an important level of land fragmentation (small, scattered patches of land) in the landscape.

From their first year of constitution to the year 2022, households on average accumulated of 4.8 Ha. This growth occurred mostly through land claiming (+3.1 ha per household on average) and land was largely claimed on the upland (+ 3.1 ha upland on average). In a minor proportion, households also accumulated holdings through land transferring (+1.6 ha per household on average), but this happened primarily in the lowland (+1.1 ha on average). Overall, claiming in old-growth forest has been the fundamental mechanism for land access and accumulation in Tamboruna; land transferring is only a secondary mean for land acquisition.

There are important disparities in land holdings among households. Overall land inequality is high in Tamboruna (Gini of 0.54), with particular severity in the upland (Gini of 0.62) (Table 2.1). A Lorenz curve graph shows that 50% of the total land holdings are held by 10% of the land-richer households in the community (Figure 2.4), a distribution pattern that reproduces in the lowland. In the upland, the proportion of agricultural area controlled by the 10% land-richer increases to 60%.

These land distribution patterns do not correspond to similar land accumulation processes. Elder families who lived previously in the lowland, hold extensive areas of *varzea* in the riverbank opposite to the community territory, in areas of public property. I documented cases of families holding entire islands in public lowlands, which are usually used for pig raising and plantain cultivation. On the contrary, certain young adult households have accumulated extensively upland in a remarkably brief time, explaining the high land inequality found in this area.

Table 2. 1 Gini index on land holdings in Tamboruna

	Initial land holdings	Current land holdings
Total area (Ha)	0.42	0.56
Upland area (Ha)	0.50	0.62
Lowland area (Ha)	0.41	0.55

[32] *Restinga* is the local denomination for levees composed of the sediment (usually clay) deposited by flooding rivers in the Amazon. *Restinga alta* is a high elevated river levee, which is rarely flooded during high water season. On the opposite, *restinga baja* is a low elevated river leeve highly susceptible to flooding (Coomes, 1992).

(1) (2)

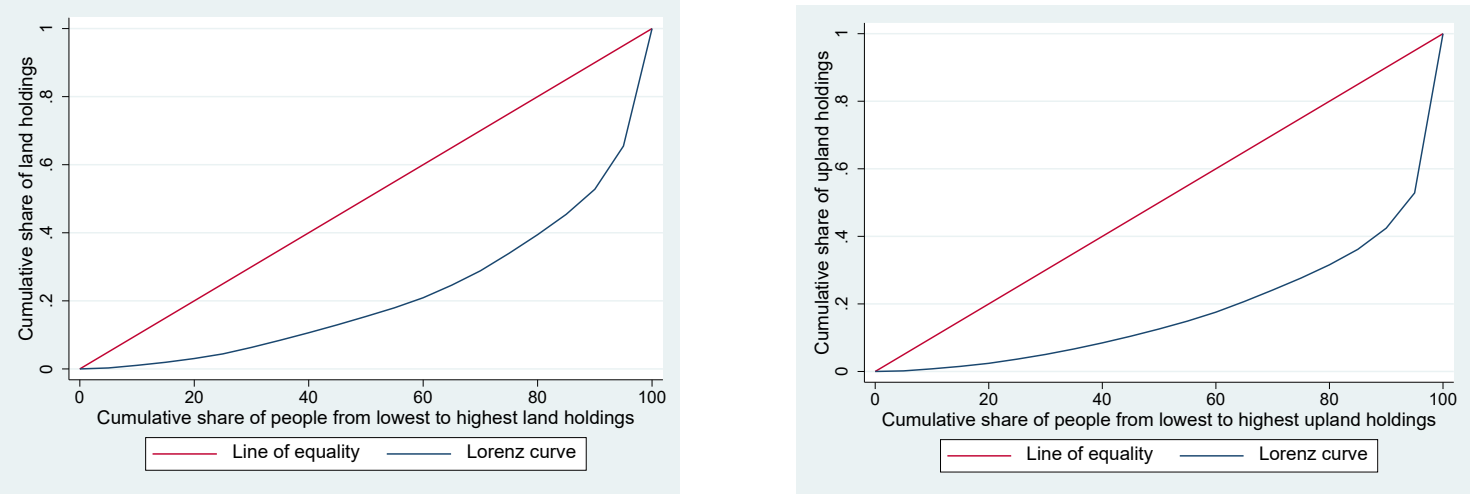


Figure 2. 4 Lorenz Curves of land holdings in Tamboruna
Inequality in current (1) total land holdings and (2) upland holdings in Tamboruna.

(1) (2)

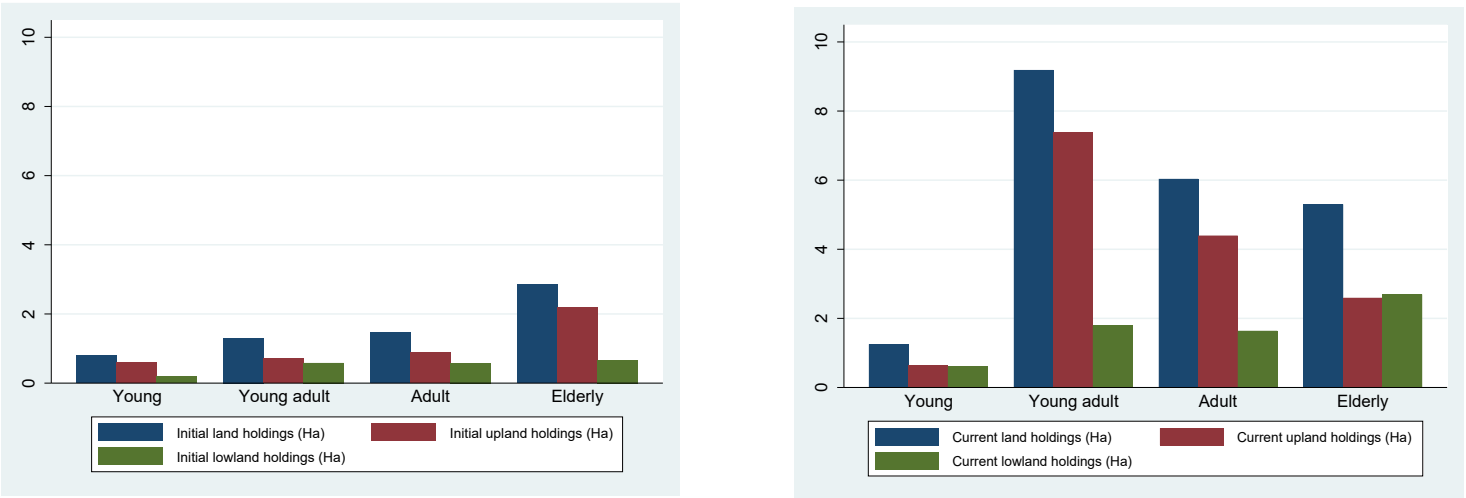


Figure 2. 5 Land distribution by age group of land holdings in Tamboruna
(1) Mean of initial land holdings by age group and per areal elevation, (2) Mean of current land holdings by age group and per areal elevation

This leads to the following point: land inequality in Tamboruna has an increasing inter-generational nature. When comparing the initial land endowments of households by age group, it is clear that elder generations had more privileged access to land than newer ones, a disparity is especially strong in initial upland holdings (Figure 2.5). One could presume that the new trends of extensive and accelerated upland accumulation among young adult households may be a mechanism to cope with initial asset poverty. The question arises whether the next generations, facing stronger constraints over land access in old-growth forest, will be able to claim and accumulate land to the same extent.

2.6 Land contentions challenging fallow access and property regimes

Tensions around land are common in Amazonian communities as in Tamboruna. The damage caused in a plot by domestic animals, or by the stealing of agricultural products are issues families deal in an everyday basis. However, in Tamboruna where the availability of land has declined, and there is a high inequality in the distribution of land, households are experiencing a rise in more problematic types of contention. In this section, I analyze the dynamics (including the resolution) of land contentions, with focus on the opposing discourses within these disputes. I show that competing claims over the land are transforming property dynamics and conventions the community.

Fallow lands, locally known as *purmas*, represent the primary focus of land contentions in Tamboruna. Due to restrictions on claiming land in old-growth forests and the limited frequency of land transfers, secondary forests have emerged as the primary source of agricultural land for households. However, in several cases, fallows are being encroached upon by other community members without acknowledgement of established possession rights over the plots. The survey I conducted reveals that 27% - almost a third - of the households in the community suffered from *purma* invasion; meaning that a part of their fallow has been cleared by another family without notice. While invasion is not always deliberate - it could happen when clearing an adjacent fallow plot -, such encroachment creates an issue regarding the usufruct and possession of the area invaded. A more striking result is that 17% or nearby one-fifth of households experienced *purma* dispossession, i.e., the complete appropriation of a household's fallow by another. In all the cases, dispossession occurred intentionally.

It is not surprising that most of the land contentions noted, particularly those involving land dispossession, are between younger and older generations of households. The increasing disparity in land distribution between generations places newly established families at a significant disadvantage in terms of land access in comparison to longstanding families. Further, there is a notable disparity in the economic needs and capacities of families at different stages of the life cycle. Having to sustain a larger number of dependents, younger households have a higher income/food demand and count on more labor force to open land than older households. Overall, despite limited social stratification, the age of the household generates a considerable level of internal differentiation between families with contrasting land access, demographic features and economic demands. Testimonies suggest that land contentions are occurring in the middle of this opposition:

> Look, Mr. F.G. **slashed-and-burn (the purma) of my mother-in-law, with all her plants and orchard inside**. It is because my mother-in-law can not cultivate plots anymore, as she is a widow, she produces only very small swiddens. […] That is why I advised her 'let him be, you can not walk much anymore, let him take the plot'. (I.P., female, 40 years old).

A key element questioned through land contentions is the legitimacy of possession rights over land. Confronting traditional long-standing possession rights, families accessing land through the encroachment of others, claim the duration of land possession rights should be reduced. In their discourse, after several years fallowing, *purmas* significantly decrease their income contribution and so, should become available to others for claiming. Interestingly, the threshold between a *purma* and an 'idle' secondary forest land is not clearly defined. Some respondents mentioned that a fallow of ~10 years or more could be freely taken, whereas others identify the decrease in production of fruit trees (*guayaba, caimito, uvilla*) as indicative of the end of possession (~15 years). Overall, in their view, land possession rights should be limited to early stages of forest succession.

Moreover, the conventions and moralities under which households convive in Tamboruna also play a part in land contention. Tacit norms inscribed in the local common sense and framed in different layers of social relations in which Tamboruna dwellers engage, as relatives, neighbors/friends and members of the same community (*comuneros*). In a context of acute land scarcity, the accumulation of *purmas* and the aversion to share fallow lands with others are considered immoral practices by younger generations. The young argue that, despite not being

able to produce and profit from all their plots, long-standing families still choose to deprive (‘*mezquinar’*) this resource from families in need. Many of my respondents labeled elders as *mezquinos,* local slang that can be closely translated as stingy, and is a moral category with a strong negative connotation across the Peruvian rural Amazonia:

> Yes, we ask them (older people) whether we can clear the plot and sow it. Because sometimes we do not have land where to cultivate one plant of yuca, one of plantain, one of *guineo*. We do not have that much space, and we can not cultivate, then it is to them, who have several plots that we have to ask for land. […] […] **lots of them have (extra land), but they deprive you from the land [*te mezquinan*], and they don’t even slash-and-burn (the *purma*) to make it.** (R.T., male, 31 years old)

Different moral and conventional benchmarks play a part in these narratives. The emphasis on condemning the act of *mezquinar* resembles the Indigenous mandate against resource and wealth concentration, broadly documented across Amazonian ethnic groups (Brown, 1984; Descola, 1994). Further, the claim for resource allocation according to need and fairness refers ultimately to the defense of the subsistence rights of every *comunero* family, a convention among peasant communities and collectives (Scott, 1976). Overall, local discourse posits the nature of secondary forest lands as common goods to the detriment of the traditional regime of private land possession.

On the other side of the dispute, families suffering from invasion or dispossession discretely but unanimously defended their land rights when interviewed. From their perspective, transforming old-growth forest into productive land remains as the definitive means of asserting possession. Their discourses are especially rich in describing their appropriation process, as the huge effort invested in clearing *monte alto*, and/or the strong identification they develop with their plots as productive spaces personally shaped over decades of continuous crop and fallow management. It was not surprise when A.A., a *comunero* of 78 years old and one of the land-richer members of the community, recognize himself as owner (‘*dueños’*) of the land. According to his view and of others like him, younger generations are lazy (*shegue,* incapable of working), and they prefer to invade other peoples’ plots rather than claiming their own land in less accessible areas:

> Of course, they go and tell everybody […] that it is me who deprives (land from others), but I say (I hold the land) because I am the **owner (*dueño*), it is me who had to (work hard to) break the primary forest (*monte alto)*.** I wonder why they take my *purmas* if there are lands in the *aguajal*

> [surface covered by aguajes], why can't they? Because they can not work, (they are) *shegue*. (A.A., male, 78 years old)
>
> **Nowadays (surviving) depends on working (opening land) in the center (of the community)** [in *monte alto*]**.** Here the people, I do not know why, they do no want to work anymore. Sometimes they come but they do not open plots, they dedicate more to steal (other people's land). (M.V., male, 41 years old)

Relevant social conventions are also broken by the 'encroachers'. By convention, an agreement with the original owner should be reached before land rights are transferred: "not even you would like to be in your bedroom and that I occupy it without telling you" (H.A., male, 37 years old, referring to *purma* dispossession). But the issue goes beyond not having permission: not recognizing that a gift has been given, even if the land transfer is not voluntary, and the consecutive failure to fulfill reciprocity obligations mark a significant departure from the expected interaction between relatives.

> (When I) walk to the church, they (my grand nephew and his family) **do not even tell me 'hey, uncle, come here, drink *masato*'**, not even a little cup. (Instead) they start laughing. They do not think where they are working at, where they are producing at. They have cultivated my *purma*, in there they have produced manioc, plantain, everything. […] (A.A., male, 78 years old)

Despite the intense animosity expressed by certain interviewees in private conversations, land contentions in Tamboruna are frequently left unaddressed by the parties involved, and resolutions through dialogue are seldom achieved. Remarkably, none of my documented cases of invasion or dispossession entailed the mediation of communal or local authorities, and most of the households prefer not to open a direct a conversation about the issue. Overall, a strong tendency to avoid active conflicts with relatives or neighbors prevails in Tamboruna, a sociability pattern deeply rooted in Amazonian ethnic groups to this day [33] (Brown, 1984).

> Nothing, we did nothing (when my purma was invaded). The only measure we took was not to make a fuss about it, not to tell anybody. (F.G., male, 41 years old)
>
> (I said nothing) because I did not want to fight with my *compadre*, because of that I just stayed silent. (C.M., female, 39 years old)

[33] Sarmiento (2016) attributes this pattern of conflict avoidance to the lack of conflict resolution mechanisms among Amerindian societies.

> Well, I did not tell anything to him, I see him very calm with his corn cultivation (in my purma) […] I won't be in a fight for *purma* anymore. Also, my wife told me to let him be, because I wanted to complain to him, but she did not want to. (C.V., male, 75 years old)

The lack of contestation against local encroachment gradually consolidates the relativization and reduction of individual land possession as a novel property dynamic.

Only in a few instances were *purma* invasions addressed and resolved in favor of the original possessor. For instance, to recover a piece of his *purma*, the *comunero* A.M. allowed a trespasser to keep his cultivation for two years in the invaded area and agreed to compensate him with a sack of yuca for his investment. After this, A.M. decided to quickly convert the rest of his fallow to plot again to prevent further encroachment. In another example, the *comunero* C.V. decided to cultivate plantain in an invaded part of his *purma* to expel the trespassers. These cases reveal that the active usufruct of land is being used as a strategy to avoid invasions or dispossessions, in turn, reflecting growing need for constantly asserting land rights through appropriation practices. Again, this finding confirms the erosion of long-standing forms of possession in a context of scarcity and local land contention.

Finally, it is important to note the ambiguous role played by the community leadership in these disputes. Following the commitment with the PES intervention, and its recommendation for reutilizing *purmas,* the choice of the leadership to not intervene over land disputes is evident. When interviewed, certain authorities claimed ignorance over well-known cases of land dispossession, whereas other leaders openly supported local encroachment by pointing to an assembly agreement allowing free *purma* appropriation. From this perspective, households appropriating the fallow of others are following *comunero* rules. Interestingly, this norm has not been included formally in the community statute and it is considered an 'interim consensus' of the community assembly. The question arises whether local authorities have any influence or can intervene in other types of disputes between community members. Overall, households do not recall any specific community rule or norm when legitimizing their claims in land contentions; on the contrary, moral and convivial conventions dominate in their discourses around land access and property.

2.7 Discussion

2.7.1 Land scarcity

My results show that factors constraining the land supply are critical in land scarcity production among Indigenous territories. In a context where Indigenous forest property rights are contested and weakly enforced by the State, competing claims by a diverse set of actors – including private actors linked to illegal economies, public officials, conservation NGOs, or Annex residents – over the community's forest, developed into actions that led to territorial enclosure, such as the imposition of a conservation area or the fission of the community's Annex. All these have significantly contributed to the suspension or loss of access to large extensions of old growth forest and thus, to the decreasing land availability for agricultural use.

This research also identified other factors that exacerbate land scarcity. Demographic growth had a significant but not steady effect over land expansion in the community. Of note, incoming migrants to Tamboruna are drawn by the new public infrastructure and services provided in the community, apparently outweighing concerns regarding land availability, and suggesting a possible evolution of household livelihoods beyond agricultural income [consistent with Amazonian livelihoods literature (Coomes et al., 2016; Wright & Muller-Landau, 2006)]. Major flood events also contributed to reduce the supply of land, especially in the lowland, supporting the importance of river dynamics in Amazonian land endowments (Abizaid, 2008; Hiraoka, 1989; Langill & Abizaid, 2020).

Overall, my findings are consistent with the relative definition of land scarcity as the interaction between drivers of land demand with factors constraining the land supply (Hartmann & Gerber, 2018). Nonetheless, my findings highlight the prominent role of problematic regional forest access and control regimes in leading to land scarcity, including the general weakness of Indigenous territorial rights over natural resources (Homer-Dixon, 1999; Scoones, 1999). Overall, land scarcity is taking place in Tamboruna as an issue of diminished access to resources rather than of resource depletion or inappropriate resource management.

This study explored the role of conservation policy and interventions in land scarcity. In the case of Tamboruna, it is striking how the PES and forest monitoring program ended up having a restricting impact over household land use, despite aiming at different objectives (e.g., protecting

communities against outside encroachment, strengthening the community's control over its territory) and not formally prohibiting claiming land in old-growth forest. This result is consistent with conservation scholarship from Amazonia and other tropical forest regions, showing a trend in conservation policy of framing the practice of dynamic shifting cultivation as deforestation (Ravikumar et al., 2016), and pushing for the confining and de-coupling of agricultural land away from the forest (Dobler-Morales et al., 2020).

Further, my findings indicate the unique power process through which this novel land-use regime have been enforced at a local level. To my knowledge, no other study has reported a case where a PES program was imposed in an Indigenous territory as a settlement for an environmental crime. This development creates the potential for environmental criminal law and prosecution to be used as coercive tools in the expansion of conservation regimes across Amazonian Indigenous and folk communities. Additionally, forest conservation governance set up in the community and supported by the NGO played a critical role in controlling and confining agricultural land use. Part of its success is due to the combination of elements of participatory government - e.g., the incorporation of Indigenous monitors, community assemblies for deforestation issues - with practices of disciplinary power supported by precision technology - e.g., invigilation of forest clearing coupled with punitive discourses -. Finally, the severity with which the community has implemented this mandate for limiting agricultural expansion shows that Indigenous peoples can also be conservative actors [not only contesting or negotiating external interventions as in Palacios & Sarmiento Barletti (2021)], especially under conditions of criminalization, penalization, the economic incentives from conservation, or other forms of subjugation and moral indebtedness with the State or civil actors.

2.7.2 Land access and property regimes

To confront the challenge posed by land scarcity, an open access turn of land property regimes has taken place in Tamboruna. Indeed, increasing pressure over land access has led to a reduction (but not elimination) of individual possession rights over fallows, by that constituting a common pool of secondary forest lands accessible to any community member. However, no other element of the land access and property regime has significantly changed in the community: centralized collective governance over land has not been established; individual possession is still recognized until early stages of secondary succession; and Indigenous households still access and use land with

autonomy as done traditionally. Rather than a complete regime shift, what has occurred is an adjustment of the property regime with respect to one element of land holdings rules.

My findings contribute to a more nuanced and multifaceted understanding of the dynamics of changing access and property regimes within Amazonian Indigenous territories. The evidence presented in this chapter highlights that an open-access pathway can emerge as a possible response to land scarcity, challenging the assumption that resource shortage inevitably leads to the further individualization of property - as suggested by Neo-Malthusian approaches (Fairhead & Leach, 1995; Galaty, 2016; Hardin, 1968; Scoones, 1999) -. More comparative research examining access and property regimes in both folk and Indigenous communities in Amazonia is necessary to determine whether there is a trend towards opening access and/or communalizing resources, and whether this trend may be exclusive to Indigenous peoples.

Additionally, this study reveals that access and property regime change does not always arise through the articulation of collective action and institutions (c.f. Oldekop et al., 2012). In the case of Tamboruna, the shift to opening access of fallow lands was driven by internal strata struggles and grounded by contentious access practices (i.e., land invasion and dispossession), overall challenging the legitimacy and morality of longstanding individual possession rights. Moreover, in agreement to Lu (2001) findings with Huaorani communities, the property regime adjustment in Tamboruna seek to regulate imbalances and inequality between community members rather than to meet conservation or sustainability objectives. Overall, this type of resource regime transformation occurring through social fabric dynamics may be proper of land systems anchored in societal conventions and customs and not in formal regulations/institutions (Cronkleton & Larsen, 2016). Of note, the reduction of internal imbalances may be a common driver in resource access and property regime change in Amazonian societies.

This study reveals the conventional and relational dynamics inherent to resource access and property regimes within Indigenous Territories [in agreement with the findings of Cronklenton & Larson (2015)]. In Tamboruna, well-established customary conventions shape land access and property practices, and moral mandates of higher order are claimed to question or support the legitimacy of these practices in a context of scarcity. These conventions and mandates exhibit diffuse contents and borders, and their hierarchy varies among different segments of the community in dispute. For families suffering from poor access to land, the imperative to ensure

the subsistence of every community member - a moral code documented by Scott (1976) in peasant societies in livelihoods crisis - prevails over the custom of recognizing full property rights to original land claimants. Similarly, the Indigenous sociability patterns of individual autonomy and conflict avoidance often supersedes the pursuit of consensual and equitable dispute resolution between *comuneros*. The overlapping of tacit and diffuse conventions and the lack of a centralized authority governing land render access and property regimes in Amazonian Indigenous communities highly malleable to adjustments and transformations in the face of resource pressure (Cronkleton & Larson, 2015).

Over time, opening the access to fallow lands may have prejudicial consequences for agricultural land use. Fallows in mature stages of succession are growingly perceived as idle secondary forest lands. As suggested above, this shift may lead households to intensify land appropriation to reaffirm their ownership more frequently and through more problematic interventions (e.g., young fallow clearing, extended crop phase), to the detriment of the soil status. In addition, claiming land in 'idle' secondary forest implicates necessarily the appropriation of plots utilized by other families. Given the strong path-dependency of shifting cultivation agricultural systems (Coomes et al., 2011), the autonomy with which families not only acquired but managed their lands could diminish. Further, increasing competition over land undoubtedly generate tensions and in some cases fractures among relatives, potentially degrading the cohesion of a former small community now in full population growth, which is a typical result of resource conflict as documented elsewhere in Amazonia and other tropical forest communities (McSweeney, 2021; Sarmiento Barletti et al., 2021). Overall, questions arise about how transitions to open-access or commons regimes may impact the sustainability of agricultural land use and the social fabric in forest communities.

2.7.3 Looking forward

With the rise of conservation regimes and the further weakening of Indigenous land rights in the last decade (Larson et al., 2018; Silva-Junior et al., 2023), scarcity resulting from the suspension or loss of resource access may become a more widespread issue among Indigenous territories in Amazonia. This study case provides an example of the flexibility of land access and property regimes in Amazonian Indigenous communities, and how an adjustment that guarantees resource access for all the community members is achievable, even if it is through internal contention. This

study demonstrates that Indigenous peoples have creative responses to high resource pressure contexts beyond either complete individualization or collectivization. Moreover, it confirms the broadly documented capacity of Indigenous societies to moderate internal inequality and imbalances. Nonetheless, the emergent access and property dynamics might rely on intensifying the use resources, and fracturing long-standing customary conventions, putting at question the potential environmental and social consequences of contemporary regime adjustments. As the resource management challenge for Amazonian Indigenous communities will be more critical and generalized in time, research on access and property transformations and governance innovations becomes more relevant.

Chapter III. Land scarcity influences household land management in Indigenous territories of the Peruvian Amazon

3.1 Introduction

Indigenous peoples (IPs) of Amazonia have made significant inroads since the early 1990s in securing rights to their land, and Indigenous territories (ITs) have been found to effectively preserve forest cover (Baragwanath & Bayi, 2020; Bennett et al., 2023; Blackman et al., 2017; C. Gray & Bilsborrow, 2020). As territorial rights are increasingly secure, the sustainable management of natural resources, especially agricultural land, arises as a critical issue (Le Tourneau, 2015). Demand is growing for expansion of the agrarian frontier in Amazonia, pushed mainly by increasing market integration and policy frameworks (Trancoso, 2021). At the same time, the area of land allocated to ITs is limited and under constant pressure of external encroaching (Sarmiento Barletti et al., 2021; Silva-Junior et al., 2023). As a result, Indigenous households in Amazonia potentially face growing land constraints and resource scarcity.

A small number of recent studies have identified land scarcity as a disconcerting issue among Indigenous and folk communities of Amazonia (Coomes et al., 2011a; Jakovac et al., 2015, 2016; Oldekop et al., 2012; Sirén, 2007). Land scarcity is experienced as a decline in the forest area available for agricultural conversion within a specific territory (Littleboy, 2022) and can have significant impacts in local land systems, including land use intensification (Coomes et al., 2011a; Jakovac et al., 2016; Sirén, 2007), land use extensification into the remaining forest (Coomes et al., 2000, 2011a), higher land inequality (Coomes et al., 2011a), and the institution of land rental markets (Herz, 2018; Sarmiento Barletti et al., 2021). Overall, land scarcity may transform the land management practices that sustain the reproduction of forest landscapes around local communities. The modest evidence accumulated to date in Amazonia, however, comes primarily from non-Indigenous settlements.

This chapter seeks to enhance our knowledge about land scarcity and its specific impacts on local land management in territories managed by Amazonian Indigenous peoples. The primary research question is: How does land scarcity transform indigenous household land management in Indigenous communities of the Peruvian Amazon? To address this question, I undertook a quasi-

experimental research project focusing on two indigenous territories differentially affected by land scarcity: one community facing severe land scarcity, and another, where land remains available. In the first section, I identify and describe the contrasts in household land management between the two communities, specifically in regards to household land accumulation, land use, and land distribution. Next, I use multivariate regression analysis to explore the association between land scarcity and differential household land management patterns, testing specifically for transitions in land accumulation and land use/cover change. The chapter concludes by discussing the extent to which land scarcity poses a threat to the sustainability of land management in Indigenous territories.

3.2 Why is land scarcity a concern?

Land scarcity occurs when "..limited resources are confronted with demands (or needs) that outreach the available supply" (Hartmann & Gerber, 2018: 3). While land demand is driven by different types of forces (e.g., population growth, market integration), the supply of land is delimited by a set of ecological conditions (e.g., soil fertility) and resource access and control structures (Hartmann & Gerber, 2018; Scoones et al., 2019). For land users, scarcity has an absolute expression, i.e., the decline of the land available within a specific territory.

Land scarcity presents a significant concern within any land system. As the resource availability decreases, the risk of losing access to land in the short-term rises for land users (Oldekop et al., 2012), fueling increased competition for the remaining assets (Hartmann & Gerber, 2018). To address the risk posed by scarcity, land users may make crucial adjustments to land use, access, and distribution practices. Two notional types of land management transitions can be distinguished. Following a neo-Malthusian approach, land scarcity may foster further individual land appropriation (Fairhead & Leach, 1995; Galaty, 2016; Hardin, 1968), contributing to the eventual depletion of the remaining resources[34]. Alternatively, as Boserup (1965) suggests, a shift could occur towards land use intensification and resource substitution, preserving the land still

[34] One of the key elements of neo-Malthusianism is the view of resources as absolute in space: fixed in quantity and quality (Homer-Dixon, 1999; Scoones et al., 2019). Therefore, an absolute decline in resource availability, is expected to fuel the rivalry over the remaining resources, in turn, increasing the cost of maintaining an open access to resources, incentivizing resource privatization. Finally, the lack of social control over private management of land may contribute to resource depletion (Galaty, 2016; Hardin, 1968).

available. Overall, the functioning and reproduction of land systems may experience considerable transformations in the face of land scarcity.

3.3 Land scarcity: an overlooked issue in Amazonia

Lambin et al. (2003) consider land scarcity as one of the main five pathways leading to land-use change in the tropics. The authors identify a multiplicity of factors leading to land scarcity, including demographic growth, soil productivity decline, and land fragmentation (Lambin et al., 2003). Nonetheless, the nature of the factors at play is not distinguished (i.e., land demand drivers, factors organizing the land supply), nor is it clearly established what are the connections and feedback loops between each other. A more nuance and critical understanding of this issue has been further developed for African local communities, where land scarcity is a combined result of increasing population, and strong ecological and political factors conditioning the land supply, including the inequal distribution of arable land, dispossession and displacement of local communities, and the burden of colonial policies (Andersson, 1999; Chamberlin et al., 2014; Jayne et al., 2014; Scoones et al., 2019).

Few studies yet have addressed the issue of land scarcity in local agrarian systems of Amazonia. Most of the existing research views land scarcity primarily as a consequence of increasing land demand. Factors commonly linked to this issue include the rapid demographic growth of Indigenous and folk Amazonian communities (Bremner & Lu, 2006; Lu, 2001b; Oldekop et al., 2012; Sirén, 2007) and greater integration into food markets (Godoy et al., 2009; Oldekop et al., 2012), both increasing the demand for additional cropland. Of note, the attribution of land scarcity to demographic growth is dissonant with the findings of population-land scholarship in the Amazon, which consistently shows that population dynamics do not have a consistent and direct effect over land expansion in local communities (de Sherbinin et al., 2007; López-Carr et al., 2005; Pan & López-Carr, 2016; Perz et al., 2006). Moreover, it does not account for the magnitude of off-farm based livelihoods practiced widely by Indigenous and folk peoples (Coomes et al., 2016), which may considerably moderate the demographic pressure over land (Wright & Muller-Landau, 2006)

There are very few studies available on the factors organizing or conditioning the supply of land in Amazonian Indigenous and folk communities. Supply factors contributing to land shortage include riverine hazards and flooding dynamics (Abizaid, 2008; Hiraoka, 1989; Langill & Abizaid,

2020), the increasing remoteness of accessible forest land (Sirén, 2007), the confinement of communities within restricted territories (Coomes, 1996; Vadez et al., 2004) and the vulnerability of Indigenous communities to encroachment and other forms of dispossession (Le Tourneau, 2015; Sarmiento Barletti et al., 2021). Overall, a critical scientific assessment of how the land rights allocated to Indigenous peoples in the Amazon condition resource management and support local livelihoods is lacking (Constantino et al., 2018; Sarmiento Barletti et al., 2021).

At an aggregated level in Amazonia, there is no indication that land scarcity is a pervasive or pressing issue for Indigenous Peoples in their territories across the basin. Research conducted at a regional level, shows that Amazonian Indigenous territories present lower rates of deforestation and a stable forest cover in comparison to other land tenure regimes (Baragwanath & Bayi, 2020; Bennett et al., 2023; Blackman et al., 2017; Coomes et al., 2022b; Gray & Bilsborrow, 2020). This has led to the positioning of Indigenous peoples as 'guardians of the forest', and the expansion of ITs as a critical policy measure to slow deforestation in the biome . As this narrative consolidates, the discursive space to analyze the limitations and socio-ecological challenges with potential land scarcity within specific Indigenous territories is significantly reduced.

3.4 The impacts of land scarcity

The most often observed effect of land scarcity in Amazonian Indigenous and folk communities, as elsewhere, is the intensification of land use. When the availability of land declines, households tend to increase land productivity by shortening the fallow length and increasing the number of production cycles on their plots (Coomes et al., 2011, 2017; Jakovac et al., 2015, 2016; Sirén, 2007; Wood et al., 2017). Although more intensive land use may threaten the sustainability of shifting cultivation systems, forest peasant households can adopt a series of resource substitution strategies to release land use pressure which include a diversity of secondary forest management practices, such as using orchards as fallows or production of charcoal (Coomes & Miltner, 2017; Wood, 2014), or the exploitation of floodplains (Coomes et al., 2022b, 2022a). The Boserupian land use transition appears to be a predominant response in these territories.

Nonetheless, increasing resource rivalry and further individual land appropriation had been also associated to land scarcity, contributing to greater inequality in the land distribution. Coomes et al. (2011, 2017) demonstrate that land scarcity drove an internal rush for land and higher asset inequality in their in-depth study of a folk community in the Amazon. In the face of land shortage,

households accelerated land claiming and secured possession over the remaining forest areas (Coomes et al., 2000, 2011). Further, the authors show that land accumulation processes did not equally benefit all the households: the land poorer families not only got to claim less land than the more privileged but also acquired plots in areas much less suited for agricultural use. In time, whereas land-size inequality has moderated due to inheritance and land transferring, land-use poverty traps arose as a more permanent consequence of land scarcity (Coomes et al. 2011).

Other studies suggest that land scarcity can be associated with transformations in local land governance and property regimes. Herz (2018) and Sarmiento Barletti et al. (2021) observe full privatization of land rights and the emergence of land markets in Indigenous territories facing scarcity, alongside other factors such as encroachment and indebtedness. Conversely, Oldekop et al. (2012) and Sirén (2007) find that formal communal arrangements or institutions are articulated to manage the scarce forest lands under common-good criteria. In general, as contention over land increases, disputes over common versus individual land rights are likely to emerge as a result of land scarcity.

In sum, research to date in Amazonia indicates that land scarcity can drive various multilinear shifts in local land dynamics. Land scarcity does appear to increase the rivalry over land in Indigenous and folk settlements; however, its impacts can vary depending upon local circumstances. The features of local agrarian systems - land use practices, internal land distribution structure, the land access and property regimes in force - and the processes they are subjected to, are critical in shaping land scarcity impacts (Coomes et al., 2011; Scoones et al., 2019).

3.5 Analytical framework

Understanding the transformations driven by land scarcity in local agrarian systems requires consideration of how the land supply is managed in Amazonian communities. In this section, I briefly characterize (Indigenous and non-Indigenous) forest peasants of Amazonia and summarize the state of knowledge regarding peasant land dynamics, specifically in the context of collective territories. I focus on two dimensions of land dynamics -- land accumulation and land use.

3.5.1 Amazonian peasants

As with other peasantry groups elsewhere, Amazonia peasants partially rely partially on a subsistence-based economy to sustain their livelihoods. Amazon peasants are dedicated to shifting

cultivation agriculture, cattle ranching, and other activities such as hunter-gathering, fishing, timber, and non-timber extraction (Coomes et al., 2016). Their monetary income comes from surplus production sales, seasonal wage labor, and State transfers (Coomes et al., 2016; Le Torneau, 2015).

Amazonian peasants, especially Indigenous peoples, often reside in collective territories referred to under different denominations according to country, e.g., native communities (Peru), indigenous lands (Brazil). These territories fall under the category of commons (Chhatre & Agrawal, 2008), "...forests for which the boundaries of the resource, the identity of the user group, and property rights to benefit from the resource are well defined." (Chhatre & Agrawal, 2008: 13286). Whereas the community owns the territory, families individually hold agricultural land by usufruct (Takasaki et al., 2014). With few exceptions (see Sirén, 2007; Oldekop et al., 2012), strong community-level governance over agricultural land is not a common feature encountered in Amazonian collective territories, nor are land markets (Cronkleton & Larson, 2015; Lu, 2001). Rather, individual land management is subjected to informal moral and customary conventions acknowledged by all land users.

3.5.2 Land accumulation

The two most important mechanisms for land accumulation of Amazon peasant households are land claiming and transferring through gifting and inheritance (Brown, 1984; Descola, 1994). To claim land, families drawn on their own household labor and collaboration of their extended relatives to clear and burn a patch of old-growth forest and convert it into agricultural land (Perz et al., 2006; Takasaki et al., 2014). In turn, receiving/giving land from/to other relatives or neighbors, usually as a gift, is also a widespread practice (Brisson, 2003). Through gifting, a plot could have several owners during its productive life, indicating that land circulation among Amazon peasants can be highly dynamic.

Land rights are derived from the labor force invested in clearing the forest and secured by continuous usufruct (Bremner & Lu, 2006; Cronkleton & Larson, 2015; Lu, 2001b). Depending on the ethnicity of Indigenous households, the duration of land rights varies: land tenure rights can last until the household leaves the community (Coomes and Burt, 2000) or can be recognized throughout generations to the same kin (Lu, 2001b; Pinedo-Vásquez et al., 2012).

Both ecological and economic factors play a part in peasant land accumulation. Amazon peasants accumulate land along the trajectory of the household life cycle (López-Carr et al., 2005; Perz, 2001b; Perz et al., 2006)[35]. The persistence of this classic Chayanovian pattern reflects the fact that Amazon peasants increase or decrease their land endowments according to their income/consumption needs (Ellis, 1993). Besides the age of the household, Coomes et al. (2011) found that the initial land holdings, i.e., the amount of land held when the household was initially formed, also matter in the subsequent land accumulation. Other variables have the opposite effect and slow household land accumulation. The greater distance to plots and the high opportunity cost of producing on less accessible lands constrains upland accumulation (Sirén, 2007). Similarly, the availability of floodplains - where soils are more fertile - offsets the need for land expansion in old-growth forest (Coomes et al., 2022b, 2022a).

In sum, the households' ability to access and accumulate land depends directly on the family labor endowments and kin networks. Further, the household decisions related to land accumulation are conditioned by their stage in the life cycle, initial land endowments, accessibility to plots, and availability of land on the floodplain.

3.5.3 Land use

As for land accumulation, ecological factors strongly condition Amazonian peasant land use. The productivity of land depends primarily on the natural fertility of nutrient poor Amazonian soils (Jakovac, 2016) but is highly path-dependent based on previous use. Path-dependency is a marked feature of secondary forest succession, such that the management of specific vegetation species allows/precludes the growing of others in the subsequent phases (Coomes et al., 2011b; Denevan et al., 1988; Pinedo-Vásquez et al., 2012).

To adapt to low soil fertility and secondary forest path-dependency, peasant households practice shifting cultivation agriculture, an agricultural system where the land cover cyclically rotates from crop/orchard stages to more extended periods of fallow (Denevan et al., 1984; Denevan et al., 1988). A long fallow period allows soil fertility restoration for the next cropping phase and household access by usufruct to non-timber and timber species (Wood, 2014; Wood et al., 2017).

[35] In frontier settlements, pioneering households accelerate land accumulation as a way to quickly build their asset holdings in the new settlement (López-Carr, 2004).

Amazon peasants can compensate for short-length fallows by manipulating orchard and fallow stages to provide similar ecosystem services and economic benefits as does a long fallow (Coomes & Miltner, 2017; Wood, 2014). Overall, forest peasant households deploy an array of strategies to control the use of land in a highly complex ecosystem such as Amazonia. Given the strong path dependency of shifting agriculture, households' initial land endowments could be critical in shaping household decisions on crop allocation and stage duration. Initial land-size poverty can lead to land-use traps and unsustainable land uses over time (Coomes et al. 2011, 2017).

3.6 Methodology

3.6.1 Study area

This study was conducted in two Indigenous territories[36] situated along the Napo River, a left bank tributary of the Amazon River, about six hours travel by riverboat to Iquitos (capital city of the Department of Loreto), in the northeast of Peru. The communities of Tamboruna and Solidaridad (pseudonyms) originated as rubber estates, where Indigenous kin were settled under the domination of *patrones* to extract rubber, rose wood, and other forest commodities. The settlements obtained their legal registration in 1919 and 1952, respectively, and their territories were titled in 1976 (Tamboruna) and 1975 (Solidaridad) as part of the Peruvian Agrarian Reform. This event marked the definitive expulsion of *patrones* and the initiation of local governance over the community territory. By 2022, Tamboruna comprised 79 households (369 individuals) and encompassed 2447 ha of land; Solidaridad had 34 households (158 individuals) and a total of 1969 ha of land[37]. People in Tamboruna identify predominantly as Kichwa del Napo, the largest ethnic group in the Napo basin whereas the people of Solidaridad are Murui-Munuane (previously known as Huitoto), a minority in the basin.

Tamboruna and Solidaridad can be categorized as upland (*terra firme*) communities. Between 60% and 70% of their territory lies on the upland; the remaining area is located in the seasonally inundated lowland. The agricultural area in the community, including fields, fallows, and other clearings encompasses 515.6 ha in Tamboruna and 620 ha in Solidaridad, representing 21% and

[36] Legal denomination of an Indigenous territory in Peru is a *Comunidad Nativa (CCNN)*.
[37] The original titled territory of Solidaridad was 969 Ha, however, the community had historically occupied areas beyond its boundaries. In 2022, a legal expansion of 1,000 ha was granted to Solidaridad, recognizing the actual extension of the settlement.

31% of their total territory, respectively. As expected, most of the agricultural area (about 70% of the cultivated and fallow lands) is found on the upland in both communities.

(1)

(2)

Figure 3. 1 Territories of the Indigenous communities of Solidaridad (1) and Tamboruna (2)
Satellite imagery from Google Earth Pro (2022); community territory boundaries elaborated by Instituto del Bien Común (2016).

As found typically in many Indigenous communities of Amazonia (Thiede & Gray, 2020), Tamboruna and Solidaridad have a pre-transitional demographic structure, with nearly half of the community's population under 15 years old, but their respective population growth trajectories

have diverged notably over the past 30 years. The population in Tamboruna has nearly doubled between 1981 and 2022 -- from 36 to 80 households -- mainly due to the growing presence of State services (i.e., high school, telephone antenna, public electricity), which attracted in-migrants and encouraged young people to remain in the community. In contrast, the population in Solidaridad has remained relatively consistent (~35 households) over the same period.

Households in both communities are income poor[38]. In 2022, households in Tamboruna had a mean yearly income of 5,747 USD (median of 4,760 USD), and in Solidaridad, an average income of 4,288 USD (median of 3,983 USD). More than 40% of the people in both communities lived in poverty earning less than 2.68 USD per day, and nearly 10% lived in extreme poverty earning less than 1.65 USD per day[39]. Agriculture and other complementary farming/extractive activities -- cattle ranching, fishing, hunting, timber, and non-timber extraction -- are the most important income sources for households in the two communities and contribute on average about 70% of household income. Maize, yuca, plantain and sugar cane are the most important crops in both communities. In addition, Solidaridad is well-known in the middle Napo for the production of pineapple, yuca *brava* (*manihot carthaginensis*) and manioc flour (*fariña*). State cash transfers[40] and wage labor - e.g., seasonal migration to work on oil palm plantations - are the second and third most important income sources, respectively. Neither the State nor NGOs have implemented long-standing initiatives to promote economic development in either community.

Agricultural land is the most significant asset held by residents of Tamboruna and Solidaridad. The average agricultural area per household is 6.4 ha and 4.3 ha in each case, with most of the holdings (between 60% and 70%) being allocated in the upland. Although households in both communities hold similar shares of lowland, their holdings differ such that families in Tamboruna hold similar shares of lowland in high levees or *restinga alta*[41] (55% on average) and on low levees or *restinga baja* (45%) whereas families in Solidaridad hold most of their lowland in *restinga baja*

[38] Household income was estimated by summing the monetary value of all agricultural and forest products produced/extracted by the household (for subsistence and for sale), salaries from wage labor, cash from State transfers received, and remittances received (in cash or assets).
[39] Poverty lines for rural Amazonia established by the National Institute of Statistics and Information Peru (INEI, 2023).
[40] State cash transfers have become a highly relevant income source for indigenous households in Peru and throughout the Amazon basin (Hecht, 2014). Since the COVID-19 pandemic, the Peruvian State has increased the number of cash transfers to support rural households.
[41] *Restinga* is the local term for river levees. *Restinga alta* refers to a high leeve, one that is only periodically flooded during high water season. *Restinga baja* refers to a low levee which are typically flooded every year (Coomes, 1992).

(75%). As such, lowland plots among households in Solidaridad are more exposed to seasonal flooding.

The forest area available for agricultural land[42] (i.e., unoccupied by houses, swiddens, orchards, fallows, or any other type of agricultural plot) differs markedly between the two communities. In 2022, the total available land in Solidaridad was 1319 ha or 38.7 ha per household. In contrast, the corresponding available forest area in Tamboruna was 414 ha or only 5.2 ha per household. The smaller area of available forest in Tamboruna is due to a larger population but also - and importantly - because nearly half of its territory (1193 ha) has been set aside for forest conservation under an agreement between the State, an international NGO (US Rainforest) and the community as part of a settlement for a complex environmental crime in which Tamboruna was involved in the 2012. In addition, 276 ha of land in the northwest is occupied by Tamboruna's Annex, a group of families which split from the original community due to kin conflicts. As such, residents in Tamboruna face acute land scarcity compared to Solidaridad.

3.6.2 Data collection

The Research Ethics Board Office of McGill University approved the methods proposed for this study (REB# 22-06-019). A reconnaissance trip was first made in the Peruvian Amazon during July of 2022 to present the project to the Indigenous federation of the Napo basin *(Federación de Comunidades Nativas del Medio Napo, Curaray y Arabela* – FECONAMNCUA) and the candidate communities for study. The research team obtained the approval of both FECONAMNCUA and the community assemblies of Tamboruna and Solidaridad.

Data were gathered during three months, between August and October of 2022, by A.L.A.R with the assistance of J.H.E, a Peruvian social scientist. J.H.E. assisted with administering the data collection tools in the two communities. A structured questionnaire was administered to the households practicing shifting cultivation agriculture in both communities. The survey was conducted in Solidaridad with all 34 households. In Tamboruna, a sample of 40 peasant households (of 79 households in the community) from the five neighborhoods was non-randomly selected.

[42] Drawing on Littleboy (2022), the forest area available for agricultural land was calculated by deducting areas already in use by houses, agricultural plots, concessions or other incumbrances from the total community territory. The result was then divided by the number of households to account for the differences in population density between the two communities.

The number of households interviewed was determined by the total number of families in each neighborhood and then upon their availability.

The questionnaire addressed the following topics: household demographics; kin group size and composition; participation of the household in community governance; income; land holding (initial and current); labor availability; and, access to natural assets. For land holdings, we documented the size, land cover, distance from home (in minutes), years under cover type, and how the land was acquired (claimed or transferred) at two points in time, the year of the fieldwork (2022) and the year of household formation. Household land accumulation can be inferred by comparing initial and current land holdings.

In addition to the household survey, a survey was conducted of one plot per household participating in the study. Plots were selected based on proximity to the home[43] and the availability of respondents. Respondents reported the long-term land cover history (type of cover and duration of the cover) for the selected plot on 40 fields in Tamboruna and 34 fields in Solidaridad.

For our analyses, households were grouped according to age and land endowments. The wife's age was selected as a proxy of the age of the household, this variable better captures household age and the number of dependents number than the number of years since household formation. Cohorts for household age were defined as: young (wife's age between 15-29 years old); young adult (30-44 years old); mature adult (45-59 years old); and, elderly (60+ years old). Households were grouped into land endowment classes for current and initial holdings as defined by terciles of the land distribution in each community (land poorer; land middle; land richer).

As some fallows in household land portfolios were still ongoing at the time of the study, I used a triangulation method to assess household fallow management. For completed fallows, I recorded for each household the (1) the age in years in fallow of the most recently opened plot; and (2) the age in years in fallow of the upland plot visited[44]. I added two more variables accounting for incomplete fallows per household: (1) the average fallow age of current fallows (i.e., incomplete fallows); and (2) the age-weighted average fallow area. The latter weights each fallow plot's area

[43] Plots could be located up to two hours' walk from the houses. For the safety of the research team, priority was given to plots closer to the houses.
[44] The sample fields selected for plot survey.

by its current length in years, creating a more area-sensitive measurement of incomplete fallow length.

3.6.3 Analytical strategies

To analyze the relationship between land scarcity and Indigenous land management, this study employs a quasi-experimental design in which two upland native communities with distinct levels of land scarcity are compared. The communities were selected based on the information provided by local NGO officials and indigenous leaders of the Kichwa indigenous federation in the Napo Basin (FECONAMNCUA). Solidaridad -- where land is still relatively availability and land use are driven by regular drivers of land demand (i.e., demographics and market integration) -- is our comparison community. Tamboruna is our experimental community where available land is scarce because of population growth, community fissioning and the conservation covenant described previously.

My analyses were conduct in two steps. I first described and compared household land holdings, land accumulation, and land use patterns between communities and within community groups. Given that household land holding data are highly skewed (common in smallholding agriculture, see Figure 3.2), I used the non-parametric Kruskal-Wallis test for community comparisons. The Gini coefficient was calculated to assess land inequality (for initial and current land holdings) in each community. In this first analytical stage, I aimed to identify household land management differences in terms of land holding, land accumulation and land use/cover between communities.

In the second step, I used OLS multivariate regression models using Stata/BE^{TM} (v. 17) to assess the association of land scarcity with land accumulation and land use outcomes at a household level. Two hypotheses were tested:

(1) A hypothesis drawing on Neo-Malthusian economics, in which land scarcity fuels further individual land appropriation of the remaining forest (Fairhead & Leach, 1995; Galaty, 2016; Hardin, 1968): households in the land-scarce community are expected to have increased their land holdings and accelerated land accumulation.

(2) A Boserupian hypothesis, by which land scarcity is linked to land use intensification (Boserup, 1965): households in the land-scarce community reduced the number of fallow

holdings, decreased the duration of the fallow or accelerated the rotation between cropping and fallow phases.

Regression analysis allowed us to determine whether Indigenous households facing contrasting scenarios of land availability exhibit different land management patterns, even when controlling for other household-level characteristics. The resulting evidence, in dialogue with the literature reviewed, provides the basis to discuss the potential association of particular land management practices with land scarcity.

The general version of the model is:

$$HH\ Land\ Management_i = \beta_0 + \beta_1 \cdot LandScarcityCase_i + \beta_2 \cdot HHAge_i + \beta_3 \cdot HHLabor_i + \beta_4 \cdot HHKinLabor_i + \beta_5 \cdot HHInitialLand_i + \beta_6 \cdot HH\%Lowland_i + \beta_7 \cdot HHLandAccesibility_i + \varepsilon_i$$

HH Land management refers to outcomes related to (1) household land accumulation and (2) land use. The variables that capture the outcomes in land accumulation include total household land holdings (ha); upland holdings (ha), land holdings accumulated by transfer (ha), land holdings accumulated by claiming (ha), and the percentage of total land holdings claimed. Land use/cover outcome variables are the household fallow holdings; percentage of holdings in fallow; average age of swidden plots, age-weighted fallow area, average age of fallow plots, and age under fallow of the last plot opened.

All models include a fixed effects variable ($LandScarcityCase_i$) to capture the effects of community characteristics (0: comparison community, 1: treatment community). Both settlements have similar social organization, geophysical features, distance to the market, and State presence on their territory. The marked contrasts between them lie in the age of each community, the area of community territory, population size, and the constraints on land use (in Tamboruna); all of which can be associated with a relative land availability. The fixed effect variable thus captures these non-controlled community-level differences, including the degree of land scarcity[45].

[45] Given the multiplicity of factors determining land availability, and the progressive nature of land scarcity (an issue that builds up in time over a territory), isolating the effects of land scarcity presents a significant challenge for

My model controls for household characteristics which include the age of the household (and age squared), the number of adults in the household (aged 15-64 years), the number of dependents in the household (≤14 years old, and ≥65 years old), the size of the household kin group[46] (as a proxy of labor endowments), the initial land holdings (ha), the percentage of total holdings in the lowland, and the average distance to household plots. The dependent variables were *log* transformed to normalize their distribution when appropriate. Robust regression models were used so as to re-weight the outliers when may distort the normality of distribution of the model errors.

The choice of the independent variables was guided by knowledge about peasant land management dynamics and the features of the study area. The models test whether land accumulation and land use outcomes are related to classical factors in peasant economics, specifically the household life cycle stage and labor endowments (both from nuclear and extended relatives). Following Coomes et al. (2011), the relevance of the household initial land holdings was also tested. The percentage of lowland holdings was included to capture the differential access to high levees between both communities. Finally, I included a variable to capture the accessibility of the plots (distance) as a constraint on land accumulation decisions.

3.7 Results

3.7.1 Land holdings

On average, households in Tamboruna hold 8.5 plots with an average area of 6.4 ha. The mean area per plot per household is 1.1 ha, indicating a high level of land fragmentation[47]. Most household holdings are found in the upland (a mean of 4.7 ha, 64% of the household area), whereas only 1.8 ha are located in the lowland (36%) (Table 3.1). Within the lowland, the working area per household is evenly distributed between high levees (0.8 ha on average, 55%) and low levees (0.9 ha on average, 45%).

In testing for differences between the communities, I found that household land holding size, number of plots, upland and lowland holdings, and the average area per plot were not statistically

quantitative research. Time-series and multilevel approaches offer robust alternatives for modelling land availability in future investigations.

[46] The number of relatives of second and third degree relatives alive and inhabiting in the communities.

[47]Land fragmentation occurs when agricultural farms are composed of numerous plots of small size. Fragmentation of plots is a typical characteristic of peasant agriculture, and in Amazonia is part of the diversification strategy of households.

different (Table 3.1). As such, households in both communities have, on average, similar land endowments, which are allocated predominantly in the upland and with considerable fragmentation. Two differences though did emerge that are statistically significant: (1) the percentage of upland area is significantly higher in Solidaridad; and, (2) households in Tamboruna hold substantially more land on high levees (Table 3.1). This initial finding indicates that the greater availability of *restinga alta* in Tamboruna (a distinct feature of this community in comparison to Solidaridad) may offset the need for upland accumulation, a substitution effect found across other communities along the Napo River (Coomes et al., 2022a).

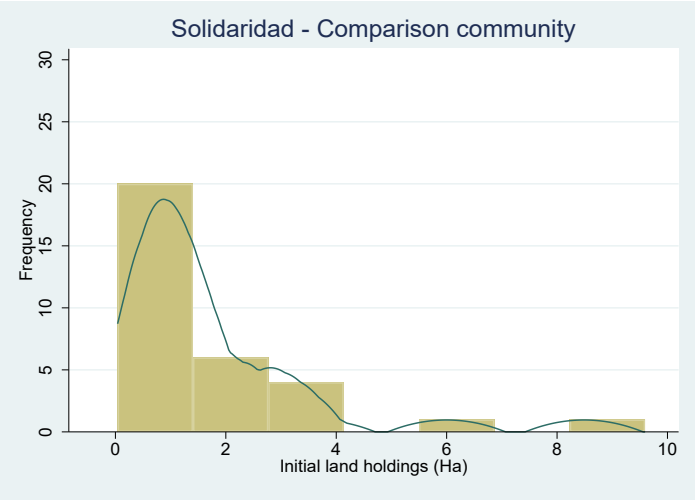
3.7.2 *Land accumulation*

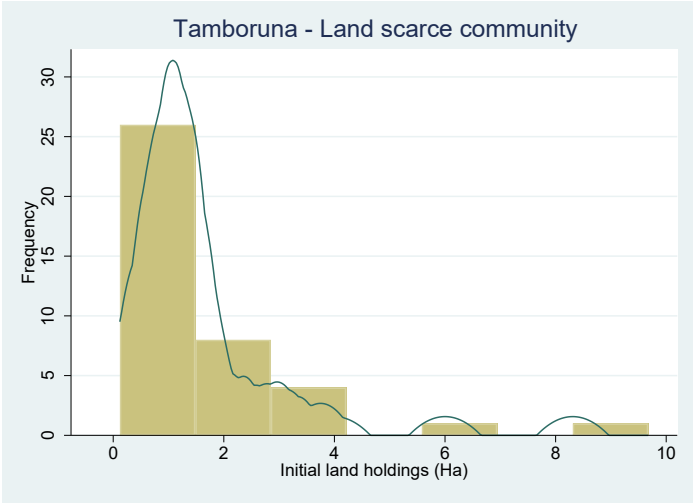
At formation, households in Tamboruna held a mean initial area of 1.6 ha, of which 61% was in the upland and 39% in the lowland. From the time of household formation to 2022 (when the fieldwork was conducted), households in the treatment community increased their land holdings by 4.8 ha on average. The upland area increased by 3.6 ha, and the lowland area by 1.2 ha. No statistical difference with Solidaridad was found in the size of initial land holdings or the area variation (Table 3.1). Thus, households in both communities started with similar land endowments and increased land holdings to a similar degree (Figure 3.2).

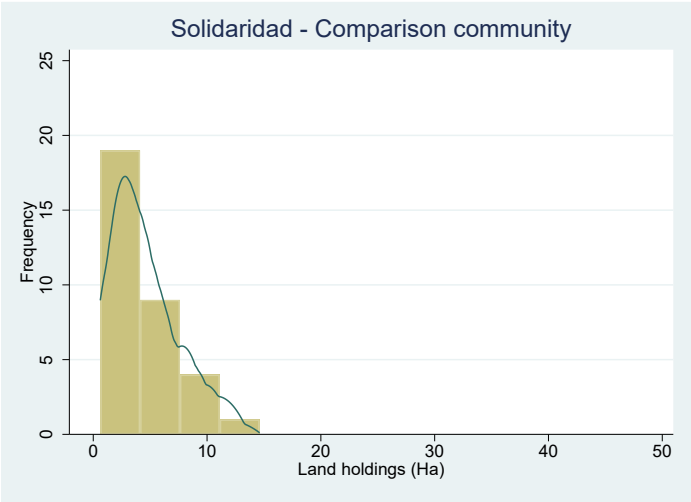
The means of land acquisition – by claiming from forest or land transfers – were analyzed for each community (Figure 3.3). In Tamboruna, the area claimed from forest rose sharply through time (+ 3.1 ha per household on average), primarily on the upland. Land accumulation by transfers also rose over time at a slower rate (+1.6 ha per household on average) and occurred predominately for land in the lowland (+1.1 ha on average). No statistically significant differences were found with Solidaridad in the mean variation in the area claimed and received. However, in Tamboruna, the average variation in the upland area claimed is higher, and the average variation in the upland received by transfer is lower than in Solidaridad. This finding suggests that land accumulation in the upland occurred predominantly through claiming of forest in Tamboruna whereas households in Solidaridad accumulated upland primarily through land transfers.

Table 3. 1 Characteristics of land holdings in Solidaridad and Tamboruna, Napo River

	Solidaridad - Comparison Community					Tamboruna - Land-scarce Community					Kruskal-Wallis
Variable	**Mean**	**SD**	**Min**	**Max**	**Obs**	**Mean**	**SD**	**Min**	**Max**	**Obs**	**chi^2**
Land holdings (ha)	9.4	5.0	3.0	23.0	34	8.7	3.7	1.0	17.0	38	0.014
Number of plots	4.4	2.9	0.6	11.9	33	4.4	3.8	0.3	19.5	37	0.010
Upland holdings (ha)	3.4	2.3	0.1	10.0	33	2.5	2.1	0.0	10.8	37	1.886
Lowland holdings (ha)	1.0	1.1	0.0	4.5	34	1.9	2.7	0.0	15.2	37	2.573
Lowland holdings – high levee (ha)	0.4	0.9	0.0	4.0	33	0.9	1.2	0.0	4.7	38	10.754***
Lowland holdings – low levee (ha)	0.7	0.9	0.0	4.5	34	0.9	2.6	0.0	15.2	37	0.351
% upland holdings	0.8	0.2	0.2	1.0	33	0.6	0.3	0.0	1.0	37	3.606*
% high levee - lowland holdings	0.3	0.4	0.0	1.0	32	0.6	0.4	0.0	1.0	33	7.582***
Average area per plot (ha)	0.6	0.4	0.1	2.0	33	0.5	0.5	0.1	2.4	37	0.002
Land claimed (ha)	1.7	2.2	0.0	10.3	33	2.2	2.2	0.0	11.0	37	2.998*
Upland claimed (ha)	1.2	1.7	0.0	5.8	33	1.7	2.1	0.0	10.8	36	5.583**
Land received (ha)	2.7	2.5	0.0	8.9	33	2.1	3.2	0.0	18.5	36	2.232
Upland received (ha)	2.2	2.1	0.0	8.9	33	0.7	1.0	0.0	4.6	36	14.008***
% Land claimed	0.3	0.4	0.0	1.0	33	0.6	0.4	0.0	1.0	35	3.621*
Initial land holdings (ha)	1.7	1.7	0.0	8.5	32	1.6	1.6	0.1	8.3	38	0.037
Variation in land holdings (ha)	2.6	2.8	-2.5	11.6	32	2.7	4.0	-5.4	18.0	37	0.062
Variation in land claimed (ha)	1.1	1.6	-0.8	7.3	32	1.0	2.7	-7.2	9.5	37	0.261
Variation in upland claimed (ha)	0.6	1.2	-1	5	32	3.1	10.1	-7.15	52	38	3.916**
Variation in land received (ha)	1.5	2.1	-4.3	8.6	32	1.6	3.0	-0.8	17.0	36	0.288
Variation in upland received (ha)	1.4	1.8	-0.9	8.6	32	0.5	1.0	-1.4	4.6	38	6.204***
Active land holdings (ha)	2.0	1.7	0.5	8.3	33	1.8	2.7	0.0	16.3	35	1.847
Fallow land holdings (ha)	2.4	2.4	0.0	8.5	33	2.6	2.1	0.0	9.0	35	1.317
% Fallow land holdings	0.5	0.3	0.0	0.9	33	0.6	0.2	0.0	1.0	35	3.392*
% Upland fallow holdings	0.5	0.3	0.0	0.9	33	0.7	0.2	0.0	1.0	35	11.023***
Average age of swidden	1.3	0.9	0.5	4.1	33	0.9	0.8	0.1	5	39	8.047***
Years in fallow of the last plot opened	22.1	14.7	2.0	50.0	28	6.9	7.4	0.0	30.0	32	19.804***
Years in fallow of upland plot visited	21.5	13.3	1.5	40	28	6.9	6.1	1	20	16	11.750***
Average age of fallows plots	12.7	11.1	1.4	55	30	7.4	5.2	1.2	22.2	38	5.366**
Weighted fallow area	3.5	3.8	0.4	18.3	29	2.3	3.5	0.2	20.0	33	4.960**







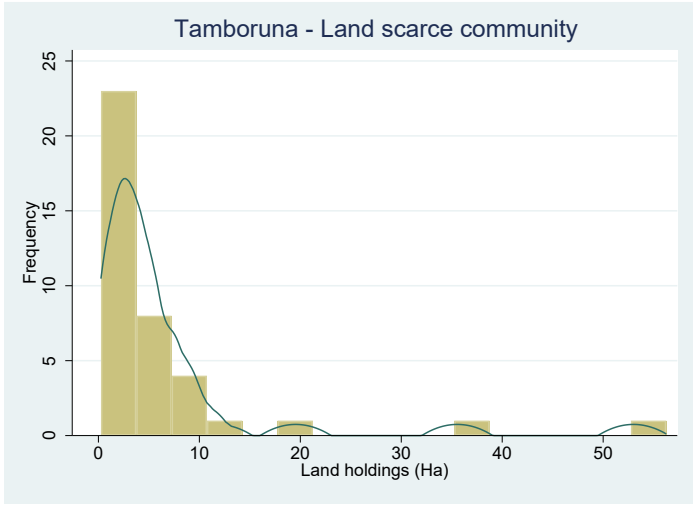


Figure 3. 2 Distribution of initial and current land holdings by community
Comparison: Solidaridad; Treatment: Tamboruna

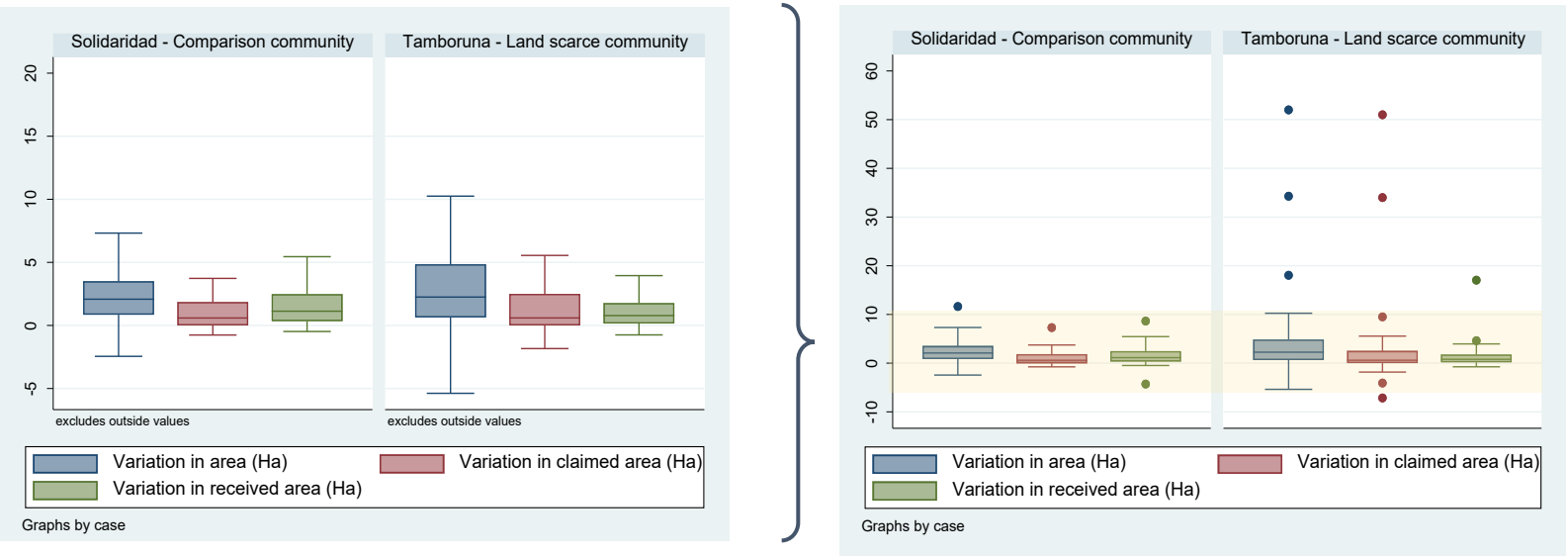


Figure 3. 3 Land accumulation by means of acquisition by community

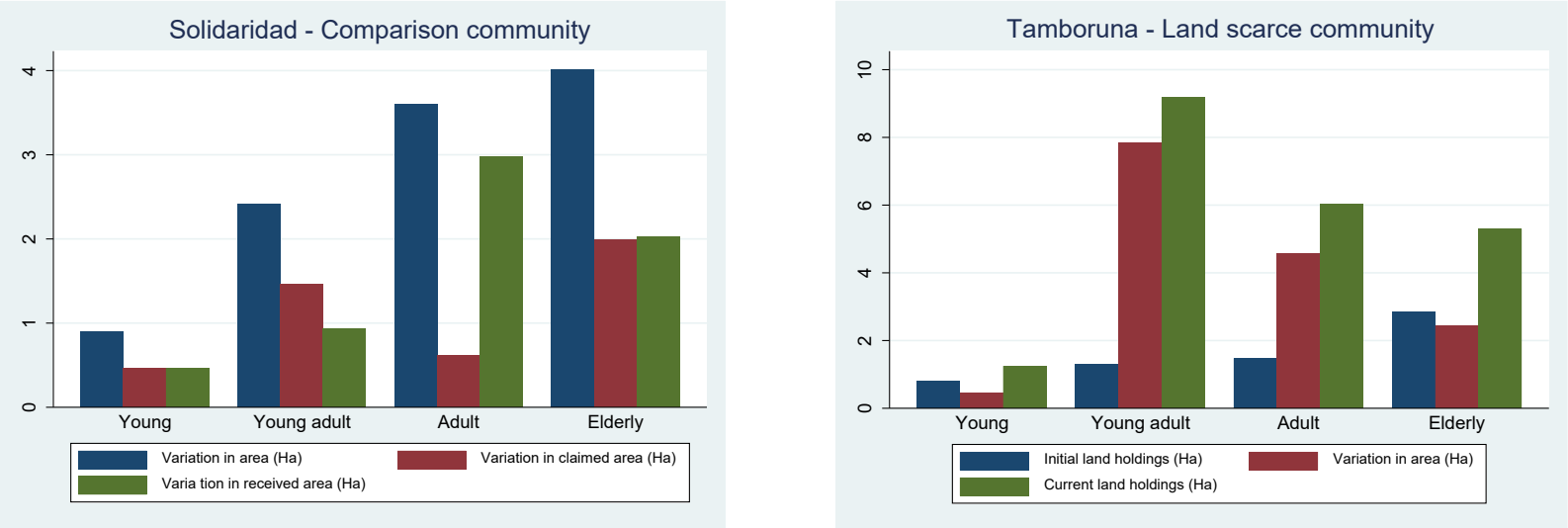


Figure 3. 4 Average initial land holdings, land accumulation, and current land holdings by age group in Solidaridad and Tamboruna

Land accumulation in Solidaridad follows the classical Chayanovian pattern through the household life cycle - with increasing age, households progressively hold more land (Figure 3.4). In Tamboruna, land accumulation dynamics are sharply different. Young households have accumulated only a very small amount of land (+0.5 ha) compared to older households, and especially among young adult households (+7.8 ha). Although young adult households began with a smaller initial land endowment than the same age group in Solidaridad, they have accumulated on average more than twice the amount of land. Land accumulation rates were also low among elderly households (+2 ha), possibly reflecting some deaccumulation of land by transfers to adult children. Clearly, young adults in Tamboruna have raced ahead of others in acquiring land, much of it through claiming of forest upland.

3.7.3 Land use and cover

Households in Tamboruna held a mean area under active cultivation (crop land) of 2.7 ha (41% of total holdings) and fallow area of 3.8 ha (59%). Fallow cover is more extensive in the upland: on average, 3 ha or 65% of upland holdings are in fallow. In the lowland, land is more actively used with 60% (1.1 ha) of household lowland holdings under cultivation. No statistically significant differences were found compared to Solidaridad in the size of cultivated area or active and fallow holdings per household. However, the percentage of the area under fallow and the percentage of upland area under fallow were higher in Tamboruna, suggesting that households in this community may be building up the stock of fallow land on the upland for future use. The availability of high levee land may also explain why households are leaving a larger share of their upland land holdings in fallow.

In addition to the larger share of fallow in Tamboruna, the fallowing period tends to be shorter in this community than Solidaridad (Figure 5). In Tamboruna, the average length of household fallows was 7.4 years; and the fallow length of the last plot opened and of the upland plot visited was 6.9 years. These data point to a mean fallow length of about 6-8 years in Tamboruna, compared with 12-22 years in Solidaridad. Concurrently, the duration of the cropping phase is also significantly shorter in Tamboruna: the average age of swiddens is only 0.9 years in comparison to 1.3 years in Solidaridad (Table 3.1). Taken together, these results suggest fallows are terminated earlier and fields are cycled faster in the community.

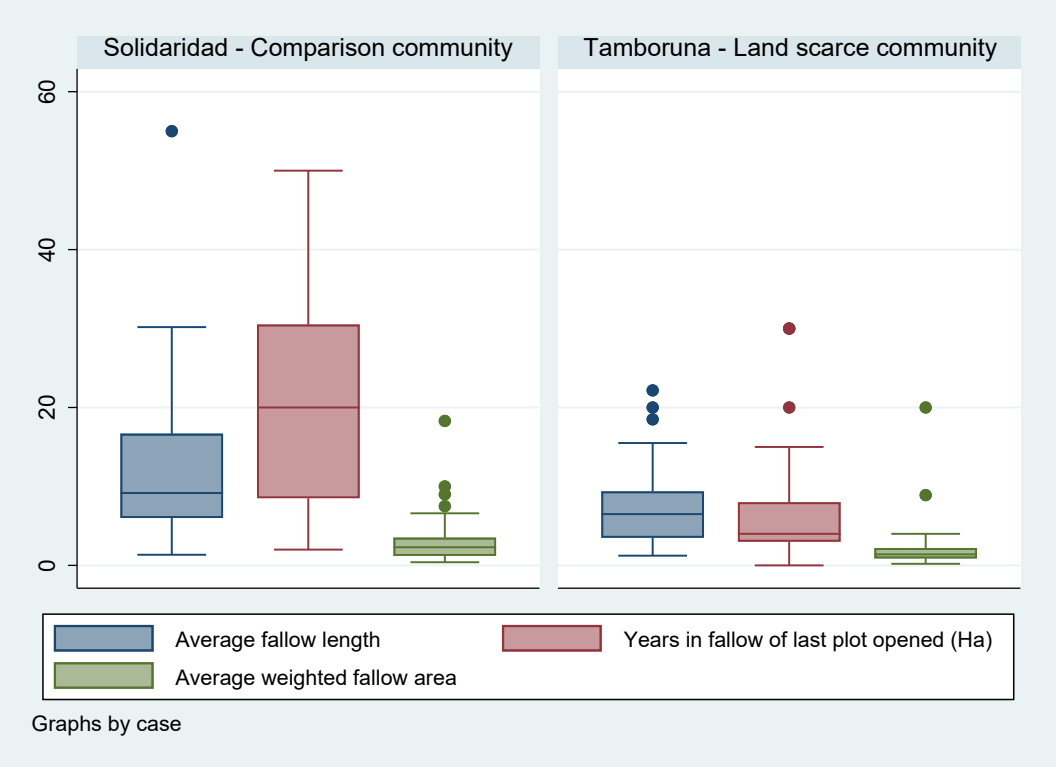


Figure 3. 5 Fallow length in years in Solidaridad and Tamboruna

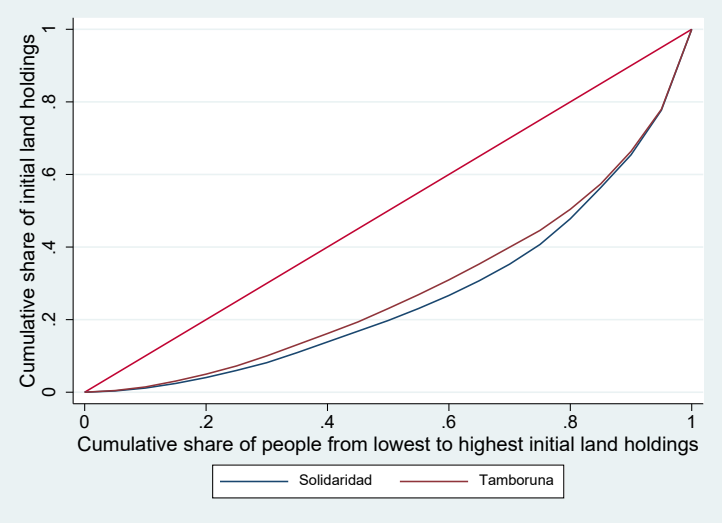
3.7.4 Land inequality

Land inequality in Solidaridad is relatively moderate for total holdings as well as upland holdings (Gini: 0.37 and 0.36, respectively) though land holdings in the lowland are more unequally distributed (Gini: 0.54) (Table 3.2). Comparing the initial and current distribution of total and upland land holdings, we find that inequality has decreased over time. The practice of land transferring among relatives may explain why land holdings today are more equally distributed than in the past.

Table 3. 2 Gini inequality coefficients on initial and current land holdings in Solidaridad and Tamboruna

	Solidaridad	Tamboruna
Initial land holdings		
Total area (Ha)	0.47	0.42
Upland area (Ha)	0.44	0.5
Lowland area (Ha)	0.61	0.41
Current land holdings		
Total area (Ha)	0.37	0.56
Upland area (Ha)	0.36	0.62
Lowland area (Ha)	0.54	0.55

(1)



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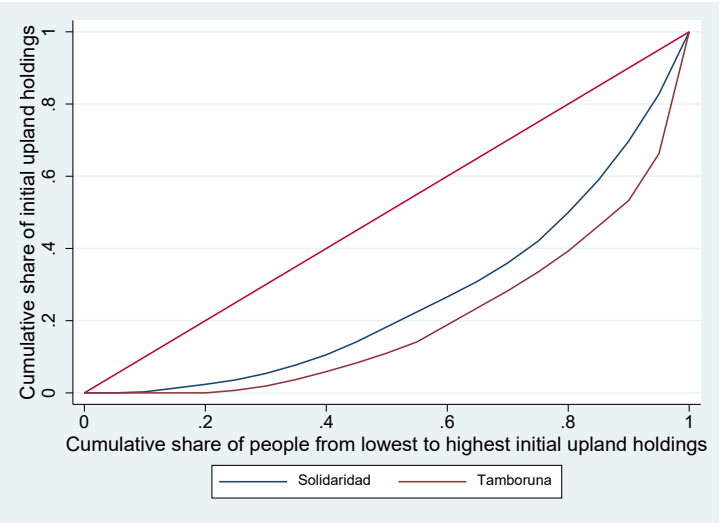

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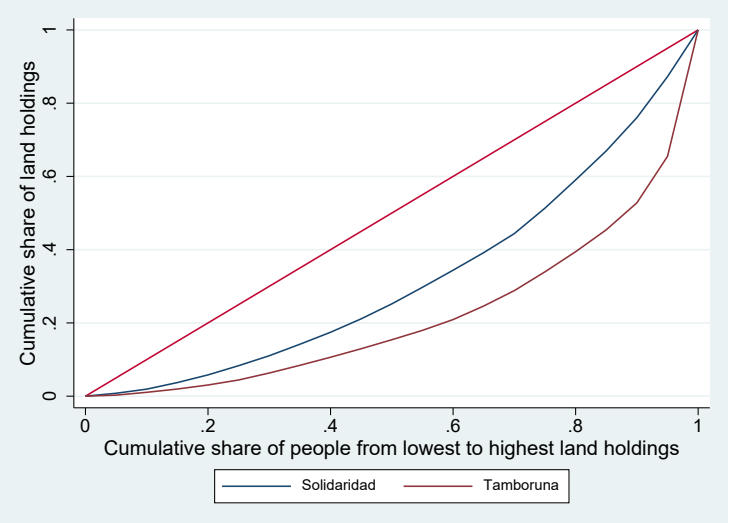

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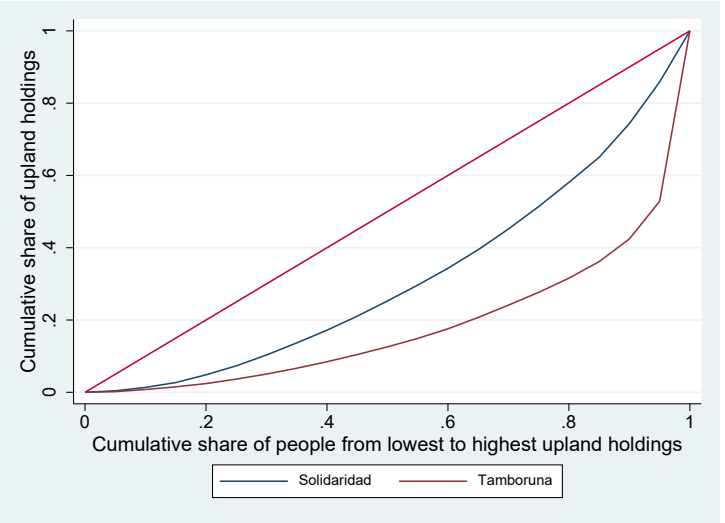

Figure 3. 6 Lorenz curves of land holdings among households in Solidaridad and Tamboruna

(1) Inequality in initial land holdings, (2) Inequality in initial upland holdings, (3) inequality in current holdings, (4) inequality in current upland holdings

In contrast to Solidaridad, land inequality is greater and has increased over time in Tamboruna (Table 3.2). The Gini coefficients on total land holding and upland land holdings are 0.54 and 0.62, respectively. In terms of land holding shares, the top 20% of land holding households hold 60% of the total working area and 70% of the upland area sampled (Figure 3.6). Although initial land inequality was similar between the two communities, total and upland land inequality is currently notably greater in Tamboruna. Again, a focus on the accumulation of increasingly scarce upland in Tamboruna and the differential ability of households to claim forest land may explain increased inequality. Land claiming on the upland appears to reflect the drive for asset accumulation over income needs.

3.7.5 Regression analyses

A series of OLS regression models were developed to estimate the effect of household characteristics and community membership on land holdings and land accumulation (models 1-5), and land use/cover (models 6-11) (Table 3.3). My regression models explain 8-40% of the observed variance in the dependent variables. Although none of the independent variables is a predictor across all the models, four of them contribute with consistency and statistical significance to one or both of the defined set of outcomes: (1) the age of the wife (proxy of the age of the household); (2) the percent of lowland in total land holdings; (3) the average distance to plots; and, (4) community affiliation (Solidaridad or Tamboruna).

The area of total land holdings is predicted uniquely by the age of the household (model 1). Similarly, upland holdings accumulated are determined by the age of household, but also by the number of dependents, and the percent total holdings in the lowland (model 2). Households in adult life cycle stages with more dependents (children and elderly), hold more land and upland. In contrast, households with a larger share of their holdings in the lowland, tend to hold less land on the upland. The mechanism through which land is accumulated is defined by a combination of factors, including the age of the wife, percent of lowland holdings, the distance to plots and community affiliation (models 3-5). Older households and those with a larger share of lowland area in their portfolio, hold more land that was received as transfers from other relatives. Where plots are more distant from the household, more land is accumulated through claiming, and less through transferring. Of note, even when controlling for household and land holdings

characteristics, households in Tamboruna are much less likely to receive land through transfers from other households (models 3 and 5).

Regarding land use/cover, households in Tamboruna have more land under fallow cover (percentage), and significantly shorter swiddens and fallow periods than in Solidaridad (models 7-11). Beyond community affiliation, fallowing characteristics have distinct determinants. The age of the household is a predictor of both the fallow holdings and average fallow length (models 6 and 9), relationships potentially mediated through the amount of land accumulated, older household tend to have more extensive the land holdings and thus a larger area under fallow cover and a longer fallow length. Interestingly, the percentage of fallow holdings is negatively related to the percentage of land holdings in the lowland (model 7), suggesting that households oriented more to lowland agriculture rely less on secondary forests on the upland.

Of note, household labor endowments and initial land holdings are not systematic predictors of land accumulation or fallow dynamics. The distance to plots, a factor presumed to constrain land accumulation also was not determinant in the household land holdings (cf. Sirén, 2007). Taken together, these findings suggest that most of labor effects may be captured through the age and composition of the household, but also, that less access to extended kin-related labor and more proximate lands are not a strong limitation for land acquisition. The disconnect between initial assets and current fallow dynamics is more difficult to interpret, given the high degree of path dependency known in shifting cultivation systems (Coomes et al., 2011). It is possible that other measures of the heterogeneity of initial land endowments (e.g., initial land type, forest status of initial land) would have significant effects on current land use patterns.

Our models indicate that community affiliation is the strongest and most consistent predictor of swidden-fallow dynamics (% fallow area, swidden, and fallow length). In contrast, belonging to Tamboruna does not determine household land holdings; the household life cycle remains as a the most relevant determinant of land accumulation trajectories, a focus on lowland agriculture tends to offset upland accumulation. In turn, land accumulation dynamics (i.e., mechanisms by which land is acquired) are linked to the household life cycle, geographical patterns, and community affiliation. Land transfers appear to be dominant over lowland holdings and for older households, whereas land claiming prevails in more remote areas and for households in Tamboruna.

Table 3. 3 Regression models predicting land holdings, land accumulation and land use patterns

	Hypothesis 1: Land accumulation outcomes					Hypothesis 2: Land use outcomes					
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
VARIABLES	Land holdings *(log)*	Upland holdings *(log)*	Holdings received *(log)*	Holdings claimed *(log)*	% holdings claimed	Holdings in fallow *(log)*	% holdings in fallow	Average age of swidden plots *(log)*	Weighted fallow area *(log)*	Average years in fallow	Age under fallow of recent plot opened
Age of the wife (years)	0.0343***	0.0316***	0.0279**	0.00733	0.00164	0.0372***	0.00541	-0.00363	0.0157	0.0262***	0.00301
	(0.0106)	(0.00978)	(0.0106)	(0.0117)	(0.00399)	(0.0125)	(0.00340)	(-0.53)	(0.0108)	(0.00845)	(0.0143)
Age of the wife *(squared)*	-0.000790	-0.000909**	-0.000541	-0.000375	9.38e-06	-0.000214	0.000120	0.000456	-0.000755	-0.00102***	0.000224
	(0.000485)	(0.000441)	(0.000495)	(0.000531)	(0.000182)	(0.000586)	(0.000159)	(-1.26)	(0.000475)	(0.000364)	(0.000609)
Number of adults	0.126	0.0816	0.139	0.0296	0.00268	0.276*	0.0629	-0.0512	-0.266**	-0.142	0.0872
	(0.119)	(0.109)	(0.123)	(0.131)	(0.0447)	(0.145)	(0.0392)	(-0.65)	(0.113)	(0.0860)	(0.142)
Number of dependents	0.0917	0.103*	0.00748	0.0456	0.00632	0.118	8.79e-06	-0.0455	0.0636	0.0204	-0.143*
	(0.0646)	(0.0587)	(0.0646)	(0.0707)	(0.0242)	(0.0760)	(0.0206)	(-1.09)	(0.0596)	(0.0468)	(0.0789)
Kin size	0.00248	0.000301	-0.000598	-0.0151	0.000232	0.00281	0.00135	0.0015	-0.00408	-0.0194**	0.00414
	(0.0125)	(0.0113)	(0.0124)	(0.0137)	(0.00467)	(0.0146)	(0.00395)	(-0.18)	(0.0114)	(0.00903)	(0.0172)
Initial land holdings (ha)	0.0357	0.0418	-0.00516	0.0687	0.00961	0.0337	0.00582	0.0451	0.0108	-0.0129	-0.00567
	(0.0657)	(0.0596)	(0.0662)	(0.0719)	(0.0246)	(0.0773)	(0.0209)	(-1.03)	(0.0603)	(0.0473)	(0.0762)
% of lowland holding	-0.467	-1.313***	0.805*	-1.005*	-0.764***	-0.774	-0.407***	0.138	0.468	0.209	0.220
	(0.464)	(0.446)	(0.462)	(0.508)	(0.174)	(0.553)	(0.150)	(-0.45)	(0.467)	(0.362)	(0.554)
Ave. distance to plots (mins)	-0.00550	0.00196	-0.0202*	0.0287**	0.0116***	-0.00623	-0.000827	-0.00533	0.00385	0.0126	-0.00895
	(0.0112)	(0.0104)	(0.0112)	(0.0123)	(0.00421)	(0.0132)	(0.00356)	(-0.71)	(0.0112)	(0.00882)	(0.0159)
Community *(0: Solidaridad; 1: Tamboruna)*	-0.0901	-0.228	-0.601**	0.284	0.296***	0.0793	0.147*	-0.354**	-0.419*	-0.432**	-1.325***
	(0.225)	(0.204)	(0.227)	(0.246)	(0.0841)	(0.272)	(0.0736)	(-2.38)	(0.214)	(0.164)	(0.281)
Constant	1.119***	1.017**	0.801*	0.0987	0.246	-0.00209	0.407***	0.189	1.283***	2.710***	3.034***
	(0.420)	(0.389)	(0.427)	(0.460)	(0.157)	(0.500)	(0.135)	-0.68	(0.413)	(0.321)	(0.514)
Observations	68	67	67	68	68	66	66	67	61	63	57
R-squared	0.244	0.340	0.253	0.225	0.387	0.285	0.266	0.209	0.259	0.485	0.407
adj R-sq	0.127	0.236	0.135	0.104	0.292	0.171	0.148	0.0842	0.128	0.398	0.293
F-Stat	2.086	3.269	2.149	1.868	4.067	2.486	2.253	1.675	1.977	5.549	3.580
Prob > F	0.0456	0.00285	0.0396	0.0751	0.000440	0.0182	0.0314	0.117	0.0616	2.29e-05	0.00186
Error (MSE)	0.824	0.747	0.821	0.902	0.308	0.959	0.260	0.533	0.740	0.587	0.935

Standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.10

3.8 Discussion

In this chapter, I analyzed household land management between a land-scarce community and a community where land remains available. Using regression analysis, I determined whether household land accumulation and land use/cover patterns are associated with community affiliation when controlling household demographics, household endowments, and land holdings characteristics.

My results show Indigenous households in the land-scarce community continue to accumulate and administer their land in a traditional Amazon peasant manner. Households accumulate land according to their consumption needs and leveraging the higher fertility of lowland soils. There is no evidence of unusual land-cover change: households still practice dynamic shifting cultivation, with most of their land holdings under fallow cover. I did though find evidence of a race for upland accumulation taking place in Tamboruna, led by households of young adult segment of the community possibly intending to offset weak initial land endowments and growing land scarcity. Regression analysis results show that the trend to accelerated land accumulation is not a generalizable to all households in Tamboruna, but rather limited to specific households. Concurrently, the predominant land access mechanism in this community is land claiming in old-growth forest, more so than land transfers. Taken together these results explain the high land and upland inequality observed in Tamboruna. Data on land cover/use, the evidence suggests households in Tamboruna are intensifying land use through the reduction of cropping and fallow period, a process which appears to be driven by increasing land scarcity. In parallel, households in this community are building up a stock of fallow land and thus hold more land in fallow.

In Tamboruna, as land scarcity arose in the community territory, land accumulation decoupled from household consumption needs and became related to increasing rivalry over land. However, this behavior was limited to initial land-poor segments of the community and may have occurred in waves; a result consistent with the findings of Coomes et al. (2020, 2011, 2017) in a non-Indigenous settlement. Nonetheless, a scenario of complete individualization of the remaining forest, and the neo-Malthusian scenario (Fairhead & Leach, 1995; Galaty, 2016; Hardin, 1968) has not been realized. The stronger constraints to old-growth forest access (e.g., accessibility, the expansion of conservation regimes), and the substitution effect of lowland exploitation over upland

accumulation (Coomes et al., 2022a) may contain further appropriation of the remaining forest. Moreover, collective arrangements regarding land governance and land distribution may arise to regulate the individual claiming of scarce upland forest as described in Oldekop et al. (2012). Finally, the further diversification of Indigenous households livelihoods in off-farm activities may stabilize the agrarian cover in the community (see Gray et al., 2020, Coomes et al., 2022a).

Consistent with previous findings in non-indigenous and Indigenous peasant settlements of Amazonia (Coomes et al., 2011; Jakovac et al., 2015, 2016; Sirén, 2007), my study shows that land scarcity is associated with higher land use intensity. Households in Tamboruna allow land to fallow only until the early stages, which is likely to result in an increase in the number of crop production cycles, the principal marker of soil fertility loss in swidden-fallow agroforestry systems in Amazonia (see Woods 2017]. The length of swiddens is as well diminished, suggesting that the capacity to sustain long cropping phases is already being affected, possibly leading to the constitution of land-use poverty traps (Coomes et al., 2011). Finally, land use intensification is occurring in parallel with secondary forest expansion in the upland. The mechanism behind this parallel trend is similar to the one described by Coomes et al. (2000) in a non-Indigenous community whereby as new forest land becomes less available, households tend to 'stock up' on land in the form of fallow fields while simultaneously accelerating rotational cycles. Overall, evidence from my study, combined with previous research (Coomes et al., 2011; Jakovac et al., 2015, 2016; Sirén, 2007), indicates that land use intensification is the most common adaptation strategy of forest peasant households facing land constrains, supporting the Boserupian hypothesis regarding land scarcity. This trend also implies that shifting cultivation systems may be particularly vulnerable to land-use poverty traps when it comes to meeting the challenge of incorporating new forest land into their cycle. In time, increased land use intensification may have significant environmental consequences for Indigenous agricultural systems, including secondary forest and soil degradation (Coomes et al., 2000; Jakovac et al., 2015).

Land scarcity gives rise to a complex feedback dynamic with respect to land inequality. Initial land inequality affects those segments of the community (i.e., newly-formed households, in-migrant households) that are most vulnerable to a decrease in land availability. As land scarcity increased over time, leading to waves of accelerated land accumulation, land-size inequality became much more pronounced in Tamboruna. As in the case of this settlement, communities where land

circulation is not an effective mechanism for land redistribution are likely to experience greater land-size disparities. Overall, these findings confirm that the local land access and distribution dynamics play a crucial role in shaping the development and ramifications of land scarcity and inequality (Coomes et al., 2011; Scoones et al., 2019)

In sum, the findings of this study coincide with those of the few previous studies that have addressed the issue of land scarcity among Amazonian communities. Specifically, land scarcity is associated with increased competition over land (Coomes et al., 2011; Sirén, 2007); the accumulation of fallowed land and resulting rise in land inequality (Coomes et al.; 2011, 2017); and land use intensification and an increase in the area of young secondary forest (Coomes et al.; 2000, 2011; Jakovac et al., 2015, 2016; Sirén, 2007). My research indicates Indigenous households' responses to land scarcity are multifaceted and multilinear, including both strategic land accumulation behavior in the remaining forest, together with land use intensification in the agricultural area already exploited. Further, this study demonstrates that Indigenous communities like non-Indigenous communities are similarly affected by land scarcity and have similar outcomes, regardless of ethnicity.

3.9 Conclusion

This study case reveals that Indigenous peoples of the Amazon are not immune to the challenges posed by land scarcity. Land scarcity is linked with critical transformations in household land management, such land use intensification, strategic land accumulation, and rising land inequality - findings consistent with the limited available scholarship addressing the issue in the region. Whereas there is not certainty a complete depletion of the forest will occur, further land use intensification and land inequality appear to be more general and long-term trends. These shifts may significantly constraint the sustainability of Indigenous shifting cultivation as well as the land access and management by younger generations which may adversely affect their livelihoods and welfare in the coming decades. This study underscores the importance of moving beyond conservation discourses constructed around Amazonian Indigenous territories to address the emerging challenges of resource sustainability within these communities (Le Tourneau, 2015).

Chapter IV. Discussion and Conclusions

In this thesis, I analyze how land scarcity develops and its impacts on Indigenous territories of the Peruvian Amazon. Local land scarcity is an overlooked phenomenon in Amazonian scholarship. The few existing studies primarily attribute land scarcity to land demand drivers such as population growth and market integration, while the focus on impacts has been in understanding how land scarcity transforms land use/cover trends. Of note, most of these studies were conducted in non-Indigenous settlements. The current conservation discourse regarding Indigenous territories as protecting tropical forest may obscure the emergence of sustainability challenges, including land scarcity. Indeed, the low rates of forest clearing found in Amazonian Indigenous territories at a regional level, and the consequent portrayal of Indigenous peoples as 'guardians of the forest' reduces the room to explore resource degradation, impoverishment or shortage issues experienced by specific Indigenous communities.

This study contributes to filling this gap by examining in deep how land scarcity is produced in Amazonian Indigenous territories, and how Indigenous communities and households deal with land scarcity by adjusting land property and management practices. To address these research objectives, this study departs from a neo-classical and Marxian economics definition of land scarcity and incorporates analytical concepts and heuristic categories from access and property regimes, peasant economics and shifting cultivation scholarship. A study case and quasi-experimental research were conducted in communities situated along the Napo River. Quantitative and ethnographic methods were utilized, combining descriptive and inferential statistic analysis, with discourse and oral history analysis.

Comprehending local land scarcity and its impacts is a topic of considerable interest to Amazonian scholars and practitioners given the profound transformations that declining land availability could trigger in Amazonian Indigenous land systems, and the major consequences this may have for the reproduction of anthropic forest ecosystems in the biome. In essence, land scarcity may shift and compromise Indigenous land management practices which have thus far sustained the continuity of the Amazon rainforest. This study contributes with an Indigenous case to the limited literature, emphasizing in the resource sustainability issues arising within Amazonian local communities. The results highlight that processes limiting Indigenous peoples access to forest, including the expansion of forest conservation regimes in ITs, are critical in the development of land scarcity

within Indigenous territories. Additionally, the study shows that Indigenous peoples are capable of innovative and rapid adjustments to their land management and property practices in the face of land constraints. However, the potential environmental and societal externalities of these transformations are also to be acknowledged. Overall, this thesis suggests that Amazonian Indigenous peoples are not immune to land scarcity and its ramifications, representing one of the most concerning emergent challenges in the region.

In the remained of this chapter, I summarize the content and key points from Chapters II and III. Following that, I discuss the main cross-cutting findings of my work. I conclude by indicating the research and policy implications of these results.

4.1 Chapter summaries

In Chapter II, I aimed at understanding how land scarcity was produced and how land access and property regimes changed in a community facing a severe decline in land availability. I conducted an ethnographic case study of Tamboruna, an Indigenous community situated in the middle Napo River. The data were collected through land surveys, interviews and participatory observation with Indigenous households, focus groups and interviews with community authorities, and interviews with Indigenous federation leaders and NGO officials. Oral history analysis and discourses analysis were the primary methods employed for examining and interpreting the data. Results from Chapter II reveal that factors limiting the access of locals to the forest, including competing claims between State and non-State actors over the community's territory, the imposition of forest conservation regimes, and internal territorial fission contributed to land scarcity in the study community. Additionally, the chapter shows that within a complex context of criminalization, indebtedness and economic incentives for conservation, Indigenous community authorities can play a critical role in enforcing forest access restrictions and confining agricultural land use. Facing severe land scarcity, a process of property regime adjustment has taken place in the community, by which individual possession rights have been constrained, constituting a common pool of secondary forest lands accessible to all community members. Notably, this open access turn in land property rights was driven by internal struggles between age cohorts holding unequal initial land endowments, and was grounded through land contestation practices.

The goal of Chapter III was to determine whether household land management differ in a community experiencing severe land scarcity. I examined two opposing hypotheses associated with land scarcity: the neo-Malthusian hypothesis which predicts further individual land appropriation following land scarcity; and the Boserupian hypothesis, which suggests land use intensification as a response. I conducted quasi-experimental research comparing Tamboruna (land-scarce community) and Solidaridad (land remains available). Data collected through household land surveys and plot surveys were the basis for my quantitative analysis. Findings show Indigenous households in the land-scarce community still accumulate and administer their land as do traditional Amazon peasants elsewhere. However, land rivalry in Tamboruna increased, resulting in a wave of accelerated land accumulation among the young adult segment of the community. Individual appropriation was not found to be a generalized behavior. Moreover, a complex interaction between land inequality and land scarcity was found, by which initial land disparities conditioned household responses to declining land availability, and land scarcity contributed to current land-size inequality. Finally, my results point to land use intensification (through the shortening of fallow length), and a greater share of fallow cover being associated with land scarcity, suggesting households deployed combined land-use/cover strategies. The concurrence of land use intensification with diminished cropping periods suggests the risk of land-use poverty traps formation among households, potentially leading to the degradation of soils and secondary forests.

In sum, this thesis provides a more nuanced understanding of the complex processes contributing to land scarcity within Indigenous territories. It also explores the impacts of land scarcity on multiple dimensions of Indigenous land systems, including land use, accumulation, distribution and land access and property regimes.

4.2 Main findings of the thesis

Incomplete and weakly enforced Indigenous forest rights set the conditions for enclosure processes that were critical in the development of land scarcity, revealing the structural nature of this issue in Indigenous territories of the Amazon.

One of the primary objectives of this study was to understand how land scarcity arises in Amazonian Indigenous territories, where forest clearing rates are generally low (Baragwanath &

Bayi, 2020; Bennett et al., 2018; Blackman et al., 2017; C. Gray & Bilsborrow, 2020). My research reveals that processes constraining the forest land supply in the community of study were critical in fostering land scarcity. In the context of incomplete and weakly enforced Indigenous forest rights (Larson et al., 2015), competitive claims from the State and non-State actors over the community's forest led to territorial fission, and the imposition of conservation area, significantly curtailing the access of locals to old-growth forest. Demographic growth, a driver of agricultural land expansion, also contributed to forest area decline, although not showing a linear and steady association; a finding consistent with recent population-land scholarship in the Amazon (de Sherbinin et al., 2007; Tritsch & Le Tourneau, 2016). Other factors delimiting the land quantity and quality, such as flooding history and soil types, were not sufficiently accounted in this research and may be also linked to declining land endowments - see Abizaid (2008); Langill & Abizaid (2020). Overall, the evidence gathered supports the definition of land scarcity as a relative phenomenon, resulting from the interaction of growing land demand with a limited land supply (Hartmann & Gerber, 2018). Further, my results underscore the relevance of problematic forest property and control regimes in force in the Peruvian Amazon in limiting the access to land at the local level, revealing the structural nature of land scarcity in this community - as defined by Homer-Dixon (1999) . Of note, structural land scarcity accounted in this study resembles the land shortage processes documented in African pastoralist and peasant communities (Andersson, 1999; Chamberlin et al., 2014; Scoones et al., 2019).

In conclusion, land scarcity was not caused by the uncontrolled advancement of the agricultural frontier in community territory; a neo-Malthusian narrative of forest depletion (Fairhead & Leach, 1995) that has largely influence State forest policies in the Amazon (Bennett et al., 2018; Ravikumar et al., 2016). Rather, it was driven in a great extent by Indigenous peoples losing access to old-growth forest in their own territory. Moreover, land scarcity has a prominent structural nature in this case, reflecting that the regimes defining the property and control over the forest were pivotal in constraining land availability (Homer-Dixon, 1999). The further weakening of Amazonian Indigenous territorial rights (Sarmiento Barletti et al., 2021; Silva-Junior et al., 2023), together with the ongoing expansion of conservation regimes may contribute to the broader emergence of land scarcity in communities of this region.

The expansion of forest conservation regimes may contribute to land scarcity by producing more constraint and less dynamic land use regimes.

The adoption of a Payment for Ecosystem Services program to offset fines imposed by the State for the community's involvement in timber laundering was a key development that increased land scarcity. This case presents a common scenario where corruption in State-regulated resource extraction schemes leads to the involvement of Indigenous and folk communities in illegal networks (Gianella & Cárdenas, 2022); but with an unprecedent resolution - the establishment of a conservation area to settle for environmental crimes. The precedent suggests that conservation regimes can be introduced in Indigenous communities facing criminalization processes and subject them to moral and economic indebtedness to the State. This poses the question whether the advancement of illegal/informal economies in Amazonia together with the evolution of environmental criminal law, would coincide with the expansion of conservation geographies. This complex relationship warrants further investigation to understand how these overlapping dynamics impact the broader region.

Shifting cultivation practiced by Indigenous households, which involves clearing new forest land, challenges conservation views on deforestation. The NGO intervention in Tamboruna pushed for the confining shifting cultivation agriculture to secondary forest lands, and the decoupling of agricultural from forest landscapes - a process typically driven by conservation projects in tropical forest (Dobler-Morales et al., 2020). Of note, my research shows Indigenous authorities can actively and strictly enforce this environmental land-use regime among community members, when conditioned by State criminalization and economic incentives from conservation. The use of satellite technology for monitoring land-use change was critical in establishing effective internal control within the community (Slough et al., 2021). Overall, the consolidation of an environmental rationality within Indigenous community government - a phenomenon increasingly documented (Palacios & Sarmiento Barletti, 2021) - may have long-term consequences for land use regimes for Indigenous peoples across the Amazon basin.

Land scarcity is associated with notable shifts in Indigenous land property and management, and these transformations are multifaceted and multilinear.

Neo-Malthusian scholarship typically associates land scarcity with further resource individualization, the development of resource markets, and eventual resource depletion (Fairhead & Leach, 1995; Scoones et al., 2019). Conversely, scholarship drawing on institutional economics (Schlager & Ostrom, 1992) and neo-classic economics (Boserup, 1965) suggests a different trajectory where by land scarcity leads to stronger collective resource regulation, resource intensification and other resource substitution strategies, and overall preservation of the available land. The second main objective of my research was to explore how land scarcity influences transformations in land property and management practices, and through that, to assess whether previous assumptions are consistent in this context.

This thesis demonstrates that Indigenous responses to land scarcity are multifaceted and multilinear, including trends towards both notional transitions: the communalization of fallow lands, accelerated individual land accumulation, land use intensification, and higher land inequality. Shifts occurred in the control and management of the remaining forest area and of the lands already in use. Notably, none of the adjustments documented occurred through the articulation of collective institutions; and yet, a scenario of complete individual appropriation of the forest to date has been avoided in Tamboruna. Nonetheless, land scarcity still had critical ramifications for Indigenous land systems with troubling implications for agricultural sustainability and land access in the next few decades. Younger generations will likely face significant constraints in obtaining and managing their lands, conditioning their livelihoods and welfare in the coming years.

Of note, my results are consistent with previous research available in non-Indigenous settlements, indicating that Indigenous peoples of the Amazon are not immune from the challenges posed by land scarcity among other peasantries. This study underscores the importance of going beyond the image of landscape stability surrounding Indigenous territories and analyzing the resource sustainability challenges emerging within these communities.

The primary response to land scarcity was significant adjustments in the property rights and management of secondary forest lands.

To make land available in a context of scarcity, the property and management regimes of secondary forest lands underwent a significant modification in Tamboruna. Land scarcity led to the reduction of individual property rights over fallow plots and the consequent constitution of a common-pool of secondary forest lands, on which ownership was traditional founded on long-term usufruct. This shift was grounded in land contentions between land poorer and richer segments of the community, which challenged the legitimacy of long-standing property practices to safeguard access to land and subsistence for every community member. This process is notable for several reasons. First, it demonstrates access and property regimes shifts with communal orientation that aimed to reduce inequality or imbalances among society segments can occur throughout internal disputes, and without the establishment of collective institutions. Second, it exposes the highly relational nature of land access and property regimes in Amazonian Indigenous communities; a phenomenon previously documented by few studies (Bremner & Lu, 2006; Cronkleton & Larson, 2015; Lu, 2001a) but usually overlooked. Finally, it may lead to the overexploitation of upland fields and increasing constraints on household land use management. Further research is needed to determine whether the communal-type of land property shifts are a trend among land-scarce Amazonian communities.

At a household level, land use intensification and upland fallow field stocking were a combined strategy broadly utilized by households in Tambrouna. Of note, my results suggest land use intensification may not only be explained by the need to maximize land availability, but also to secure secondary forest lands possession rights. Aligned with existing scholarship, this study confirms land use intensification as an intuitive and frequent response to land scarcity among forest peasants of the Amazon, a phenomenon with well-documented negative impacts on soil fertility status. Further, this study also provides an Indigenous case supporting the prediction that Amazonian communities landscapes are increasingly composed of young secondary forest (Coomes et al., 2000). This intensification process, a trend already identified in tropical forest at a global scale (Lawrence et al., 2010), has critical implications for the sustainability of shifting cultivation and anthropic forest ecosystems.

Land scarcity increases rivalry over land, having significant impacts over the internal land distribution of Indigenous communities.

In Tamboruna, a race for claiming land in the remaining old-growth forest occurred as land scarcity built up, especially among initial-land-poorer families. This land accumulation strategy is characterized for being decoupled from households consumption needs and rather driven by interest in asset expansion, leading to the constitution of a new land-richer segment and higher land inequality in the community. My results suggest land scarcity may be linked to increasing land rivalry, accelerated land accumulation waves, growing asset inequality and potential internal economic differentiation. I also found that disparities in initial land endowments and land redistribution dynamics are critical to determine the severity and extent of land-size inequality in time - suggested by Coomes *et al.* (2011). Overall, this development suggests land access will become increasingly contentious in land-scarce communities.

Still, complete individual appropriation of the forest has not happened in the community, and the cultivated land appeared to have stabilized in the last decade. Many factors may be containing a further advancement over the forest, including the substitution effect of lowland use, the access and property regime innovations described ahead, the enforcement of forest conservation regimes and the diversification of households livelihoods outside agriculture. Full individualization of property may ultimately arise in specific circumstances, for example, critical environmental crises, social fabric erosion or indebtedness - see Herz (2018), or Sarmiento et al. (2021).

4.3 Research and policy implications

Contributions to the conceptualization and analysis of land scarcity

This thesis contributes to the conceptualization and analysis of land scarcity and its implications within local territories of Amazonia. These contributions can be summarized as follows.

a. Analyzing land scarcity arising and building up in a territory requires a comprehensive and historical approach. A diverse array of factors driving land demand, delimiting the land supply, and organizing land supply access and control are involved in land scarcity production. These factors have not pre-determined nature, and may include ecological, demographic, market, and political processes. Moreover, land scarcity can build up

progressively and non-linearly in a territory, because of feedback relationships with internal land distribution structures and local scarcity perceptions.

b. To effectively address the evolving nature of land scarcity, measurements of variations in land availability can help identifying land scarcity trends [as in Coomes et al. (2000)], and better isolate and model its effects in a given territory. Thus, measuring absolute land availability according to the particularities of different land systems, an effort made by Littleboy (2022) for African communities, can greatly benefit further land scarcity research, despite the criticism of being 'reductionistic' (see Scoones et al., 2019). In this thesis, the three approaches to land scarcity, absolute, relative and structural (Homer-Dixon, 1999; Scoones et al., 2019), were instrumental in developing a nuanced understanding of this phenomenon.

a. My study supports and extends existing theoretical understandings of the effects of land scarcity. Land scarcity was found to be associated with increasing land rivalry (Hartmann & Gerber, 2018). The transformations identified do not adhere to a fixed trend towards communalization or individualization, rather it is showed that land scarcity can lead to access and management shifts both in the remaining land and the land already in use, with differentiated responses of land users. My findings revealed that interactions with local land distribution structures were highly relevant in defining specific land scarcity ramifications in the territory (Coomes et al., 2011).

Contributions to the understanding of Indigenous land access and property regimes

In this thesis, I examined the multifaceted aspects of Amazonian Indigenous land systems, encompassing agricultural land use, access, accumulation, distribution, and property. My research contributes by shedding light on Indigenous land access and property regimes, a critical dimension that has been largely ignored in Amazonian scholarship.

a. My research aligns with Cronkleton and Larson's (2015) portrayal of Indigenous land access and property regimes as deeply relational. Rather than governed by centralized, formal institutions, land access and property practices are anchored in common moral agreements, implicit conventions, and social networks. There is no actor or institution centralizing the control of land access of others; configuring the most important feature of

Amazonian Indigenous land property regimes. Overall, my research reveals the complex duality of resource management in Amazonian Indigenous territories, where highly individualized household land management coexists with tacit access and property societal regulations (Cronkleton & Larson, 2015; Lu, 2001).

b. My study suggests that, where property rights are not officially sanctioned or coercively enforced, the act of land appropriation through physical claiming (Kronenburg García & van Dijk, 2020) is crucial for maintaining access to resources. Common and implicit property conventions legitimize specific claiming practices, such as cutting and burning old-growth forest and sustained use, as acceptable sources of land ownership. Of note, claiming practices described in this research were related to converting old-growth forest into an anthropic agricultural space, and controlling or 'taming' secondary forest succession, a finding consistent with other ethnographic descriptions of land tenure in Amazonian Indigenous and folks settlements (see Gow, 1991; Ocampo-Raeder, 2008). As resource pressures increase and customary property conventions weaken, Indigenous households may intensify their land appropriation efforts by making claims more frequently or with more conspicuous landscape interventions, as seen in the case of Tamboruna.

c. The relational nature of Indigenous access and property regimes makes them highly flexible and adaptable to contexts of resource pressure (Cronkleton & Larson, 2015). My thesis demonstrates that an adjustment to certain elements of access and property regimes can occur instead of a full regime shift. Moreover, it is shown that regime adjustments can take place through internal disputes in which property conventions are contested in the moral arena rather than in the realm of governance. Additionally, my findings support the work of Lu (2001), indicating that these adjustments are primarily driven by imbalances in social strata rather than concerns for conservation or sustainability, but these adaptations can compromise the sustainability of agricultural production, as suggested in the case of Tamboruna.

d. Relational land access and property conventions are deeply intertwined with local moralities and sociability patterns, significantly influencing regime transitions. My research underscores the prominence of subsistence rights morality within Amazonian Indigenous communities, akin to that found in other peasant societies globally (Scott,

1976). It also emphasizes the strong influence of distinct Amazonian cultural and sociability norms, including the strict sense of autonomy, the avoidance to open conflict between relatives/neighbors, and intolerance of asset over-accumulation. In the case study, all these norms played a key role in legitimizing property discourses and practices, and in some instances, shaped the property regime adjustment in turn - e.g., avoidance of conflict allowed internal land dispossessions to remained in the private sphere.

Policy implications

a. For Amazonian Indigenous communities, land scarcity is still an issue of incomplete and weakly enforced territorial rights. My findings suggest land scarcity in these territories is explained to a great extent by structures defining forest control and access in Amazonia, and challenge the presumption that resource sustainability issues are decoupled from land rights struggles. Strengthening the protection to Indigenous territories and improving resource extraction regulations in which Indigenous communities are involved, are urgent policy measures advocated by most of Peruvian civil society (see Gianella & Cárdenas, 2022). The results from this thesis not only bolster these calls but introduce a new argument: the detrimental impacts vulnerable Indigenous territories have on the sustainability of Indigenous resource management systems, and overall, in the livelihoods and welfare of Indigenous communities in the next few decades.
b. Despite the forest preservation effect of Amazonian Indigenous territories, we must acknowledge the local sustainability challenges arising within Indigenous communities, including growing resource scarcity and landscape degradation. Concurrently, in the face of greater resource constraints, my thesis shows that Indigenous peoples can innovatively shift and adapt their resource management practices and arrangements according to new circumstances. However, these adaptations can exert significant pressure on local ecosystems. From a policy perspective, comprehending Indigenous resource management systems, their transformations, adaptations, and limits is essential for determining how external initiatives from State or NGO's may support these processes and address their potentially adverse impacts.

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Appendix 1: Soil analysis results of producers in Tamboruna and Solidaridad

Results NPK pH test							
Code of household	**CE ds/m Relación 1:1**	**pH Relación 1:1**	**M.O. %**	**P ppm**	**K ppm**	**$Al^{+3}+H^{+1}$**	**Location of plot**
Tamboruna							
001	0.13	3.91	2.92	10.11	54.80	1.70	Upland
002	0.08	4.09	2.96	9.92	47.00	2.10	Upland
003	0.06	4.30	2.53	8.72	40.00	1.50	Upland
004	0.13	5.34	1.55	30.43	84.00	0.32	Upland
005	0.11	4.39	3.24	14.63	76.80	1.50	Upland
006	0.06	4.30	2.32	12.14	46.40	1.60	Upland
007	0.11	4.09	2.96	8.81	50.40	2.20	Upland
008	0.07	4.26	2.32	9.18	64.80	1.50	Upland
009	0.07	4.23	2.74	4.38	49.20	1.75	Upland
010	0.06	4.79	2.57	10.29	59.60	0.35	Upland
011	0.06	4.21	2.24	8.44	76.80	1.65	Upland
012	0.07	4.26	2.56	6.41	40.40	1.10	Upland
013	0.10	4.73	2.02	10.20	79.80	0.40	Upland
014	0.05	4.34	3.06	7.24	51.60	1.30	Upland
015	0.07	4.09	3.67	7.43	62.80	1.98	Upland
016	0.06	4.28	3.26	5.76	75.20	1.40	Upland
017	0.03	4.51	2.96	7.52	50.40	1.05	Upland
018	0.10	4.11	4.10	9.09	57.00	1.60	Upland
019	0.07	4.16	3.87	6.60	80.20	1.61	Upland
020	0.08	4.20	2.79	7.52	80.60	1.60	Upland
021	0.12	4.15	3.23	8.63	77.00	1.12	Upland
022	0.02	4.69	2.79	9.37	67.40	1.90	Upland
023	0.09	5.40	0.63	26.18	79.60	0.50	Lowland
024	0.11	5.96	0.49	34.58	70.80	0.09	Lowland
025	0.07	5.89	0.95	31.72	92.00	0.05	Lowland
026	0.11	5.86	3.03	20.17	86.20	0.05	Lowland
027	0.08	5.84	1.27	20.82	48.60	0.12	Lowland
028	0.07	5.98	0.76	26.45	72.40	0.05	Lowland
029	0.09	5.86	1.99	26.64	83.40	0.05	Lowland
030	0.03	6.09	1.70	25.72	102.40	0.07	Lowland
031	0.12	5.89	1.41	22.94	86.00	0.05	Lowland
032	0.03	6.30	2.05	14.82	106.40	0.05	Lowland
033	0.13	5.72	2.99	23.89	128.60	0.05	Lowland

034	0.11	6.24	2.22	17.13	120.00	0.05	Lowland
035	0.04	6.03	1.45	24.61	101.60	0.05	Lowland
036	0.12	5.82	1.58	23.87	127.00	0.05	Lowland
037	0.07	5.81	1.11	25.99	73.60	0.05	Lowland
038	0.06	5.81	2.46	20.45	80.40	0.05	Lowland
039	0.24	5.95	1.24	23.04	175.20	0.05	Lowland
Solidaridad							
001	0.05	4.38	1.92	13.43	37.80	2.90	Upland
003	0.06	4.22	2.29	14.54	40.20	5.50	Upland
004	0.09	4.09	2.80	15.28	89.40	3.70	Upland
005	0.09	4.30	2.86	16.11	49.80	4.10	Upland
006	0.06	4.30	2.57	9.09	89.00	4.60	Upland
007	0.08	4.07	3.84	10.57	48.60	4.30	Upland
008	0.08	4.18	2.14	15.46	65.00	5.50	Upland
009	0.06	4.26	1.57	15.09	42.00	5.40	Upland
010	0.09	4.11	1.49	13.62	38.60	5.40	Upland
011	0.09	4.16	2.47	19.62	52.80	5.30	Upland
012	0.08	4.22	2.79	16.29	63.40	4.90	Upland
013	0.15	3.87	3.68	18.97	49.40	3.71	Upland
014	0.06	4.23	2.75	18.23	42.80	5.30	Upland
015	0.06	4.13	2.99	12.88	71.80	2.95	Upland
016	0.05	4.19	2.28	15.00	59.60	3.20	Upland
017	0.14	3.82	3.38	16.29	38.40	4.20	Upland
018	0.04	4.35	2.21	7.52	69.80	5.20	Upland
019	0.10	4.06	4.00	18.42	49.00	6.20	Upland
020	0.09	4.07	2.00	17.13	54.40	6.10	Upland
021	0.15	3.94	3.35	15.19	90.00	5.50	Upland
022	0.09	4.16	2.65	15.55	87.40	6.00	Upland
023	0.07	4.22	2.50	13.25	60.80	5.60	Upland
024	0.21	3.93	2.57	14.08	57.20	5.70	Upland
025	0.12	4.15	2.72	19.53	49.00	6.00	Upland
026	0.09	4.03	2.41	13.80	41.80	3.10	Upland
027	0.05	4.22	2.15	16.02	35.80	3.18	Upland
028	0.11	3.95	1.82	19.62	41.40	4.00	Upland
029	0.21	3.80	3.06	13.25	131.20	4.40	Upland
030	0.07	4.26	2.67	11.95	27.40	3.35	Upland
031	0.07	4.27	2.47	19.25	49.40	2.80	Upland
032	0.09	4.04	3.77	13.06	45.40	3.11	Upland
033	0.07	4.21	3.19	11.40	56.60	4.42	Upland

034	0.15	3.95	2.93	17.59	41.00	3.90	Upland
036	0.11	4.03	1.82	17.13	40.40	3.35	Upland

Appendix 2: Example of soil analysis report delivered to households in Tamboruna and Solidaridad

RESULATADOS DE ANÁLISIS						
Código	CE ds/m	pH	M.O. %	P ppm	K ppm	$Al^{+3}+H^{+1}$
001	0.13	3.91	2.92	10.11	54.80	1.70

PH (ACIDEZ)	
Ultra Acido menos de 3.5	
Extremadamente Acido entre 3,6-4,4	X
Muy Fuertemente Acido entre 4,5-5,0	
Fuertemente Acido entre 5,1-5,5	
Moderadamente Acido entre 5,6-6,0	
Neutro entre 6,6-7,3	
Ligeramente Alcalino entre 7,4-7,8	
Moderadamente Alcalino entre 7,9-8,4	
Fuertemente Alcalino entre 8,5-9,0	
Muy Fuertemente Alcalino mayor de 9,0	

MATERIA ORGÁNICA	
POBRE (M.O) menor de 2	
MEDIO (M.O) entre 2-4	X
BUENO (M.O) mayor de 4	

FÓSFORO (P)	
BAJO (P) menor de 7	
MEDIO (P) entre 7-14	X
ALTO (P) mayor de 14	

POTASIO (K)	
BAJO (K) menor de 100	X
MEDIO (K) entre 100-240	
ALTO (K) mayor de 140	

ALUMINIO (Al me/100gr)	
BAJO (Al)	
MEDIO (Al)	
ALTO (Al)	X